Open TRANSCAT Conference

Integrated Water Management of Transboundary Catchments

- A Contribution from TRANSCAT

24-25-26 March, 2004 - Venice, Italy

CONFLICTS, AGREEMENTS AND UNCERTAINTY IN THE HYDRAULIC RESOURCES USES OF TRANSBOUNDARY CATCHMENTS

Luis G. Castillo E.[*]

Technical University of Cartagena, Spain

ABSTRACT

In this work, the different conflicts in the use of the hydraulic resources in transboundary catchments are analysed, and some significant bench marks established. Next, the climate change impact and its associate uncertainty on the hydraulic resources, the international agreements and consensus about transboundary catchments in Europe, as well as the Sustainable Use of the Hydraulic Resources and, how these criteria are incorporated in the EU Water Framework Directive are analysed.

Then, three cases of shared use of water resources in different transboundary catchments are shown, characterizing each case according to the different hydraulic planning level: the Iberian Peninsula (Spain - Portugal), the Guaraní Aquifer System Project (Argentina – Brazil - Uruguay - Paraguay) and the Catamayo - Chira Project (Ecuador - Perú).

Finally, a comparative analysis is carried out by identifying their principal differences and common points, and the solutions or agreements that have been reached in the different conflicts.

Key-words: *Transboundary Catchments; Agreement; Resources; EU Water Framework Directive; Water Policy; Impact Climate Change; Spain; Portugal; Brazil; Argentine; Paraguay; Uruguay; Ecuador; Peru.*

1. INTRODUCTION

Water is the support and the main component of alive beings, there is no life without water; so, water plays a key role in the evolution of life and in its sustentation. It serves as an excellent solvent of the organic and inorganic compounds, as a means for the dissociation of some molecules and a hydrator of some compounds. As a controller of physical processes, the water vapour intercepts the ultraviolet rays dangerous for alive beings, it regulates the thermal and environmental conditions through their changes of phase, transports energy and mass as much in alive beings like in environment and preserves the structure of virtually all alive beings of the earth (Uchijima, 1992).

[*] Titular Professor of Hydraulics Structures and Hydraulics Resources. Thermic and Fluids Engineering Department. EU Ingeniería Civil. Paseo Alfonso XIII, 52. 30203 Cartagena, Spain. e-mail: luis.castillo@upct.es

On the other hand, water intervenes basically in all the productive processes, directly or indirectly, being therefore indispensable for the economic activity. Water is more and more a scarce resource, which is frequently not available of natural form in the required place and moment so water should be administered equally, economically and ecologically.

For those reasons, water has been a source of continuous concern for humanity from the down of history and, it has been the origin power and discord that has created large conflicts (Castillo, 1996).

2. GENERAL BALANCE OF WATER RESOURCES

If we keep in mind water resources availability worldwide, the following situations are observed (Fernández-Jáuregui, 2000):

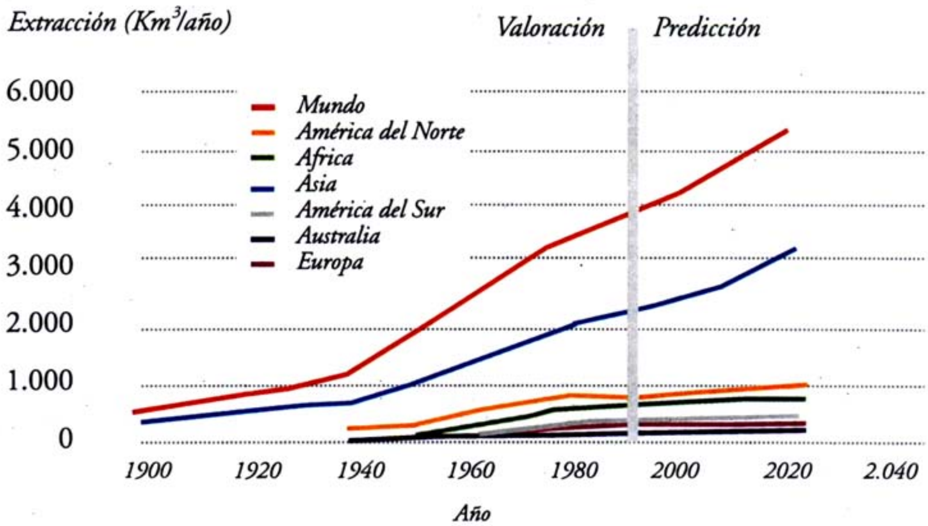
Asia has 60% of the population and provides only 36 % of water resource; Europe has the 8 % of the population and possesses 13 % resource; 13 % people live in Africa with only 11 % resource. However, in North and Central America there is 8 % of the population and they enjoy 15 % of water resource. Finally, South America has only 6 % of the world population, but it enjoys the 26 % of water resources.

If the space and temporal variability of the resource are also regarded, we observe that even in the zone of the world where a great surplus exists like in South America, some regions like Peru have water stress, considering their situation as one of the most fragile and delicate in the world (Table 2).

The use of water will grow to 5,000 km^3 in the year 2025, what means an increment of a 35 %.

Figure 1 shows the distributions of the resource extractions through years in the different continents. The extractions have been quintupled in shorter than one century,.

Figure 1. Distributions of the extractions of the resource through years in the different continents*.



YEAR

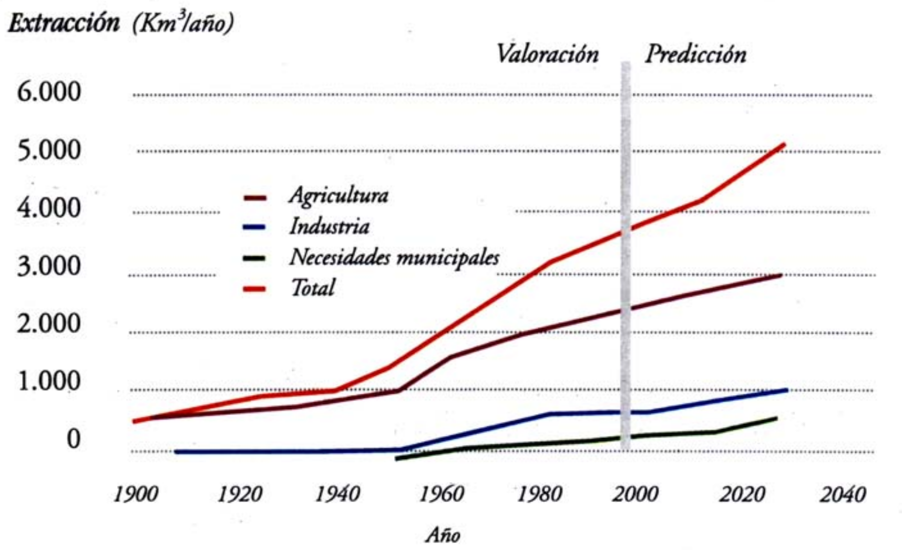
Although the amount of water in the planet stays constant its quality deteriorates, producing a decrease of the water resource in terms of supply. In turn, the resource demand increases proportionally to the growth of the population, what could lead to a chronic social conflict. With the aim to avoid this situation, efficient techniques should be developed to restore

* From: http://www.unesco.org.uy/recursos/recursos.html

the system and establish a dynamic balance between supply and demand, looking for a certain social harmony.

Figure 2 depicts the distribution of the resource extractions by sectors of production through time. In global terms one could affirm that the use of the resource is distributed in a 75 % for the agriculture, a 22 % for the industry and mining, and only a 4 % for the domestic consumption in the cities.

Figure 2. Distribution of the resource extractions by production sectors through time *



YEAR

There exist more than 200 basins shared by two or more countries which represent around 60% of the terrestrial surface of the planet. In accordance with the World Bank (1994), in spite of signing more than 300 treaties to solve problems related to the international water resources, and existing more than 2,000 treaties with water dispositions, the coordinated ordination of the international basins continues being not very frequent, which causes economic losses, international conflicts and the degradation of the environment.

The administration of water resource must and can be compatible with the concepts of basin and country or minor political divisions.

The concept of water stress designates the resources supply deficit in a basin in respect to the demand. Table 1 shown the repercussion of this concept in the world in function of the population, in the year 1997 and a projection to the year 2025.

We could observe that in the year 2025 the level of water stress would go up on all levels, increasing 30 % of the population (to 1,305 million inhabitants) in the Half Stress situation and, in more than 100 % in the case of High Stress (to 254 million inhabitants). If this situation continues, 90 % of the world population will be vulnerable in the 2025, and 50 % highly vulnerable, particularly China and Middle East.

The countries protect fervently their right to exploit water resources considered as own. Despite the concerted treaties, few countries have destined funds to the combined ordination of

* From: http://www.unesco.org.uy/recursos/recursos.html

the resource of underground and surface waters. They even do not share the available information freely and the cooperation is usually nonexistent. In consequence, controversies about the water assignment are still unsolved, and nowadays there is a rising concern about the effects of the bad quality water and the scarce flow of the aquatic ecosystems.

Table 1. Water Stress level. Population in millions. Raskin et al. (1997)[1]:

REGIÓN	**Non Stress**		**Low Stress**		**Mean Stress**		**High Stress**	
	1997	2025	1997	2025	1997	2025	1997	2025
North America	27	30	280	310	-	-	-	-
West Europe								
East Europe	18	18	180	180	300	310	15	14
Pacific	-	-	50	65	16	18	17	20
Ex URSS	-	-	25	26	120	122	-	-
Africa	14	15	200	220	50	52	18	20
Latin America	100	200	395	810	200	400	27	160
Middle East	-	15	360	480	140	200	-	-
China	-	-	27	45	138	200	29	40
Southeast Asia	-	-	120	700	1.200	1.680	-	-
	-	-	480	500	1.080	1.685	-	-
TOTAL:	**159**	**278**	**2.117**	**3.336**	**996**	**1.305**	**106**	**254**

The conflicts linked with the water have been located mainly in Middle East. the following countries live in open crisis: Syrian, Jordania, Israel, Egypt and Yemen, existing a latent crisis in Saudi Arabia, Iraq, Kuwait and Libya. The dependence of the water resources in shared basins overcomes the 50 % in many of these countries.

Table 2 indicates the countries belonging to the water-stress classification and to the most fragile and delicate situation in the world.

The sceneries have been developed under the presumptions and interactions of several elements like the following: population and their tendencies, lifestyle and habits of consumption, economic aspects and their scales, technology and its efficiency and finally, institutions and their policies. Through mathematical models, the results incorporate some of the involved forces such as: the growth of the population, urbanization, economic globalization, cultural homogeneity, environmental degradation and technological innovation.

The technique of generation of scenery is not projection either prediction, but it allows to visualize future alternatives. The following results are to highlight:

- The growth of the population dramatically increases the risk of social conflict. 95 % of the increasing population is located in the developing countries.
- Another important element is urbanization, which gives rise to a worrying deficit of water infrastructure. At the moment the urban population increases 85 %.
- The economic globalization has accelerated the development of the technologies of the information and has increased the commercial exchange. This implies new economic powers and the growth of the transnational corporations, giving rise to a transference of

[1] It is elaborated with data of mentioned reference by Fernández -Jáuregui (2000).

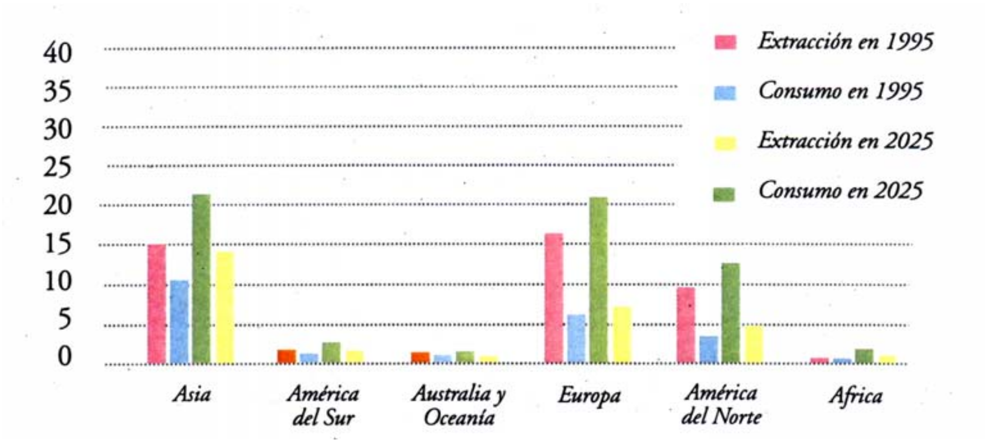
the North American culture, promoting the culture of consumerism and reducing the cultural diversity. As a result, tensions among the different nations increase.

Table 2. Countries with Water Stress[2]

REGION	Countries	
	Year 1997	Scenary 2025
West Europe	Belgium	Belgium
Ex USSR	Azerbaizhan	Azerbaizhan
	-	Turkmenistán
Africa	-	Algeria
	Egypt	Egypt
	Libya	Libya
	-	Morocco
	-	South Africa
	-	Tunis
Latin America	Peru	Peru
Middle East	Afghanistan	Afghanistan
	Saudi Arabia	Saudi Arabia
	Bahrein	Bahrein
	Iran	Iran
	Iraq	Iraq
	Israel	Israel
	Jordan	Jordan
	Kuwait	Kuwait
	Qatar	Qatar
	Arabian Emi. Union	Arabian Emi. Union
	Yemen	Yemen
Southeast Asia	Korea	Korea
	Pakistan	Pakistan
	-	Singapore

According to Shiklomanov (1998), during the next decades the major increment of the extraction of water will take place in Africa and South America (1,5-1,6 times more), and the minor in Europe and North America (1,2 times); increasing the use in 2025 between 15 % and 30% in the developed countries, and between 200 % and 300 % in developing countries. Figure 3 shows a comparison between the water resources extracted and consumed by continents.

Figure 3. Water resources extracted and consumed by continents*



[2] It is elaborated with data of mentioned reference by Fernández-Jáuregui (2000).
* From: http://www.unesco.org.uy/recursos/recursos.html

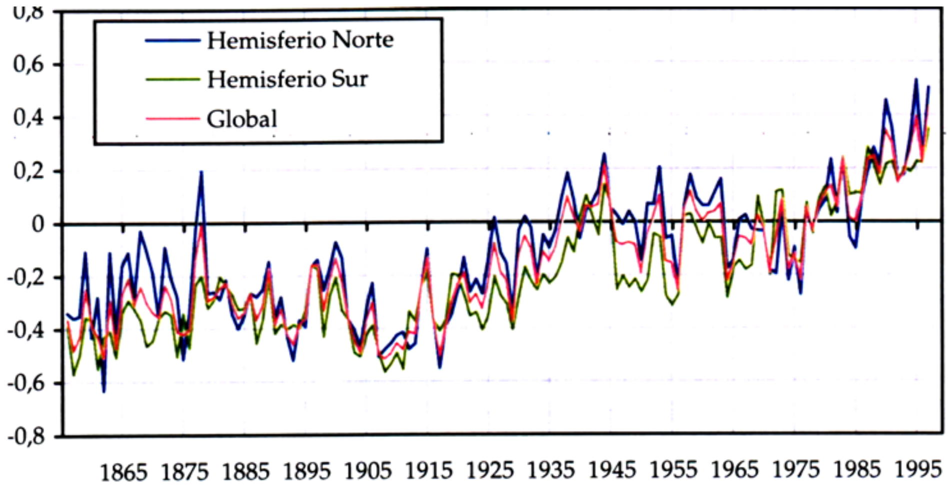
Nowadays, 76 % out of the total population makes use of less than 5,000 m^3 inhabitant/year and 35 % of this population has very low disposal. If this situation continues deteriorating, in 2025 most of the population will live under very low and almost catastrophic conditions of drinking water.

3. IMPACT OF CLIMATE CHANGE ON WATER RESOURCES

At the present time, there is a concern for the possible climatic changes provoked by an increase in the levels of Dioxide of Carbon CO_2 and other gases in the atmosphere, which cause the so called greenhouse effect.

The climatic register available indicates that in the last century, there has been a tendency toward the global heating. The mean temperatures in the surface of the Earth, in general, have had rises oscillating between approximately 0.3 and 0.6 º C, in the early XIX century and late XX (Figure 4).

Figure 4. Global temperatures evolution on the Earth in respect to mean temperature (º C) (MIMAM, 2000)



The countries of the European Union have suffered a higher rise, oscillating between 1º and 2 º C during the XX century.

In general, the registrations demonstrate that temperatures experienced an ascent from the late XIX century until approximately 1940, followed by a period of relative cooling up to 1970, when a new period of heating was restarted.

It is uncertain whether the observed tendency corresponds to a natural variation in the climatic conditions, or corresponds to the green house effect on the atmosphere in the last 200 years; in any case, most of the studies have concluded that the tendency toward the observed "heating" is very unlikely to be considered as a totally natural phenomenon (MIMAM, 2000).

The tools used in those research are General Models of Ocean-Atmospheric Circulation. Although the uncertainty of prediction is still very high, there exists some agreement on the tendencies of variation of some climatic variables, such as temperature and rainfall.

The changes in temperature or rainfall would have effects on the water resources of a territory, since, in long term, their runoff is equal to the difference between the rainfall and the evapotranspiration. According to the scientific evaluation reports emitted by the Intergovernmental Group of Experts on the Climatic Change (IPCC), a thermal ascent of approximately 2º C together with a drop of a 10 % in the rainfalls could lead to a reduction between 40 % and 70 % in the annual runoff in the semiarid zones (IPCC, 2001).

If the annual mean rainfall experiences a slight fall and temperatures go up in the European countries, there would be a fall in the runoff in the future. Besides, those areas are anticipated to undergo an increase in the temporal irregularity of the rainfalls with clear consequences on the rise in flood frequency. The decrease in resources would affect mainly the aridest regions, which already suffer from the effects of a certain shortage. (EEA, 1997).

4. INTERNATIONAL AGREEMENT AND CONVENTIONS ON TRANSBOUNDARY WATERS IN EUROPE

Traditionally and for different reasons, the Rhine, the Elba, the Danube and the Spanish-Portuguese rivers (Guadiana, Tajo, Duero, Miño) are the fluvial systems that have been more the object of international disputes between the States members of the EU. The conflicts generally have been around the sailing, amount of the water resources and fishing, which have a direct effect on a series of questions such as trade, generation of hydroelectric energy and agriculture. At the moment, the problems about water quality and nature preservation are getting more and more important.

In general, most of the international agreements and conventions concern with the protection of water quality or some aspects related to the use of water resources. Topics like the influence of the water cycle detractions in ecological flows have not still been included in these agreements and conventions.

The agreement of the United Nations on the Protection and Use of the Transboundary Water Courses and International Lakes (1992) were ratified in May of 1997 by 25 countries, except Ireland. The Agreement urges the parts to prevent, control and reduce the causes of contamination in superficial and underground transboundary waters, by means of a rational and ecological administration of the water and the environmental protection of the resources (EEA, 1999).

The agreement also includes the transboundary waters ending directly in the sea, constituting the limit a straight line imaginary, traced through the outlet between the extreme points of the banks, during the low tide.

5. WATER FRAMEWORK DIRECTIVE

Directives on the water have been enacted in Europe since the seventies. They reflected the quality objectives in function of the final uses of water. The control of the polluting emissions to the water was considered for the first time in a Directive. Later on, at the beginning of the nineties, other directives arose like this relative to the treatment of the urban waters and that referring to the protection of the waters against the contamination produced by nitrates, applicable to the superficial waters and groundwater.

So, the great number of directives available demanded a new controlling frame that gathers and simplifies the legislation on water. The objective of the new Water Frame Directive (Directive 2000/ 60/ CE, 2000) is to get the integration of all the legislation and the establishment of a frame for the protection of water resources.

The directive is based on the same principles as other environmental policies of the European Union: that is to say, *who contaminates pays, principle of subsidiary, principles of caution and of preventive action, and correction of the aggressions in the origin.*

The structural principle of the Water Frame Directive is the integrated administration of the water on the basin level, reflecting the hydrological realities of the administrative and political limits. The Directive presents a frame that establishes common objectives, principles and basic measures in order to get a good state of water. The necessary actions are:

- Responsibility of the competent authority.
- Administration Plan on the basin level.
- A combined approach to control the waste and emissions in the superficial waters, based on some limit values of emission and norms of quality.
- Recovery of costs of the services related the water, with the purpose of regulating demand and achieving a sustainable use of the resource. The real cost of water services should included as well as the environmental and resources costs.
- Combined Administration of superficial waters and groundwater, in order to guarantee the long term resources.
- The good state of water, a novel concept that includes the quantitative and chemical state of the groundwater and the ecological and chemical state of the superficial waters.

In the case of an international basin with territory inside the UE, the states members must:

- Guarantee the conformation of a District of Basin of International River.
- Assure coordination and cooperation, producing an only Plan of Administration of Basin or, if this is not possible, produce each plan inside the territory of the basin.

The administration will be really integrated and will make some horizontal activities operative, on a methodology of group work, developed successively in time:

- Exchange of information.
- Analysis of technical problems (characteristic of the basins, pressures and impacts, economic, etc.).
- Information and administration of data, trying to develop a concept of construction of wide base, integrating the administration of water inside all the sectors as much as possible, including the activities of soil uses.

In a global context, the EC resolved to include implicitly in the European Unique Act of 1986, the necessity of improving the technological bases of their industry.

The frame programs are the main instruments of planning in half term (generally 5 years) of the Investigation and Development policies. They mark the areas considered as priorities and establish the budget of the funds to use.

Five Frame Programs have been developed so far, from the I Program developed in the period 1984-87, until the V Program that covered the period 1999-2002. At the moment the VI Frame Program is developing and covers the period 2002-2006.

The thematic program titled Environment and Sustainable Development contemplate most of the contents related to continental waters and are divided into key actions. Among them, the most related to water resources is the so called Sustainable Administration and Water Quality. It consists of six areas and each one indicates two or three priorities (Table 3)

Table 3. Areas and Priorities of Key Actions in Sustainable Administration and Water Quality of the V Frame Program

AREAS	PRIORITIES
Integrated administration and sustainable uses of the resources at integrated scale of basin	- Tools and methodologies for the strategic planning and the integrated administration at scale of basin - Socioeconomic aspects of the sustainable water use - Plans of operative administration and systems of support to the decision
Ecological quality of the ecosystems of freshwater and wetlands	- Characterization of the ecosystems processes - Objectives of the ecological quality
Technologies of treatment and purification	- Administration of the water in the cities - Systems of purification and re-utilization
Prevention of the contamination	- Reduction of the contamination of the water caused by the laundry of soils - Diffuse contamination
Surveillance, early detection and systems of communications	- Assessment and control of the contamination - Improvements in the forecast of droughts and floods
Regulation of the water reservations and technologies adapted to arid regions and semiarid regions and, in general, regions with deficit of water	- Administration and use of the water resources - Prevention and reduction of the marine intrusion - Technological development and tools of administration

The VI Frame Program for research actions, technological development and demonstration will be developed according to the three general objectives of the EC Treaty:

- Improving the technical and scientific base of industry in the Community
- Fomenting competitiveness
- Promoting the research activities required according to the Treaty

Water is included in different priorities, like the following (Tilche, 2002):

- A clean production in "Nanotechnologies, intelligent materials and new procedures of production"
- The environmental risks to the health in "Quality and food security and risks to the health"
- Hydrological Cycle in the context of the global change, and wetlands and aquatic ecosystems in the context of the diverse biology in "Sustainable Development and global change." It is also included the Hydrogeological dangers, the net of prediction of droughts, and the net of observation, assessment, measurement and models of the hydrological cycle.

The implementation of the rules of the Directive Frame of the Water requires an important research process and the use of the results developed during the V Frame Program of Investigation.

In this way, the application of the Water Frame Directive of the EU is associated with diverse research necessities (Tilche, 2002):

- Methodologies in order to evaluate and classify the ecological state
- Methodologies in order to establish the conditions of reference
- Very modified water masses
- Modelling tools and decision support systems

- Groundwater
- Economic aspects
- Priority of dangerous substances

6. THE IBERIAN PENINSULA CASE

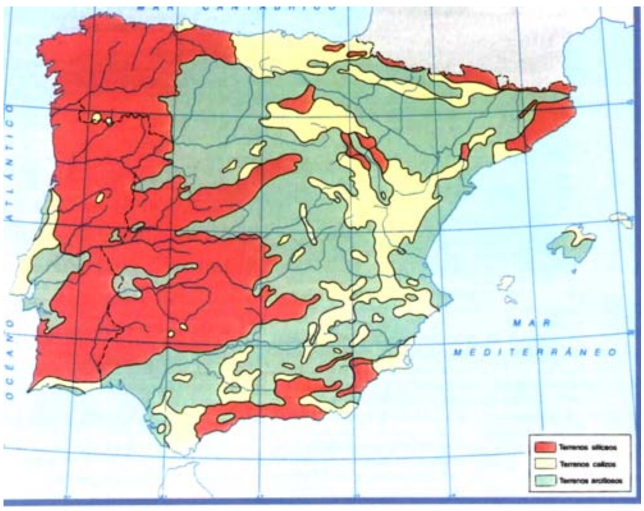
6.1 Geography, geomorphology and geology

Spain and Portugal have a unique physiographical nature. The Iberian peninsula is placed in Europe´s west-south side, whose main hydrographical characteristics is its isolation from the rest of the European system. The meseta's most outstanding feature is the series of flat lands with an average height of 600 meters above sea level that occupies around half of the mainland area. This land is surrounded in the north and east by the Cantabrian and Iberian mountain ranges, respectively, and in the south by the Sierra Morena. The land has a distinct tilt towards the Atlantic coast in such a way that virtually all the large mainland rivers (with the exception of Ebro and Guadalquivir, which drain into their own basins) flow across Portugal to the Atlantic.

The existence of mountainous chains guided in the sense of the parallel makes the main rivers also flow in this direction. The head stretches are short and with strong slopes as long as the middle stretches are of major longitude and characterized by the existence of a step when leaving the meseta. Here there are strong slopes with significant flows, after having picked up the drainages from a great part of the basin. This characteristic has permitted the hydroelectric use and it has been the base of the first international agreements related to the use of these rivers. Figure 5 shows the morphological structure of the Iberian Peninsula.

A quick description of the peninsular geology divides the Peninsula into three clearly differentiated zones: siliceous, calcareous and argillaceous. The siliceous land occupies the Westerner strip of the Peninsula- basically Portugal, Galicia, Extremadura, Asturias and the Central mountain range-; the calcareous lands the rest of the Cantabrica cornice -Cantabria and PaísVasco-; the Iberian mountain range, the Pyrenean external axis and some zones of Andalucía related to the Betico System; and the argillaceous lands occupy the rest of the Peninsula, that is, most of the Duero and Ebro basins, part of the Tajo basin, the Guadalquivir valley and great part of the Segura basin (Figure 6).

Figure 5. Morphologic Map of Iberian Peninsula Figure 6. Lithologic Map of Iberian Peninsula



6.2 Iberian Peninsula Climatology in Relation with Europe

Regarding rainfalls, in contrast to the rest of the territory of the EU, in the Mediterranean countries there is a dry station (in spring and summer) the longer the more eastern and southern the zone is. In the Western Mediterranean (from Spain to Italy) the maximum autumn rainfalls occur essentially because if convective origin rains, with moderate intensities and high pressures. This rainfall is related with the advection of air coming from the sea Mediterranean in low levels and in some occasions, with Atlantic air in high levels, permitting a humid feedback in all levels. It is not strange to overcome the 200 mm in 24 hours.

Figure 7 indicates the annual mean rainfall in Europe, highlighting that in the Iberian Peninsula these rainfalls vary from more than 2,000 mm in the Northeast zone, even the 300 mm in the Southeast of the Mediterranean zone.

A typical characteristic of the rainfalls in the Mediterranean littoral zones is their unequal distribution in time, mainly in some places from Spain, where the maximum rainfalls registered in 24 hours approach the annual mean values. Also, the storms often happen in a short period of time on a very reduced area, giving rise to strong intensities that affect directly not only to the generation of flood, but also to a major degradation of the soil.

The Potential Evapotranspiration (ETP) that depends on diverse physical-climatic factors (temperature, hours of sunshine, wind speed, atmospheric humidity or the vegetable covering of the soil), is very superior in the zones of semi-arid climate, as it happens in diverse zones of the Mediterranean Europe and concretely in the Iberian Peninsula, where the ETP overcomes the 1,200 mm in most of its surface, as long as in Central Europe it varies in a range between 600 and 800 mm (Figure 8).

Figure 7. Annual Mean Rainfall (mm) in EU, period 1940/41 – 1995/96 (CRU, 1998)

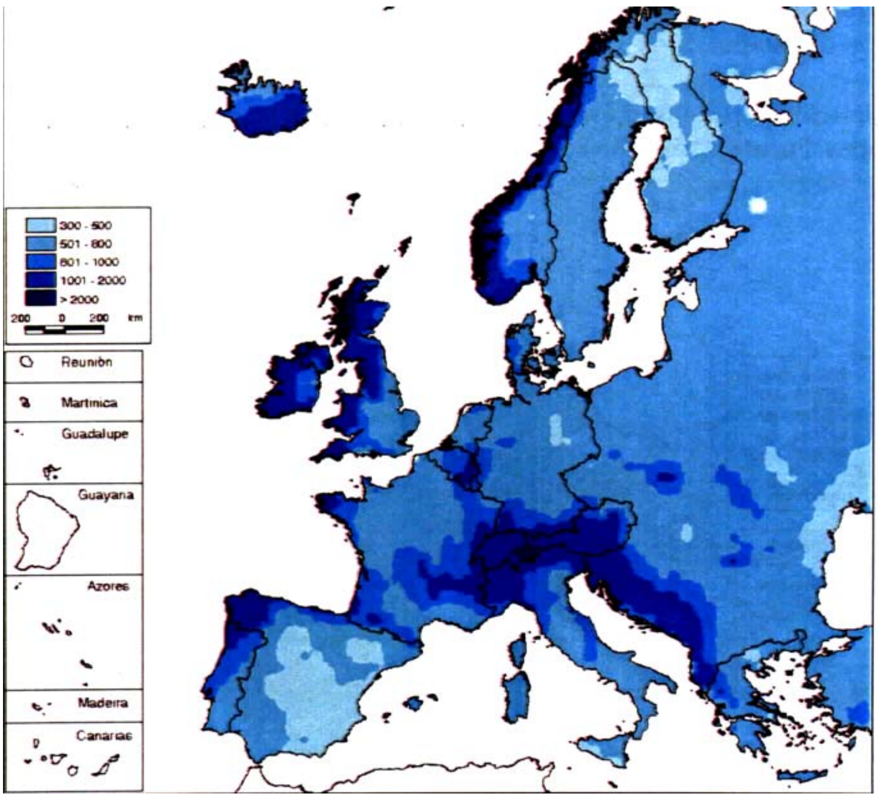
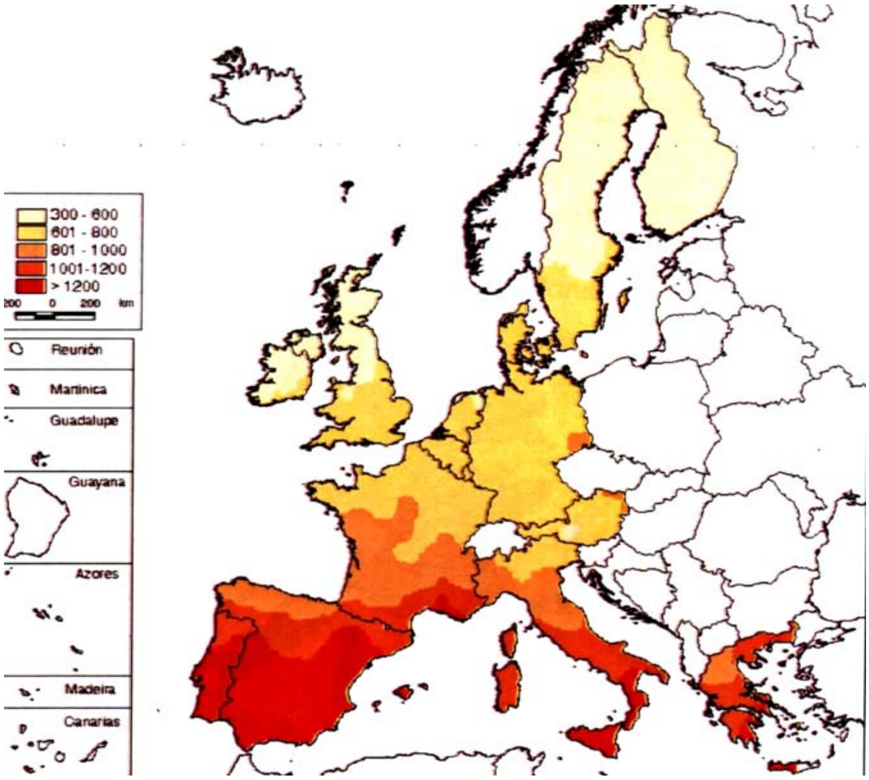
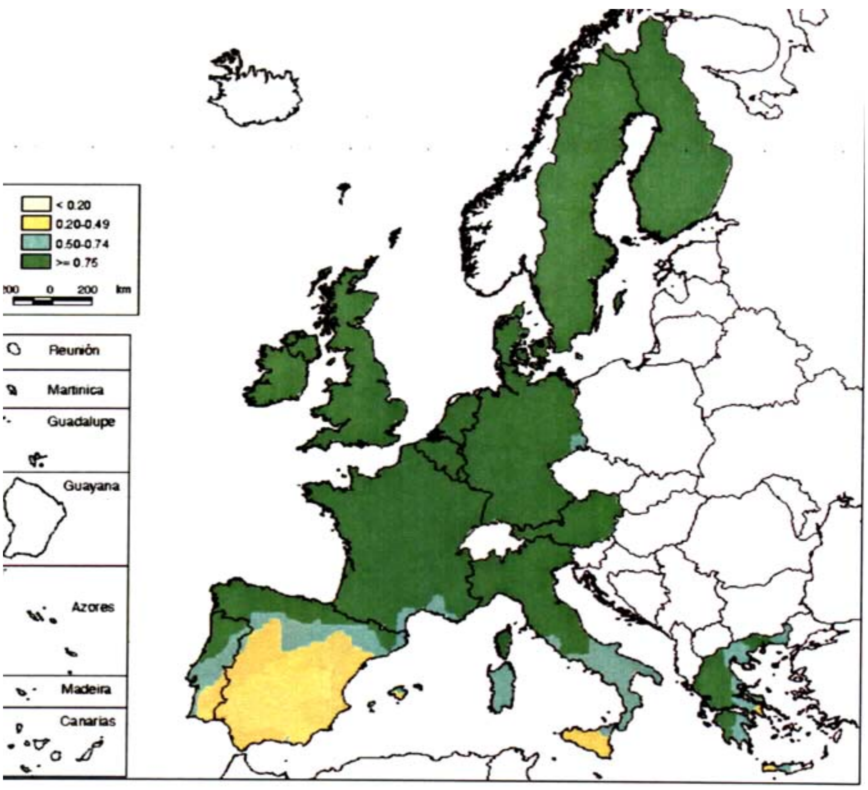


Figure 8. Potential Evapotranspiration (mm) in EU (CEDEX, 2003)



The Index of Aridity (P/ ETP) varies between humid zones in most Europe, the east and north of the Peninsula, and the semiarid zones in most Spain and the south of Portugal (Figure 9).

Figure 9. UNESCO Index of aridity in the European Union (CEDEX, 2003)

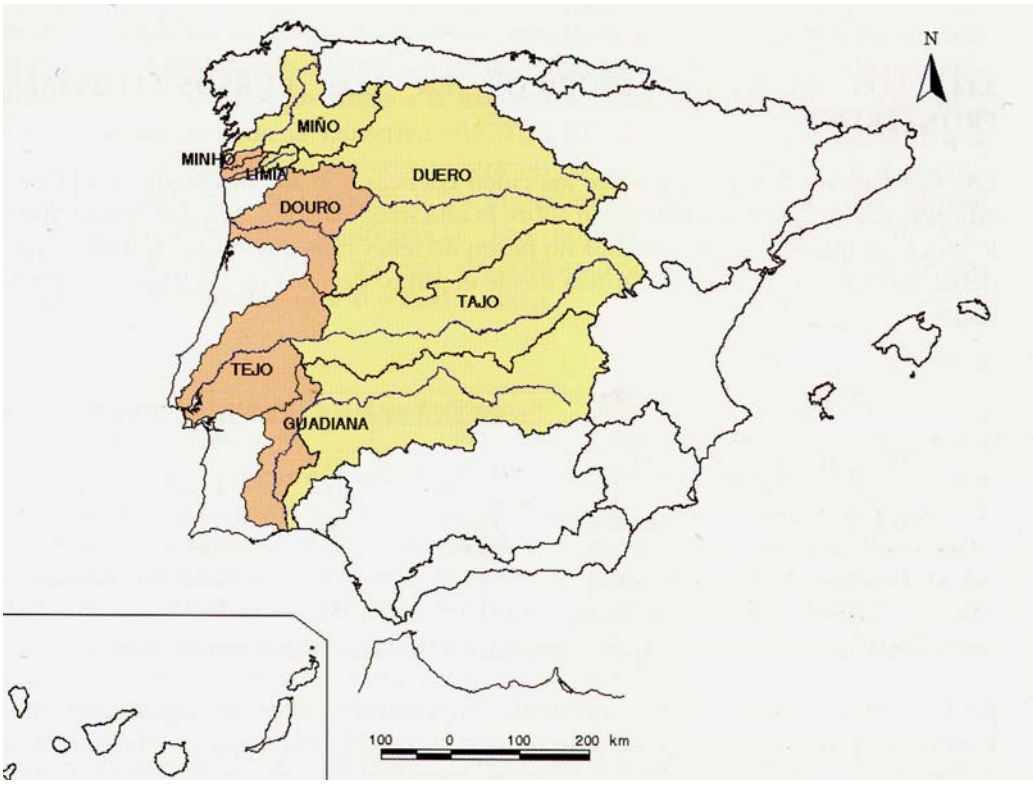


6.3 Hydrographical basins of the Iberian Peninsula

The surface of the basins shared by Spain and Portugal covers a 46 % of the mainland territory. Although Portugal owns 64 % of the shared surface, it only contributes 30.7 % of the average contributions. This is due to the marked Atlantic climate of Portugal against the more continental climate of the castellan meseta. This contrast is even greater if we consider that the distribution of rainfall in Portugal is much more regular in time and space, making a greater natural exploitation of its own surface water runoffs possible. On the other hand, it has notably fewer possibilities for building dams with an important regulation capacity. Figure 10 shows the features of Spanish – Portuguese basins.

Table 3 shows the surfaces and flows of the shared and non shared basins in Iberian Peninsula (Santafé, 2003 and Maia, 2003). As the information does not agree, the author shows the average values. We can observe that out of the total shared surface of 264,560 km^2, the 78 % (207,630 km^2) corresponds to a Spanish territory and 22 % (56,930 km^2) to Portugal; out of a total natural flow of 70.3 km^3/year, 69 % (48.7 km^3/year) is produced in the Spanish territory and the 31 % (21.6 km^3/year) in the Portuguese territory.

Figure 10. Map of the Spanish-Portuguese basins.



This is a shared natural mean flow of 0.266 hm^3/year /km^2, 0.235 hm^3/year /km^2 in Spain and 0.379 hm^3/year /km^2 in Portugal.

The natural run-off of the shared basins are the 46 % of the Peninsula flows (153.4 km^3/year), corresponding to 41 % (48.7 km^3/year) out of the Spanish total flows (117.4 km^3/year) and, 60 % (21.6 km^3/year) out of the Portuguese flows (36 km^3/año).

Table 4 shows the water resources and uses of the shared basins (Maia, 2003), from the Portuguese Water National Plan (INAG, 2001), but corrected to average with the data supplied by Santafé (2003).

Table 3. Resume of surfaces area and natural run-off average*

BASIN	SURFACE AREA					NATURAL RUN-OFF AVERAGE (km^3/año)		
	Total Area (km^2)	**Spain** (km^2)	**Spain** (%)	**Portugal** (km^2)	**Portugal** (%)	**Spain**	**Portugal**	**Total**
Miño	17.080	16.230	95	850	5	11,2	0,8	12,0
Limia	2.480	1.300	52	1.180	48	1,9	1,5	3,5
Miño / Limia	19.560	17.530	90	2.030	10	**13,1 [A] - 15,5 [B] (14,3) [C]**	**2,3 - 3,3 (2,8)**	**15,5 - 18,8 (17,2)**
Duero	97.600	79.000	81	18.600	19	**15,0 - 16,7 (15,9)**	**8,2 - 10 (9,1)**	**23,2 - 26,7 (25)**
Tajo	80.600	55.800	69	24.800	31	**12,2 - 13,3 (12,8)**	**6,4 - 8,9 (7,7)**	**18,6 - 22,2 (20,4)**
Guadiana	66.800	55.300	83	11.500	17	**5,0 - 6,3 (5,7)**	**1,7 - 2,3 (2)**	**6,7 - 8,6 (7,7)**
Total Shared Basins	**264.560**	**207.630**	**78**	**56.930**	**22**	**48,7**	**21,6**	**70,3**
Cantabrica and Atlantic-Galicia	36.469	36.469	100	0	0	31,4	0	31,4
Between Miño-Duero (Cavado, Ave)	3.714	0	0	3.711	100	0	6,2	6,2
Between Miño-Tagua (Mondego)	14.228	0	0	14.228	100	0	6,7	6,7
Sado, Mira and Algarbe	13.900	0	0	13.900	100	0	1,5	1,5
South Atlantic (Odiel, Tinto)	4.612	4.612	100	0	0	1,1	0	1,1
Between Guadalq.yGibral.	62.762	62.762	100	0	0	7,8	0	7,8
Sur, Segura and Júcar	79.827	79.827	100	0	0	7,5	0	7,5
Ebro and France	101.047	101.047	100	0	0	20.9	0	20,9
Total Non Shared Basins	**316.559**	**284.167**	**90**	**31.839**	**10**	**68,7**	**14,4**	**83,1**
Peninsula Total	**581.119**	**491.797**	**85**	**88.769**	**15**	**117,4**	**36**	**153,4**
Sharin / Penín. Total (%)	**46**	**42**		**64**		**41**	**60**	**46**

[A] Data by Santafé (2003). [B] Data by Maia (2003)
[C] Average value between Santafé and Maia data .

We can observe that there are important differences in the quantifying of natural internal resources. For example, in the case of Duero river, the total internal resources are 26.7 km^3/year according to Maia (2003), but 23.2 km^3/year regarding Santafé (2003). There is a difference of 13%.

From table 4 it is drawn that the Intensity of Use in shared basins increases from humid North to dry South and, from East (Spain) to West (Portugal) in the case of Miño/Limia and Tajo, and major Intensity of Use in the East (Spain) in the case of Duero and Guadiana.

* Table made with data by Santafé (2003) and Maia (2003).

In accordance with CEDEX (2000), from Spain to enter to Portugal about of 25 km^3 in mean year and represents the contribution of total water resources in mean year (there isn´t significations shared groundwater resources); increasing about of a 70 % the Portuguese internal resources.

Table 4. Characterization of the resources and uses related with shared basins**

	ZONE	MIÑO/ LIMIA	DUERO	TAJO	GUADIANA
Inhabitants (10^6 inhabit)	Spain Portugal	0,86 (76%) 0,27 (24%)	2,27 (57%) 1,73 (43%)	6.10 (68%) 2.89 (32%)	1,67 (88%) 0,23 (12%)
Natural Internal Resources (1) (km^3/año)	Spain Portugal Peninsula	14,3 (83%) 2,8 (17%) 17,2	15,9 (64%) 9,1 (36%) 25	12,8 (63%) 7,7 (37%) 20,4	5,7 (72%) 2 (28%) 7,7
Uses of Water (2) (km^3/año)	Spain [a] Portugal Peninsula [b]	0,62 (70%) 0,26 (30%) 0,83	3,86 (70%) 1,69 (30%) 5,55	4,4 (61%) 2,81 (39%) 7,21	2,69 (86%) 0,44 (14%) 3,13
Intensity of Use (2) / (1) (%)	Spain Portugal Peninsula	4 9 5	24 19 22	34 36 35	47 22 41

(a) For Limia, only to irrigation
(b) In accordance with (a)

Maia (2003) establishes in accordance with the data from the EU (1998), that only 4,3 km^3 are useful resources, since there is a big difference in the storage reservoir in the two countries and the corresponding rules of operation. Spain is the country of the EU with major capacity of storage (about of one third of all countries in the EU), regulating the 40 % of its annual mean total resources, whereas Portugal only regulates 26 %.

Regarding INAG (2001), the storage capacity of the shared basins is only 4,7 km^3 for Portugal and 31,1 km^3 for Spain. This is a global relation about 1/7, corresponding to 1/7 for Duero; 1/4 for Tajo and 1/20 for Guadiana.

6.4 Water Management in Spain and Portugal

Both countries have quite different systems of water management. In general it could be said that in Spain the administration is enough decentralized and Portugal has a more central orientation. In both cases water constitutes a good of public domain, that is, a good whose ownership corresponds to the State, whose private enjoyment can only be carried out by means of an authorization of the corresponding managing organisms.

In Spain, the administrative competence is developed by the Ministry of Environment and the water administration is managed by some entities - Confederaciones Hidrográficas- of public and autonomous character. Confederaciones, which operate on the territory of one or several basins, were created in 1926 and they are composed by representatives of the basin water users, as well as several public administrations.

The Autonomous Communities have important competence in waters resources and from the reformation of The Law of Waters of 1985, it is not a direct competence (only if the basin is entirely inside the territory) but rather derived from the application of the basic legislation: environmental, civil protection, etc. Municipalities are in charge of supply and sewerage,

** Table made of data by Maia (2003), Santafé (2003) and corrected to average value although the Autonomous Community and even the central government play an important paper in this field.

The Law of Waters was revised in 1999 to be adapted to the EU regulations. The 14 continental Plans of Rivers Basin were concluded in 1997, and the last ones were approved in summer of 1999. The National Hydrologic Plan was made public (and officially presented to Portugal) in September 2000, being effective from July 2001. In the PHN (2001), it is planed to transfer 1,100 hm^3/ year from the low part of Ebro river, toward the deficit basins of the Spanish south–east (Júcar, Segura and Sur).

In Portugal, there are not continental autonomous regions, and the units of the administrative territory of water do not coincide with the basin limits, although the planning of the water resources is carried out on the base of basin.

The Plans of River Basins were completed in October 2000 for the four main international rivers (and then officially presented to Spain). In 2001 the remaining 11 basins (one shared, Limia) were completed, one under the responsibility of the Institute of Portuguese Water (INAG), and the rest by the Offices of Territorial Ordination and Environment (DRAOT). Finally, the valid Law of Waters from 1919 is completely out of date.

The existence of both models of disparate nature, although it does not disable the relationships in the shared basins, it expounds problems to the hour of finding structures of homogeneous cooperation that do not introduce elements of rigidity or additional tension.

6.5 Different Agreements between Spain and Portugal on the subject of water

The first document concerning the Spanish-Portuguese relations on the subject of water is the Limit Treaty of 1866, completed by the Change of Notes in 1912. In the first case, it was shown that the water resources existing in the border stretches had to be used for mutual benefit and any country could appropriate them exclude and exclusively.

In the 1912 document, a set of simple rules for the industrial use of the water in the border stretches was given, assigning a half of the running flow for each country and requiring a technical project. The 1912 document has not been formally repealed and therefore today it is still a subsidiary legal element.

The 1927 agreement regulated the hydroelectric use of the international stretch of Duero river until meeting Huebra river. By virtue of this agreement, Portugal and Spain have built different dams that have worked since the sixties. The second agreement to regulate the hydroelectric planning of international stretches of Duero river and their tributaries is an extension of the 1927 agreement. The second agreement has been a legal element since July 1964 and it has permitted the construction of different deviation works for hydroelectric power. The two countries signed in May 1968 a new agreement to regulate the use of the international stretches of the rivers Miño, Limia, Tajo, Guadiana, Chanza and their tributaries.

From a technical point of view, all the actions included in the Agreements were carried out; there are only two important act left: the construction of the Alqueva Dam in Portuguese Guadiana (sometimes proposed), and the Sela hydropower (in river Miño) with serious environmental problems.

From the seventies on, there has been an increase in the consumptive uses of water, which leads to an increase in the sector and territorial tensions and to a growing deterioration in water quality. This process was reinforced in the nineties by the appearance of the so called "new water culture," which means to take into account the different characteristics of water resources. Furthermore the substantial political, social, and economic changes experimented by Spain and

Portugal since the signing of these Agreements, have forced a rethinking of all kind of bilateral relations.

The model designed by the 1964 and 1968's Agreements suddenly entered a crisis in 1993. The immediate cause was determined by the Spanish Ministry of Public Works and Transport that presented the Preliminary Project of the Law on the National Hydrological Plan (APHN-93). The plan ignored not only Portugal's situation and its requirements, but also set forth transfer aqueducts from the transboundary rivers, particularly from the Duero to other zones in Spain, a point that formed a substantial modification of *the status quo*.

The political dimension of the water crisis put this question on the agenda of the Spanish-Portuguese ministerial summit meeting in Palma de Mallorca, held in autumn 1993. A formal negotiation process for the new Water Agreement was opened, widening the field of the Pacts in force to more general aspects of use and protection of water resources.

At the following Ministerial Summit held in Oporto in November 1994, the contents of the new Agreement were studied in depth. The results of the summit expressed in the so-called "Oporto Declaration" that formed the commission at the highest level for the negotiations. The foundations of the bilateral agreement are:

- Broadening of the frame of territorial and material reference of the effective Agreements.
- Perspective of global cooperation.
- Coordination of the planning and administration of the water resources in the basin environment.
- Respect and compatibility with the existent situations and those derived from the valid Agreements.

After ten formal meetings of negotiation, completed by other multiple technical and juridical ones, the "Agreement on cooperation for the protection and the sustainable use of the waters of the Spanish-Portuguese hydrographic basins" or "Agreement of Albufeira" of November 1998 was signed *ad referendum*, within the frame of the summit celebrated in the Portuguese city of Albufeira, although it went into effect January 17th, 2000. The inspiring fundamental principles standing out are: the seek of balance between use and protection of water in the frame of a sustainable development, and the coordination of the efforts to carry out between both countries for the water administration.

The Agreement establishes a frame for the cooperation in the protection of the waters of the shared basins, in the protection of their aquatic and terrestrial associated ecosystems, in the combined administration in extreme situations of flood, drought and incidents of accidental contamination. The agreement recognizes the right of each part to a sustainable use of the rivers water inside their territory. Finally, the agreement was elaborated and approved under the principles and rules of the International laws and of the EU, concretely on the base of the Directive Frame of Water (Directive 60/ 2000, of 23 of December of 2000).

The regime of flows tries to fix some guaranteed flows in determined points, similarly to México-USA Agreement of 1944 (commitment of fixed volumes), Egipto-Sudán in 1957 (in order to regulate the flow that should arrive in Assuán) and the protocol Turquía-Siria in 1997 (with respect to the Eúfrates waters).

The Regime of Flows established provisionally is detailed in Table 5. It represents a fraction of the mean flow, with the purpose of keeping in mind the hydrological variability of the peninsular rivers and providing a margin of security for future demands. An only variable has been chosen, easily to contrast by any interested person or entity. This approach has been the object of criticism in Portugal and maybe a new reflection on its opportunity is needed, when the regime of definitive flows is studied.

Table 5. The regime of minimum flows of the Agreement. Santafé (2003)

BASIN	**Gauging Station**	**Mínimum Flow** (m^3/year) x 10^6	**Periods of Exception**	
			START of Period	**END of Period**
Miño	Salto de Freira	3.700	$P^{(R)}$ up to 1st July < 70% $P^{(M)}$	Following month to December if $P^{(R)} > P^{(M)}$
Duero	Presa de Miranda P.Saucelle+ÁguedaGS Crestuma Dam	3.500 3.800 5.000	$P^{(R)}$ up to 1st June < 65% $P^{(M)}$	Following month to December if $P^{(R)} > P^{(M)}$
Tagus	Salto de Cedillo Ponte de Muge G.S.	2.700 4.000	$P^{(R)}$ up to 1st April > 60% $P^{(M)}$ or $P^{(R)}$ up tp 1st April < 70% $P^{(M)}$ and $P^{(R)}$ previous year < 80% $P^{(M)}$	Following month to December if $P^{(R)} > P^{(M)}$
Guadiana	Badajoz Dam Pomarao G.S.	600-300 2 m^3/s / daily	According to rainfall and State of reference reservoirs	Following month to December if volume in ref. reservoir > 3.150 x 10^6 m^3

$P^{(R)}$ is the accumulated reference rainfall in the basin, from the beginning of hydrological year to the date indicated.
$P^{(M)}$ is the mean accumulated rainfall in the basin in the same period.

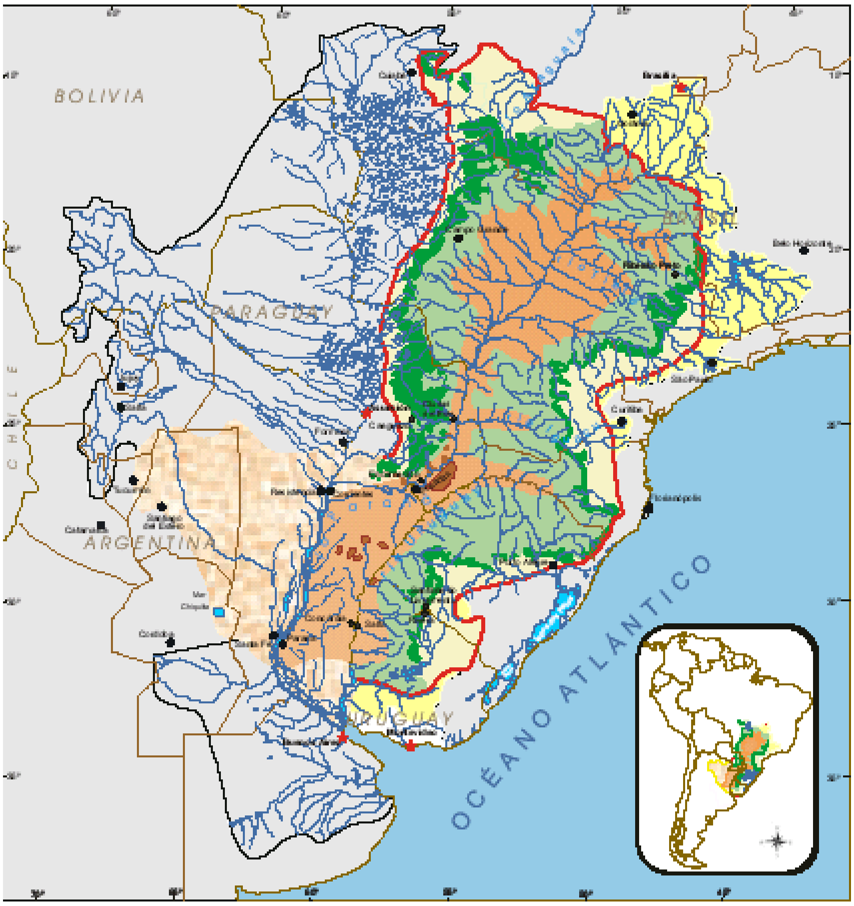
It is considered that the years with abnormally low rainfall are exception years when the fulfilment of the guaranteed flows is not required. This does not mean that this is really going to happen. In order to define these exception situations objectively, indicators referring to a reference rainfall for each basin have been established, calculated on the volume produced over two or three selected rain gauge stations, in terms of their representativeness and length of observation period. This indicator does not try to define a drought situation, only a state in which it is not possible to ensure guaranteed flows.

7. THE GUARANI AQUIFER SYSTEM PROJECT*

The Guarani Aquifer System, so named in honour of the Guarani Indigenous Nation, is one of the largest groundwater reservoirs in the world. It is located on 12° and 35° South Lat.; 47° and 65° West Long. under the four MERCOSUR countries: Argentina, Brazil, Paraguay and Uruguay. Until recently, the Guarani Aquifer System was known as the Botucatu Aquifer in Brazil, the Tacuarembó Aquifer in Uruguay and Argentina, and the Misiones Aquifer in Paraguay. The Guarani Aquifer System extends from the central-west region of Brazil into Paraguay and the south-eastern and southern regions of Brazil, and into north-eastern Argentina and central and western Uruguay (see Figure 11). It has an estimated total area of approximately 1.2 million square kilometres (839,800 km^2 in Brazil, 225,500 km^2 in Argentina, 71,700 km^2 in Paraguay, and 45,000 km^2 in Uruguay). The portion within Brazil encompasses about two-thirds of the total area extent of the System, and includes parts of eight Brazilian states—an area equal to that of England, France and Spain combined. An estimated fifteen million people live within the aquifer's area of surface influence.

* From: http://www.sg-guarani.org/sistema/descripcion.htm

Figure 11. Map of Guaraní Aquifer System*



About 40,000 km^3 of freshwater are contained within the Guarani Aquifer System. About 90% of this volume is estimated to be potable, although, locally, potability can be reduced due to salinity and elevated fluoride content (affecting less than 10% of the volume). The volume of water in the system is equivalent to the total volume of water conveyed by Paraná River over a period of almost 20 years (based on a mean flow rate of 10,000 m^3/s). It is estimated that the aquifer could meet the water demands of 360 million people on a sustainable basis, based on a water use of 300 liters/day per capita. Only about 10% of the total freshwater reserves would be depleted after a period of 100 years. Current usage, from deep wells, sustains a rate of abstraction of up to 1 million litres/hour per unit. The Guarani Aquifer System has an average thickness of 250 meters varying from lenses of a few meters at the borders of the groundwater basin to about 600 m in its central parts, such as in the northern parts of the States of São Paulo, Paraná and the southern parts of Mato Grosso do Sul in Brazil. Its depth below the land surface varies from zero in outcropping areas and its vicinity to more than 1,000 meters in Argentina.

Besides the excellent quality of the water (which is very suitable for consumption) another important characteristic of the Guarani Aquifer is the thermal quality of the waters. In a number of regions, the water emerges naturally at temperatures of between 33 and 50 degrees Celsius, at a flow rate of about 100,000 liters/hour. At present, this water is used principally for water supply and tourism, although it could potentially be exploited as an alternative energy source, substituting for non-renewable energy sources in the project area.

In natural conditions, only a portion of the regulating reservations is possible of exploitation. In general, this part is calculated between 25% and 50% (Rebouças, 1992) out of

* From: http://www.sg-guarani.org/sistema/descripcion.htm

the regulating reservations, respectively between 40 to 80 km³/year. This volume could increase depending on the adoption of techniques of aquifer development available; however, the studies will be deepened in order to define the rate of sustainable exploitation of the reservations, once the add of the extractions with the natural discharges of the Aquifer for the rivers and ocean, are not superior to their natural recharge.

The aspects relative to the development and use of the functions of the Aquifer are still incipient. The use of the thermal energy of its water could eventually derive in the energy saving of other sources and in the cogeneration processes of electric power. Nowadays, the use of energy in baths and agricultural industries stand out.

Despite large surface of water reserves, the drinking water supply in this heavily populated region of the MERCOSUR is increasingly dependent on groundwater. Future problems may occur if groundwater use is not managed in a sustainable manner or if the groundwater becomes polluted. In São Paulo State, Brazil, more than 60 % of the water supply needs in urban centres are served totally or partially from groundwater sources, supplying a population of about 5.5 million people. Demands for groundwater are increasing, due to both demographic growth and economic expansion, and as a consequence of the pollution of surface water sources (although governments are also increasingly tackling surface water pollution).

The use of the Guarani Aquifer System's water has increased significantly in the last decades, as a consequence of the extreme urbanization pattern of some areas on the one hand and developments in large scale agriculture schemes on the other. In some areas of the aquifer system there is a high concentration of wells whose water is used for different purposes. Maps produced based on the assessments undertaken during project preparation show the spatial distribution of water uses (77 % urban household use, 11.5 % industrial use and 11.5 % agricultural use), as well as maps with location of wells and their respective depths.

Some of the conflicts related to water quantity are already well identified. These include, among others, the reduction of piezometric and phreatic levels, and the interference between wells experienced in the highly urbanized areas around Ribeirão Preto and Bauru, in São Paulo State (Brazil) and the transboundary thermal sites between Uruguay and Argentina, particularly in the area of Salto (Uruguay) and Concordia (Argentina).

Table 6: Current Knowledge and Importance of the Guarani Aquifer System

Characteristic	Argentina	Brazil	Paraguay	Uruguay
Approximate Extent of the Aquifer	**225,500 km^2 (19.1 %)**	**839,800 km^2 (71%)**	**71,700 km^2 (6.1%)**	**45,000 km^2 (3.8%)**
Percent of Territory Occupied	**6**	**10**	**18**	**25.3**
Characteristics of the Aquifer	Supply source	Recharge and supply area	Recharge and supply area	Recharge and supply area
Extent of Exploitation	9 deep wells for thermal use	300 to 500 cities partially or entirely supplied by the Aquifer System (70% of household use); industrial uses (25%), irrigation and recreational uses (5%)	About 200 wells, mainly for domestic water supply	135 wells for public water supply, 7 of which are for thermal usea
Principal Environmental Issues	1. Potentially uncontrolled drilling and extraction 2. Subject to pollution from other countries	1. Point and nonpoint source pollution 2. Uncontrolled drilling and extraction 3. Subject to pollution from other countries	1. Point and nonpoint source pollution 2. Uncontrolled drilling and extraction 3. Subject to pollution from other countries	1. Point and nonpoint source pollution 2. Uncontrolled drilling and extraction 3. Subject to pollution from other countries
Level of Information	Limited information available, especially about the western extent of the Guarani Aquifer System	Considerable information available but dispersed in different states and institutions	Limited information available	Considerable information available

7.1 Experiences of the region at transboundary waters management

The beneficiary countries have long-standing experience in collaborating on transboundary water issues, most notably with regard to the Plata River basin which has had a general treaty and an Intergovernmental Committee since the 1960s. In addition, bilateral projects and specific treaties exist with respect to other water systems, such as the Uruguay River (Uruguay and Argentina), and the Paraná River (Brazil and Paraguay). To date, the success of these agreements has been mixed, especially with respect to hydrological allocation and pollution control issues. The countries do recognize, however, the importance of cooperation in transboundary waters issues. The attempt to reach an agreement on groundwater is a historical first and will certainly enhance the dialogue on other waterbodies within the region and may contribute to improved water management at a transboundary level.

7.2 Project objective

The long-term objective of the process started through the proposed Project is the sustainable management and use of the Guarani Aquifer System. The purpose of the proposed project is to support the four countries in jointly elaborating and implementing a common institutional, legal and technical framework to manage and preserve the Guarani Aquifer System for current and future generations. To achieve this, seven component projects are envisaged:

(i) expansion and consolidation of the current scientific and technical knowledge base regarding the Guarani Aquifer System

(ii) joint development and implementation of a Guarani Aquifer System Management Framework, based upon an agreed Strategic Program of Action

(iii) enhancement of public and stakeholder participation, social communication and environmental education

(iv) evaluation and monitoring of the project and dissemination of project results;

(v) development of regionally-appropriate groundwater management and mitigation measures in identified “Hot Spots”

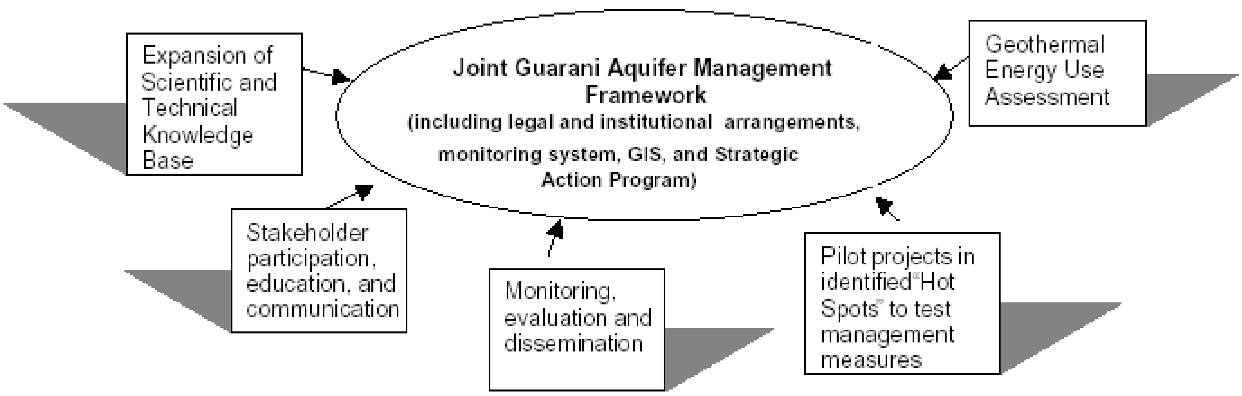
(vi) consideration of the potential to utilize the Guarani Aquifer System’s “clean” geothermal energy

(vii) project coordination and management

7.3 Approach

The joint development and implementation of the Guarani Aquifer Management Framework is the core of the Project. The other project components are designed to provide the scientific, technical, social, legal, institutional, financial and economic basis for the Framework, as illustrated in Figure 12.

Figure 12. Guarani Aquifer System Manage Framework



The project has seven interrelated components that quantify the state of the aquifer in terms of its morphology and behaviour, its use and conservation, it relationships to communities and institutions, and its planning and organizational needs for improving coordinated management of its waters. This knowledge will provide a scientifically-sound and well-documented base for establishing a framework for the coordinated and consensual management of the Guarani Aquifer System, capable of providing for its environmental protection, and integrated and sustainable development. The project will identify and test key management elements (including policies, mechanisms, and instruments) that will facilitate the sustainable and coordinated management of the Guarani Aquifer System. The resulting management framework will provide the means to mitigate and/or resolve the most pressing transboundary environmental problems that threaten the aquifer.

In addition, this framework will provide a means to address local conflicts arising from the use of the waters of the aquifer system (especially those related to water pollution and over exploitation to provide a long-term strategy for risk mitigation), and to assess its potential to provide "clean" geothermal energy to communities within the region.

8. CATAMAYO-CHIRA project[*]

The Catamayo-Chira hydrographical basin is placed in the North of South America, in the South West of Ecuador Republic, province of Loja, and the North of Peru in the provinces of Sullana, Piura, Ayacaba, Talara and Paita, where there are 817,968 inhabitants.

Its geographic coordinates are 03º 30´ to 05º 08´ South latitude and 79º 10´ to 81º 07´ West longitude. The basin area is 16.800 km^2, 7,950 km^2 are in Ecuador and the rest 9,850 km^2 in Peru.

The river origin is in the Occidental Cordillera of Los Andes at 3,600 m and flows into the Pacific Ocean. The confluence of Catamayo and Macara rivers origins Chira river, which before a short run along the boundary enters in Peru where it receives the waters of Quiroz river (3,020 km^2), Chipillico river (1,176 km^2) and other minor tributaries. In Ecuadorian territory it is important to mention the Alamor River.

The whole longitude of the binational basin is 315 km, 196 km are in Ecuador and the rest in Peru.

The initial stretch of the basin, in Ecuador, presents these characteristic:

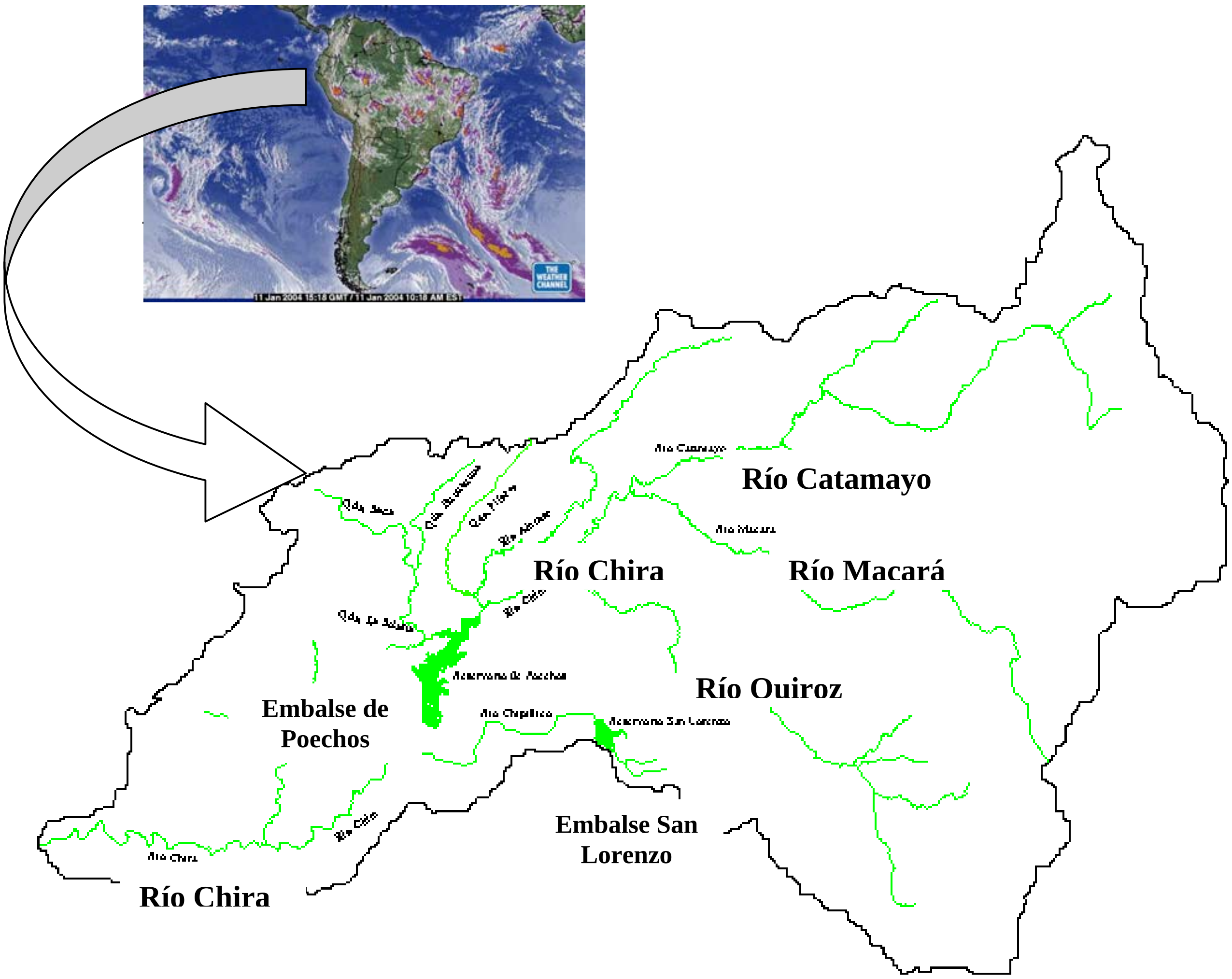
- The Hydrographical net is catalogued as High mountain (longitudinal slopes between 35 % and 1.2 %); The basin is subdivided into three great sub-basins: Catamayo river in central sector; Macara river sub-basin in the south, and the Alamor river sub-basin in the West)

- In general, the climate is influenced by the Intertropical Zone of convergence (ZCIT), and the interaction of the marine currents, the warm one of El Niño and the cold one of Humboldt.
- The basin annual mean rainfall is about 800 mm, varying between 500 mm in the lower zone and 1,000 mm in the upper zone; the rainfall presents different distribution in space and time. The rainy periods are from January to April, being more intensive in March.

[*] From: http://www.inbo-news.org/ag2000/irager.htm

- The hydrographical basin is developed inside an abrupt topography, between 200 and 3,700 meters about seal level (masl). This characteristic allows eleven different Life Zones, in accordance to Holdridge table, that permit a high richness in their biodiversity.

Figure 13. Hydrographical basin of Catamayo – Chira river



In the low basin, placed in Peru, the river has these characteristics:

- In the initial sections the topography is accidental, the mountains has a moderate height and the slopes have a regular slope, allowing riverbed erosion and solid material to be carried in suspension .
- The second stretch begins below the 300 masl. A low slope and dry valleys characterize it, except from the riverside where tropical vegetation can be seen. There, the great irrigation systems of San Lorenzo and Chira – Piura are developed.
- In Peru zone the climate is hot and dry, typical of the North coast of Peru, because of its proximity to the equatorial linear and the change of direction of the marine current of Humboldt.
- In normal periods the mean rainfall is between 400 mm/year and 600 mm/year.

It is worth to mention that in the Peruvian area, there are important interdependences:

- The Chipillico river sub-basin and the partial diversion of Quiroz river to the San Lorenzo Dam, attend Chira and Piura Basins irrigation areas
- The Chira and Piura derivation channel has allowed to incorporate the farming area of Cieneguillo that shares the Chira and Piura Basins.
- In the Peruvian area the water management has been made from the Valleys and Irrigation Areas, that share more than an Hydrographical basin and are directed to the water resource management in the irrigation area.
- It is necessary to make a better delimitation of the Chira basin influence area, and it should made necessarily at the operative phase.
- The Catamayo - Chira Basin is directly related with the middle and low parts of the Piura basin, to which contributes with an important inflow through the Daniel Escobar derivation channel.

In Table 7 are the principal dates obtained from the Catamayo - Chira hydrographical basin, from IRAGER (2000), AECI-Plan Binacional (2001) and INERHI-CEDEX (1989). It has to be mentioned that some dates are contradictories, such as the area data corresponding to each country. However, in order to have a first estimation, the author has estimated the resources with respect to the information from IRAGER.

Table 7. Resource characterization and social characteristic

	ECUADOR	**PERÚ**	**CATAMAYO-CHIRA**
Basin Area (km^2)	7.950	9.850	16.800
Mean Rainfall (mm)	800	500	672
Mean Flow (hm^3/año)	2.274	2.494	4.768
Natural Internal Resources (A_{90}) (km^3/año)	1,5	1,6	3,1
Population (habitantes)	221.686	596.282	817.968
Population Density (hab/km^2)	31,3	58,1	47,1
Poverty Index (%)	86,4 (96,2 – Calvas)	67,5 (95,4 – Ayabaca)	72,6

8.1 Management Planning Preceding of the Binational Basin

As an initial precedent, the Comision Mixta Peruano Ecuatoriana of 1971 on the Catamayo-Chira Hydrographical Basins, establishes as a criterion that the basins had to be exploit until its maximum capacity (in accordance with technical considerations) in order to obtain the greatest social and economic incomes, independently from politic considerations.

Then the planning, negotiations and agreements have to include all the aspects, in order to obtain a harmonious development with similar advantages for Peru and Ecuador.

However, in 1995, a war broke out between the two countries, that lead to a social and economic disaster still persisting. This was one out of the many problems in the relation of these boundary countries.

The signature of the Peace Agreement on October 18 of 1998, was the end of fifty years of problems.

The IRAGER initiative of Piura (Peru) to organise the First Binational Technical Meeting Catamayo-Chira Basin, made it possible that in June 18th and 19th 1999, representatives of 24 institutions from the two countries met in Piura, with representatives from the Agencia de Cooperación International and the Dirección General de Obras Hidraulicas del Ministerio de Medio Ambiente in Spain, with the aim to establish the fundamentals and promote the actions to obtain the sustainable development of the basin.

The meeting allows to reach the next agreements:

1. Constitution of the Instancia Binacional: Comite de Coordinacion Binacional (CCB), composed by six members, three from each country, representatives of the Government Organisms, ONGs and Universities.
2. Naming an Executive Secretary integrated by two members:

   - SINERSA (Peru), PREDESUR (Ecuador)

3. Agreement to create in Ecuador an organization similar to IRAGER

As a result of this meeting and the works of the CCB, between march 22nd and 23rd 2000, it was possible to organise the second binational meeting where all the members of the IRAGER and the Ecuadorian entities integrated in the CECC participated. In the meeting both entities resolved a detailed program of activities, including as an urgent activity, the elaboration of the Reference Terms to formulate a Management Planning of the Binational Basin Catamayo - Chira.

The CCB interaction with the Dirección General de Obras Hidráulicas of the Environment Ministery in Spain, led to the decision of supporting the sustainable development and management of the basin, through their technical collaboration together with the financing from the Agencia Española de Cooperación Internacional (AECI).

In January 2000 Spain sent a delegation to Peru and Ecuador, in order to make a basin diagnosis. Back in Spain, a document was elaborated for the consideration by both countries.

The document analyses the possibilities and determines the procedures for joined work by the three countries, represented by the management unit. The document is a base for the cooperation agreement of Spain with Peru and Ecuador.

8.2 Project objectives

The complete and sustainable management of the Catamayo-Chira basin in order to improve inhabitants' life conditions, with the support of social and institutional actors.

In accordance with this general objective, the first phase of the Project, financed by the Spanish Government, with the participation of the Peruvian and Ecuadorian Government, includes the following specific objectives:

- Establishment of the basic agreements that allow the Project development
- Basin authority constitution
- Establishment of the General Management Planning, defining the works to be done, and the relation with the first phase of the Project.
- The information system starting, including Hydrometric nets
- Compilation and analysis of the basin basic information and the natural resources principal parameters (place, quality, availability, quantity, interaction and others)
- Improvement of the production promotion activities and education training promotion.

8.3 Cooperation agreement considerations

According to the shared work experience, made by IRAGER (Perú) and CECC (Ecuador), with the aim to develop a joint general planning of the basin, it is possible to define some criteria to guarantee the execution of the objectives:

a) Reinforcement of the existing institutions because they have to be the principal centre of development. IRAGER y CECC- joined for the binational basin management in the Binacional Assembly Catamayo-Chira, with its directive organism, the Binational Coordination Committee (CCB), its executive secretary and its Rules, constitute an element of the greatest importance.

b) The CCB that depends on both organisms is realizing diverse activities for the sustainable development programme. This will allow both organisms to support successfully the effort of the international cooperation.

c) The sustainable development can be successful if the experts knowledge and technical experience improve as long as the Project development. This is possible with the shared work of the Spanish, Peruvian and Ecuadorian experts. The Spanish experts have to act more intensively at the beginning, and then the binational basin experts will take the programme over little by little, assuming more responsibilities, so that at the end of the programme they will be capable to manage, control and develop the basin.

d) As that zone has important academic institutions in both countries (Universities of Piura and Loja), the institutions experts have to be included in the project development, what will guarantee the project quality, minimum costs and optimal training during the project development. However the membership of the universities to the Binational Assembly Catamayo-Chira makes these actions be performed through the CCB.
The CCB represents the binational institution, chosen by the whole actors of the Project zones and it can be the origin of the future Basin Authority.

Finally, the main conclusions contained in Anexo I of the document PROCEEDINGS IN THE AREA OF THE BASIN NATURAL RESOURCES ARRANGEMENT[*] are the following:

- The Catamayo-Chira basin presents an extremely social and economic depression. There is a high poverty index and a high natural resource degradation, resulting from resources over utilization. In the Catamayo zone, the area of overexploitation is around 3,294 km^2, equivalent to 41,4 % of the Ecuadorian

[*] AECI – PLAN BINACIONAL. Binational Project of Ordination, Handling and Development of the Catamayo-Chira Basin. Area of Characterization of the Resources of Basin. December, 2001.

area (7,950 km^2). In the Ayabaca zone, the area estimated is 2,615 km^2, equivalent to 26,5 % of the Peruvian area (9,850 km^2).

- The specific degradation on the high zone of Catamayo River is 2,386 m^3/km^2/year (3,397.882 ton/year), and on the low zone it is estimated in 300 ton/ha/year. Around 6,256 km^2 are prone to be eroded in the whole basin, that is equivalent to 37 % of the whole area.
- The great quantity of eroded soil has led to the sedimentation of Poechos Dam, with a loss of 43 % of its usable capacity, with 25 years of utilization. The San Lorenzo Dam has a loss of 20 % of its usable capacity, with 30 years of utilization.
- It is remarkable to mention the advance of the desertification process that implies the ecosystem degradation, caused by natural phenomenon and anthropic actions. The same that threatens to devastate important productive and natural resources areas, leading to limitations in the social and economic development of the inhabitants.
- The bad treatment of the basin resources and the unsuitable irrigation practices. The common use is irrigation by gravity .
- Water contamination is alarming, because of the high concentration of coliforms and toxic residues, as a result of high utilization of pesticides.
- The floods or maximum flows are important subjects in the Chira basin, because of the frequent presence of El Niño phenomenon (FEN). The Chira basin and its influence area suffers the threat of floods for this recurrence.
- At the end of the years 1982 and 1997, just as in the beginning of 1983 and 1998, the FEN appeared in the most intensive way in the 20th century, bringing about great losses.
- The recurrence of this phenomenon forces to adopt measures in order to reduce the basin vulnerability, taking into account that the “El niño” is a present an permanent factor, counteracting its negative impacts and taking advantage of its positive effects.
- 1983 and 1998 were hydrological exceptional, during these years the flows into Chira river were 6,995 m^3/s in 1983 and 7,301 m^3/s in 1998, corresponding to a Return Period of 400 and 500 years.
- The important hydraulic substructure existing in the Chira river basin with Poechos and San Lorenzo Dams, requires a differentiated treatment of population and farming, since they are placed outside the basin but depend totally or partially, on these water resources.
- In the Peruvian zone, the treatment as a basin is recent. Water resources have been managed by Valleys and Irrigation Districts, whereas the other productive, social, economics components have been treated under province and district boundaries in accordance to the Peruvian legislation. That will demand the homogenisation of the treatment as a basin in the Peruvian zone in the operative phase.

9. COMPARARISION BETWEEN THE ANALYZED CASES

Table 8 summarises the main characteristics of the analysed cases. It is worth emphasizing the great difference in the area of the different basins, as well as the different stages of the hydraulic development.

As for the natural flow, we can observe that in the Guaraní Aquifer case, is much greater than shared basins in Iberia Peninsula, having to attend a similar number of inhabitants.

Table 8. Main characteristics of the analysed cases

	Shared basins of Iberic Peninsula	**Guaraní Aquifer Project**	**Catamayo – Chira Binational Plan**
Basin Area (km^2)	264.560	1.200.000	16.800
Involved Countries Sup. (km^2)	Spain (207.630) Portugal (56.930)	Argentine (222.500) Brasil (840.000) Paraguay (71.700) Uruguay (58.500)	Ecuador (7.950) Peru (9.850)
Natural Flow (hm^3/año)	70,3	40,000 – 80,000	3,1
Storage Capacity (hm^3/año)	Spain (31,1) Portugal (4,7)	166	Ecuador (0,5) – Inventory Peru (> 0,5) - Possible
Population (10^6 inhabitants)	16,02	15,00	0,82
Population Density (hab/km^2)	60,6	12,5	47,1
Poverty Index (%)	< 20	60	73
Hydraulic Development Stage	Integral	Unconnected - Integral	Unconnected
Main Conflicts and Necessities	- Terrestrial and water ecosystems protection - Basin planning and management coordination - Flooding and drought control - Quality and contamination reduction control - Irrigation consolidation and modernization, energy and water supply and sanitation improvement	- Institutional, legal and technical pattern formulation. - Sustainable and environmental protection of Aquifer - Technical and scientific knowledge - Local conflicts of diffused contamination and overexploitation - Water supply (77 %), - Industry (11,5 %), - Irrigation (11,5 %) - Development of geothermic energy and the tourism	- Formation authority of basin and General Plan - Improving conditions of life of inhabitants - Basic studies, characterization natural resources, systems of information, gauging nets - Improvement activity production and formation - Irrigation, supply, hydroelectricity - Erosion and wilderness - Droughts and floods

As for the storage capacity the Guaraní Aquifer has a capacity from 2 to 4 times its natural flow capacity and more than 5 times the natural flow of the Spanish shared rivers.

As for the storage capacity of the Catamayo – Chira basin, at present there is not any important regulation reservoir in the Ecuadorian zone. Table shows the value corresponding to the capacity of the inventoried dams. This value have to be higher in the Peruvian territory, where there are already two important dams.

The shared basins in the Iberian Peninsula have a population density higher than the mentioned cases, although this index is 4 times higher in the Catamayo – Chira Basin than in Guaraní Aquifer.

The poverty index is of 72,6% in the Catamayo - Chira Basin, a common index in Latin America because of the social, economic and political degradation of the last thirty years. This index is supposed to be around 60 % in the Guaraní Aquifer zone and less than 20 % in the Iberian Peninsula.

Finally, these shared basins are currently in the Hydraulic Development Stage, from an Unconnected Development Stage in the Catamayo- Chira basin, an Unconnected - Integral mixed stage in the Guaraní Aquifer, to an Integral Development stage of the shared basins in the Iberian Peninsula.

10. CONCLUSIONS

A nation is vulnerable and could be threatened by conflicts depending on its water resources system. Its capacity to sustain its aquatic ecosystem and provide its population with the required level of social and economic development, is committed by the nature of its hydrological system, infrastructure of water resources and/or its system of water resources administration (Raskin et al., 1997).

The solution to conflicts as a tool for the management of the sustainable water resources could be a very appropriate technique (Fernández-Jáuregui, 2000):

- The conflicts could be structured like a hierarchy and analysed according to priorities.
- By solving conflicts, the advance process involves the determination of the most appropriate selection for the present situation.
- The setback approach is used to solve conflicts, establishing first the wanted result and determining how to get it.
- The combination of the wanted and the most probable solution could lead to a suitable solution for all the parts in conflict. This process itself could induce people to look beyond the existent conflict.

The number of countries in conflict could descend from 112 to 85 in 2025 if the suitable actions are carried out, linked to the negotiation of their water problems and with the participation of the whole community.

In many countries, the capacity of revenue increase would permit a reduction in tension.

With respect to Global Climate Change at hydraulic resources, we can say (Castillo, 1996):

- The study of the climatic global change problem requires the participation of all the Countries, because the means and economic necessities are very big. At the moment, we have modestly to recognize that we know little of the problem, for the lack of data at global level, as for the excessive simplifications that the climatic models have, being therefore their forecasting very imprecise still. However, we are conscious that we are changing our environment and, therefore, we should act in consonance; generating a type of development that guarantees the satisfaction of the present necessities without committing the capacity of future generations to satisfy their own necessities.
- The sustainable development implies a fundamental prerequisite that is the nations' stability in a very wide sense: population, political-economic-social and protection against the natural risks (floods and droughts, tornados, hurricanes, eruptions and earthquakes, etc.). Social systems should be sustainable at international, national, local and family level, so that an equal distribution of the benefits of the goods and produced

services, and the sustainable life support systems are ensured. This in short implies the development of more just economic international systems.

- The hydraulic resources systems are sustainable, if we have enough amount and quality water and with a suitable price, to satisfy the demands and the standard quality of the region population, now and in the future, without causing environmental deterioration. Nourishment, improvement in human health and work opportunities must be assured in a context that permits the tolerance of one another, solving the foreseeable conflicts. This implies that water has to be a priority in the demands of the economic and financial resources of a Country: enough funds and time to plan the project and operate, negotiate and maintain continuously the project of hydraulic resources development. There should be a trend to make users pay for the cost of water.
- The new paradigm of hydraulic policy implies the substitution of the policy guided toward the increase of water resources offer, for a more balanced policy that puts more emphasis on saving and reusing. A policy adequate offer based on superficial, grounwater and marine waters (by means of the desalination) could be positive though. The administration system will obey to a regulation and market combination, where the emphasis is on the emission of signs of shortage. Finally, there must be an increase in the participation and responsibility of the beneficiaries on the decisions of hydraulic policy.

REFERENCES

- Araujo, L.M. Francia, A.B. Y Potter, P.E. (1995). *Acuífero Gigante del Mercosur en Argentina, Brasil, Paraguay y Uruguay: Mapas hidrogeológicos de las formaciones Botucatú, Piramboia, Rosario del Sur, Buena Vista, Misiones y Tacuarembó*. UFPR y Petrobras, 16 p Curitiba, Paraná - Brasil.
- Banco Mundial (1994). *La ordenación de los recursos hídricos*. Documento de Política del Banco Mundial. Washington, D.C.
- Castillo-E. L.G. (1996). *Present problematic of the hydraulic resources planning in Spain and the World*. Autonomous University of Madrid. CEDEX, Madrid.
- CEDEX (2003). *Las aguas continentales en la Unión Europea*. Centro de Estudios Hidrográficos del CEDEX. Secretaría de Estado de Aguas y Costas. Ministerio de Fomento-Ministerio de Medio Ambiente. Madrid.
- CEDEX (2000). *Aguas Continentales de los Países Mediterráneos de la Unión Europea.* Centro de Estudios Hidrográficos del CEDEX. Secretaría de Estado de Aguas y Costas. Ministerio de Fomento-Ministerio de Medio Ambiente. Madrid.
- CEDEX – INERHI (1989). *Plan Nacional de los Recursos Hidráulicos de la República del Ecuador*. Quito, Ecuador.
- CRU (1998). *Representing twentieth century space-time climate variability. II Development of 1901-96 monthly grids of terrestrial surface climate*. Authors: New, M., Hulme, M., Jones, P. climate Research Unit. School environmental Science, University of East Anglia. Norwich, NR4 7T, United Kingdom.
- Directiva (2000). *Directiva 2000/60/CE del Parlamento europeo y del Consejo de 23 de octubre de 2000, por la que se establece un marco comunitario de actuación en el ámbito de la política de aguas*. Diario Oficial de las Comunidades Europeas, 43 (L 327): 1-72 (2000).
- EEA (1999). *Sustainable water Use in Europe – Part 1: Sectorial Use of Water*. Enviroment assessment report Nº 1. European Environment Agency. Copenhagen.
- EEA y UNEP (1997). *Water Stress in Europe – can the challenge be met?*. EEA, Copenhage.
- Fernández-Jáuregui, C.A. (2000). *El agua como fuente de conflictos: Repaso de los focos de conflictos en el mundo*. Uruguay: UNESCO. Versión Internet, Mayo.

- INAG (2001). *National Water Plan* (Vol. I and II, in Portuguese). Portugal: Instituto da Água, Ministerio do Ambiente e Ordenamento do Territorio.
- IPCC (2001). *Climate Change*, Third Assessment Report. Contribution by working group 2, Climate Change 2001: *Impacts, Adaptation and Vulnerability, Summary for Policymakers.* WMO/UNEP/IPCC, February.
- Maia, R. (2003). *The Iberian Peninsula´s Shared Rivers Harmonization of Use: A Portuguese Perspective*. International Water Resources Association. Water International, Vol. 28, N0. 3, pp. 389-397. September.
- MIMAM (2000). *Libro Blanco del Agua en España*. Ministerio de Medio Ambiente. Madrid.
- PHN (2001). *Ley 10/2001, de 5 de julio, del Plan Hidrológico Naciona*l. España. BOE núm. 161, 6/7/2001.
- Rocha, G.A. (1997). *El Gran manantial del Cono* Sur. USP, Estudios Avanzados en los 30. pág. 191-212.
- Reboucas, A.C. 1992. *Los recursos Hídricos Subterráneo de la Cuenca del Paraná: Análisis de la Previabilidad*. Tesis libre de Docencia. La Universidad de San Paulo, 143p.
- Santafé-M. J.M. (2003). *The Spanish-Portuguese Transboundary Waters Agreements*: Historic Perspective. International Water Resources Association. Water International, Vol. 28, N0. 3, pp. 379-388. September.
- Shiklomanov, I. (1998). *World Water Resources-A new appraisal and assessment for the 21st. century*. París: UNESCO.
- Tilche, A. (2002). *The global Water System Project in the light of the research priorities of the* 6^{th} *European Framework Programme*. Communication of Andrea Tilche, European Commission DG Research – Brussels, Head of the Unit “Water Cycle and Soil-related aspects”.
- UE (1998). *Portugal and Spain Water Resources Assessment*. Luxembourg: European Commission, European Community edition (in Portuguese).
- Uchijima, Z. (1992). *Life and Water in the Global Role of Tropical Rainfall*. Theon, J., Matsuno, T., Sakata, T. and Fugono,N. Eds., Deepak Publishing Hampton, VA.