Sustainable water management in the tropics and subtropics

and case studies in Brazil Vol. 2

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The book Sustainable Water Management in the tropics and subtropics - and case studies in Brazil is the result of a joint initiative between the Federal University of Pampa (Jaguarão Campus, Brazil) and University of Kassel (Germany). It is also supported by the Culture and Society Postgraduate Programme of the Federal University of Maranhão (PGCult / UFMA), the Federal University of Lavras, Brazil, and the German-Brazilian Chamber.

The publication aims to gather scientific production on water from Brazil and other parts of the world in a multidisciplinary way. Its common theme should make it a global book. The 53 articles of the first volume deal with Water and Agriculture. The 30 articles of the second volume address Water and its technologies. The 49 articles of the third volume show research on Water and Environment. The 63 articles of the fourth and final volume address Water Management. In addition to the articles of the first volume, four photographers were invited to showcase their visions of the theme before each chapter. Antonio Azevedo (MA), Léa Scomazzon (RS), Palê Zuppani (SP) and David Rotbard (NY).

Two years after its inception, the organizers now present this book, hoping that the four volumes will contribute significantly to the ongoing debate about water management.

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INTEGRATED ENERGY RESOURCES PLANNING AND WATER MANAGEMENT FOR REGIONAL SUSTAINABILITY IN BRAZIL

Paulo Hélio Kanayama
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Luis Cláudio Ribeiro Galvão
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INTRODUCTION

The world's population in 2050 will be more or less 9 billion people and that amount is concerning to the developing world growth. In fact this increase will cause big impact on the earth natural resources (including water), biodiversity and the equilibrium of the natural systems. Because those issues it is mandatory to implement a new approach for the earth resources use and how are assess them. In other words the balance of ecosystems are not going to be enough to supply the needs of the planet sustainability; unless a new manner of how to manage the earth resources will be developed.

The current development paradigm only prioritizes the technical-economic dimension and this has caused unbalance between raw materials and residues. On the other had we also know that not all residues coming from human activities are usable. For that and other reasons the issues linked to the people (like policy, life-style, customs etc.) are a factors to include in the design development of the near future global economy and processes, and, that people will be the stakeholders for change the actual resource economics paradigm. Of course these new paradigm of development is necessary to combat problems which current pattern is incapable to solve, such as reduction of biodiversity, pollution, social inequality and the climatic changes

But water because everybody drink it, wash and bath with it or as a natural system is a one of the keys that will redirect no matter what development new way. More than that water is directly related to single but necessary things like dishes, clothes, homes, cars and industries; It is true that food crops no grow without water even human been no survive more than 144 hours without it. In that sense water is a critical sustainable development issue together with energy and food security. Availability of freshwater is steadily decreasing and the 2050 scenario (with emerging economies increase consumption levels and global warming disclose) will inevitably worse as the world's population enlarges towards 9 billion.

Nearly 20% of world population does not have access to safe drinking water and 40% does not have access to basic sanitation system. Water withdrawals from rivers and lakes have doubled since 1960. In terms of orthodox economic development all businesses will be have uncertainties, tensions and dilemmas with their use of water over the business-as-usual scenario. Thus in this scenario, stakeholders will be demand sustainable water management.

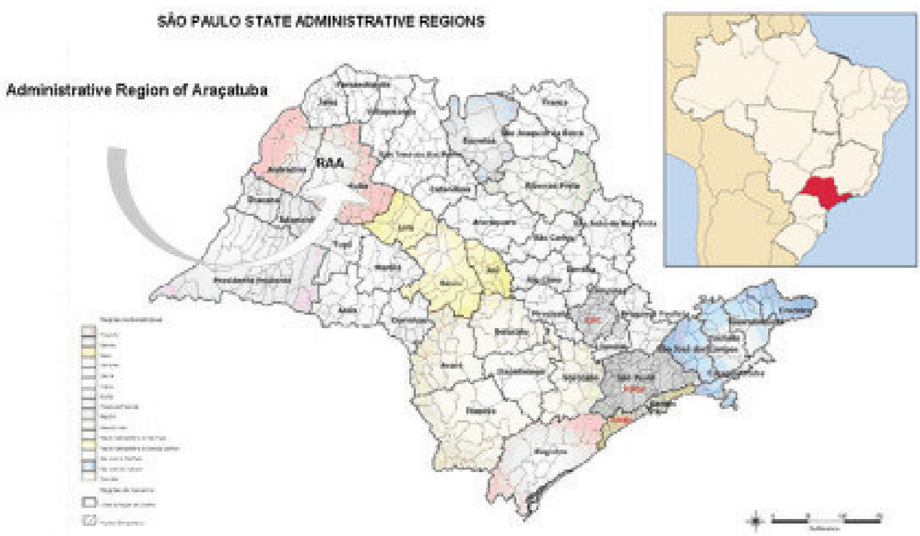
Sustainable water management means that water, energy and climate changes are well interconnected. For instance, the freshwater management big challenge is to allocated limited water resources between agricultural, public supply and environmental uses. This means to consider the integration of supply, demand, quality and environmental issues

Afterward and specifically in the context of this work it is clear that the new paradigm demands for integrated energy resources planning (PIR) (FAPESP 03/06441-7, 2009), even considering water essentially in the sense of sustainable energy use (supply and end-use),

PIR (Integrated Energy Resources Planning)

In this work the philosophy of PIR (Integrated energy Resources Planning) is used looking for the local sustainability for the Paulista west region, which is the Araçatuba Administrative Region (RAA) of São Paulo State in Brasil (see figure 1). The PIR, conceptually amongst other procedures, includes the energy resources integration, where these resources are RELO (Supply Side Energy Resources) and RELD (Demand Side Energy Resources), and satisfy the energy needs forecasted in the local of energy planning study. That means the PIR try to rethink the development model to reach sustainability (UDAETA, 1997).

Figure 1. The Administrative Region of Aracatuba (RAA)



The PIR in coherence with the UN Sustainable Development index of Agenda 21, beyond economic and technique aspects; it is necessary to incorporated in equity the social, environmental and politician dimensions also.

Therefore, in the PIR, the local, regional and national needs are analyzed and the energy planning is made considering these four dimensions named: Technical-Economic, Environmental, Social and Politician. PIR consider those four development dimensions for the full cost account of energy resources fundamentally because nowadays that economic single costs do not reflect, necessarily, social, environmental and politician costs (FAPESP 03/06441-7, 2009).

The current development paradigm only prioritizes the technical-economic dimension and this has caused throw into disarray the earth natural resources use, that is unbalance between raw materials and residues. Nor all residues from human being activity is usable as raw materials for other processes nor the time that natural systems spend to recycle them are so long, that they cause ecosystem alterations that are harmful even to the human life. So, a new paradigm of development is necessary to combat other problems that the current paradigm is incapable to solve, as the reduction of biodiversity, the pollution, the social inequality and the climatic changes.

Depending on the region where the PIR is applied this energy planning philosophy, not necessarily proper information is counted on. Therefore, it is necessary to apply inferences and deductions among others regions of the globe to improve demand forecast and restrained demand estimation. Restrained demand becomes especially conflicting in regions such as the western of São Paulo State (RAA/SP/Brazil), because it is in development country that still must consider more new efficient technologies and other global warming restrictions.

In the developing countries the restrained demand of basic necessities brings the result of poor technology contributing on the increase of environmental problems.

In that sense, this chapter covers ground and surface water resources, river basins, environmental degradation and energy generation always considering the local PIR methodology for RAA, composed by 43 municipalities in the western area of Sao Paulo (SP), the most important state of Brazil . On the figure 1 and 2, the RAA is shown; located in the west of Sao Paulo state.

Figure 2. Infrastructure of Administrative Region of Aracatuba

RAA CHARACTERIZATION

The Administrative Region of Aracatuba (RAA) presents good roads, waterway (Tiete-Parana rivers) and railway structures that promote trade and make Aracatuba an important route from the Atlantic to the Central-West of Brazil.

In RAA the understanding of the importance of relationship between ecosystem and economical growth is very poor. Although water scarcity is a significant problem in some parts of Brazil, in the region of Aracatuba the water demand is less than 50% of its availability. Three river basins, Baixo Tiete, Aguapei and Sao Jose dos Dourados, supply water to 43 municipalities with approximately 1.4 million people. Table 1 shows the demand and availability of surface water and ground water of the river basins in Aracatuba. Table 2 shows the population of each river basin and the surface water pollution in terms of wastewater load.

Table 1. Surface water and groundwater demand x availability

	Surface water			Ground water		
	Demand	Availability	Use	Demand	Availability	Use
River Basin	m^3/s	m^3/s	%	m^3/s	m^3/s	%
UGRHI* 18 (Aguapei River)	1,59	12	13,3	0,98	4,4	22,3
UGRHI 19 (Baixo Tietê River)	12,88	27	47,7	1,2	12,2	9,8
UGRHI 20 (S.J. Dourados River)	3,78	n.a.		1,4	n.a.	

Source: 1999 Sao Paulo state water resources situation report (Relatório de situação de recursos hídricos do Estado de Sao Paulo, 1999)

*UGRHI - Unit of Water Resources Management abbreviated

Table 2. Surface water pollution

	Population [hab.]		Wastewater Load [kg BOD/day]	
River Basin	Total	Urban	Potencial	Recovery
UGRHI 18 (S.J. Dourados River)	222.322	193.926	10.472	2.301
UGRHI 19 (Baixo Tietê River)	719.580	662.016	35.749	13.463
UGRHI 20 (Aguapei River)	357.649	313.519	16.930	6.317

Source: 2005 Sao Paulo state groundwater quality report - CETESB/2006 (Relatório de Qualidade das Águas Interiores do Estado de Sao Paulo 2005 - CETESB/2006)

In Aracatuba, although the demand of water is less than 50% of its availability, the issue of water management is similar to the energy issue in the context of regional development. Energy resources are abundant, but it is not available in the same way for everybody. In the context of sustainable development, the balance between social equity and economic growth must be improved. Both water and energy can be used to promote economic growth, create jobs and eradicate poverty, maintaining the functioning and resilience of ecosystems.

In RAA, the supply side generates about four times more energy than needed; this statistic is considering only the explored energy resources. RAA exports surplus energy to other regions, considered clean energy; generated by hydropower plants or cogenerated from sugarcane bagasse and also alcohol from sugar cane. The curious fact is that RAA imports fossil fuels. Table 3 presents the energy balance of the RAA.

In RAA today we can consider the following:

- local electricity - about 68%
- imported energy from derivatives oil - about 21%
- alcohol - 10%
- natural gas - 1%

Table 4 presents the energy balance classified according to the potential of renewal of the source. Figure 3 presents the same information. In RAA, although the renewable energy sources are 78%, the demand is predominantly non-renewable, using only 4% of renewable energy.

The energy consumption *per capita*, which was estimated to be 1,376 toe/hab in 2004, was higher than the national average in 2007 which was 1,301 toe/hab; what shows a potential economic growth in RAA. Depending on the public policies that surround the strategic energy planning of RAA, this potential can be efficiently explored or contrariwise.

If the demand for non-renewable energy could be substituted by renewable energy, which local energy resources would create more jobs?

Which ones would cause less environmental impacts and which ones would be easier to explore? How would the characteristics of the region be used to allow an economic growth without an excessive increase of energy consumption per capita?

In other words, which energy resources from both, supply and demand side could be explored at a lower economic, social, political and environmental cost?

These questions can be better answered if we have a broad view of the entire region.

Table 3. Energy supply and demand in RAA

	Supply [toe]	Demand [toe]	Demand/ Supply
Electricity	2.601.893	93.366	4%
Hydropower	2.580.000		
Thermopower	21.893		
Oil	814.646	814.646	100%
Diesel	301.721	301.721	
Gasoline/Petrol	119.057	119.057	
Naftha	88.070	88.070	
LPG	62.790	62.790	
Oil fuel	61.160	61.160	
Others	181.848	181.848	
Natural Gas	44.160	18.768	43%
Alcohol	376.860	36.706	10%
Anhydrous	192.240		
Hydrated	184.620		
Total	3.837.559	963.486	25%

Source: Elaborated by the authors (2004)

Figure 3. Supply and demand of non-renewable and renewable energy

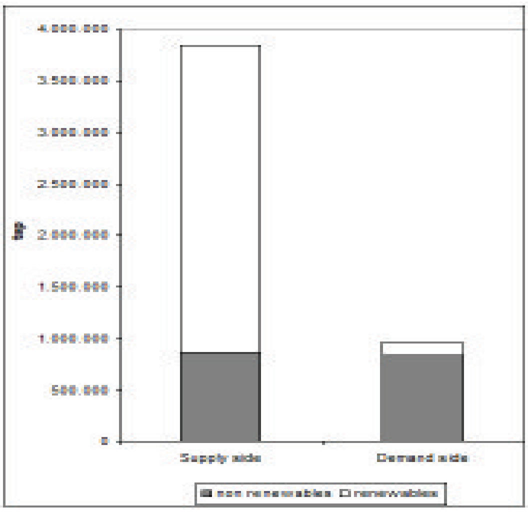


Table 4. Supply and demand of renewable energy

	Supply [toe]	Participation	Demand [toe]	Participation
Non-renewables	858.806	22%	833.414	86%
Renewables	2.978.753	78%	130.072	14%
	3.837.559		963.486	

SUSTAINABILITY OF ADMINISTRATIVE REGION OF ARACATUBA (RAA)

The fact that RAA is an important route from Atlantic to the center of the country and has great energy availability, one of the largest hydropower plants in the world and is cut across by Brazil-Bolivia gas pipeline makes the region a great potential for economic growth.

However, the actual paradigm of development in this region has caused some inequality during its development. At RAA 56% of population are concentrated only in 4 municipals, and 44% are spreaded among 39 municipals. The high density of population concentrated only in 4 municipals; bring tipical problems from great metropolis, such as pollution, social inequality and violence which were not concerning issues few years ago. On the other side, the 39 municipals are left over, no jobs; poor health services and poor education system make residents, in special youth to leave their homes searching for better opportunities in one of those wealthy municipals.

Nevertheless, a new paradigm is necessary; otherwise the inequality tendency will increase in RAA.

From the statistic of MHDI (Municipal Human Development Index – 2004), this only exists in Sao Paulo state.

Despite of RAA has excellent transport structure, excelent production of grain and fruits (mango, pineapple and guava), development of olericulture, tourism industry started growing from the 70s as 3 large hydroelectric dams were constructed, the good industrial foundation producing sugarcane, furniture and shoes, it also has municipals considered the least social-economic developed by MHDI. See the position of RAA municipals in Sao Paulo state ranking by MHDI:

Ilha Solteira - 10th; Aracatuba -12th; Birigui - 34th

Penapolis is in 4th by RAA and is in 105th by Sao Paulo state.

Guzolandia is the last by RAA and is on the 610 position out of 646 municipals which compose the whole state of Sao Paulo.

Pragmatically, energy or water security exists when energy and water are affordable, reliable and accessible to everyone. Considering the fact that security is not properly addressed so far, nor characterized within the traditional energy planning or water management, the central problem of regional development must be the comprehensive analysis of the strategy of security of sustainable energy and water supply over time.

One of great challenges in this century is that, policy makers' face how growing energy and water demand is taken into account to combine security with adverse environmental effects; such as global climate changes, biodiversity loss, water, soil and air pollution.

For instance, the analysis of global warming makes sense for time horizons of 50, 100 and 200 years or more in scenarios where the average temperature can increase from 1 ºC to 5 ºC or even more.

At the moment there are no studies that assure what is going to happen with the energy system operation in this condition. For example, on hydroelectricity system, is evident that the correlation of evaporation and precipitation cycle and alteration of dam volumes change the hydroelectric potential, especially in the tropics and sub-tropics.

The aquatic ecosystems exchange energy and matter among themselves and also with adjacent terrestrial systems. They suffer from different types of alterations coming from increase of demand and releasing of waste from anthropogenic activities. Even 'clean energy' coming from biomass, wind and sun brings a negative impact in the environment.

The susteinability of RAA will happen only if the vulnerable parts have been taking in consideration. The sources of pollution are numerous and diffuse in the whole RAA.

THE USE OF PIR METHODOLOGY TOWARDS THE WATER SUSTAINABILITY

PIR methodology has being used by RAA to identify and encourage the use of energy resources (ER) which most contribute to the sustainability of determined region, while considering social, environmental, political and technical-economic aspects.

With regards to health system, only 20 of 43 municipals of RAA have hospitals, both public and private. For this reason, it is difficult to correlate the problems of sugarcane burning in the fields with other types of energy related to enterprises with respiratory diseases notifications in the region. The solution for these problems was to make questionnaires about health and well-being related to air quality. A pilot study was carried out in the municipal of Aracatuba. Questions with regards to typical symptoms of respiratory diseases related to air quality were elaborated to find out the percentage of how many people were suffering from respiratory problems. This type of research is much cheaper and accurate than collecting dates from hospitals, especially because not everybody with respiratory problems goes to hospital. This example should be carried out not only in municipals but in whole RAA and then spreaded out in the country, in order to correlate the state of population's well-being to the power plants and the wastewater loads.

Table 5 shows the generic format of the final result of energy resources analysis, comprising both energy resources, supply and demand side after taking into consideration the peculiarities and needs of each municipal. Vertically, in the generic model in Table 5, municipalities which have the best conditions to use certain energy resource (ER) are shown. The sum up of vertically placed indexes shows which resources are most adequate for the whole region. The word "adequate" must be understood to be rational-efficient-sustainable in time and the geographic region, considering four dimensions: social, environmental, political and technical-economic.

Table 5. Classification of Energy Resources (ER)

	Sub region	ER_1	ER_2	...	ER_n
Region	Municipal 1	a_{11}	a_{12}	...	a_{1n}
	Municipal 2	a_{21}	a_{22}	...	a_{2n}
	Municipal 3	a_{31}	a_{32}	...	a_{3n}
	...	...	...	...	...
	Municipal m	a_{m1}	a_{m2}	...	a_{mn}
	Total	$\sum_{k=1}^{k=m} a_{k1}$	$\sum_{k=1}^{k=m} a_{k2}$	...	$\sum_{k=1}^{k=m} a_{kn}$

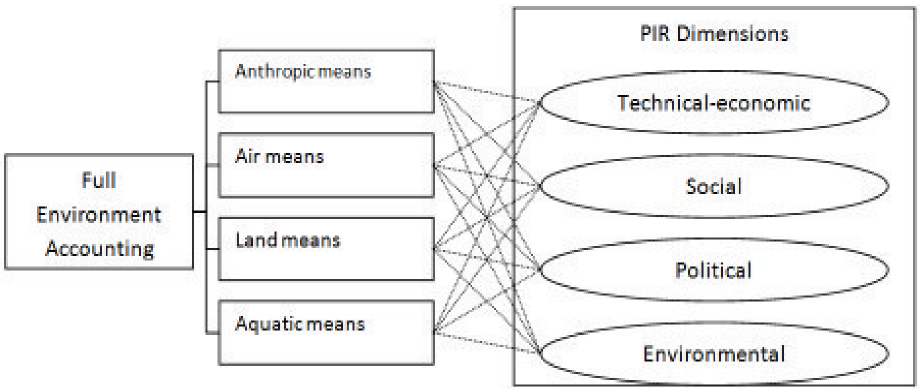
If we have two regions to analyse, the total sum up of the indexes will show which resources are adequated for the number of municipals in these regions. For example, if we want to know the energy vocation of a certain state, firstly we have to determine the vocation for each municipal, and then determine for each Administrative Region, and finally we have the answer which applies to the whole state.

PIR methodology presents the environmental, social, economic, technological and political characteristics of the region, and also identifies energy resources found in this region.

The first step of PIR consists on the elaboration of "Full Environment Accounting", which has important database to enable creating strategic plans for the development of RAA, including energy planning.

The Full Environment Accounting shows the situation of the region with limitations and competitive advantages, such as vulnerabilities, deforestation, biodiversity, education, poverty, water, air and soil pollution etc. It also points out if human activities are adequated or harmfull.

Figure 4. Full Environment Accounting Diagram



Each of the dimensions used in PIR analysis, technical-economic, social, political and environmental, are based on information from the Full Environment Accounting which is subdivided in: anthropic means – air means – land means - aquatic means as can be seen in Figure 4

Anthropic Means Also known cultural environment - directly influenced by man's activities. Some examples that comprise the anthropic means are:

- Historical evolution of the region

- Demographic density and distribution of population by age and gender

- Urban and rural participation of population

- Health, Education and Social indicators like HDI
- GDP
- Infra-structure
- Basic sanitation
- Transport
- Energy
- Policies

Land Means Characterized by the following variables:

- Biodiversity, referent to animal and plants
- Relief
- Soil - characterized by the types of soil, susceptibility to erosion and pollution.

One of the subjects of the land means is biodiversity. Table 6 illustrates how the level of biological importance of each municipal of Sao Jose dos Dourados River Basin was characterized, with regards to fauna and flora. This type of information permits a decision maker to have access to possible environmental restrictions at municipals with regards to energy enterprise. It is possible to calculate "*a priori*" risks that projects can present before implemented.

Table 7 presents the remaining forest areas in each municipal of S. J. dos Dourados River Basin

Table 6. Biological importance of S. J. dos Dourados River basin

	Biological Importance		
Municipal	Mammals	Birds	Flora
Auriflama	1	1	1
General Salgado	1	1	1
Guzolandia	1	5	1
Ilha Solteira	1	1	1
Sao Joao de Iracema	1	1	1
Suzanapolis	1	1	1

Source: Elaborated by the author using information from the Forest Inventory of Ministry of Environment, 2002.

Key (only odd numbers are used) *1=Irrelevant; 3=Insufficient knowledge, but probable biological importance; 5=High biological importance; 7=Very high biological importance; 9=Extreme biological importance

Table 7. Remaining forest areas in each municipal of S. J. dos Dourados River Basin

Municipal	Semideciduous Seasonal Forest (ha)	Secondary Vegetation of the Seasonal semideciduous Forest (ha)	Seasonal Forest in contact with Savannah / Seasonal Forest (ha)	Secondary Vegetation of the Seasonal Forest in contact with savannah / Seasonal Forest (ha)	Trees/bushes, Herbs in the valley region (ha)	Savannah (ha)	Forested savannah (ha)	Savannah in Contact with Savannah / Seasonal Forest (ha)
Auriflama		272		62		368		
General Salgado	222	833		118		579		
Guzolandia		62	11	21		452		
Ilha Solteira	214	131			30	274		
Sao Joao de Iracema		968		241	14	40	30	
Suzanapolis		21			126	633	267	
Total	**436**	**2.288**	**11**	**441**	**170**	**2.346**	**297**	**0**
Participation in RAA	2,1%	10,2%	0,9%	14,1%	3,2%	23,9%	42,4%	0,0%

Source: Brazilian Institute of Geography and Statistics (IBGE – *Inst. Brás.o de Geografia e Estatística*), 2002

Table 8. Biodiversity indexes of each municipal of S. J. dos Dourados river basin

Municipal	Real value		Participation		
	Sum of the remaining natural forests (ha)	Sum of biological importance mammals, birds and flora	(a) Sum of the remaining natural forests	(b) Biological importance mammals, birds and flora	Biodiversity index =(a) x 50% + (b) x 50%
Auriflama	702	3,0	1,1%	0,9%	1,01%
General Salgado	1.752	3,0	2,7%	0,9%	1,82%
Guzolandia	546	7,0	0,8%	2,2%	1,51%
Ilha Solteira	648	3,0	1,0%	0,9%	0,97%
Sao Joao de Iracema	1.293	3,0	2,0%	0,9%	1,47%
Suzanapolis	1.047	3,0	1,6%	0,9%	1,28%

From the information on Table 6 and Table 7, the biodiversity indexes of Sao Jose dos Dourados River basin municipals were determined (Table 8).

The forest areas in each municipal and the biological importance of the mammals, birds and flora are summed up. The columns of participation on Table 8 indicate the percentage of each municipal in relation to the sum up of all 43 municipals of RAA.

Finally, the biodiversity index is calculated on avarage between participation of remaining forests and biological importances. The greater is the index, the greater the probability of environmental restrictions in the municipal.

Air Means It is the concept of topography delimited by a minimum quota, which difficults the dispertion of pollutants emitted from industrial and social-economic activities and the transport sector. Variables that can characterize the air means are divided in two main groups:

- Atmospheric pollutants such as particle matter, smoke, sulphur dioxide, etc.

- Green house effect gases, for example carbon dioxide and methane.

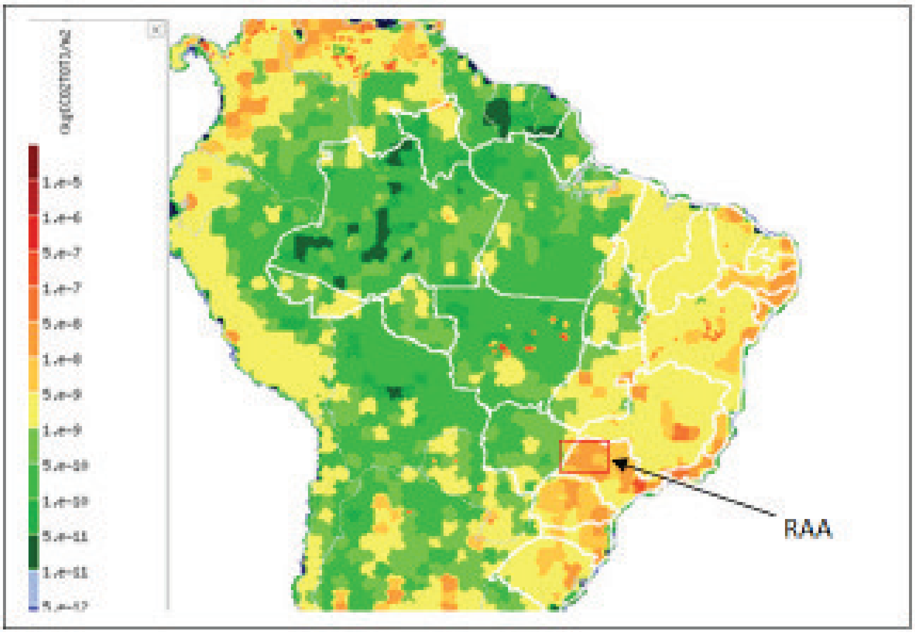
Greenhouse gases emissions

In the atmosphere, a large concentration of carbon dioxide, one of the green house effect gases, mainly a result of sugarcane burning in plantations and emissions from large hydropower dams, can be seen via satellite (Figure 5).

The problem of sugarcane burning tends to be lessened by the legislation that obliges substitution of burning by mechanized harvesting. In any case, the development of anthropic activities that emit more carbon dioxide can saturate some air basins in the region.

In case of hydropower plants reservoir, there are no dates of green house gases emissions available. The solution to this was to use emission rates of other hydropower reservoirs in Brazil with similar characteristics in terms of the age of the reservoir (Table 9). Errors are encountered due to the fact that the amount, in mass and volume of biomass in the reservoirs are less likely to be equal.

Figure 5. CO_2 emission rate at 12:00 P.M. on 25/02/09**.**



SOURCE: CPTEC / INPE

As a curiosity, see bellow (Table 9) that Nova Avanhandava hydropower plant (HP) has the highest CO_{2eq} emission rate and the lowest flooded area.

Table 9. GHG emission in RAA hydropower plants

Power plant	Flooded Area	Beginning of Operation	Emission Projection Reference			Annual Projected CH_4 emission [t/year]	Annual Projected CO_{2eq} emission [t/year]
			Plant	Annual Emission of CH_4 kg/km²/day	Annual Emission of CO_2 kg/km²/day		
Ilha Solteira HP	1357,62	1978	Barra Bonita/Segredo	5508,5	390.155	7.478,45	524.682,23
Nova Avanhandava HP	218,05	1982	Samuel	8920,6	2.484.920	1945,13	541.836,80
Promissao HP	572,72	1975	Barra Bonita/Segredo	5508,5	390.155	3154,8	223.449,60
Tres Irmaos HP	659,59	1993-1999	Usina Segredo	2766	219.263	1824,42	144.623,68
Jupia HP	321,68	1974	Barra Bonita/Segredo	5508,5	390.155	1771,97	125.595,06

Source: Elaborated by the authors using data from MCT-COPPE, 2006

Table 10 presents information of atmospheric pollutants. Since there are no pollutants measuring devices in all municipals, we used dates from other regions which have proper devices. From the result obtained, inference using vehicle fleet and jobs in industries was used to calculate the quantity of polution emited in RAA.

Table 10. Atmospheric pollutant emissions in some municipals of RAA

Municipal	Total Emission [kt/year]				
	CO	HC	NO_2	SO_2	TSP
Alto Alegre	5,14E+00	1,18E+00	1,22E+00	7,86E-02	1,91E-01
Andradina	3,07E-01	6,95E-02	8,39E-02	3,29E-03	9,16E-03
Aracatuba - ERP	2,24E+01	5,18E+00	3,96E+00	1,94E-01	5,32E-01
Auriflama	1,28E+00	2,95E-01	3,25E-01	2,41E-02	5,65E-02
Avanhandava	5,24E-01	1,19E-01	1,37E-01	5,98E-03	1,61E-02
Barbosa	2,83E-01	6,58E-02	6,93E-02	6,73E-03	1,49E-02

Source: Elaborated by the authors

CHARACTERIZATION OF RAA AQUATIC MEANS

It is constituted by water in the liquid state and it is subdivided into:

- Surface water, created by the rivers, streams and drained rain water.

- Interior waters that correspond to ground water.

- Coastal waters (not applied in Aracatuba).

The study of a region can be made in two different ways: Created by man, delimitating lands forcefully and other from the nature, which is defined by river basins.

The study of the influence of river basin on geographic limit defines the aquatic means.

The river basins can be classified as follows:

- by importance
- by location
- by water availability and quality

On Table 11 see the water balance in RAA.

Table 11. Water balance in RAA

	Area	Annual precipitation		Annual average evapotranspiration		Overland flow
River Basin	[km^2]	[mm]	[m^3/s]	[mm]	[m^3/s]	[m^3/s]
UGRHI 18 (Aguapei River)	6.783	1.250	269	1.013	218	51
UGRHI 19 (Baixo Tiete River)	15.588	1.210	598	982	485	113
UGRHI 20 (S.J. Dourados River)	13.196	1.220	511	988	413	97

Source: 2005 Sao Paulo State Groundwater Quality Reports CETESB 2006 (Relatorio de Qualidade das Aguas Interiores do Estado de Sao Paulo 2005, CETESB/2006)

The quality of water is related to, soil use and occupation coming from urban and rural drainage of domestic, industrial and agricultural pollutants. The domestic sewages contain biodegradable organic compounds, nutrients and bacteria; the industrial wastes contain pollutants coming from raw materials and chemical processes involved.

In Brazil, Federal and State have laws controlling the use of surface and groundwater, as well as programs monitoring water quality. The Sao Paulo State Environmental Sanitation Technology Company (CETESB - *Companhia de Tecnologia de Saneamento Ambiental*) monitors some water bodies in RAA in terms of pollution and oxygen demand, what influence the aquatic life (Table 12). Some water quality indexes adopted by CETESB are:

IQA (Water Quality Index): The quality parameters, which are part of the calculation of the IQA reflects mainly the contamination of water bodies caused by the release of domestic sewage. This index was developed to evaluate water quality for public supply, considering aspects of the treatment status. The parameters involved are temperature, pH, dissolved oxygen, BOD, total coliforms, total Nitrogen, total Phosphorus, turbidity and Total Dissolved Solids.

IAP (Public Water Supply Index): This index is more accurate than IQA and is used to monitor drinking water supply.

IVA (Aquatic Life Protection Index): In this index two groups of parameters are considered; chemical toxicity and eutrophization.

IET (Trophic State Index): This index assesses water quality with regards to nutrient such as nitrogen and phosphorus and its effects related to excessive growth of algae or increased infestation of aquatic weeds.

Table12 presents an example of monitoring results for Baixo Tiete River Basin.

Table 12. Baixo Tiete river basin water quality variables

Monitoring code site	Water body	Quality variables	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Average
BAGU02700	Baguacu Stream	IAP											33		33
		IQA											36		36
		IVA					3,2						5,6		4,4
		IET					53						59		54
LAGE02500	Lageado Stream	IAP											58		58
		IQA											65		65
		IVA					2,2						3,2		2,7
		IET					51						53		51
PARN02100	Parana River	IAP		76		77		89		11		90		88	72
		IQA		82		81		89		90		90		88	87
		IVA		3,4		3,2		3,2		8,2				4,4	4,5
		IET		4,7		52		49		48		52		49	48
TIET02700	Tiete River	IAP		89		92		89		85		88		87	87
		IQA		89		92		89		85		88		87	87
		IVA		3,4		3,4		3,4		3,4				3,4	3,4
		IET		49		49		49		49		52		49	50
TITR02800	Tres Irmaos Reservoir	IAP		87		84		89		89		83		82	86
		IQA		87		84		89		89		83		82	86
		IVA		3,4		3,2		3,2		3,4				4,4	3,5
		IET		53		53		55		51		55		53	52
XOTE02500	Baixote Stream	IAP											35		35
		IQA											39		39
		IVA					4,1						4,6		4,4
		IET					49						52		49

Legend of colors for IAP, IQA and IET

Quality:

Very bad | Bad | Normal | Good | Very Good

Trophic state:

Ultra oligotrophic | Oligotrophic | Mesotrophic | Eutrophic | Super eutrophic | Hiper eutrophic

Legend of colors for IAP, IQA and IET

Quality:

Trophic state:

Source: 2005 Sao Paulo State Groundwater Quality Reports CETESB/2006 (Relatório de Qualidade das Águas Interiores do Estado de São Paulo 2005) CETESB/2006

The hydropower potential for small power plants in RAA

See the estimated energy potential of rivers and streams on hydrological maps (Figure 6). The hydropower potential at RAA is about 447 MW.

The plants are classified as follow: Pico 1 - Hydropower plants up to 1 kW; Pico 2 Hydropower plants from1 kW to 100 kW; Micro-Hydropower plants from 100 kW to 1 MW; Mini-Hydropower plants from 1 MW to 10 MW and Small-Hydropower plants from10 MW to 30 MW (Table 13).

Figure 6. Hydrological map of RAA

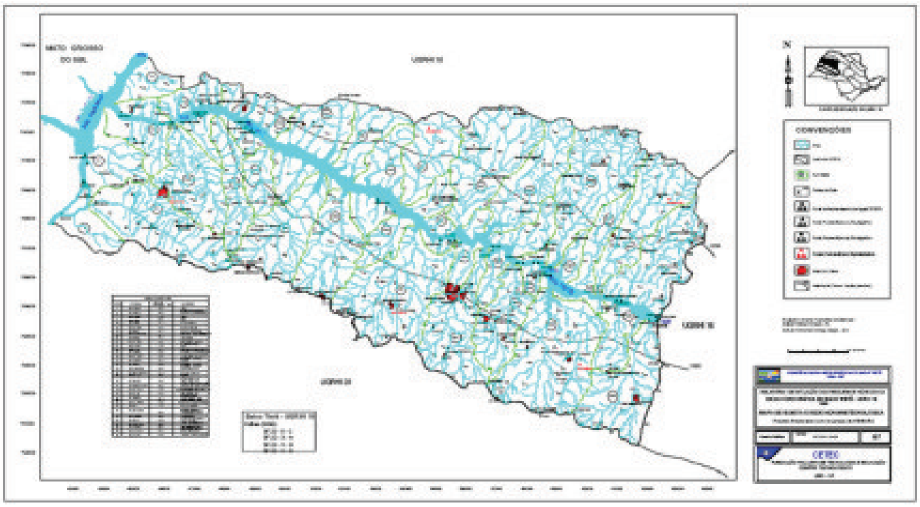


Table 13. Hydropower plant potential in RAA

	Hydropower Plants types Pico 1, 0 < P < 1 KW	Pico 2, 1 < P < 100 KW	Micro 0,1 < P < 1 MW	Mini 1 < P < 10 MW	Small, 10 < P < 30 MW
Potential	-	933 KW	48,60 MW	373,64 MW	24,09 MW
Identified places	-	6	88	160	2
Low height, 0<H<15 m	-	6	35	1	-
Medium height, 15<H<50 m	-	-	58	55	-
High height, H>50 m	-	-	1	104	2
Turbine		Banki or Pelton	Banki or Pelton	Francis or Kaplan	Francis or Kaplan

Using hydraulic turbine curves (Figure 7), the appropriate turbine technology is chosen to calculate installation and energy costs.

This study does not take into consideration the large hydropower plants; because they will no longer be built in addition to the existing dams (Table 13). Hydroelectric reservoirs cause severe impacts, such as displacing human populations, flooding of terrestrial ecosystems and radically altering aquatic ones. Depending on the circumstances of the reservoir, hydropower plants can not even be presented as clean energy, in the perspective of global warming, as the release of methane is very large, especially in the tropics.

Figure 7. Example of hydrological turbine curve

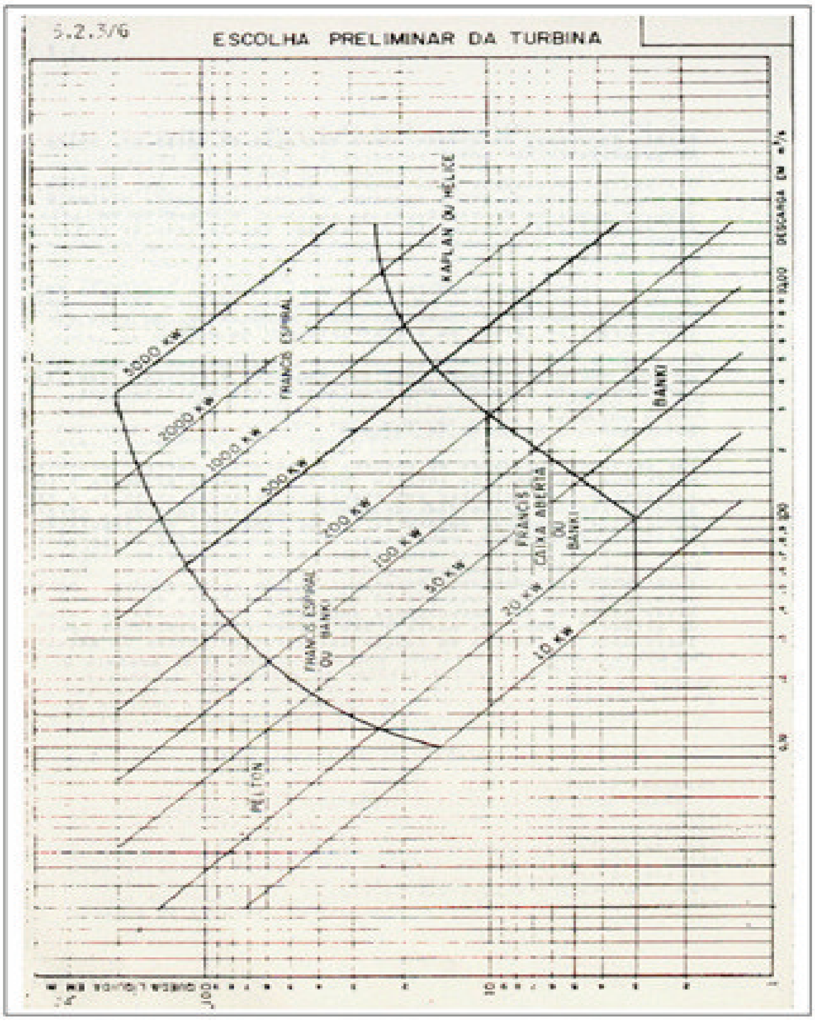


Table 13. Large Hydropower Plants in RAA

River Basin	Municipal	Hydropower plan	Capacity [KW]
Aguapei	Ilha Solteira	Ilha Solteira	3.444.000
Baixo Tiete	Castilho	Jupia (Engº Souza Dias)	1.551.200
Baixo Tiete	Pereira Barreto	Tres Irmaos	1.292.000
Baixo Tiete	Buritama	Nova Avanhandava (Rui Barbosa)	347.400
	Total		6.634.600

CURRENT STATUS AND FINAL CONSIDERATIONS

Brazil presents a wide range of natural resources, and as a consequence, the sustainable use of resources becomes a complex matter that requires a paradigm breakdown in the Brazilian long-term energy planning and water management. It is possible that unforeseen problems in the planning stage take the country to rationing, unsure supply and rising prices.

RAA was chosen due to the partnership with USP (IEE/USP and GEPEA/EPUSP PIR team) and COOPERHIDRO (Cooperative of Aracatuba Hidroway Pole) a local NGO in the São Paulo Western. An important aspect that must be taking in consideration, when studying the region, is to identify its key element, such as eligible stakeholders, who can be identified by local NGO which has a good understanding of the region. Besides, RAA is a particular case with many similarities with the whole country, having an abundance of natural resources and social inequality. This pilot project aims to help change the current ways of development to a Sustainable Development program, taking account of social, environmental and political factors in long term planning.

To change the current paradigm policy makers need new approaches, such advanced tools, methodologies and models to develop long-term policies for water, energy and environment which are all inter-connected. This pilot project at RAA can help other regions and the country to understand that there are different ways of development with better sustainability.

To achieve this understanding, PIR/USP team with COOPERHIDRO´s partnership, organize visits to RAA, which is located 650 km from Sao Paulo University (USP), where PIR is located. These visits aim to analyze the interaction between stakeholders and RAA within the four dimensions of development – technical/economical, environmental, social and political.

Georeferencing of energy and water resources, measuring devices to monitor environmental variables and IT are examples of modern tools that are used by PIR methodology in RAA. What makes the PIR methodology different is its integration of supply side energy resources with demand side energy resources to achieve the future end-use energy needs.

To prioritize energy-environmental inventory, PIR takes in account quantitative and qualitative variables obtained from stakeholders' surveys.

Unfortunately, at the moment municipals stakeholders' worries are directed on basic needs more than environmental issues.

To assemble energy resources portfolio for RAA it is necessary to know not only how much resources each municipal has to offer but to combine basic needs, such as construction of hospital and schools.

PIR could be acting faster if the restrictions were diminished. Integration and co-operations of municipals, state and federal stakeholders must exist.

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