Is climate change the major issue of water resource in the Mediterranean basin?

The example of two case studies:
Rio Mannu di San Sperate (Italy) and the Thau coastal lagoon (France)

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This research project was carried out as our final study project undertaken in the fifth year in the planning department of the engineering school of Polytech'Tours, May 2012.

It is a contribution to the CLIMB (Climate Induced Changes in the Hydrology of the Mediterranean Basins) research project, which is part of the European Seventh Framework Program (FP7). The broad objectives of FP7, which runs from 2007 to 2013, are grouped into four categories: Cooperation, Ideas, People and Capacities. For each type of objective, there is a specific programme corresponding to the main areas of EU research policy.

One of them is the CLIWASEC Cluster, "Climate Change Impacts on Water and Security (in Southern Europe and neighbouring regions)" which was selected for funding through the 2009 FP7. It regroups three projects: CLIMB and WASSERMed, (Water Availability and Security in Southern EuRope and the Mediterranean) which address Theme 6 of the FP7 ("Environment, including Climate Change), and CLICO (Climate Change Hydro-Conflicts and Human Security), addressing Theme 8 ("Socioeconomic Sciences and Humanities"). The main objective of the Cluster is to identify and foster scientific synergies and to establish a more efficient policy outreach strategy, also forming a comprehensive representation of issues faced in the Mediterranean region. CLICO focuses on the political and social responses to the threat of water scarcity, while CLIMB focuses on scientific knowledge about current and future water availability in the Mediterranean. All three projects draw insight on specific aspects of the issues faced through the analysis of Case studies in the Mediterranean region.

The CLIMB project is divided into seven work packages (WP). Our study is a contribution to WP7, which objectives are to assess with stakeholders the impact of climate change on uses and rivalries of water resources at the catchment scale. This WP is implemented in two steps: first of all with an analysis of local uses and rivalries on local case studies; secondly, on the basis of these analysis confronted to the results of hydrological modeling, interactive workshops will be organised with the stakeholders involved in each local case under investigation, in order to assess the impact of Climate change on those uses and rivalries and to design the way they would plan to regulate it. Our research project was carried out as being the first step of this project, for the catchments of Rio Mannu di San Sperate in Italy (Sardinia) and Thau's coastal lagoon in France (Languedoc-Roussillon).

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ABSTRACT:

This research based article is a contribution to the European research project CLIMB (Climate Induced changes on the Hydrology of Mediterranean Basin). It is a multi-disciplinary project taking into account the hydrological but also economic and social changes induced by the predicted climate change.

Climate change is likely to exacerbate many challenges despite uncertainty about the detail of its impacts on water resources. The Mediterranean basin is confronted with many challenges and is a primary hotspot for responsiveness to climate change. This paper focuses on the major issues over the uses of the water resource and the potential rivalries that occur over it in two specific sites of the Mediterranean basin: Rio Mannu di San Sperate (Sardinia, Italy) and Thau's coastal Lagoon (Hérault, France). This research examines the uses of water in the past, present and close future and is interested in determining if the actors sense that climate change is a crucial factor of shift towards the issues of water or if it is in fact other causes that put pressure over the water resource.

KEY WORDS: water resource, water rivalries, climate change, Mediterranean basin, CLIMB, Thau's coastal lagoon (France), Rio Mannu di San sperate (Italy)

1. INTRODUCTION

Water is viewed as a multifunctional resource. This complexity is taken into account in the development of water policies and plans. This recognition leads to finding a balance between the multiple functions and uses of water and is a key basis for a sustainable management of water resources. It forms a basis for an integrated management of the water since it takes into account all the possible uses, including those of the ecosystems. Nowadays, this integrated management occurs at the catchment area scale. However, the water issue is closely linked to the political ambitions of the States, the perception of threats, and the spatial priorities of development (A. Iskandar Boctor, 2002); therefore it is a real geopolitics and geo-economics issue, in the sense that rivalries are at stake with territorial issues. In territorial planning, communities are required to cooperate to manage better the scarce resources available on their territory. A main concern is the distribution of the roles played by the different actors.

Water can be seen as a renewable resource, but pressure over it has increased in the last decades. Indeed, the world population had doubled between 1950 and 1997 (going from 2.5 billion inhabitants to 5.7 billion inhabitants), but the global consumption of water has quadrupled over the same period (going up to 761 m^3 per year and per person) (Hoflack, 2007). Water is becoming a rare good, wasted by some, too expensive for others but needed by most. The nature of water in the 21st century has become something strategic, potentially destabilizing (Besset, 1998). The idea of a major conflict due to water issues exists, if nothing is done to fight against the threats of water stress (W. N'DOW, 1996). It could become as contentious as the petrol resource as by 2025 two thirds of the world population will know a situation of water stress or water constraint (Otchet, 2001). The water security (or hydro security) being "the availability of an acceptable quantity and quality of water for health, livelihoods, ecosystems and production, coupled with an acceptable level of water related risks to people, environments, and economies"(Grey & Sadoff, 2007), we can think that climate change makes "water security harder to achieve and sustain" (Grey & Sadoff, 2007). If a challenge of the 21st century regarding water seems to be to understand how to divide a fixed amount of water among a variable and growing number of users, another one would be to know how to manage water in response to climate change. In fact, water is the unifying element in the climate system (IWMI, 2011). However, global warming is affecting the complex interactions between the air, the water and the land. Our climate is changing and those changes will affect the quantity and quality of water available to us all. Models and experts show that some of the climatic modifications putting pressures on the water availability are: the decreasing precipitations trends, the increasing in both evaporative losses and water demands caused by higher temperatures (the IPCC expects an increase of 2 to 4°C of the average annual temperature by 2100 and a rainfall deficiency through springs and summers, strongest in the West than in the East, are expected (IPPC, 2007)) and the changing in groundwater recharge processes. Changes in precipitation patterns are anticipated to affect flow regimes, inflows to reservoirs, and the availability of water for agriculture and ecosystems. Changes in temperature regimes may also shorten cropping seasons. Local impacts of climate change and their specific adaptation measures are less obvious than the global ones.

Given the reality of increased water scarcity and variability, water management for agricultural production seriously needs to be rethought, integrating solutions about domestic, industrial and environmental water uses. 60% of the world's food is produced on rain-fed cropland (IWMI, 2011). It is known that climate change will alter rainfall patterns; which constitutes a major threat to food supply and livelihoods. What is less visible, but not less alarming, is the growing threat to our capacity to produce enough food under new and uncertain climate conditions. Food production and food prices are pillars of social stability. Chapter XVIII of Agenda 21 stresses that the sustainability of food production will require a rational use and efficient practices while maintaining and using water. This is particularly relevant about irrigation techniques, the use of soil and water withdrawals. Another fundamental issue concerning food security in many regions is that of the preservation of commercial fishing species.

Climate induced changes are predicted but there is little information available on the quantification of these changes and a lack of suitable and effective monitoring and modeling systems. The uncertainty related to the climate change science derives from a number of factors including: regional data gaps, deficiencies in the understanding of natural systems, the fact that predictions of climate change are based on the use of models that cannot consider all factors linked to the climate systems, and the limitations of emissions scenarios which can only estimate future greenhouse gas emission levels (Loftus, 2011). There is a lack of multi-disciplinary assessment covering both natural and associated social and economic changes. This is why a cluster of collaborative research projects under the 7th Framework Programme (FP7, called "Climate Change Impacts on Water and Security, in Southern Europe and neighbouring regions (CLIWASEC)) has been created to coordinate the environmental topic, including Climate Change with Socio-Economic Sciences and Humanities. The CLIMB (Climate Induced Changes on the Hydrology of Mediterranean Basins) consortium is made up of 19 partners, comprising four European member states (Italy, Austria, Germany, and France), four SICA countries (Turkey, Tunisia, Egypt, and Palestinian-administered areas) and one non-EU member country (Canada),(CLIMB, 2011). This four year program which started in January 2010 aims to create an integrated quantitative risk and vulnerability tool which is intended to link climatic, environmental and socio economic variables with conflict or cooperation. In order to have an operational dissemination of results of hydrological and risk models, the work package (WP7) "Interactions with Stakeholders and Dissemination" addresses the question of security threats through an analysis of nowadays water uses and rivalries compared to the projected situation under climate changes conditions. Indeed, climate change impacts are to be considered in relation with water uses and rivalries. Involving stakeholders in the identification of such uses and rivalries strengthens the project's impacts on the adaptation of water regulation to face climate changes conditions. The WP7 tackles the understanding of water rivalries within 7 case studies in the Mediterranean Region: Kocaeli Province (Turkey), Rio Mannu di San Sperate (Sardinia), Thau coastal lagoon (France) Chiba Watershed in Cap-Bon (Tunisia), Noce River (Trentino, Italy), and Gaza Strip (Palestine). The present article focuses on two sites: Rio Mannu di San Sperate (Sardinia Region, Italy) and the Thau coastal lagoon (Languedoc-Roussillon, France).

Figure 1: the seven case studies' sites of the CLIMB project

1) Thau - France
2) Rio Mannu di San Sperate - Sardaigne - Italie
3) Chiba - Cap Bon - Tunisie
4) Noce - Alpes du Sud - Italie
5) Baie d'Izmit - Kocaeli - Turquie
6) Delta du Nil - Nil - Egypte
7) Aquifère de Gaza - Autorité palestinienne

2. MATERIALS AND METHODS

A. Two case studies in two different political contexts

The two case studies correspond to two different catchments. A catchment is a territory which is defined by natural boundaries called "drainage divides". Each catchment supplies a main water course, usually accompanied by several tributaries. Thus, every rain drop falling on this surface will go to the river or by runoff or through groundwater circulation after infiltration in the soil.

Our sites are located within Europe, therefore they both must respect the European water policy. The Directive 2000/60/EC, Water Framework Directive (WFD) establishes a framework for community action in the field of water policy. It defines the institutional framework for the protection and sustainable use of water resources. Its aim is to protect surface waters, transitional waters, coastal waters and groundwater to promote the sustainable management of water resources. Thus it also redefines the role of the water stakeholders by developing a management based on participatory governance. The directive emphasizes that water is a natural but scarce resource so it cannot be compared to a commercial product.

The objectives are planned for 2015: a "good" quality must be reached by all waters, there must be a gradual reduction of waste and a decrease of the effects of floods.

a. Water Management In Italy

In Italy, every region is expected to define the different water basins composing its territory and to assign them different management authorities from the regional and national organisations already in place. . These authorities are in charge of the water management of the region and in charge of establishing the price of water to allow a rational and efficient use of the water resources by all economic and social components.

At the national scale, different laws define the institutional rules over water. One of the most important laws are the following. The law of May 18th 1989 "Norme per il riassetto organizzativo e funzionale della difesa del suolo" (Madau, 2009), intends to organise and protect the soils. This law sets up plans of basins, established for 3 years, which are as important as regional planning schemes. The Galli law of January 5th 1994 is the device through which the Italian legislation began a process to reform the water sector. It focuses on identifying new levels of coordination that go beyond traditional administrative boundaries. Then, the law 36/94 underlines that surface water and groundwater are to be considered as public and it stresses that the priority use of water is for human consumption and that the second in the scale of priorities is to respond to agriculture needs. Finally, there is the Law 152 of 2006, a text regulating the water management. It is a specialized text on the environment including an entire chapter devoted to the water management in Italy.

Concerning the tools used in this water management context, it is the ATOS (Optimum Territorial Area) of every zone which define the zones where to use the tools. It aims to overcome the fragmentation of existing management by integrating planning (definition of basins used in the optimal size) and functional integration of the various cycle activities (services of water supply network sewer, sanitation and wastewater treatment).
In the case of Sardinia, there is only one ATO as it is an island and that it does not interfere with other regions. In this ATOs the planning tool is the Piano di Ambito (Management Plan of the Area) in accordance with Art. 11 of Law 36/1994, it is the fundamental programming tool to set up the framework for the comprehensive management of water for both aspects of quantity, homeland security (flood control and drought) than that of quality.

i. Specific Water management in Rio Mannu di San Sperate

The River Basin studied is the one of Rio Mannu di San Sperate at Monastir. It is located in the south of Sardinia and it drains an area of 472.5 km^2.The site's land is mostly occupied by agriculture fields and grassland (CLIMB, 2011). Sardinia is characterized by wet periods from October to April, where more than 90% of the rainfall is accumulated, very dry summers (May - September) and a yearly mean precipitation of about 700 mm. The yearly average temperature is 16° C and snowfall rarely happens. The groundwater provides a negligible contribution to the streamflow in the channel network.

In conformity with European decisions, the region of Sardinia has created a unique Optimal Territorial Identity to provide both a unique price for the water and a single governing body.

The Autorità d'Ambito (in English the local authority) is the organisation in charge of implementing the reform and providing regulation for the water distribution system. It is composed of municipal and provincial administrations (AGRIS, 2011). Their duty is to regulate, plan and monitor the water services in order to guarantee water users the quality of water and its wise utlisation. The management network and the wholesale of water is operated by ENAS (Ente acque della Sardegna).

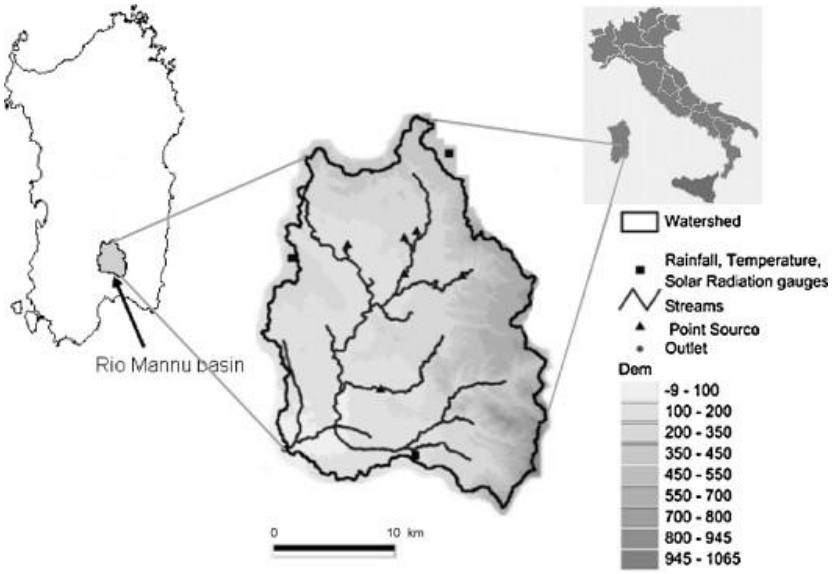

Figure 2 : Situation of the Rio Mannu's di San Sperate's site in Sardinia (Italy)

ENAS was born with the law number 19 of the 6th of December of 2006, which transformed the autonomous agency of Flumendosa (former body in charge of the water management). It uses a system of 32 artificial reservoirs, 850 km of aqueducts, 210 km of canals, 47 pumping plants and 4 hydroelectric facilities. ENAS is in charge of the water collection throughout the island and its rational distribution to the three main Sardinian bodies: Abbanoa, Consorzi di Bonifica and Consorzi Industriali.

Abbanoa processes the water to make it drinkable; it supplies the island with domestic water but it also collects and purify the industrial and domestic wastewaters. The local Consorzi di Bonifica redistribute the water for irrigation purposes. It uses water in great quantity. Indeed, Sardinia is a very agricultural island. The agriculture in Rio Mannu di San Sperate is quite diverse; it is made of cereals (mainly wheats), fruits (agrums), vegetables (artichokes), olives, wine and forage crop. Finally the Consorzi Industriali provide water for the industrial uses.

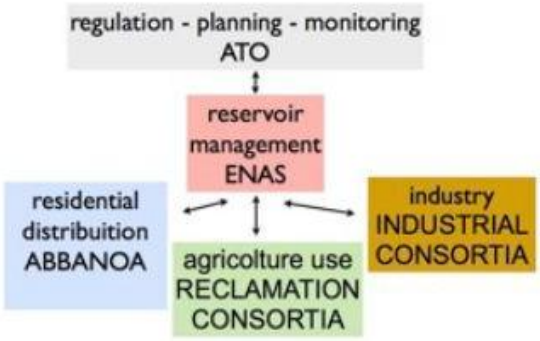

Figure 3: Diagram of the management organisation of the water in the Rio Mannu di San Sperate basin. Source (AGRIS, 2011)

b. Water Context in France

If the administrative France is divided according to regions and departments, the France of water encounters a different partition, based on the 1964 law. The territory is divided into twelve geographical zones (seven on the mainland and five overseas), which are called "basins". A basin, called "hydrographic district" in the WFD corresponds to the catchment of one or several big rivers and its tributaries (FNE, 2008), which go to the sea. Once the geographical territories have been defined, we can talk about the different regulations, decision-making bodies and documents defining the objectives of the water policy in our country (Cf. **Erreur ! Source du renvoi introuvable.**). For each hydrographic district, a basin committee, "Comité de Bassin", composed with representatives of the local authorities (40%), users (40%) and state (20%), draws the guidelines according to the national and European water policies. In France, the European Directive was reinforced by the "Grenelle de l'Environnement". Since 2009, French water management is based on master plans called "Schéma Directeur d'Aménagement et de Gestion des Eaux" (SDAGE; in translation: outline for the organization of the development and management of water resources) based on these laws and the one of 1992. The SDAGE scheme was drawn up together by the national, regional and departmental authorities and is managed by a water agency called "Agence de l'eau". There is one for every hydrographic basin. It serves as a general framework for the development and management of the water of each hydrographic unit. They are essentially financial institutions: they collect some taxes on the water bills, which they redistribute to local authorities and companies to help them manage the resource and fight against pollution.

To achieve the goals set up by the SDAGE, the actions to be taken are defined in measurement programs ("Plan de Mesures"; PDM). The SDAGE is the structure which produces and implements the water management plan for the whole basin. It can be supported at smaller scales by diverse "Schémas d'Aménagement et de Gestion des Eaux" (SAGE; water resource development and management outlines), a non constraining structure built by local motivations, which acts through a Local Water Commission ("Commission Locale de l'Eau" (CLE)). This commission is composed with representatives of the state (25%), the local authority (50%) and the users (25%). Among the users, there may be consumer groups, industries, farmers, organizations fighting for environmental protection, residents.

In France, local authorities have two options to manage water: whether by direct management or by delegated management through leasing or concession with a private company.

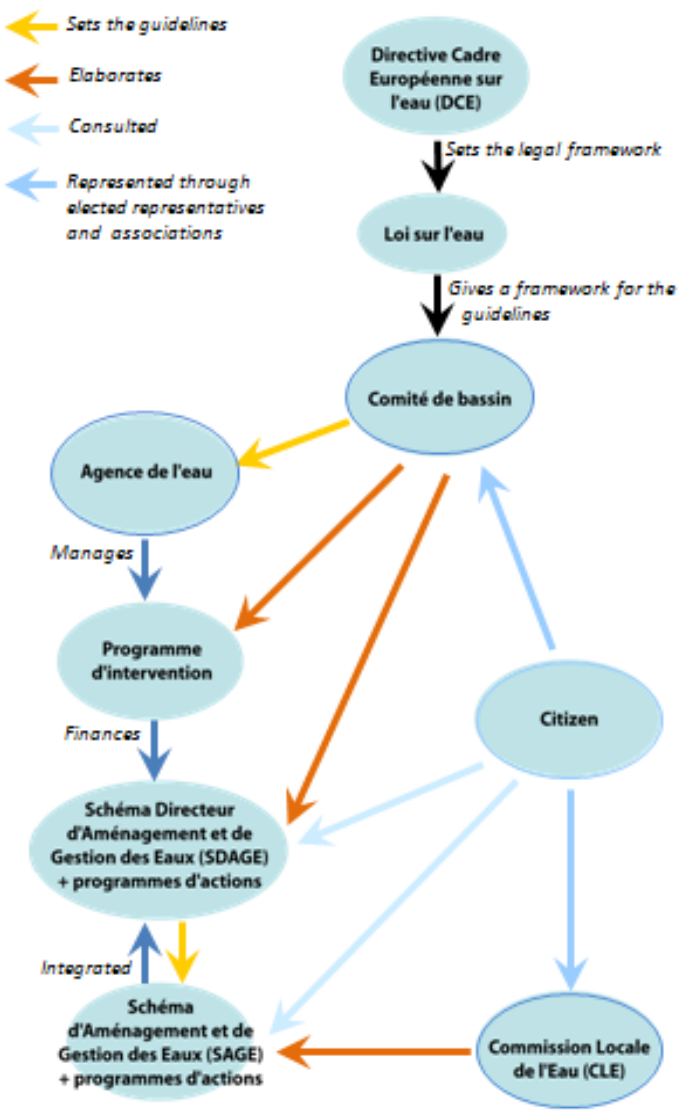

Figure 4: French water management system

i. Specific Water management in Thau's coastal lagoon

The catchment of Thau covers an area of 250 km², within which there is a coastal lagoon of 75 km², separated from the sea by a narrow sandy strip.
The basin's land is mostly occupied by vineyards and forests (garrigues). The basin of Thau is characterized by an annual average temperature of 14°C, a yearly mean precipitation of about 750 mm and a population that doubles in the summer (80,000 inhabitants) compared to winter times (40,000 inhabitants) (CLIMB,2011).

The catchment of is drained by numerous little streams (3–13 km) with intermittent flows. It is relatively important to note that, using a geomorphologic criteria, two different zones can be differentiated on the catchment area (Ben Othman et al. (1997) and Anon. (1997)): the eastern part which is composed of strongly karstic Jurassic limestone and is fed by two karstic resurgences, the Vène and Issanka springs, and the western part which concerns the Pallas river and is mainly composed of Eocene marls and Miocene molasses. Thus, the river response delays to rainy events are supposed to be shorter in this area than in the karstic zone, where more water infiltrations are likely to occur. Stream flows of temporary waters vary sharply depending on the periods of drought and torrential rains that occur in autumn and spring, characteristics of the Mediterranean climate. Only the Vène River has a steady supply through a karst origin.

The lagoon in the catchment plays an important role as it is a major element of the history and development of the territory of Thau. Indeed, it is home to shellfish farming (mainly oysters (85%) and mussels (15%)), which occupies one fifth of the lagoon area. Shellfish farming production accounts for 10% of the national production, with about 13,000 tons of oysters and 2,500 tons of mussels. It represents the most important economic activity of the lagoon, generating over 2,000 direct jobs. 500 shellfish licenses are divided into three sectors (Bouzigues, Mèze and Marseillan). The fish resource in the lagoon enables nearly 400 fishing professionals to live.

Another main source of economy in this catchment is linked to tourism, with boating and bathing, but especially with the important hydrotherapy activity that exists in Balaruc-les-Bains because of the geomorphological context mentioned above. Within this context, controlling the water quality of the lagoon and its catchment is a priority issue for the territory.

As explained in part 2.A.b Water management in France, many actors are responsible for water management in France. In addition to the institutions described, local organisations deal with its management. At a local scale, State management is made through the decentralized services of the "DREAL" (Regional Direction of Environment, Planning and Housing) and the DDTM (Departmental Direction of the Territories and the Sea).

Furthermore, there is a multitude of stakeholders, mainly due to the administrative division of the territory at different scales from the region to the municipalities. As shown on the map, the catchment of Thau recovers 14 municipalities (Cf. Figure 5), separated into two public establishments for intermunicipal cooperation (EPCI) called "Communauté de communes": the "Communauté de Communes du Nord du Bassin de Thau" (CCNBT) and the Communauté d'Agglomération du Bassin de Thau (CABT). These two structures are responsible for the treatment of wastewater

However, the elected representatives of Thau's territory decided in 2004 to create a structure in charge of water management at the catchment scale: the "Syndicat Mixte du Bassin de Thau" (SMBT). It is in charge of the complex issues existing in the territory, especially those of:

- the protection of the environment, which is the main support to its economic activities Containing and managing the demographic and economic growth ;
- integrating the evolution of regulations, such as the WFD ;
- clarifying the overall allocation of coastal space and resources by understanding the multiplicity of their uses.

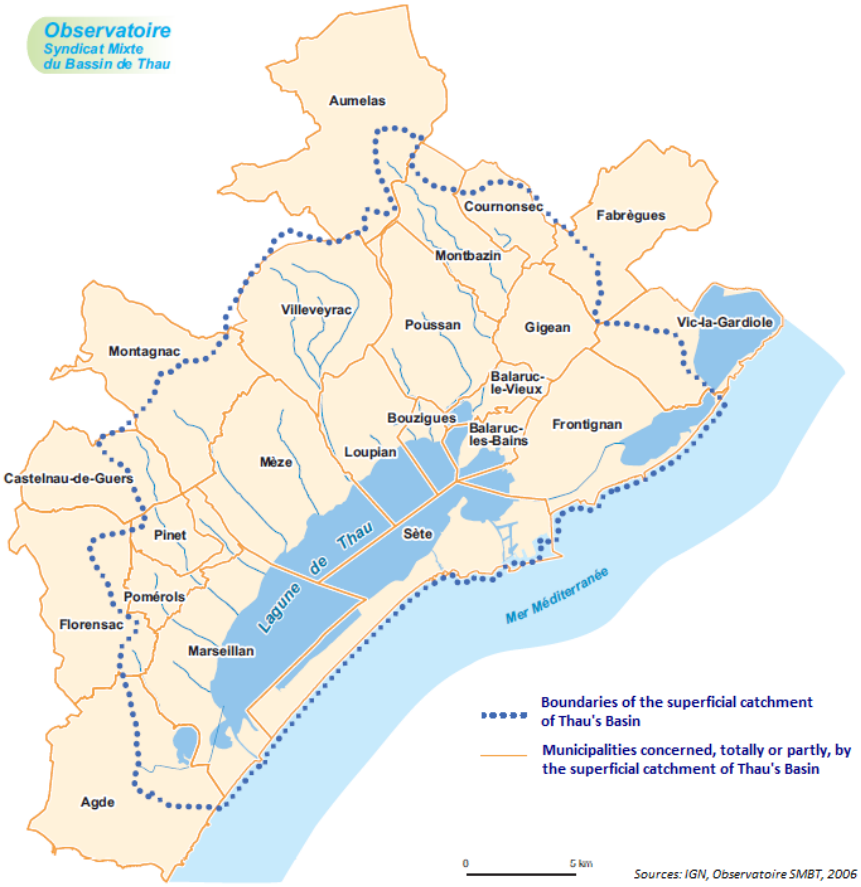

Figure 5: municipalities represented by the SMBT (France)

Concerning water management in the basin of Thau, there also are important scientific and technical partners (such as IFREMER, Egis-eau and BRL,) and many institutions of users which are taken into consideration ("Section Régionale de Conchyliculture" or "Prud'homie de pêche Thau-Ingril" for example).

B. Creation and dissemination of questionnaires

25 and 15 semi-structured interviews were respectively conducted in Rio Mannu and Thau case studies between June 2012 and March 2012. The purpose of these interviews was to build a questionnaire for the identification of water uses and rivalries at a wider scale in all of the seven CLIMB case studies. The aim of the questionnaire is to identify the different uses of the resource, the existing rivalries and the capability of the actual water management to solve "problems" regarding them. The questionnaire is titled "study of water uses and rivalries in the case study region".

The success or the failure of the study relies upon the involvement of the case study leader in each of the case studies. It depends on his or her local network and also anticipates trust building between the different actors (researchers and stakeholders) during the entire project's period. Participants were selected through "snowball" sampling initially based on the case study leader's local network. The targeted group, called "key informants", included both water managers and water users.

Most of the questions in the questionnaire are open, enabling the participant to explain in details some relevant situations for water resource rivalries.

Concerning their dissemination, a particular attention was dedicated to balance not only the number of water users and water managers, but also the representation of each water use or water institution.

C. Choice of the vocabulary

- Conflict vs rivalry

"Conflict does not just refer to armed conflict between nations, but also involves « a range of negative interactions that encompass mild verbally expressed discord and cold interstate relationships, as well as hostile acts or declarations of war » (Goulden et al., 2009). Water conflict (or Hydro Conflict) is a "conflict between individuals, groups, nations stemming from incompatible claims over water resources and ways to manage them, or from the side effects of hydrological hazards, such as droughts and floods" (Kallis, 2010).

The term "conflict" has negative and strong connotations associated to in people's minds, therefore they tend to deny the existence of "conflicts", unless a war is going on. On the other hand, if no violent argument is seen, it is considered that it is because there is "cooperation". Nonetheless, "cooperation is not simply the absence of conflict" (Goulden & Porter, 2010). In addition, because water conflicts are mostly silent, asymmetrical cooperation in water management tends to mask those conflicts (Zeitoun & Warner, 2006). Thus, so that people actually identify and/or mention the existence of a water "conflict" (a competition over water being considered as a conflict), an alternative term has to be used.

"Water rivalries" (Bressers & Kuks, 2004), "water disputes", "water frictions", or "water tensions" (Gleick, 1993) are terms used in the literature as synonyms of "water conflicts" but in a milder version, since "not all water resources disputes will lead to violent conflict" (Gleick, 1993).

"A rivalry is a situation in which two users face incompatibility between their respective uses, and at least one user does not have enough to satisfy his needs" (Aubin, 2008). Rivalries exist between people who work together, so the term water rivalry reflects both the conflictive and collaborative dimension of water interactions (La Jeunesse, 2011). Therefore, "rivalry" is the term used throughout this study.

- Climate change

"Climate change refers to a statistically significant variation in either the mean state of the climate or in its variability persisting for an extended period (typically decades or longer). Climate change may be due to natural processes or external forcings, or to persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC, 2001).

In the questionnaires created there is intentionally, , no reference to climate change in order to avoid any associated judgment values that could distort the past and current situation regarding water uses and rivalries.

D. Choice of the language

Once finalised, the questionnaire, initially in English, was translated in each case study language thanks to the case study leader. However, it was decided to treat the results in French as it was the easiest way to translate them back from each case study.

E. Choice of two different ways of dealing with the data

The questionnaire had to be analysed in two different ways. The first sections were treated with the spreadsheet Microsoft Office Excel while the last section was processed with the Ucinet software.

a. Microsoft Office Excel

As explained previously, the questionnaire is used in order to have qualitative answers. Therefore, the Microsoft Office Excel software was employed to transcribe the answers given as faithfully as possible. Each question was transcribed in a column so that every line corresponds to one actor. The processing mainly consisted in regrouping the answers, for each site, into categories and counting the occurrences in order to identify the major themes standing out. The results obtained were represented into graphs, which are presented in the "result" section of this article.

b. Ucinet

Games Theory is interesting here as it may explain the decision of economic agents in a situation of interdependence (Oumar, 2003). Relaying on this, one can properly address the decisions of stakeholders relative to the rational use of the scarce resources of their respective territorial space. Game theory is at the heart of Social Network Analysis (SNA). This computer software method is used to analyse social networks. It studies social relationships in terms of network theory, consisting of nodes representing individual actors within the network and links which represent relationships between the individuals, such as friendship or organizational position for example.

Social network analysis is used in this project to understand the connections between the different actors of the various basins. In this type of analysis, actors are described by their relations and not their attribute (Hanneman, 2005), it tries to comprehend individuals as nested in a network. The main difference between this type of analysis and a conventional one is that the conventional one focuses on actors and their attributes whereas network analysis puts actors at the centre of its research and tries to understand how actors are embedded in the network.

The choice was made to use the software UCINET to represent the graphs which is a quite user friendly software, easier to control in limited time, compared to other softwares as performant such as pajek or tulip.

3. RESULTS

- Social Network Analysis

Figure 6: Social Network Analysis Diagram of the powerful influences of Rio Mannu di San Sperate basin and figure 7: Social Network Analysis Diagram of the powerful influences in Thau's coastal lagoon

The respondents were asked whether or not the other actors of the basin had an impact on their decisions and the other way round, if they thought they had an impact on the other actors' decisions. The further the points are from the centre of the diagram, the more excluded they are from the circles of important decisions.

Figure 6 represents 30 actors of the water management of Rio Mannu di San Sperate basin as seen by 28 people to whom the questionnaire was given.

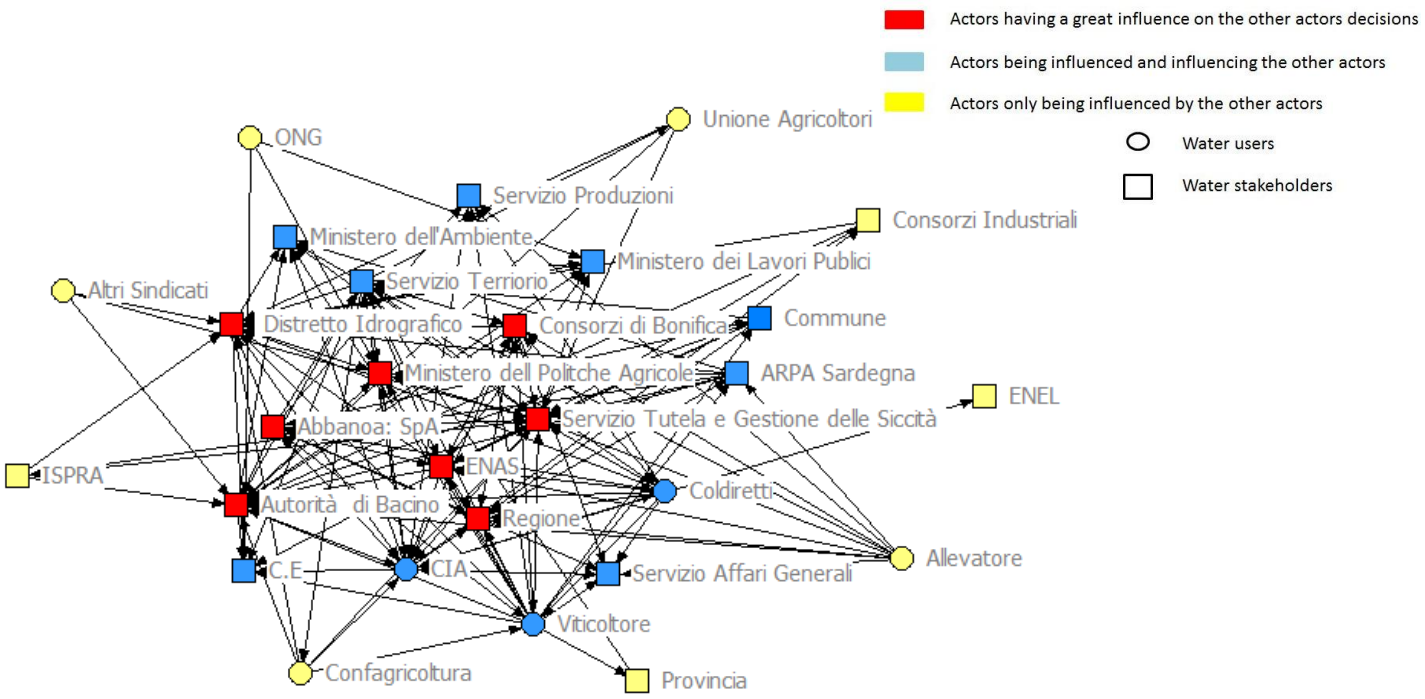

Figure 6: Social Network Analysis Diagram of the powerful influences of Rio Mannu di San Sperate basin

29% of the actors can be considered as having influence on the other actors of the basin; no water users appear in this category of chiefs of the decisions. According to the diagram, the most important actors of the water basin are ENAS, the Autorità di Bacino and the Servizio Tutela e Gestione della Siccità. The majority of the actors here (40%) both have an influence on the other's decisions and are influenced by the others. An important number of organisations (31%) have their decisions mostly influenced by others without giving them the change in terms of mutual influence, in this category, both water stakeholders and water users are represented.

Figure 7 represents 41 actors of the water management of Thau's coastal lagoon basin as seen by 21 people to whom the questionnaire was given.

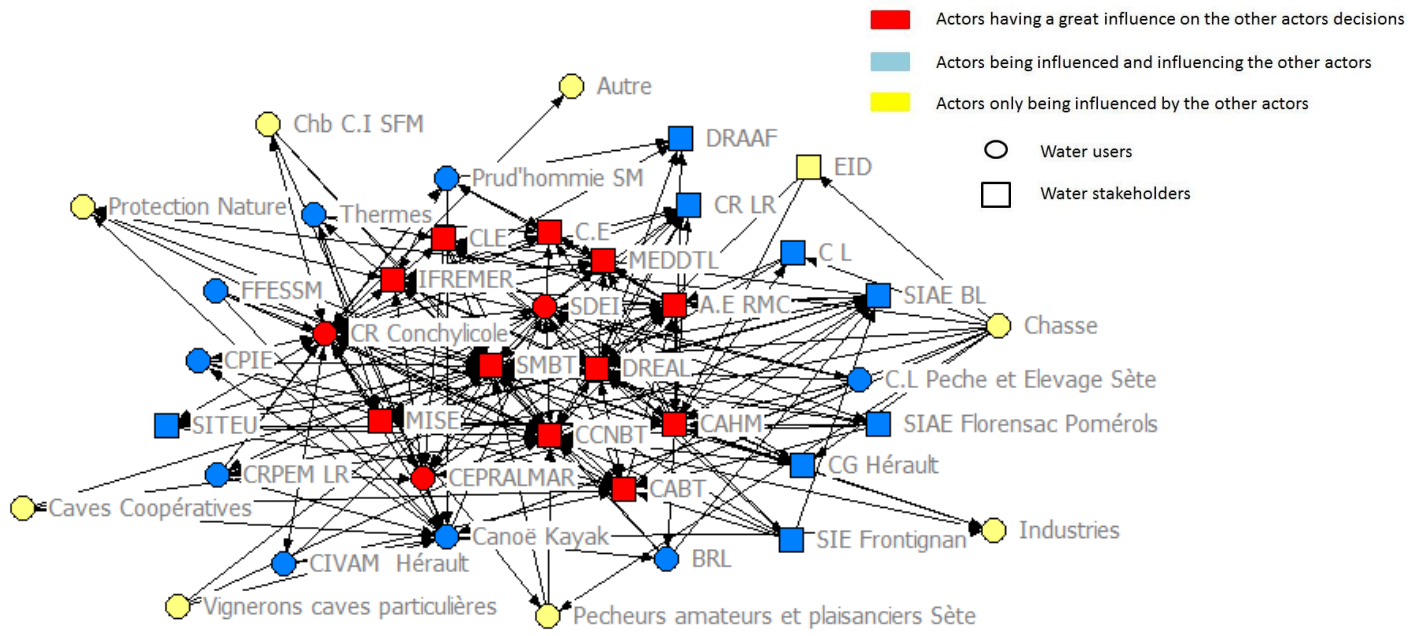

Figure 7: Social Network Analysis Diagram of the power influences in Thau's coastal lagoon

This represents the 41 major actors of water management in Thau's coastal lagoon as seen through the answers extracted and analysed from the questionnaire given to 21 people.

More than a third of the actors (34%) can be considered as having an important influence on the overall network decisions, not all of them are stakeholders though, three of them, SDEI, CEPRALMAR and C. R conchylicole, are users. Most of the organisations (41%) represented are both influenced and influence the other actors of the basin. A small number of organisations (22%) only have their decisions influenced by the other organisations and do not have any impact on the other actors' decisions. Every organisation within this category is a water user and not a water stakeholder. One actor has not been represented (COVED SAUR) because it did not have links with any other actor on the diagram.

- Microsoft Office Excel

Figure 8: Table of results of the water uses and their evolutions over the last 20 years in the two sites of Rio Mannu di San Sperate and Thau's coastal lagoon

This table of results is extracted and treated from the answers obtained through the questionnaires given to the water users and stakeholders of the two sites. The respondents were asked what type of water use existed in the region of the water basin and its trends of development over the last 20 years. The numbers were stressed in bold when the difference between the figures seemed to be relevant.

We can notice on this Figure 8 that on The Rio Mannu site, the major water uses are for drinking water and irrigation. Over the last 20 years, there has been a significant increase in the two uses of water storage and drinking water. Several uses do not seem to be important on the site as their category was not answered in the questionnaire.

However, on the coastal lagoon of Thau, the main water uses are those for aquaculture, drinking water and fishing. Since 20 years, there has been an increase in the uses of drinking water and irrigation. Just like in Rio Mannu's case, hydroelectricity and transfer do not seem relevant for this case study as their category was not filled in the questionnaire.

	Types of uses	Drinking Water	Irrigation	Breeding	Hydroelectricity	Industry	Thermal	Leisure
				Total en %				
Thau	Major	**85,7%**	**57,1%**	0,0%	0,0%	19,0%	**61,9%**	28,6%
	Minor	9,5%	33,3%	**57,1%**	33,3%	**42,9%**	33,3%	**47,6%**
	No answers	4,8%	9,5%	42,9%	66,7%	38,1%	4,8%	23,8%
	Increase	**85,7%**	**71,4%**	0,0%	0,0%	9,5%	33,3%	**42,9%**
	Constant	4,8%	9,5%	**38,1%**	28,6%	**52,4%**	**61,9%**	23,8%
	Decrease	0,0%	9,5%	9,5%	0,0%	14,3%	0,0%	0,0%
	No answers	9,5%	9,5%	52,4%	71,4%	23,8%	4,8%	33,3%
Rio Mannu	Major	**75,0%**	**85,7%**	42,9%	10,7%	14,3%	7,1%	0,0%
	Minor	17,9%	10,7%	**50,0%**	32,1%	**42,9%**	7,1%	**50,0%**
	No answers	7,1%	3,6%	7,1%	57,1%	42,9%	85,7%	50,0%
	Increase	**50,0%**	**39,3%**	21,4%	7,1%	7,1%	3,6%	32,1%
	Constant	28,6%	21,4%	35,7%	28,6%	28,6%	7,1%	10,7%
	Decrease	10,7%	**39,3%**	35,7%	10,7%	25,0%	3,6%	3,6%
	No answers	10,7%	0,0%	7,1%	53,6%	39,3%	85,7%	53,6%

	Types of uses	Esthetics	Water storage	Transfert	Fishing	Aquiculture	Transport	Extraction
				Total en %				
Thau	Major	33,3%	33,3%	4,8%	**81,0%**	**95,2%**	33,3%	0,0%
	Minor	**47,6%**	**47,6%**	9,5%	14,3%	0,0%	**52,4%**	**52,4%**
	No answers	19,0%	19,0%	85,7%	4,8%	4,8%	14,3%	47,6%
	Increase	23,8%	9,5%	0,0%	4,8%	28,6%	23,8%	4,8%
	Constant	33,3%	**57,1%**	9,5%	**57,1%**	**47,6%**	**47,6%**	33,3%
	Decrease	14,3%	0,0%	0,0%	33,3%	19,0%	4,8%	14,3%
	No answers	28,6%	33,3%	90,5%	4,8%	4,8%	23,8%	47,6%
Rio Mannu	Major	3,6%	35,7%	7,1%	7,1%	3,6%	0,0%	3,6%
	Minor	**60,7%**	**39,3%**	17,9%	**42,9%**	28,6%	14,3%	**53,6%**
	No answers	35,7%	25,0%	75,0%	50,0%	67,9%	85,7%	42,9%
	Increase	32,1%	**35,7%**	7,1%	10,7%	3,6%	0,0%	7,1%
	Constant	25,0%	28,6%	10,7%	21,4%	14,3%	7,1%	25,0%
	Decrease	7,1%	10,7%	7,1%	7,1%	10,7%	3,6%	25,0%
	No answers	35,7%	25,0%	75,0%	60,7%	71,4%	89,3%	42,9%

	Types of uses	Environment	Leisure Activities	Wash	Cultural activities	Impacts of the urban or industrial wastes	Impacts of the Agricultural activities
				Total en %			
Thau	Major	**66,7%**	**66,7%**	4,8%	0,0%	**81,0%**	**54,2%**
	Minor	9,5%	14,3%	**42,9%**	**47,6%**	9,5%	33,3%
	No answers	23,8%	19,0%	52,4%	52,4%	9,5%	12,5%
	Increase	**33,3%**	**42,9%**	4,8%	0,0%	**47,6%**	14,3%
	Constant	**33,3%**	33,3%	**33,3%**	**38,1%**	4,8%	**52,4%**
	Decrease	4,8%	0,0%	9,5%	4,8%	38,1%	19,0%
	No answers	28,6%	23,8%	52,4%	57,1%	9,5%	14,3%
Rio Mannu	Major	28,6%	3,6%	10,7%	3,6%	**35,7%**	**57,1%**
	Minor	**42,9%**	**46,4%**	**28,6%**	**35,7%**	**35,7%**	21,4%
	No answers	28,6%	50,0%	60,7%	60,7%	28,6%	21,4%
	Increase	17,9%	21,4%	14,3%	10,7%	32,1%	28,6%
	Constant	**32,1%**	17,9%	17,9%	17,9%	10,7%	32,1%
	Decrease	10,7%	3,6%	3,6%	3,6%	21,4%	14,3%
	No answers	39,3%	57,1%	64,3%	67,9%	35,7%	25,0%

Figure 8: Table of results of the water uses and their evolutions over the last 20 years in the two sites of Rio Mannu di San Sperate and Thau's coastal lagoon.

Figure 9: Table of results of the perceived paired conflicting uses Rio Mannu di San Sperate and Figure 10: Table of results of the perceived paired conflicting uses in Thau's coastal lagoon

This table of results reflects the uses of water in competition according to the respondents of the questionnaire on the two basins. To illustrate the question, an example of competition that could occur when there was water shortage was given. The uses presented in the columns are the most conflicting ones.

Rio Mannu	Drinking water	Irrigation	Industry	Urbanisation	Esthetics	Agriculture
Irrigation	15	0	6			
Industry	4	6				
Drought	3	1				
Environment	2	4	3	1		1
Water Quality	1	0				
Breeding	1	2	1			
Recreational activities	1	1			1	
Trades		1				
Urban wastes		1				

Figure 9: Table of results of the perceived paired conflicting uses in Rio Mannu di San Sperate basin

On Rio Mannu di San Sperate's site, the most important competition between two uses is the water used for drinking against irrigation, there is also a noticeable conflict between the water used for irrigation and the one used for industry.

Thau	Shell fishing	Fishing	Irrigation	Environment	Drinking water	Wash
Thermal et Recreational activities	4	5	3	3	5	
Environment	4	1	4		3	
Drinking water	4	1	8	3		
Irrigation	3	1	1	4	8	
Town planning	2	1		1		
Industry	2	1		2	2	
Water Quality	1	2	1			
Fishing	1					
Urban wastes	1		1	1		
Under dimensionned processing station						2
Shortage of the water ressource					1	
Water storage					1	
Esthetics			2	1		

Figure 10: Table of results of the perceived paired conflicting uses in Thau's coastal lagoon

On Thau's coastal lagoon, the water used for drinking is sensed to be in competition with several other uses: irrigation, hydro-therapy and shell fishing. Shell fishing is also sensed to be in competition with environmental uses and recreational activities.

Figure 11: perception of the main water uses in the Rio Mannu basin and figure 12: perception of the secondary water uses in the Rio Mannu basin.

These graphs were obtained with the responses given by 28 respondents, which were given a list of uses and for which they had to decide whether they were major or minor uses, and what was their evolution tendency (increase, decrease or stable).

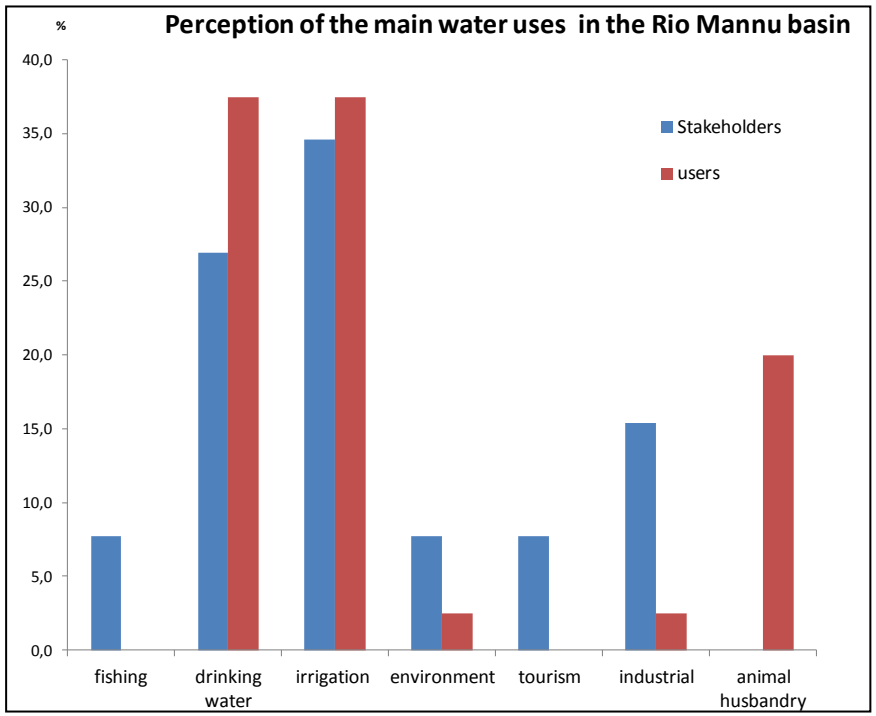

Figure 11: perception of the main water uses in the Rio Mannu basin

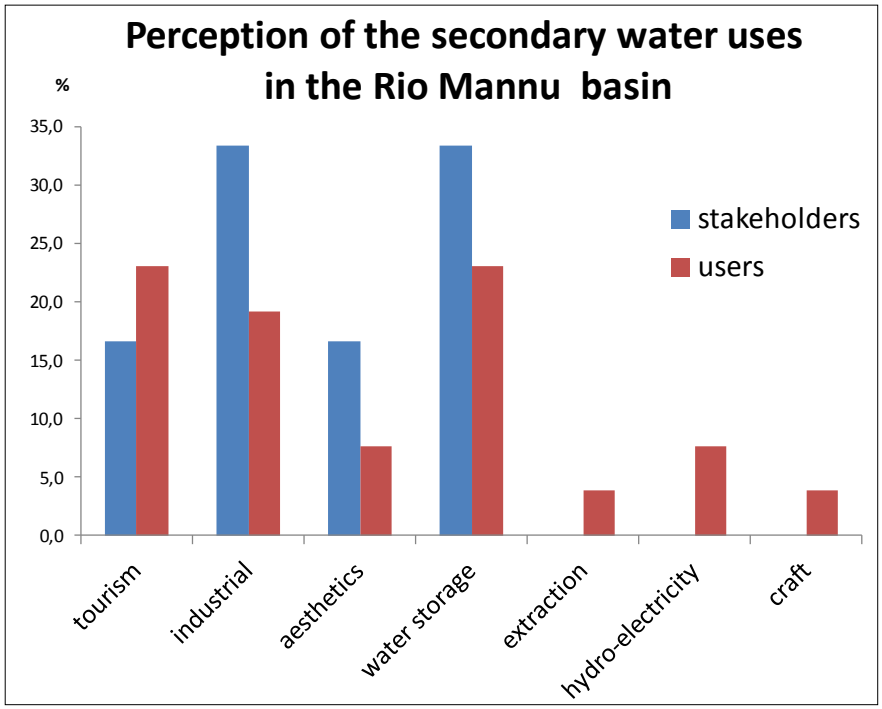

Figure 12: perception of the secondary water uses in the Rio Mannu basin

In the case of Rio Mannu, the results that obviously stand out are that the major uses of water are to supply the population with drinking water and food thanks to irrigation, animal husbandry and fishing.

On the other hand, anthropogenic activities such as tourism and industrial activities, followed by aesthetics issues, are seen as important secondary issues. But, still comes first (35% of stakeholders and 25% of users) the matter of water storage to ensure drinking water to the growing population.

Figure 13: perception of the main water uses in the Thau basin and Figure 14: perception of the secondary water uses in Thau basin

The same method than described for Rio Mannu's basin was used, except that 21 respondents gave their point of view instead of 28.

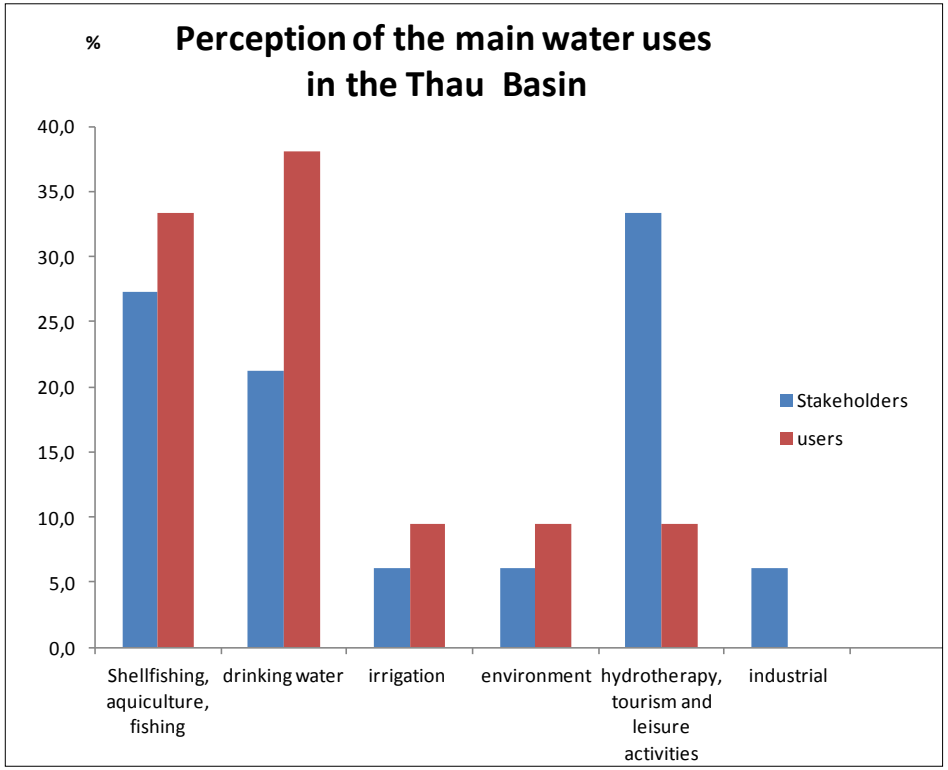

Figure 13: perception of the main water uses in the Thau basin

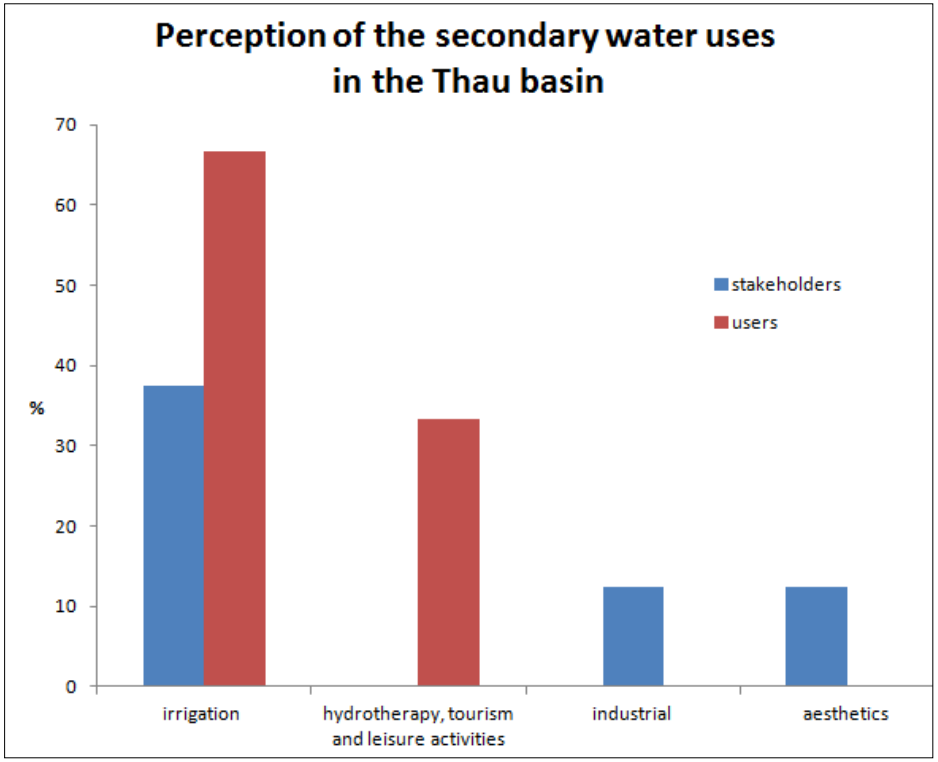

Figure 14: perception of the secondary water uses in Thau basin

Through these answers, we can notice some differences in opinion between stakeholders and users; anyhow the main uses of the water resource in Thau are for hydrotherapy, tourism and leisure activities, for shell-fishing, aquaculture and fishing, and to supply the population with drinking water.

The use of the water resource that stands out as a secondary use is irrigation (infirmed by 53%, average between the stakeholders and users).

Figure 15: Perception of the major developments of the uses of the water resource over the past 20 years in the basin of Rio Mannu and figure 16: Perception of the of the major developments of the uses of the water resource over the past 20 years in the basin of Thau.

In the questionnaire, the participants were asked in an open question what they thought were the causes of the major changes over the last twenty years. The answers given were classified into categories when they were similar.

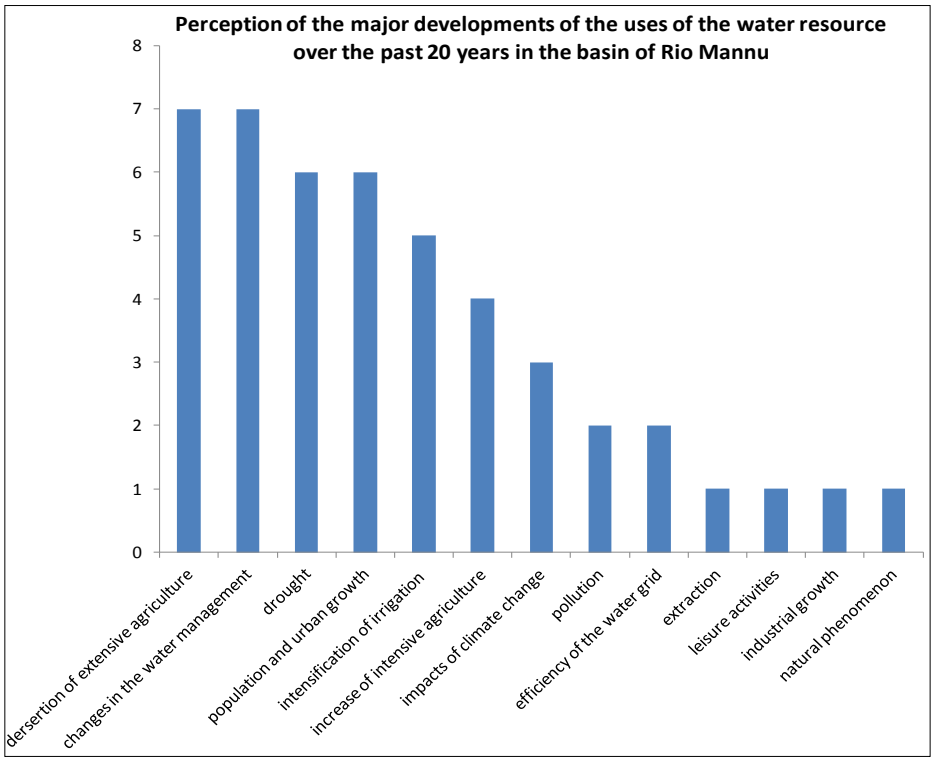

Figure 15: perception of the major developments of the uses of the water resource over the past 20 years in the basin of Rio Mannu

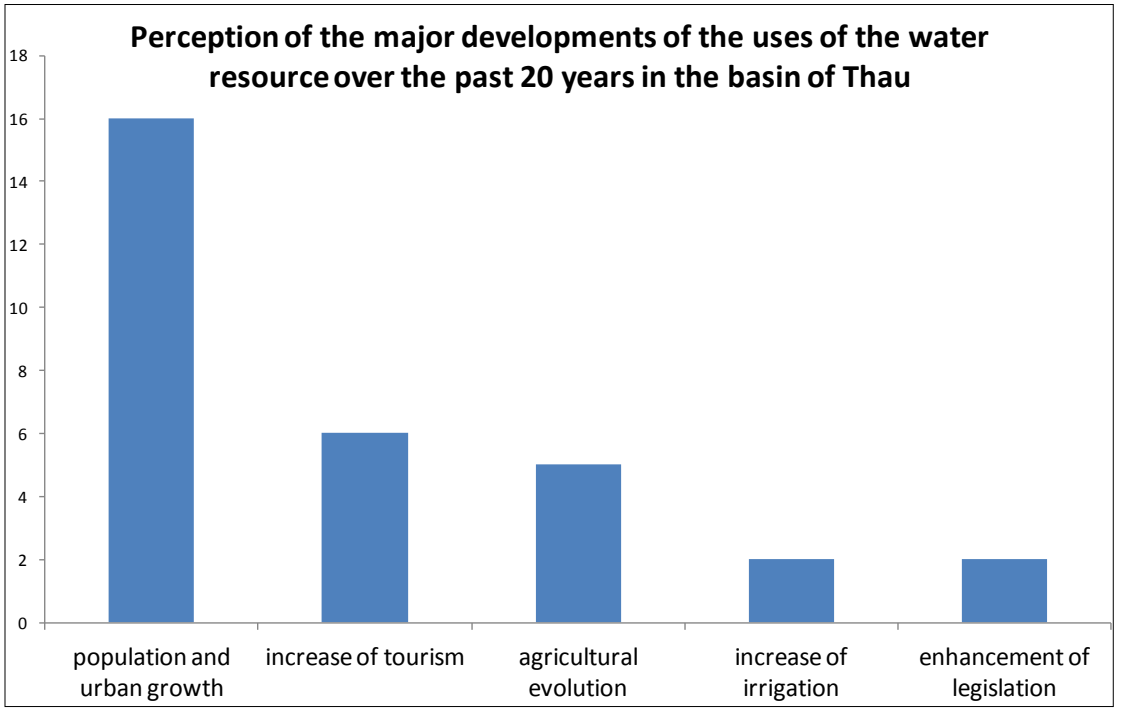

Figure 16: perception of the major developments of the uses of the water resource over the past 20 years in the basin of Thau's coastal lagoon

The main changes in the uses of the water resource in Rio Mannu, over the last twenty years, are closely linked to the agricultural methods used in the region (infirmed by 57% of the participants): with a decrease of extensive farming activities (infirmed by 7/28 of the respondents), an increase of intensive farming activities (infirmed by 4/28 of the respondents) and because of an increase of irrigation uses (infirmed by 5/28 of the respondents). Only three people mentioned climate change as a main source of change.

In the case study of Thau, we can clearly notice that fewer causes were mentioned as a change in the uses of the water resource in the past twenty years, and that one noticeably stands out: out of 21 respondents, 77% adduced the population and urban growth as the main cause of change. On the other hand, climate change does not seem to have worried any of our participants as no one has mentioned it.

Figure 17 and figure 18: Perception of the major developments of the uses of the water resource over the next 20 years.

In the questionnaire, the participants were asked in an open question what they thought were the causes of the major changes that will occur over the next twenty years. The answers given were classified into categories when they were similar.

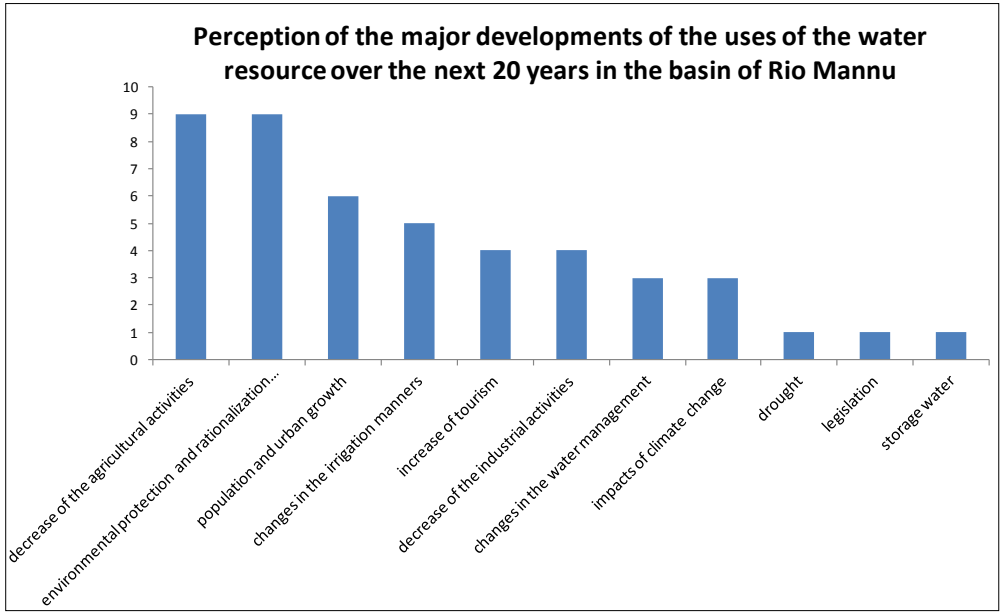

Figure 17: perception of the major developments of the uses of the water resource over the next 20 years in the basin of Rio Mannu

Interviewed people predict that one of the main causes of change for the future is still linked to the agricultural and irrigation methods. Nonetheless, appears as important, the protection of the environment and a rationalisation of the resource (infirmed by 32% of the respondents), followed by the issues related to population and urban growth (6/28 of the respondents).

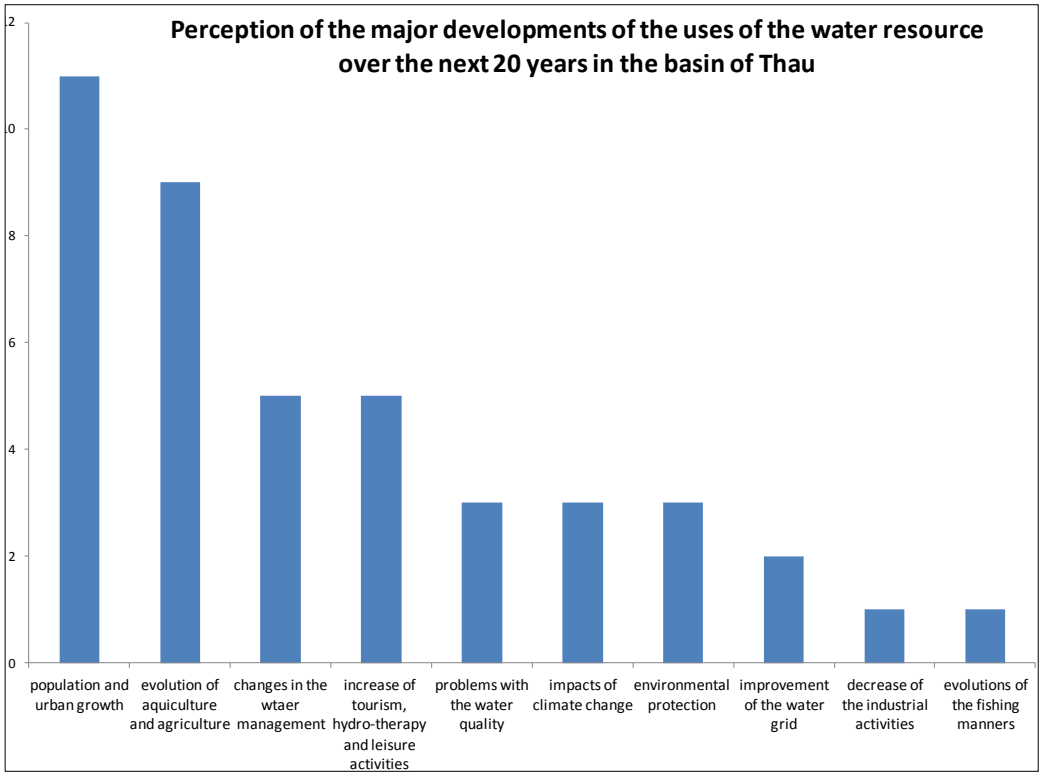

Figure 18: perception of the major developments of the uses of the water resource over the next 20 years in the basin of Thau

Unlike Figure 16, for the next twenty years, the participants to our study have mentioned many more possible reasons to the change in the uses of the water resource.

4. INTERPRETATION

A. Several Water uses in each basin

According to Figure 8, on the Rio Mannu di San Sperate's basin, out of the 20 uses proposed by the questionnaire to 28 people, only 3 (which corresponds to 15% of the uses) are considered major: drinking water (75%), irrigation (85,7%), impacts of the agricultural activities (57,1%). This is also confirmed by Figure 11 and Figure 12, where the same 2 uses stand out, followed by the importance of water to give to the animals. The second graph shows that water is used in a second place for anthropogenic activities such as tourism and industrial activities followed by aesthetics but still comes first (35% of stakeholders and 25% of users) the matter of water storage to ensure drinking water to the growing population.

Highlighted by Figure 8, the minor uses listed are numerous (9 out of 28 which corresponds to 32, 14%), the most important of them being aesthetics (60,7%), extraction (53,6%), breeding (50%) and leisure (50%). Several uses did not strike the answerers to be important: transport (89,3%) and transfer (75%) had very high scores of no answers.

As demonstrated in the different figures, water on the basin of Rio Mannu is used as a feeding resource in the first place (water for drinking, water to irrigate the future food, water to give to the animals and water storage). It is only in a second step that water is considered as a motor of the economy and development of the island used in sectors such as aesthetics, tourism and leisure activities. The theme of the environment does not seem to be a priority to the answerers as it is pointed as a minor use at 42,9% and in a constant trend at 32,2% in Figure 8 and it is only cited as a major use by less than 10 % of the water stakeholders and less than 5% of the water users in the Figure 11).

According to Figure 8 but for the site of Thau (21 respondents), out of the 20 uses proposed in the questionnaire, 9 were considered as major uses, those with the highest scores being: aquaculture (95,2%), drinking water (85,7%), fishing (81%), impacts of the urban or industrial wastes (81%) and hydro-therapy (61,9%). These results show that even if people do not know about all the different uses that exist, everyone is conscious that aquaculture is the main resource of the territory, as presented earlier. The perception of the fishing activity seems rather accurate as industrial and commercial activities are related to Frontignan's and Sète's harbours—the later being the first fishing port of the French Mediterranean coast. However, Figure 13 gives additional information concerning the perception of hydro-therapy. The stakeholders regard it as a major use (35% of them) while less than 10% of users do. This underlines the different roles played by both categories, the stakeholders being more aware of the different uses of the water resource on the territory (especially if it involve economics), the users being more focused on their own use of the water. What seems really surprising though is that irrigation is the following one on the list with 57% believing it is an important source of use of the resource while little irrigation exists on the basin. Indeed, the major agricultural activity is viticulture (65% of the agricultural area of the SAGE) which is rain-fed. Moreover, on the whole SAGE area, only 9,2% (SAGE, 2009) of the agricultural area is irrigable. This could be explained by the fact that worries about drought or scarce resource increase in people's mind; therefore they expect irrigation to be a solution to maintain the quantity of water used in agriculture. Another important issue is Environment: 66,7% of the respondents consider it as a major issue while it is barely mentioned as a minor one in the basin of Rio Mannu. We could suggest that this difference is due to the fact that, in Rio Mannu's basin, people have been struggling against drought for many years and had to think ahead already about the environmental concerns. In Thau, the main struggle that can be seen is to cope with the rapid demographic growth, that is why in Figure 13 drinking water is seen as the second major use of water, and this is also revealed by Figure 8 detailed previously.

The same number of uses in Thau was considered as minor, the most important ones being: breeding (57,1%), transport (52,4%), extraction (52,4%), esthetics (47,6%) and water storage (47,6%). As for the Italian site, the respondents barely answer for the uses which do not exist, or are poorly represented, on the territory. Such is the case with hydroelectricity and transferred water that were not answered at 66,7% and 85,7%.

All these same uses' evolutions are then evaluated (increase, decrease or stabilization) over the past twenty years. According to the table, for the Italian site, 6 uses have the increased over the past twenty years, the most being: drinking water (85,7%), irrigation (71,4%) and impacts of the urban or industrial wastewaters (47,9%). However, most of the uses (55%) have stabilized over the past 20 years such as thermal (61,9%), fishing (57,1%) and water storage (57,1%). None of the uses is pointed as having dramatically decreased.

B. Evolution since the last 20 years and the reasons of these evolutions

According to Figure 8, where answerers were asked to evaluate the trends of the uses over the past twenty years, 2 uses which were already considered major in Rio Mannu, have increased during the last 20 years: drinking water (50%) and water storage (35,7%). Irrigation has a trend a little bit more complicated to analyze because 39,3% think it has increased and the same percentage think it has declined. The Environment use has stabilized (32%).

Several reasons may explain these shifts in the evolution of the water use. The growing urbanization and the new water consumption habits per person could partly explain this phenomenon of increase in the use of drinking water.In the world between 1940 and 1990, the consumption of water per person has shifted from 400 to 800 m^3 per year (INRA, 2004). The increase of the population in Sardinia cannot be taken as a reason of this increase in drinking water because over the last 20 years, the population in Sardinia has decreased (ISTAT, 2006). However, Tthere has been a growth of tourism in Sardinia and of the building of new complexes consuming an important quantity of water, such as golf courses, spas, indoor pools, which can also explain the results of the Figure 8. Moreover, it underlines that other uses which used to be considered as minor, have changed status and have increased such as the sectors of leisure activities (70%), aesthetics (50%) and recreation (50%).

There is both a feeling of increase and decrease of the water use in the irrigation sector according to the Figure 8, Figure 15 points out that the major changes in the last 20 years that could go join this feeling of decrease of the irrigation uses is due to the change of the water management in Sardinia. Since its change there have been efforts to reduce the loss of water. Indeed, as the price of water is fixed on the surface rather than on the volume pumped, there was a need to reduce excessive water use, for example in 1999, the Consorzi di Bonifica has implemented electronic water counters which allows the farmers to manage their own volume of water attributed at the beginning of the year and enables to reduce water losses in the agricultural sector
On the other hand the increase of the intensive agriculture emphasized in the results of the Figure 15 , could explain the feeling of increase of the water use for the irrigation sector.

Another interesting point is that there has been an increase in the water storage over the last 20 years according to Figure 8. This must be linked with the severe droughts that occurred in 1995, 2000 and 2002 which have forced the Sardinian people to react and find solutions to these critical situations. Indeed, the period between 1998 and 2002 has been the driest period of these last 80 years (Sistu, 2004). Only three people (11% of the respondents) mentioned climate change as a main source of change in Figure 15 which means climate change has not, in the minds of the people questioned, changed the trends of the water uses.

In the case study of Thau, it is clearly noticeable that fewer causes (five compared to thirteen in the case of Rio Mannu) were mentioned as a change in the uses of the water resource in the past twenty years One noticeably stands out: out of 21 respondents, 77% adduced the population and urban growth as the main cause of change. This can easily be explained as the region is really attractive and has to deal with different issues concerning population. First of all, demographic growth occurs as everywhere, but the territory is characterised by an important increase of the summer population: there are as many secondary homes than principal homes on the territory, plus many camping sites, hotels and other tourist facilities, bringing the annual population to at least double (or even be multiplied by 8 in some municipalities (La Jeunesse, 2001) during summer. Thus, the presence, and its growth, of human being (demographic growth and tourism) is seen as the main pressure for the past twenty years on this

fragile ecosystem and its resource. Climate change on the other hand does not seem to have worried any of our participants as no one has mentioned it (Figure 16).

C. What will be the major changes of water uses in the next 20 years ?

According to the results presented on figure Figure 17, in the next 20 years, in Rio Mannu di San Sperate's basin, there is going to be a decrease in agricultural activities, a more important interest in the protection of the environment and an increase in the urban population. If in 20 years' time, as expected by the answerers, there is a decrease in agricultural activities and an increase in urban population, there will be a decrease in the water used for the irrigation and this water will shift from the irrigation use to the drinking water use.

For the basin of Thau, if anthropogenic issues (demographic and urban growth (infirmed by 11/21 respondents) and the increase of tourism, hydro-therapy and leisure activities (5/21 respondents)) remain the major worry about the uses of the water resource, it is also said that a change in its management will have an impact on the uses (such it has been said in the case study of Rio Mannu). In addition, a few people mentioned the impacts of climate change and environmental issues (6/21 respondents). Let's remember that in the questionnaires, the terms of climate change have never been mentioned. New issues have appeared these last years, such as water, especially fresh water, becoming a scarce resource. New projects or ideas have emerged to divert the problem, such as the Aqua Domitia project that consists in bringing into Thau's catchment water from the Rhône River, or the idea of desalinisation of sea water. With such projects, environmental issues necessarily come into sight.
No matter what, the coastal zone is continuously exposed to the expansion of small villages (connected to Montpellier city by a highway) so urban growth and the change of land use remain key issues to be dealt with in the future.

Rivalries on uses

According to Figure 9, the chiefs of influence in the water basin of Rio Mannu di San Sperate are only water stakeholders. For Thau, a few users' associations also stand out (Figure 10). For both sites, even if questioned people say there is no conflict, we can feel a certain tension between the actors due to the high percentage of non-response (89% for the Italian site and 91% for the French site) to the question " With whom do your share the same position on water management questions and with whom do you tend to disagree?"(Question 5, section 2 "Social Network Analysis").

Going back to the Italian catchment, according to Figure 9, the most significant result (mentioned 15 times) is the perceived competition between the irrigation and domestic use. However, there is a misunderstanding of the felt competition because in case of a severe drought or extreme climate conditions, water used as drinking water will always be privileged in front of the water used for irrigation.

In the same figure, there is also a feeling of competition between industry and other uses such as Irrigation, Domestic and Environmental uses, mentioned 4 times each. It is clearly noticeable that all the rivalries mentioned are located in the 3 sectors managed by ENAS: Abbanoa (drinking water), Consorzi di Bonifica (Water for the irrigation) and Consorzi Industriali (Water for the industrial use).

On Thau's coastal lagoon, the domestic use of the water is sensed as in competition with several other uses (Figure 10): irrigation (mentioned 8 times), recreational activities such as hydro-therapy activities (mentioned 5 times) and shell fishing (mentioned 4 times). This is important as a big part of the economy is linked to health tourism (hydro-therapy), which suffers from the "inversac" phenomenon during the summer time. Fresh water is "contaminated" by salted water preventing thermal activity from being possible. Shell fishing is also sensed as in competition with environmental uses or recreational activities (both mentioned 4 times). But the activity that comes far ahead as in

competition with others is shellfishing (it is mentioned 22 times in conflict with another use) followed by fishing (15 times).

This comes back to the general context in which the coastal lagoon of Thau is situated, its economy being based on shellfish farming. The whole system is based on this activity, which needs a good water quality to be efficient. However the quality is easily affected by the other activities or changes in the water and land use, so the competition is emphasized. The main environmental concerns for shellfish farming and fishery in the lagoon are contamination from faecal bacteria, phytotoxic algal blooms and anoxia both mainly due to the eutrophication of the lagoon waters. For the last two years, a virus is damaging the oysters' production when water temperatures exceed 16°C. Also, high water temperatures (up to 29°C) have recently devastated the entire mussels' production. Hydroclimatic conditions are mostly decisive in the phenomena of eutrophication as precipitation generates large inputs of nitrogen and phosphorus, while high temperatures promote the growth of algae. The shellfish production relies on the fragile balance between the phytoplankton production and its consumption by the shells (oysters and mussels). Thau's coastal lagoon, suffers episodically in summer from anoxic crises known as 'malaïgues'. Such crises mostly occur under warm conditions and low winds, often in August (Chapelle, 2002). Malaïgues are found to be frequently preceded by increased precipitation in July which contributes to a larger nutrient input into the lagoon and to its eutrophication. Moreover, more and more nutrient intakes come from the catchment through leaching during rainfall, so urban growth also accentuate this phenomena. As said previously, the population doubles during summer time. But this is when the environment is the most fragile and the water resource the poorest. Thus, we can see as conflictual the demographic growth with the environment and the water quality, which has a major impact on shellfish farming, therefore on the economy too since it is during summer time and Christmas holiday that sales should be the highest.

Finally, we can say that in the basin of Thau, the main issues about the water resource rely on its quality rather than upon its quantity as it is the case in the basin of Rio Mannu di San Sperate.

5. DISCUSSION

Etymologically the word "rivalry" comes from the word river. The rivals were originally different communities that used to share the same river for a living, without any negative connotation. Difficulties in sharing this resource, source of tension, transformed the meaning of the word, which underlines that the difficulties of sharing the water did not start yesterday.

Man has a different relationship towards lagoons and rivers. Indeed, a lagoon is a motor of the economy in the sense that it is exploited differently from the river. Rivers are used mostly to supply with water for drinking purposes and irrigation. On the other hand, lagoons develop aquaculture activities which enable economic growth and the development of a territory. The water resource in general suffers from different pressures whether it comes from a lagoon or a river.

Whatever the type of pressure put on the water resource, what seems to be overly important is its management. Indeed, everyone needs water for a living and/or to develop: human beings, animals and economic activities. Therefore everyone is concerned, everyone is a user of the water resource and many are stakeholders. They can be found at every institutional and administrative level, for every state subdivision. For an optimum performance and the best water distribution possible, it seems important to have a good communication between the actors. Most actors cooperate as for them cooperation means absence of conflict and reasonable management of the rivalries. The absence of conflict reduces uncertainty; a cooperative behavior towards others brings stability (Iskandar Boctor, 2002). Towards this goal, in the basin of Thau has been set up an "Integrated Coastal and Zone Management" (ICZM; "Gestion Intégrée de la Zone Côtière") in 2011, pursuing the same dynamic engaged by the quality contract of the lagoon achieved in 2009 (Cicin-Sain & Knecht, 1998). Its objective is to put into relation, and in coherence, all the

public policies and planning documents existing on this territory (SAGE, SMVM[1], SCOT[2], Natura 2000). It is an ambitious programme to integrate water policy and territorial planning, but during the sixth world conference about water that was held in Marseille (France) in March 2012, it was said to be considered as an example of integrated management in France. The European Commission defines the ICZM (born in the Agenda 21, Chapter 17) as follows: "ICZM is a dynamic, multidisciplinary and interactive process to promote sustainable management of coastal zones. It covers the full cycle of information collection, planning (in its broadest sense), decision making, management and monitoring of implementation. ICZM uses the informed participation and cooperation of all stakeholders to assess the societal goals in a given coastal area, and to take actions towards meeting these objectives. ICZM seeks, over the long-term, to balance environmental, economic, social, cultural and recreational objectives, all within the limits set by natural dynamics. 'Integrated' in ICZM refers to the integration of objectives and also to the integration of the many instruments needed to meet these objectives. It means integration of all relevant policy areas, sectors, and levels of administration. It means integration of the terrestrial and marine components of the target territory, in both time and space". In the case of Rio Mannu, there are fewer stakeholders as, unlikely to the French system, water management is centralized at the regional level, which seems efficient. We could then wonder about the role and efficiency of centralized or decentralized state services, but we can notice that management systems such as the ICZM can limit this debate.

The "snowball sampling" methodological approach of this research was to question the highest number of organisations and actors of the water management of the site. As it was said earlier, the case study leader has given depending on the situation the questionnaire through his or her network. Therefore it has the advantage of having answers for many different institutions as the case study leader does his/her best to meet people from different types of institutions, but going in through only one network could lead to some biases.
Even if efforts are made to have the different actors cooperate, water management mostly occurs at the catchment, or watershed, level. But we could wonder about the accuracy of this delimitation, since water is a world common resource and not "prisoner" of boundaries. Water runs through the catchments so it constantly changes as it moves. Moreover, transferring water from a place to another happens to be seen as the solution to the difficulties met by territories. In the 90s, Italy suffered from severe droughts due to precipitation and runoff deficits. With very little or no recharge, all lakes and reservoirs for agricultural or multiple use attained minimum storage levels. During the summer, municipalities and water companies had to reduce domestic water delivery to a few hours every few days (Rossi & Somma 1995). To shade this problem, the regional government funded the construction of new water supply facilities and new connections between existing aqueducts and reservoirs, thus facilitating within-basin and interbasin water transfers. Some of the water supply devoted to agricultural uses, both from reservoirs and wells, was diverted to satisfy the municipal demand. To give an example for the basin of Thau, the Aqua Domitia project is being debated at the moment to face issues of water scarcity for agriculture, thinking of diverting water from the Rhône River to the Languedoc Region. The first ideas of this project, later abandoned mainly for cost matters, even were to bring water from the Rhône River up to Barcelona (Spain). With this kind of externalization of the water resource, we are confronted with water coming from a different catchment than the one in which we focused our study and questionnaire dissemination. This stresses the question of the "real boundaries" defined for water management, but overall the importance of cooperation and communication between the different stakeholders at all levels.

The difficulty with the questionnaire was to obtain the same number of answers and of the same level of details. It seems difficult for most of the people questioned to realize what the other uses for the water are and what the other actors might do or think. Thanks to the visits and the interviews on the site, it is possible to draw a global vision of the pulse of the water management and the water uses on the site.

[1] Schéma de Mise en Valeur de la Mer
[2] Schéma de Cohérence Territoriale

The economic and financial crisis has somehow put in the shadow climate change (Le Monde, 2011); climate change does not seem to be an important concern by the answers given in our questionnaire as people must try to cope with their everyday life and issues.

People generally do not have the vision of all the water uses as they focus on their own, as human beings also generally tend to look at short term effects rather than long term effects. In our research we can note a greater concern for urban growth than for climate change. This can be explained by the fact that urbanization usually has short term effects that are noticeable (land use change, decrease of the natural resources available, increase of the demand for the same quantity of resource, etc.) while climate change rather has long term effects. What is however interesting to note is that these concerns appeared in the opposite order in our two case studies. While Sardinia has first focused on the environmental issues, Thau has focused on that of urban and demographic growth. But as shown throughout this paper, the Italian site has early undergone draught crisis while the French site is a major attractive region but developed on a fragile ecosystem. Both sites had to react rapidly to the changes occurring both in water scarcity and in the demand for water. Over the years, the difficulties have changed with the evolution of the territories, and since solutions have been developed little by little to face the former ones. It has appeared that the sites are going to be more confronted with issues linked to urbanization for the basin of Rio Mannu and with climate change for the basin of Thau. In the end, these two themes are greatly linked because climate change will disproportionately affect cities. These concentrate populations and economic activities and they are mostly located in climate sensitive areas such as flood plains and coastal zones.

Many strategies in order to adapt to the climate change in Europe are currently at the stage of research or policy investigations. Measures of adaptation have already been thought of, such as the improvement of the forecasting information, flood protection measures covering dykes and restriction of building development in risk areas. However, the uncertainties of the impacts of climate change make adaptation all the more complex (EEA, 2009) and necessitates that management organisations take the most cost effective benefits to lead to a climate-resilient society.

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Appended: Main water actors of the two sites

Rio Mannu di San Sperate (Sardinia, Italy)

Agenzia Regionale del Distretto Idrografico della Sardinia	Direzione Generale, Agenzia Regionale del Distretto Idrografico della Sardinia
Allevatore	Altri Utilizzatori: Allevatore
Viticoltore	Altri Utilizzatori: Viticoltore
Abbanoa: SpA	Abbanoa: SpA
Altri	Altri
Altri Sindicati	Altri Sindicati
ARPA Sardinia	Agenzia regionale protezione dell'ambiente Sardinia
Autorità di Bacino regionale della Sardinia	Autorità di Bacino regionale della Sardinia
C.E	Commissione Europea
CIA	Confederazione Italiana Agricoltori
Coldiretti	Coldiretti
Comitati Locali	Comitati Locali
Commune	Commune
Confagricoltura	Confagricoltura
Consorzi di Bonifica	Consorzi di Bonifica
Consorzi Industriali	Consorzi Industriali
ENAS	Ente acque della Sardinia
ENEL	Ente Nazionale per l'Energia Elettrica
ISPRA	Istutito Superiore per la Protezione e la Richerca Ambientale
Ministero dei Lavori Publici	Ministero dei Lavori Publici
Ministero dell Politche Agricole	Ministero dell Politche Agricole e Forestali
Ministero dell'Ambiente	Ministero dell'Ambiente e per la tutela del territorio e del mare
ONG: Legambiante	ONG: Legambiente
Provincia	Provincia
Regione	Presidenza, Regione Autonoma della Sardinia
Servizio Affari Generali	Servizio Affari Generali, Assessorato dell'Agricoltura, regione autonoma della Sardinia
Servizio Produzioni	Servizio Produzioni, Assessorato dell'Agricoltura, Regione Autonoma della Sardinia
Servizio Terriorio	Servizio Terriorio, Assessorato dell'Agricoltura, Regione Autonoma della Sardinia
Servizio Tutela e Gestione delle Siccità	Servizio Tutela e Gestione delle Risorche Idriche, Vigilanza Sui Servizi Idrici e Gestione delle Siccità
Unione Agricoltori	Unione Agricoltori

Thau coastal lagoon (Languedoc-Roussillon, France)

A.E RMC	Agence de l'eau Rhone Mediterrannée Corse
autre	autre
BRL	Bas Rhone Languedoc
C.E.	Commission Européenne
C.L Peche et Elevage Sète	Comité Local des Pêches Maritimes et des Elevages Marins de Sète
CABT	Communauté d'Agglomération du bassin de Thau
CAHM	Communauté d'Agglomération du bassin de Thau
Canoë Kayak	Canoë Kayak
Caves Coopératives	Fédération Départementale des caves coopératives
CCNBT	Communauté de communes du nord du bassin de Thau
CEPRALMAR	Centre d'études et de Promotion des Activités Lagunaires et Maritimes en Languedoc Roussillon
CG	Conseil Général de l'Hérault
Chasse	Association intercommunale de chasse de l'étang de Thau
Chb C.I SFM	Chambre du Commerce et de l'Industrie Sète-Frontignan-Mèze
CIVAM	Chambre d'Agriculture CIVAM de l'Hérault
CL	Conservatoire du Littoral
CLE	Commision Locale de l'eau
COVED SAUR	Gestion des déchets COVED SAUR
CPIE	Centre Permanent d'Initiatives pour l'Environnement du bassin de Thau
CR	Conseil Régional du Languedoc-Roussillon
CR Conchylicole	Comité Régional Conchylicole de Méditerranée
CRPEM LR	Comité Régional des Pêches en Méditerranée
DRAAF	Direction régionale de l'alimentation, de l'agriculture et de la forêt
DREAL	Direction régionale de l'environnement, de l'aménagement et du logement
EID	Entente Interdépartementale pour la Démoustication du Littoral Méditerranéen
FFESSM	Fédération Française d'Etudes et de Sports Sous marins
IFREMER	Institut Français de Recherche pour l'Exploitation de la Mer
Industries	Industries (agro-alimentaires, cimenterie, etc.)
MEDDTL	Ministère de l'écologie
MISE	Mission inter-services de l'eau de l'Hérault
Pecheurs amateurs et plaisanciers Sète	Association des pêcheurs amateurs et plaisanciers de Sète
Protection Nature	Société de protection de la nature Languedoc-Roussillon Section du Bassin de Thau
Prud'hommie SM	Prud'hommie des Pêches Sète-Môle
SDEI	Société de distribution d'Eau Intercommunale
SIAE	Syndicat Intercommunal d'Adduction d'Eau de Florensac Pomérols
SIAE BL	Syndicat Intercommunal d'Adduction d'Eau Bas Languedoc
SIE Frontignan	Syndicat Intercommunal des Eaux de Frontignan Balaruc
SITEU	Syndicat Intercommunal de traitement des eaux usées de Pinet Pomérols
Thermes	Thermes de Balaruc-les-Bains
Vignerons caves particulières	Syndicat des vignerons de l'Hérault vinifiant en caves particulières