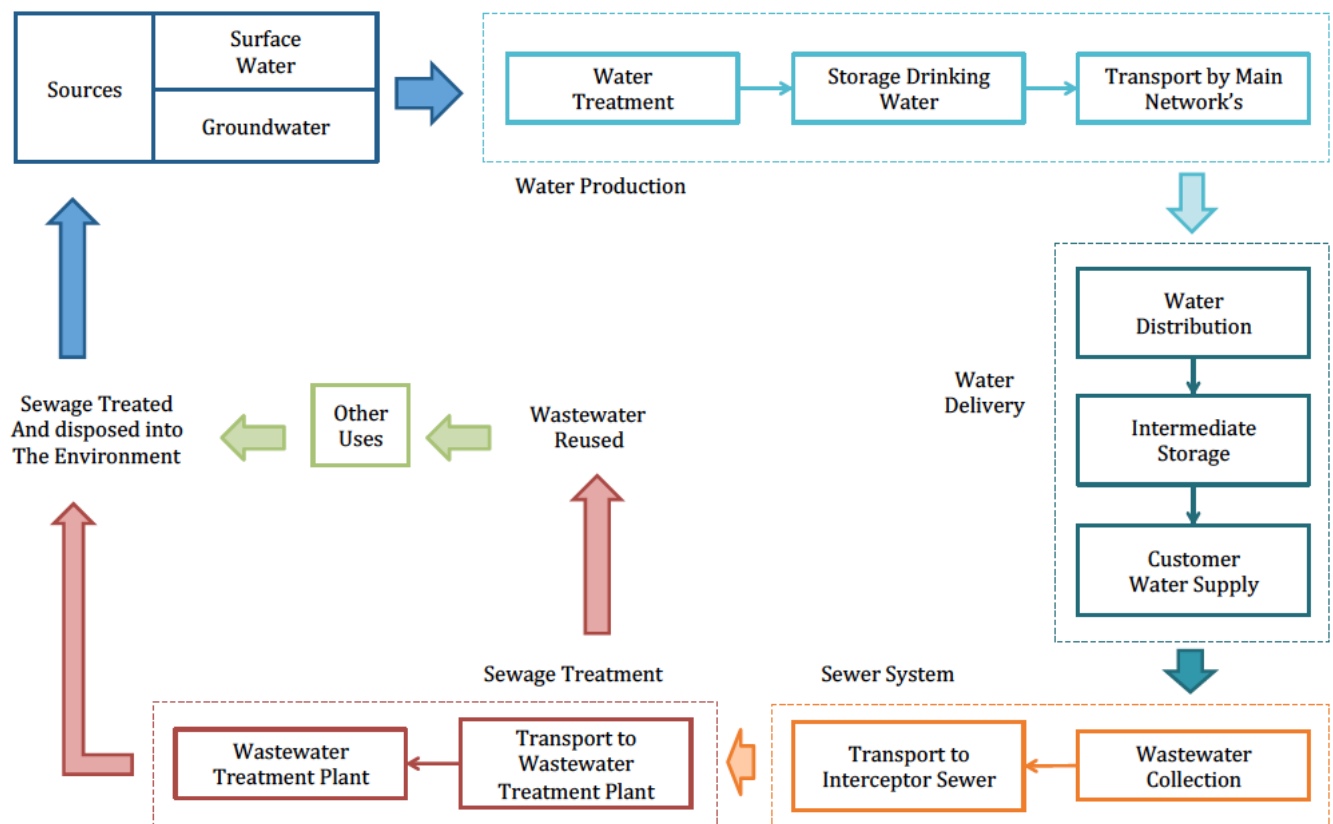


Evaluating Asset Management Strategies of Water Cycle Systems under Different Socio-Technical Contexts

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Evaluating Asset Management Strategies of Water Cycle Systems under Different Socio-Technical Contexts

By

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in partial fulfilment of the requirements for the degree of

Master of Science
in Civil Engineering and Geoscience

at the Delft University of Technology,
to be defended publicly on Friday November 14, 2014 at 16:00 PM.

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Acknowledgments

This report is the outcome of my master thesis work and is also the termination of my three-year studies. The research is conducted to finalize my master program of Water Resources Management in water management department in Civil Engineering and Geoscience Faculty of TU Delft, in the Netherlands.

In order this research to be completed, there were a lot of people inside and outside TU Delft that provided me with their time, interest and knowledge. I would like to express my sincere gratitude to all of them. Firstly, I would like to thank my daily supervisor Jan Peter van de Hoek for his assistance and the useful comments during my research. I would also like to thank my external supervisor from Vitens, Rian Kloosterman for giving me the opportunity to work on this topic and for introducing me to the interesting topic of asset management. His comments and his knowledge over this topic contributed to the outcome of my research. Finally, I would like to thank Nick van de Giesen for giving me the chance to work on a thesis from the Sanitary Engineering section. It shows the integrate character of this master.

Furthermore, I want to extend my sincerest thanks to the people I met when visited last July EYDAP in Athens and last September Aigües de Barcelona, in Barcelona during my interviews. Every interview was very valuable and without the time of every participant this thesis wouldn't have been possible. I would like to especially thank Christos Makropoulos, from National Technical University in Athens, as he was the first person that got us in contact with EYDAP and brought up the idea of visiting the company. Then, my previous supervisor from Technical University of Crete Evangelos Paleologos for helping me in order to get in contact on his behalf with Directors from EYDAP. Finally, I would like to thank Ramon Ferrer Embodas, from Aigües de Barcelona for making the field research in the company possible.

To conclude my acknowledgements, I want to thank all the people outside the university for their support during these three-years of my studies. My friends in Greece for being always there for me as well as my new friends in Delft – Adam, Georgiana, Maria and Lefki – for their support. Of course my family, my sister, my grandfather, my aunt, my cousins and especially my parents Fragkisko and Nikoleta for their infinitive love. Nothing of this would have happened without their daily support and encouragement.

Thank you all!

Ioanna Livaniou
2014

Summary

The main objective of this research was to understand on what extent external elements are taken into account in the strategic decision-making process on the management of the physical assets and why specific external elements are more important than others. This objective has shaped the two main research questions presented in this thesis:

What are the interrelations between the strategic decision-making process about asset management and the socio-technical context on the water companies under study (Aigües de Barcelona and EYDAP)?

How does the ownership rights influence the strategic decision-making process about the management of the physical assets in water companies?

In order to reach this objective two water companies operating in different socio-technical environments were evaluated. First the external elements that form the socio-technical context were identified and separated in four categories. The four categories were formed based on Williamson's 4-layer approach. Williamson offered a useful model that allows treating different types of social and institutional arrangements in an integrated way. The approach can be expanded to model the technical and social sub-systems simultaneously. The theoretical framework used as a tool for answering the sub-research questions was based on the extended model.

Furthermore, sub-questions were formed related to the elements that considered affecting the socio-technical context which are Physical Characteristics, Cultural Embeddedness, Institutional Arrangements and Governance Characteristics.

Sub-Questions:

1. What are the relevant elements of the **Physical Characteristics** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
2. What are the relevant elements of the **Cultural Embeddedness** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
3. What are the relevant elements of the **Institutional Arrangements** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
4. What are the relevant elements of the **Governance Characteristics** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

The findings coming from answering the sub-questions on the case studies can be summarized in the following Table.

Table: Summary of the findings coming from answering the sub-questions

Level	Aigües de Barcelona	EYDAP
1. Cultural Embeddedness	• Mediterranean Climate • Decrease of water consumption – poor water quality • Health and Safety influence introduced by the French culture of the shareholders • Increase consumption in the suburbs of the area – houses with gardens	• Mediterranean Climate • Decrease of water consumption due to price increase measures, only for the period of the drought • Supply oriented culture – structurally induced abundance
2. Physical Characteristics	• Limited available water resources • Poor raw water quality • High leakage percentages – introduction of smart metering and other water demand management techniques • Application of innovative techniques – desalinization treatment • Attention in maintenance for long-term – preventive maintenance plan	• Limited water resources availability in Attica region – big water transfers • Good raw water quality – rain as main source • Not so good performance of the water system – introduction of water demand management techniques the last years • Short-term investments – corrective maintenance plan
3. Institutional Arrangements	• Privatization of the drinking water supply • Decentralized institutional system – gives strong power to municipal authorities • Concession contract – competition for the market	• Semi-privatized in 1999 • Centralized institutional system – strong power of the Greek State • 20-year concession contract with an exclusive responsibility
4. Governance Characteristics	• Annual price review period • Strong regulatory structure • International vision • Strong marketing activities – advanced innovation department that sells the innovations inside and outside Agbar Group	• Long-term periods of strategic plans – price review every 5 years • Not strong regulatory structure • Limited innovative behavior – only to cover company's needs

Although asset management can follow different standards, its implementation relies on the asset manager and the decision-making process of each organization. Based on that, changes on any of the components that form the four categories, influence the strategic decision-making process and as a result the development of strategies and objectives of a company. Taken this into account, it was considered that the asset management plan is characteristic of its organization and the impact that the external environment has on the strategic decision-making process varies depending on the value that it's given from each organization

on each component. In other words the decision-maker has no control on the external influential factors but does have control on the level of consideration within the decision-making process.

This was proven in the two companies under study during the evaluation process of their strategic decision-making process on the layout of the infrastructure. It was seen that the same external factors are affecting the strategic decision-making process, but each company has taken different measures to deal with them. Hence, it was concluded that there is an interrelation between the strategic decision-making process about asset management and the external socio-technical context.

The external factors that were discussed and were shown to influence the strategic decision-making process about the management of the physical assets of the two companies are shown in the following Figure. All of these external factors were proven to have an influence on the strategic decision-making process, but on a different scale.

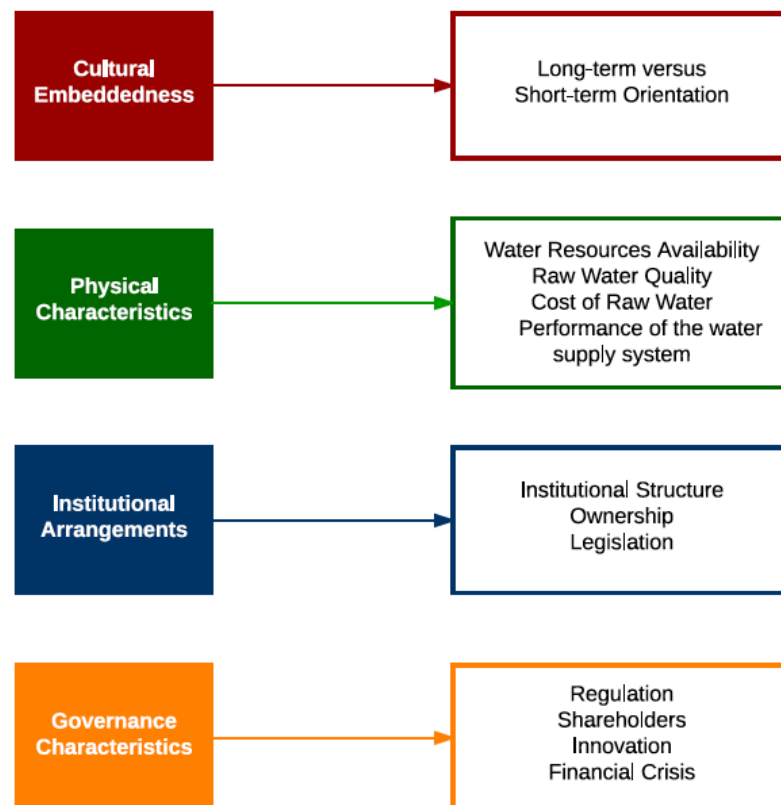


Figure: Influential external factors

It was found that the biggest problems that the two companies have to face are coming from the physical characteristics category. However, the way that each company incorporated the effects on its strategic decision-making process as well as the value given varied.

The external factors comprising the physical characteristics category are causing the same problems to the companies under study. While, the external factors coming from the governance characteristics and the institutional arrangements are the ones used in the strategic decision-making process in order the companies to find a solution. However, the impact that the governance aspects have on the strategic decision-making process on asset

management of the infrastructure is very big. The contextual factors coming from this category are highlighting the most the difference in scale between the two companies. This difference is caused not by the scale of operations and services provided, as the population served is the same, but mainly from the financial support and hence the opportunity of making investments. Furthermore, a strong relationship between the firm and the economic regulator is an important aspect that is missing from EYDAP as it was indicated in the governance characteristics category. Finally, the cultural embeddedness reflects a substantial element that is relevant to the strategic decisions of the two water companies. As the culture of the long-term versus short-term orientation was reflected not only on the strategic decisions concerning the reaction to a drought event that flows from the physical characteristics, but also in the institutional arrangements and in the governance characteristics.

Furthermore, it was concluded that the strategic decision-making process about the layout of the infrastructure in the two companies under study is different. It was shown that one of the reasons causing this difference originates in the different ownership rights. However, it's a combination of factors including the different ownership rights that actually makes the strategic decision-making process in the two companies to vary. Factors like the competition for the market that is identified in the case of Aigües de Barcelona and the difference in the range of the two companies operations are considered as equally important.

This research tried to link the external environment with the strategic decision-making process about the layout of the infrastructure of the two companies under study. By gaining insight in the external environment it can be understood why specific strategic decisions were taken. The theoretical framework used in this research was suitable for evaluating the interrelations between the strategic decision-making process about the asset management and the socio-technical context for water companies. Furthermore, The final outcome has contributed to Vitens objective by gaining insight in the strategic decision-making on asset management of water companies working in different institutional environments. The socio-technical context might be different from the one that Vitens is working in and thus creates different influences, but as it was recognized in the beginning of this thesis, describing and evaluating the strategic decision-making process of a water company operating in a different institutional environment can provide valuable information that could be relevant to Vitens' decision-making process on asset management.

Finally, the theoretical framework can be applied in other utility companies like electricity, natural gas or telecommunications in order to find the influences of the external environment in their strategic decision-making process.

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CHAPTER 1

Introduction

1. Introduction

In developed countries, water systems have been modified or trained to fulfill the demands of water services in the longer term. The future is, however, more complex and dynamic and is surrounded by large uncertainties that have to be faced during their projected lifetime. First climate change and second the hydrologic response are major causes of this uncertainty, as they may affect water availability. In addition, various unknown socio-economic and agro-economic developments might affect the hydrological cycle through land use changes or determine water demand through for example population growth or industrial expansion, which means that water systems interact as society responds to events and their state changes in response to management. Uncertainties are also introduced by social issues in terms of a change in our core beliefs, such as a moral sense of caring for the environment and the demand for sustainable developments. These factors together determine possible futures that are envisaged. Depending on the perspectives of the future, different water management strategies may be adopted (Haasnoot, et al. 2011).

Single plants, firms, or entire industrial sectors constitute socio-technical systems if technological components and social arrangements are so intertwined that their design requires the joint optimization of technological and social variables (Bauer and Herder 2009). Infrastructure sectors can be considered as a particular class of socio-technical system (Kroes, et al. 2006); (Ottens, et al. 2006): technology is central for their operations and both organizational as well as sectoral forms of social control are established to ascertain a range of public values associated with their operation, such as ubiquitous and affordable supply. Engineering and social design issues arise at multiple levels of these socio-technical systems.

Water Cycle Systems (WCS) are characterized by an urban water cycle similar to the hydrological cycle located within an urban catchment (Figure 1). They are defined as the structures related to the production of drinking water, the water use, and the collection, purification and discharge of wastewater. Thus, WCS are complex systems in which technology; economics and institutions are closely related. It is of importance that changes in the different elements cohere, that is, that changes in the technology correspond with supporting changes in the institutions and vice versa. However, changes in various infrastructures (such as telecommunication, energy, water, rail transport) are often solely perceived as a matter of institutional or technical modification, ignoring the relationships with the other elements of the infrastructures as a complex system. The difficulty to achieve efficiency and effectiveness in these complex capital-intensive systems intensifies under settings such as regional water scarcity, climate change, drought events, and increasing urbanization. These challenges affect the resource availability (supply) and augment the water use (demand), increasing the stress on urban water infrastructure.

For Water Cycle Systems as capital-intensive infrastructures, the primary asset management objective is to deliver clean water in accordance with the demand and in the most effective way (Bradshaw, 2008). The challenge is to provide technical and budget flexibility to ensure the adaptation of the initial design to these changing requirements (Herder and Wijnia 2012).

The first outstanding feature of the activity carried out by water utilities concerns the task, which is most clearly recognized by clients, which takes the form of domestic water supply. The overall services of the urban water cycle include the following tasks: water capture from a river, an aquifer or even sometimes from the sea; water treatment to guarantee a healthy supply; distribution to homes, industry and other organisms; collection of sewage through the sewage system and sewage disposal. After this last phase, the water can be returned into the environment without negative repercussions and, if subjected to a more specific treatment, part of the water can even be reused for different purposes (Gómez and Rubio 2008). In Figure 1 the different phases of the urban water cycle are illustrated as well as their interrelations.

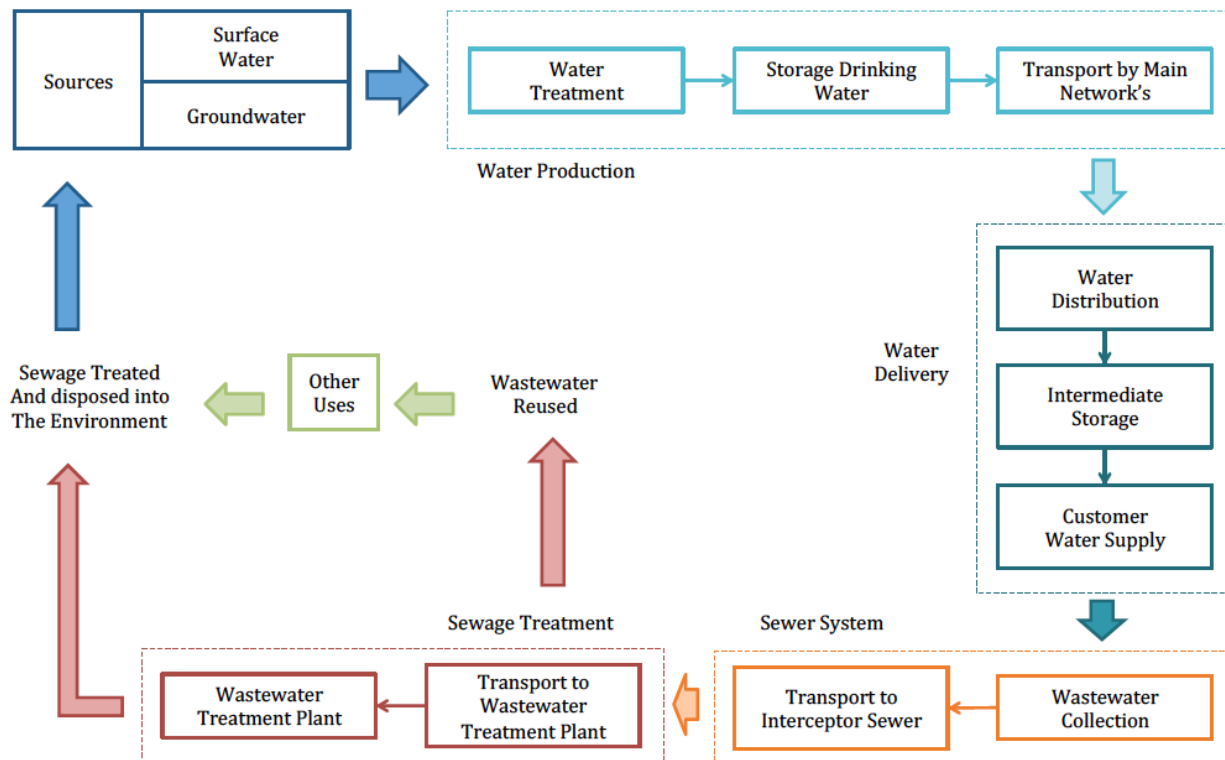


Figure 1: Urban water cycle, (Gómez and Rubio 2008)

It should be highlighted that the companies in water industry are multi-product entities meaning that there are both companies that manage all the tasks involved in the urban water cycle and companies that only manage certain phases. The most likely separation is between drinking water tasks, which include the production and the delivery of drinking water and wastewater tasks for collecting; treating and safely return the treated water in the environment. The water companies that are evaluated in this research are of both types.

Water utilities are customer-focused industries and this makes them face increasing customer expectations together with challenging quality and efficiency targets. Successful achievement of these targets requires a solid understanding of the business and global environment, together with the linkages between asset deterioration and service performance. There is a clear need to understand the interactions between the needs and capabilities of a business, both now and in the future, and how these might be affected by external events. Future needs are defined as the current needs together with changes in customer expectations, quality, quantity and environmental legislation and statutory levels of service. An unpredicted population growth and a consequential impact upon the supply/demand balance might

generate big problems for the water industry. Furthermore, affordability and willingness to pay for levels of service, can also be limiting factors affecting the level of service risk that companies will be expected to carry (Heather and Bridgeman 2007).

Water has no substitute and concerns all human beings, with no exception. As such, it is perceived as a “social” good that imposes strict constraints on operators, whether they are public or private, particularly when it comes to pricing and operation. Last, because there is no substitute, competing usages are a continuous and increasing source of tension (Ménard and Peeroo 2011).

1.1. Problem Definition

Vitens the largest drinking water company in the Netherlands is a public water utility company. The company supplies high-quality drinking water to cover over five million domestic and industrial customers in 1/3 of the Netherlands and groundwater is their most preferred water source. Its main objective is to keep providing good quality drinking water in the lowest price, but in the same time improve the efficiency and effectiveness of the drinking water infrastructure system. This will increase the value of water for the society and reduce its social costs. Water infrastructure systems are more demanding than ever. The world of infrastructure is constantly changing, as it is not only that the use is ever increasing; but also the public becomes more critical and demands better quality and better service, whereas on the other side the need to limit the costs is arising.

However, what makes the problem more complicated, besides of the technological component, complex technological systems as drinking water infrastructures, require an institutional structure that coordinates the positions, relations and behavior of the parties that own and operate the system. Since water infrastructures are deeply embedded in society, they are not only subject to rapid technological changes, but they also have to keep up with the institutional and economic developments, such as deregulation, liberalization and increasing prices. Water institutions are undergoing unprecedented changes worldwide. These institutional changes observed in the global water sector can be grouped into endogenous factors that are internal to water sector and exogenous factors that are outside the strict confines of both water institution and water sector. The endogenous factors include water scarcity, water conflicts, financial and physical deterioration of water infrastructure and operational inefficiency. The exogenous factors include economic development, demographic growth, technical progress, economic and political reform, changing social values and ethos and natural calamities including floods and droughts (Saletha and Dinar 2000).

Vitens has recognized the need to change their existing asset management approach of their physical assets to guaranty the water supply under future challenges and uncertainties. A longer-term view is essential for effective management of the assets to accommodate possible changes in circumstances so as the company achieves its specific strategic objectives. Thus, Vitens considers that changing their risk-based asset management approach from short-term investment horizon, input¹ oriented to a long-term investment horizon, outcome² oriented in line with the institutional environment can improve the efficiency and

1 Inputs are the resources that the company has to deliver for its activities or for a particular output. These could be specific resources (such as goods, services, energy, labor or capital), or they could be enablers (such as skills based). An organization with input-oriented objectives focuses on obtaining the best economy value of their resources.

2 Outcomes are defined as the result of an impact on a particular subject or beneficiary. An example of an outcome that a water company may aim for is sustainability. The criterion to reach this objective will reflect, not only the quality of the water environment, but also the sustainability of the solutions used to deliver it. An organization with

effectiveness of their long-term strategies. The new approach will incorporate long-term and asset system level strategies on an outcome level that considers external factors such the ones mentioned before in their decision-making process. As a result the decision-making process of the company about the management of the physical assets would shift to a more integrated approach by considering in their decision criteria the influences and the changes of the institutional environment.

Strategic decision-making on the asset management of the infrastructure is the process of identifying and choosing alternatives based on the values and preferences of the decision maker. Reliable information is important for effective decision-making. Where there are alternative choices, choosing the one that best supports organizational aims, values, goals and objectives is key (Vreeker, et al, 2002). Decision-making should start with the identification of the decision maker(s) and stakeholder(s) in the decision, reducing the possible disagreement about problem definition, requirements, goals, and criteria (Bouyssou et al, 2000).

Therefore, water infrastructures have to deal with performance criteria that are imposed by external bodies, like water quality standards that should be applicable on day-to-day basis. Managing the asset management system of a drinking water supply company is not an easy procedure, but by considering the complete production chain, distribution chain and entire asset life cycle, decisions on preventive asset maintenance and investments can be made more effectively and improve at the same time in a high level the efficiency of the company. An important component for success is the collection of information that can support the decision-making process within the drinking water supply company. It needs to be carefully considered initially; reviewed from time to time and ensure that stakeholder's needs are aligned with the business objectives. Vitens aims to improve its performance now and in the future by upgrading the company's strategic asset decisions. This research can contribute in Vitens goal by gaining insight in the external factors that influence the decision-making process of different Water Cycle Systems over the management of their physical assets.

Water companies in the Southern Europe and more specifically in Spain and in Greece are evaluated for this research. The drinking water company in Spain located in Barcelona, Agbar (Aigües de Barcelona) is a private drinking water company, responsible for the drinking water treatment and distribution in the Metropolitan Area of Barcelona, while the one in Greece based in Athens, EYDAP S.A. is a semi-privatized drinking water company in charge of the whole urban water cycle that is planned to be fully-privatized in the upcoming years. Southern Europe countries are characterized by different political, cultural, economic and institutional behavior than the Netherlands where for example the drinking water market is dominated by Public Limited Companies acting as agents on behalf of the municipalities and provinces and the wastewater treatment market is dominated by the water boards. The companies involved in this research are working under different ownership and regulatory structures but under the same drinking water and wastewater standards as set by the European Union in 2000 (European Framework Directive, 2000/60).

Concluding, Water Cycle Systems are complex capital-intensive infrastructures as they depend on both social and technical operations. Therefore, the problem that rises is to take into account the changes in both sub-systems – social and technical – simultaneously and incorporate them in the strategic decision-making process about asset management. Based

on that and taking into account Vitens objective, of changing its asset management approach to long-term outcome oriented in line with the institutional environment, the problem definition is formed. In order to help Vitens reach its objective the external factors that are influencing and are included in the strategic decision-making process in the two companies under study are going to be analyzed.

1.2. Research Objective

The research object of this thesis are Water Cycle Systems working under different socio-technical environments. As they have been defined in the problem definition are the technical (drinking water and waste water) system and the environmental and physical systems directly related to the production of drinking water; the water use and the collection; purification and discharge of the waste water as well as the actors involved. The actors included are customers, regulators, asset owners and investors. As it mentioned already WCS should be operationalized as arrangements of multiple purposive actors and material artifacts interacting in ways that require analyzing the total system and not just the constituent subsystems. As a result of this interdependency, technology and social arrangements co-evolve and this should be taken into consideration.

The research objective of this thesis is to evaluate the impact that the socio-technical context has on the strategic decision-making process of a water company on the management of its assets. The external socio-technical system includes the elements that influence the organization and are reflected on the service provided by the WCS. The research objective will be reached by gaining insight on the external factors that are taken into account in the strategic decision-making on asset management in the two water companies under study (Aigües de Barcelona and EYDAP S.A.). Although, the two Water Cycle Systems under study are operating under different physical and institutional environments than Vitens but also from each other, it is important that utilities can learn from each other. Therefore, the strategic decision-making process of the two water companies is expected to be comprised by different external elements. The socio-technical context of the two companies is analyzed based on the elements of Physical Characteristics, Cultural Embeddedness, Institutional Arrangements and Governance Characteristics.

The final outcome from the analysis of the socio-technical environments that the companies in Spain and in Greece are making their decisions and their interrelation will be provided to Vitens in order to help the company reach its objective to improve its performance by taking into consideration the socio-technical context in its long-term asset management plan.

On this research the strategic decision-making approach it is considered to be:

- Characteristic of each organization
- Influenced by internal factors, such as the business objectives, vision, internal policies, mission, etc.
- Influenced by external factors:
 - Social elements, such as culture, ownership, regulations etc.
 - Physical-technical elements, such as climate, water resources availability, geology, etc.

The social and the physical-technical elements are forming the socio-technical context and are considered external factors in the decision-making process and are part of this research. The internal elements of the organizations are out of the scope of this thesis. The following Figure 2 shows schematically how Vitens goal is translated in this thesis research objective and

how the external socio-technical context is connected with the decision-making process.

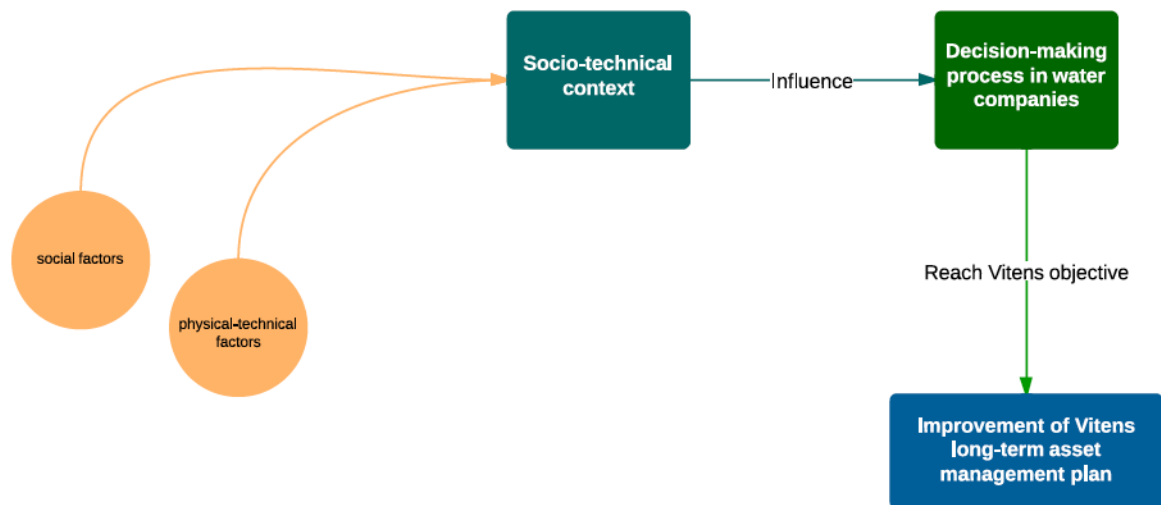


Figure 2: Research Objective of this thesis

1.3. Hypothesis and Research Questions

1.3.1. Hypothesis

By analyzing the two case studies in Spain and in Greece different forms of the water institutions will be illustrated. The type of ownership is a variable that has attracted much attention lately in the literature for the water market for privatization. Since the 1990s one can observe within the water sector a trend of governments to change the existing institutions by giving more importance to the private sector involvement and the use of market mechanisms. Before, governments were in many cases acting as both the responsible as well as the executing entity of service provision, but such has changed significantly in the last decades. It is hypothesized that publicly owned companies display a national style of management and national 'culture' in decision-making, while subsidiaries of multinationals represent an implanted (probably more 'sophisticated') decision-making style. Thus, it is of interest to test whether important differences can be detected.

The decision-making processes are expected to vary depending on the environment in which they are conducted since there are factors which managers cannot control but can influence business activity. Different ownership in water companies is one of these factors that is considered to influence the decision-making process. The companies under investigation as it is going to be illustrated in much more detail in the following sections are operating under different property rights since the one in Spain is a private drinking water company part of a multinational group, affiliated in the water sector all around the world, while the Greek company is recently partly privatized but still the biggest shares are owned by the government and there is a plan of its full privatization in the following years. Therefore, the case studies are suitable for the hypothesis. Finally, the hypothesis comes from the main objective of this research, which is to define whether water sector providers operating in a different institutional context have a different decision-making process.

1.3.2. Research Questions

In this section the central research questions and sub-questions are defined. The research

questions are based on the hypothesis and the objective of this research. A theoretical framework is used as a tool for answering the questions.

Main Research Questions:

The main research question is based on the impact that the socio-technical environment has on the strategic decision-making process of the two water companies under evaluation over the layout of the infrastructure. Also, on what extent the possible detected differences between the two case studies socio-technical context can explain differences in the strategic decision-making process of water services providers. The answer of the main research question will help in understanding on what extent external elements are taken into account in the strategic decision-making process and why specific external elements are more important than others.

1. What are the interrelations between the strategic decision-making process about asset management and the socio-technical context of the water companies under study (Aigües de Barcelona and EYDAP S.A.)?

It is hypothesized that the two water companies under study are expected to follow dissimilar strategic decision-making processes due to their different ownership regimes. Since one of the factors included in the socio-technical context is the ownership rights, by answering the main research question it will contribute to find whether the hypothesis is verified or not. So, a second main research question is formed coming from the hypothesis.

2. How the ownership rights influence the strategic decision-making process about asset management in water companies?

Furthermore, sub-questions are formed related to the elements that considered affecting the socio-technical context which are Physical Characteristics, Cultural Embeddedness, Institutional Arrangements and Governance Characteristics. A more specific description of the elements under evaluation is shown in Figure 3.

Sub-Questions:

5. What are the relevant elements of the **Physical Characteristics** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
6. What are the relevant elements of the **Cultural Embeddedness** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
7. What are the relevant elements of the **Institutional Arrangements** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?
8. What are the relevant elements of the **Governance Characteristics** that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

1.4. Approach and Outline of the Thesis

In this section the methods used for data collection and analysis are illustrated and explained in detail. The research object is the Water Cycle Systems of Barcelona and Athens and the

running environments. The process of the thesis started with the decision of which companies were going to be under evaluation. This thesis comes as a second part of the research that Vitens wants to do for the upgrade of the decision making process. The first part was the evaluation of the socio-technical environment that a water company in London operates.

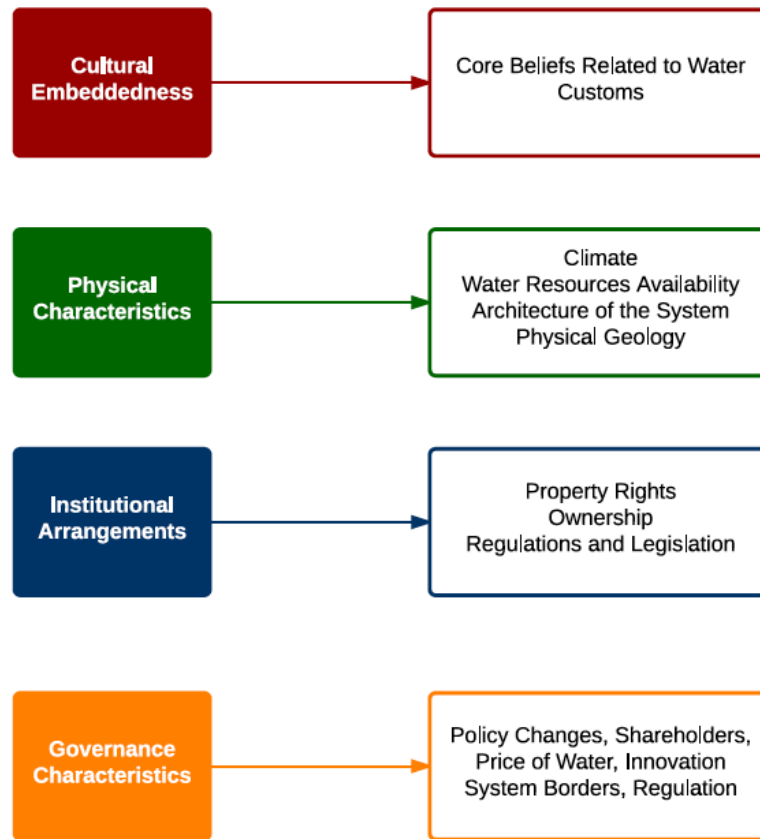


Figure 3: Elements under evaluation

Spain and more specifically the region of Metropolitan Area of Barcelona was selected as the case to represent the private sector involvement in the field of water supply management. A private company Aigües de Barcelona is in charge of the water supply in the region and at the same time is one of the main providers in Spain as it supplies around 25% of the population (836 municipalities) in the country. The comparative case from Greece features as an example of a recently semi-privatized managed model. In Athens, the most populated city in Greece, a state owned company has recently been restructured and partly privatized as the state floated 28% of the company to private shareholders. Further privatization may follow in view of the desired reduction of public deficit. Both countries have comparable economic, social, cultural and climatic conditions. Finally both companies are considered as large size companies according to the amount of customers they serve (around 4 million people).

After deciding on the case study water companies, connections were made in order to make sure that the employees of the visited companies were willing to contribute in this research. At the same time, a questionnaire was prepared. The questionnaire is based on the sub-questions defined before for gaining insight by collecting the necessary information for characterizing the socio-technical context of the two companies and in the end give and answer.

The theoretical framework to study the decision-making and development in this field is the institutional economy and performance management. Wherein institutions are seen as the driving factors to reduce costs and/or increase the performance. The interrelation and influence of the socio-technical context on the decision-making process is described by applying the theoretical framework based on Williamson's 4-layers approach. Williamson (2000) offered a useful model that allows treating different types of social and institutional arrangements in an integrated fashion. The approach can be expanded to model the technical and social sub-systems simultaneously. The theoretical framework used is based on the extended model and is going to be addressed in more detail in the following Chapter. The analysis is conducted by first describing the socio-technical context, and second characterizing the interrelation between the decision-making process and the external elements: Cultural Embeddedness, Physical Characteristics, Institutional Arrangements and Governance Characteristics. Each external element is characterized by different components that were examined in the analysis part. More specifically, the evaluated components are showed in Figure 3.

The final interrelation and influences defined are based on a combination of analysis from the interviews, literature based theories and research articles and official documents related to the water environment in Spain and in Greece. The analysis is based on organizing the data using the defined external elements and explanatory schemes to reveal the concepts and relationships.

1.4.1. Data Collection and Data Analysis

The institutional analysis of water service institutions in Spain and Greece has been identified and evaluated based on information obtained from structured in-person interviews and desk research. These interviews were conducted from the mid of July until the beginning of October 2013. Responders included employees of the two companies and academics in entities related to the water sector.

The interviews took approximately 60 minutes and the questions were pre-selected depending on the position of the participants and there were forwarded in advance with the research proposal of the thesis in order the interviewees to know the objective of this research. In most cases, the questions were used as a guideline and open questions or extra were used whenever it was necessary according to the topic discussed. A total of 8 people were interviewed and the list as well as the questions used is provided in Section 9.3.

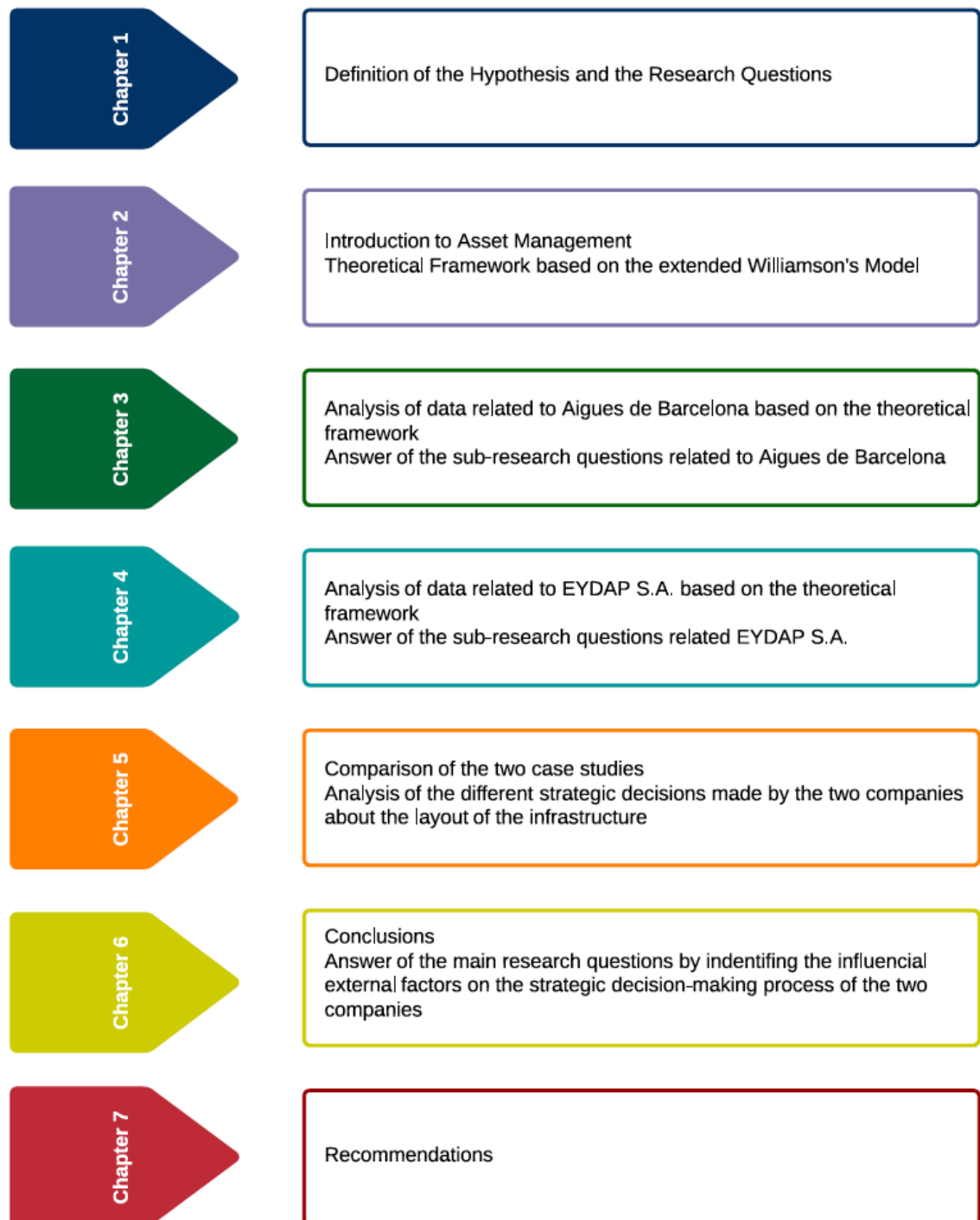
The main problems encountered during the interviews were employee's availability due to workload and confidentiality issues for providing more detail answers and documents mainly in the private company Aigües de Barcelona. Furthermore, since both companies weren't the sponsors of this research, no access was possible to the internal documents for verification. The information used as documented support come from public documents published on the companies' officials' websites such as year books; published articles in scientific journals and reports related to the water governance and regulation in Spain and Greece.

The analysis is structured in the following manner. A case description is provided from Spain and Greece. The first part is separated in the analytical description of the past and current situation of the two case studies by evaluating the internal and external elements of the social and technical-physical environments. In the second part the description shifts towards

the comparison of the two case studies in order to identify the similarities or differences in institutions and to which extend this explain differences in the decision-making process.

1.4.2. Thesis Outline

The research steps that have been taken in this study and the proceeding chapters are outlined below by a flow diagram.



CHAPTER 2

Theoretical Framework

2. Theoretical Framework

The objective of this chapter is to develop and analyze the theoretical framework that will work as a tool for giving an answer to the research questions. The framework has the purpose to show the interrelation and influence of the socio-technical context on the decision-making process.

The chapter is structured by first giving a brief introduction on the concepts of asset management and its application in different sectors and countries. Afterwards, the institutional theory that the theoretical framework is illustrated as well as the expanded institutional model that characterizes the social and the physical-technical environments related to the water sector. The four-layer theoretical framework that is been used is relevant as it distinguishes between different kinds of institutions. These institutions are different in a number of ways: for instance, with regard to the kind of things they address, the way they work and evolve, and the extent to which they can be influenced.

2.1. Introduction to Asset Management

The term 'asset management' first arose in the financial industry with its core component being the trade-off between risk and return. Investors identify acceptable risk, and asset management techniques are used to achieve this level of risk for the highest possible return (Brown and Humphrey 2005). The approaches, techniques and tools developed there have been adapted to suit asset management practices in other industries, such as electricity, gas and water. Brown and Humphrey (2005) chose to define asset management as "the art of balancing performance, cost and risk. Achieving this balance requires the alignment of corporate goals, management and technical decisions. It also requires the support from three pillars of competence: management, engineering and information"; this stresses that asset management is not a straightforward scientific discipline but a corporate strategy that involves many decisions and results in maximization of shareholder's value by meeting all performance, cost and risk constraints over the life-cycle of the physical assets (Figure 4).

The Institute of Asset Management (IAM) – professional institute based in the United Kingdom – defines asset management as "*systematic and coordinated activities and practices through which an organization optimally manages its assets, and their associated performance, risks and expenditures over their lifecycle for the purpose of achieving its organizational strategic plan*". The IAM developed the Publicly Available Specification (PAS) 55 for the optimized management of physical assets (IAM and BSI 2008). In spite of being a national standard in the UK, PAS 55 is considered the first internationally recognized specification and is broadly used in many countries and in various sectors such as highways, power infrastructures, roads, railways, and last but not least, urban water systems. One of the strong points of PAS 55 is that it aligns very well to a certified quality management system according to ISO 9001 (ISO 2008) (Velde, Klatter and Bakker 2013).

Drawing upon several different definitions, Alegre (2007) suggests that "*Asset Management is a multidimensional approach that may be defined as the corporate strategy and the*

corresponding planning and systematic and coordinated activities and practices through which an organization optimally manages its assets, and their associated performance, risks and expenditures over their lifecycle" (Figure 5). According to this definition, effective decision-making requires a comprehensive approach that ensures the desired performance at an acceptable risk level, taking into consideration the costs of building, operating, maintaining and disposing capital assets over their life cycles. The cube shown in Figure 5 is based on that and symbolizes an integrated infrastructure asset management approach. On the x-axis there are the three main pillars of competence as mentioned also by Brown and Humphrey (2005): business management, engineering and information. On the y-axis the different planning decisional levels are placed: a strategic level driven by long-term views; a tactical level where the best medium-term intervention solutions are selected; and an operational level, where the short-term actions are planned and implemented. Finally on the z-axis the dimensions of analysis are appointed. Therefore, in a long-term perspective service performance is kept adequate, risks incurred are acceptable and the corresponding costs are as low as feasible (Alegre and Coelho 2012).



Figure 4: Asset management is based on three functions (asset owner, asset manager and asset provider), a single process and many decisions, (Brown and Humphrey 2005)

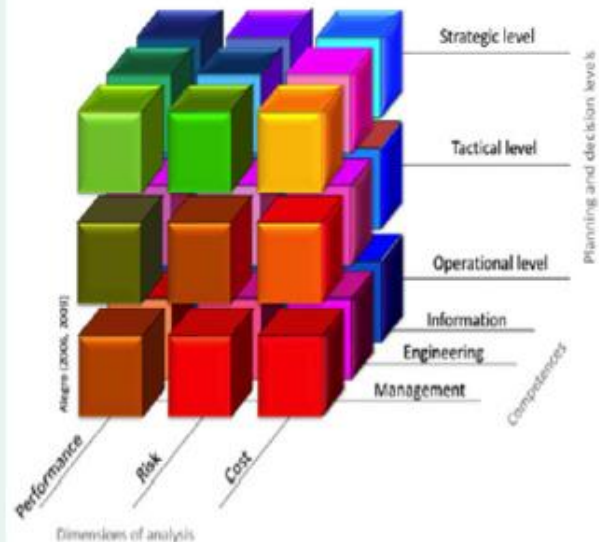


Figure 5: Infrastructure asset management as an integrated approach, (Alegre and Coelho 2012)

All the definitions about asset management have common characteristics and it can be concluded that it is located in the area where the technical, economic and process points of view overlap, Figure 6. Furthermore, the different definitions show that asset management is seen as the whole of activities an organization has to undertake for achieving its strategic plan. The assets should be managed in such a way for reaching this goal. In this view the physical assets are central to the operational success of the organization as by getting the most value from them can promote efficiency and public confidence.

Asset management is assumed as a single approach that is implemented differently in different industries. Its implementation differs in a number of ways and depends on the characteristics of the assets and the environment of the assets, in relation to the most relevant life-cycle phases and management of the organizations (Van der Lei, Wijnia and Herder 2012). Between others asset management considers and optimizes priorities upon

which an organization has to make decisions. These conflicts arise between short-term performance opportunities and long-term sustainability, asset utilization and asset care, capital investments (CAPEX) and operating expenditures (OPEX), (IAM and BSI 2008). This can be accomplished with asset management since as it is mentioned already from the different definitions; it considers life-cycle costs instead of only optimizing costs during a specific phase (e.g. initial costs, maintenance costs).

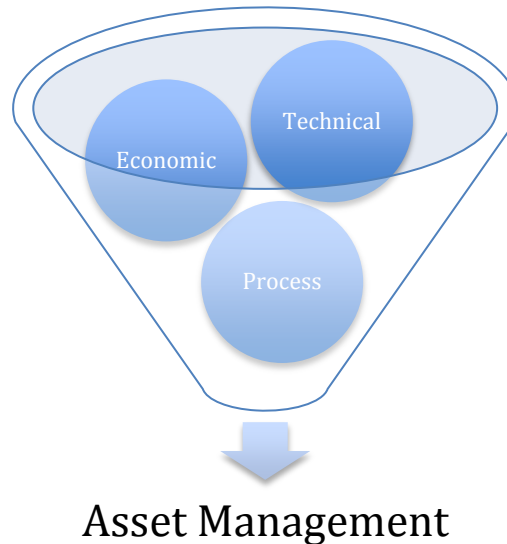


Figure 6: Important areas that asset management is located in by its definition

From an infrastructure perspective, asset management is often viewed as a framework to facilitate more informed decision-making. Applying a systems approach to the management of civil infrastructure is gaining acceptance within the infrastructure asset management field (Valencia, et al. 2011). However, when getting into details of the infrastructure system, it becomes clear that the total operation not only depends on the physical assets, but also on other elements, like information, systems, data, standards and procedures, employees, capabilities and culture. These elements are only to a certain extend independent to each other, but over time might influence each other. Therefore, it is better to speak of elements that are loosely coupled, instead of independent. Wijnia and Herder (2009) explicitly chose the metaphor of a mass-spring system, as it provokes the image of objects reverberating and exerting forces on other elements. The metaphor also demonstrates another characteristic asset managers are familiar with: you can increase the strain on the system to achieve a higher (financial) performance, but it either will come back at you in the future (for example, postponing maintenance and having to replace the asset in a few years because of irreparable damage) or have a (delayed) impact on the performance. Short-term financial gains can be achieved, but it is much more difficult to sustain them (Wijnia and Herder 2009).

Asset management decisions are based on policy goals and objectives. The companies establish policy goals and objectives to reflect the desired system condition and target level of service (Butenko, et al. 2007). All forms of management have an internal hierarchy of decision-making levels. The structured process inherent in most corporate systems aggregates information and generalizes the scope of decisions to be made higher in this hierarchy. There are various decision-making levels that represent different perspectives on the system, ranging from the very specific, detailed, project oriented views to generalized, comprehensive, strategic ones. Although asset management is mostly perceived as a

strategic level tool, it nevertheless affects – and can be equally successful as – lower levels of decision-making within an organization. The various decision-making levels are strongly interconnected. The decision-making levels do have, however, different scopes and require different data and information inputs in order for the process to be carried out effectively and efficient (Flintsch and Bryant 2009).

Asset management decision processes are the individual decisions that need to be made in every level of decision-making. Decision processes can therefore be concerned with budget allocation, network optimization, works programming, and selection of alternative implementation methods, among other things. As a result, the decisions at each level are different, as are the aggregation data level and the corresponding detail and quantity of the collected data. Higher levels require more generalized information whereas lower ones tend to need more detailed and specific data (Flintsch and Bryant 2009). A structured asset management system must be able to provide information about both the short-term and long-term impacts of allocating different amounts of resources among the organization's activities.

The strategic decision-making process that is based on reaching outputs and outcomes is developed on the basis of diverging requirements from different stakeholders, such as asset owners, local authorities, regulatory bodies and customers, and at different decision-levels within an organization. This procedure is a complex decision-making process that balances contradicting inputs with decision criteria (Nordgård, Solvang and Solum 2005). This procedure reaches higher level of complexity when decisions are considered in different planning timeframes (operational – short-term, tactical – medium-term and strategic – long-term).

2.2. Decision-Making and External Environment

Strategic decisions are highly complex and involve a host of dynamic variables. They are means by which perennially scarce resources are rationally committed to fulfill managerial expectations for success (E. F. Harrison 1996). In making a decision the decision maker has several alternatives and the choice involves a comparison between these alternatives and an evaluation of their respective outcomes. In this thesis a decision is defined as a moment, in an ongoing process of evaluating alternatives for meeting an objective, at which expectations about a particular course of action impel a decision maker to select that course of action most likely to result in attaining the objective (Eilon 1969).

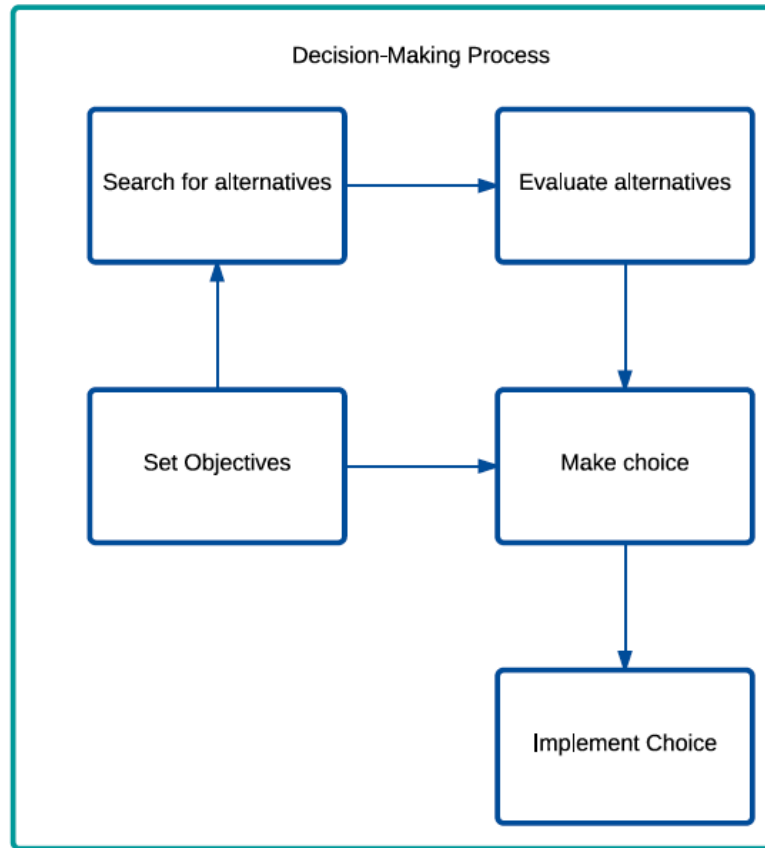


Figure 7: Definition of Decision-Making Process in this thesis

Strategic decisions are oriented towards the relationship between a given organization and its external environment. Information received from the external environment is used to link it with the strategic decision-making process in order to turn the weakness and threats of the uncertain and unknown external environment into opportunities and strengths for the organization (E. F. Harrison 1996). By using this information the objectives of the organization can be fulfilled or readjusted. The final outputs of the implemented strategic decisions can be used as a feedback from the external environment permitting management to assess the outcome of its choice and to take corrective action in the future. A successful strategic decision can be considered the one that results in the attainment of the objective that gave rise to the decision within the constraints that had to be observed to bring about such an attainment.

Asset management links the decision-making and action with information since it is about decision-making, rather than the blind pursuit of technical performance (Brown and Humphrey 2005). Decisions are driven by the actual condition and performance of assets individually and collectively as well as by the risks to corporate objectives from asset failure (Too 2010).

The purpose of this research is to give insight in the external environment. It can be said that it is positioned to link the external environment with the strategic decision-making on the layout of the infrastructure. In order to do this, specific strategic decisions taken influenced by the external environment are going to be evaluated. The following Figure 8 presents what the relation of the socio-technical context that represents factors like the institutional arrangements and the physical environment with the strategic decision-making process of an organization as defined in this thesis.

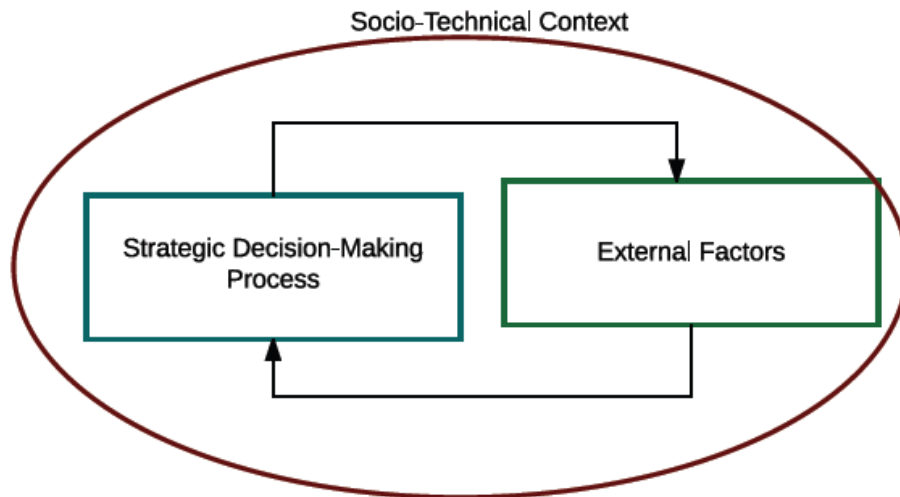


Figure 8: The link between strategic decision-making process and the external environment

The following section shows in detail the way that the external environment is going to be researched and what specific information is going to be needed to evaluate the strategic decision-making process.

2.3. Description of the Socio-technical Context

For the purpose of this chapter socio-technical systems will be operationalized as arrangements of multiple purposive actors and material artifacts interacting in ways that require analyzing the total system and not just the constituent subsystem. Each subsystem aims to meet its own objectives, by using its own means, but is also in an interdependent relation with other subsystems (Bauer and Herder 2009). The socio-technical context is defined as the external environment of the decision-making process in the water companies under study. As it is defined in Chapter 1, the water cycle systems under study are considered as complex socio-technical systems and it will be explored how this can be achieved by employing a socio-technical system's perspective, including technical as well as economic and social requirements.

A socio-technical system can be described using the technically enriched four-level institutional framework developed by Williamson (1998) to describe the economics of institutions. Williamson offered a useful model that allows treating different types of social and institutional arrangements in an integrated fashion. The four levels in this framework are analytically defined. In multi-layer systems, top-down and bottom-up causation interact: upper levels enable and impose constraints on lower levels and vice versa. The approach can be expanded to model the technical and social-subsystems simultaneously, as depicted in Table 1. The idea that needs to be coherence among the technical and institutional subsystems, (Finger, Groenewegen and Künneke 2005); (Jonker 2010), on all layers, in order for the whole system to function well, is reflected by the two columns.

Table 1: Layers and time scales in socio-technical systems, (Bauer and Herder 2009)

Time scale	Social Environment	Technical Environment
1. Embeddedness Changes 10^2 to 10^3 years often non – calculative	Informal institutions, customs, traditions, norms, religion	Informal conventions embedded in the technical artifacts
2. Institutional Environment Changes 10 to 10^2 years, institutional setting	Formal rules of the game (property, polity, judiciary, ...)	Technical standards, design conventions technological paradigms
3. Governance Changes 1 to 10 years design of efficient government regime	Play of the game (contracts, governance of transactions)	Protocols and routines governing operational decisions and (best available) technology
4. Operation and Maintenance Continuous adjustments	Prices, quantities incentives	Operational choices

Good asset management is based in both technically and institutionally aligned processes. It is based on thorough technical knowledge of the system and a conscious effort to embed that system into the social and institutional environment. More specifically, asset management takes place in layers 1 and 2 and to some extent on level 3. Thus, Williamson's framework will be used as tool to show how a system's perspective on infrastructure asset management, combining technical aspects with economic, social and institutional aspects, will help to understand what uncertainties and risks are present in complex infrastructure systems and how to cope with them.

Williamson's four-layer model falls within the evolutionary tradition of explaining institutional change and will help in understanding how the regulatory framework and the water infrastructures are related one another. Williamson's conceptual framework initially set out to illustrate the position of the New Institutional Economics within different levels of social analysis. According to Williamson the New Institutional Economics comes in two parts. Part one deals with the institutional environments – the rules of the game – and traces its origins to Ronald Coase's 1960 paper on "The Problem of Social Cost". Part two deals with the institutions of governance – the play of the game – and originates with Coase's 1937 paper on "The Nature of the Firm". The four-layer model is based on three criteria: main purpose, frequency of institutional change and level of analysis. More precisely, the framework contributes to understanding "why economic institutions have emerged in the way that they did and not otherwise" by offering a set of categorical variables (O. E. Williamson 1998). Williamson's framework is rather heuristic and aims to illustrate differences between different approaches in a quite general way. Hence, the main criteria are indicative and only aim to highlight some general differences. In reality it might not always be obvious how to operationalize these measures (Künneke 2007).

More specifically, the second column of Table 1 that corresponds to the social environment, Williamson distinguishes between four variables that represent different levels of analysis. In essence, these variables are informal institutions, the formal institutional environment, institutional arrangements and (market) behavior (O. Williamson 2000). From the way Williamson has arranged his framework it can be noted that he perceives structures as an institution that separates formal and informal institutions, and institutional arrangements.

The most upper level of institutions deals with the ***social embeddedness***, which means that economic and social behavior of actors is rooted in society. Values, broad beliefs, mores, norms etc. are located in this level. Mostly these institutions are informal and socially and culturally inherited through many generations (Künneke 2007). North further includes under informal constraints, sanctions, taboos, customs, traditions and codes of conduct (North 1991). These informal institutions are assumed to be stable with changes only occurring once every one hundred years, or even more slowly than that. Through continuous interactions with behaviors at the lower levels, this layer is shaped and molded, while at the same time functioning as a brake or anchor for the faster moving levels (Ghorbani, et al. 2010). As Künneke noted, these embedded values and norms are very deeply rooted in society and have a very pervasive influence on social and economic processes (Künneke 2007). In the same sense, Hofstede and Hofstede (2005) demonstrated that countries might differ fundamentally in values of uncertainty avoidance, individualism, or the relation to authority. At a certain point, certain norms are so embedded in a culture that specific rules are not necessary anymore (Hofstede and Hofstede, *Cultures and organizations: Software of the mind* 2005). From a water infrastructure perspective, the physical embeddedness (water and soil) provides constraints and enables lower layers in the social and technical subsystems.

On the second level, Williamson places the rules of the game. The relevant ***formal institutions*** comprise the polity, the judiciary and the bureaucracy of government. Here, “the laws regarding property rights – their definition and enforcement – are prominently featured” (O. E. Williamson 1998). These ‘economics of property rights’ theories provide important insights how formal rules influence economic behavior (Ghorbani, et al. 2010). In addition to international treaties, national laws and constitutions, other elements of the market design are determined within this layer. Often the rules that appear in this level are codified and the outcome of lengthy negotiations. The institutional design at this level is important to the economic productivity of an economy (as the focus is on economic incentives and opportunities for enforcing formal rules), however difficult to orchestrate because of the many different actors and interests involved, the complex nature of these formal institutions and the accompanying decision processes. The development of the European Union might serve as an example in this respect (Ghorbani, et al. 2010). According to Williamson, it needs a sharp break from established procedures – like civil wars, occupations, or financial crisis – whereby rare windows of opportunity are opened. Therefore the frequency of change of these formal institutions is estimated between ten and hundred years. At this level considering the technical subsystem, reflects tacit technical conceptions and prior design decisions (Bauer and Herder 2009).

Taking the formal legal arrangements of layer two as given, ***governance structures*** or the ***play of the game*** is the topic of the third layer. Thus, this level is concerned with how formal rules are translated or enforced and its implications for different outcomes. The need for a good governance structure arises particularly when there are unforeseen problems in the contractual obligations in which parties are involved (O. Williamson 2000). Such problems arise mainly due to two reasons: lack of foresight, and asymmetric information (Furubotn and

Richter 2005). Although the important role of the formal rules in the economic performance, a perfectly functioning legal system in order to enforce contracts is not contemplated. Within institutional arrangements actual regulatory instruments and decisions, firms' tariff structures and trading practices, forms of private-public cooperation and contracts are placed. Every one to ten years, one can observe the process of aligning governance structures with transactions (O. E. Williamson 1998). This is a rough estimation of the typical period in which governance structures like contracts, concessions, and joint ventures are renewed and/or changed (Künneke 2007). Level three is often referred to as transaction costs economics, which involves the economic rationale of various contractual arrangements and organizational structures. About the technical subsystem, decisions as to how the technical artifacts are designed are made. These include both the architecture of the physical systems as well as the control processes for these systems (Bauer and Herder 2009). The decisions related to the Water Cycle Systems are based on elements, such as water demand, technology, internal protocols and routines of the organization.

Finally level four is where the *individual actors* are positioned and where the actual economic outcome is located. The individual actors are assumed to be characterized by bounded rationality, possible opportunistic behavior, and a utility maximizing – and cost/effort minimizing – nature. As a result this level is characterized by interactions between actors with different objectives. Market strategies are chosen and deployed, lobbying comes into play, and buyers and sellers exchange goods. Actual behavior is circumscribed by the space offered by the market design and regulation. Here prices, quantities and investments are more or less continuously adjusted in response to changing (market) conditions. At the lowest level of the technical subsystem, continuous operational decisions are made in response to its state. The nature of these decisions is dependent on the specific technical system. These decisions may be taken by human agents and hence be directly linked to the social system, or they may be automated based on pre-specified routines and technical protocols. In the latter case, they are in-directly linked to the social system (Bauer and Herder 2009).

Williamson assumed that the main direction of influence was from the first level, where the beliefs and norms are located, downwards, feeding through to the forth level which describes economic performance. An implicit assumption is that while other causal relationship may arise, they will be less strong (O. E. Williamson 1998). "The basic causality in this model flows from the top towards the behavioral layer. But it should be clear that via processes of learning, lobbying, technical development and societal change in the broader sense, there is also an upward influence on the form and content of the basic values and beliefs " (Linde, et al. 2006).

Design decisions are in all levels. Although in the upper layers of the socio-technical system, deliberate design decisions become less prevalent and emergent characteristics become more important. Emergence refers here to lack of thorough system knowledge. Table 2 summarizes expected elements of design decisions that arise in the various layers. In the social domain, the combination of choices forms a particular institutional arrangement (or institutional design). In the technical domain one could refer to a specific technical arrangement (or artifact design). Taken together, social and technical design realizations form a highly differentiated and complicated socio-technical arrangement (socio-technical design) with corresponding unique performance characteristics (Bauer and Herder 2009).

Table 2: Socio-technical elements emerged in the external context for decisions on Asset Management in the water industry, (Bauer and Herder 2009)

Williamson		Social Environment WCS	Technical – physical Environment WCS
1. Cultural and Physical Embeddedness Time of change (10^2 to 10^3 years)	Informal institutions, customs, religion, traditions, (Sociology)	Anglo-Saxon's, Rhineland, Asiatic culture etc.	Climate, geo-hydrologic system, water availability
2. Institutional Arrangements Time of change ($10 - 10^2$ years) "First order economics"	Formal rules, property rights (Law)	Property rights (public, private Laws)	Architecture technical infrastructure, water rights, change in water use
3. Governance Time of change (1 – 10 years) "Second order economics"	Governance, contracts, permits (Economy)	➤ Policy changes, regulation, ➤ Technical standards ➤ Employees and management of the company ➤ Expectations of the customer, shareholder and stakeholders etc.	System borders (time, space and content) Supply Demand Balance
4. Operation and Management Time of change (<1 year) "Third order economics"	Resource Management	Daily operations (Out of research scope)	Daily operations (Out of research scope)

This research will use the Bauer and Herder multi-level framework to gather insight into the interrelations between strategic decision-making for asset management and the socio-technical context (Bauer and Herder 2009). The four-layer framework is relevant as presented in Table 2 as it distinguishes between different kinds of institutions and decisions taken at each level. At the lowest level 4, continuous operational decisions are being made in response to the technical status of the respective system; at the next higher level 3, decisions as to how these technical artifacts are designed and investment decisions are made; at the second level decisions pertaining to the institutional environment are made and lastly, and the highest level cannot be influenced by decisions – this layer shows emergent behavior and is a result of past decisions within the bottom three layers (Patil and Herder 2010).

Decisions at the 'Level 4: Operation and management' are not relevant for our study, as these decisions are focused on continuous adjustments and not in shaping the processes that produce new structures.

Based on the characteristics of each level four main categories will be used to evaluate the external context of the WCS in the two case study companies. These four categories are Physical Structure, Cultural Embeddedness, Institutional Arrangements and Governance Characteristics.

More precisely the four categories are based on the following components:

- ❖ The availability of the water resources is depended on the hydrologic system and the climate of the region in which the water infrastructure operates. The change in the availability of the water resources occurs in almost non-calculative timeframe. The **Physical Characteristics** will describe the region where the WCS operate.
- ❖ **Cultural Embeddedness** reflects the factors from informal actions and values that influence the decision-making process of the asset management in the WCS.
- ❖ Regulatory structures, arrangements and responsibilities, such as ownership, property rights, architecture of the system and regulations and legislations over the WCS are going to be analyzed in the **Institutional Arrangements** part.
- ❖ Finally, in the **Governance Characteristics** factors such as the price of water, the regulator interaction, the supply-demand balance and the systems borders are included.

Concluding, the external context of the decision-making process is constituted by these four groups. The elements indicated before are representative for evaluating the exogenous environment that affects the asset management system of the Water Cycle Systems under estimation. Thus, the external socio-technical context of Aigües de Barcelona and EYDAP is rated placed on a description of these factors. Figure 9 illustrates the elements of the socio-technical context and its interrelation with the decision-making process for the asset management of the physical assets.

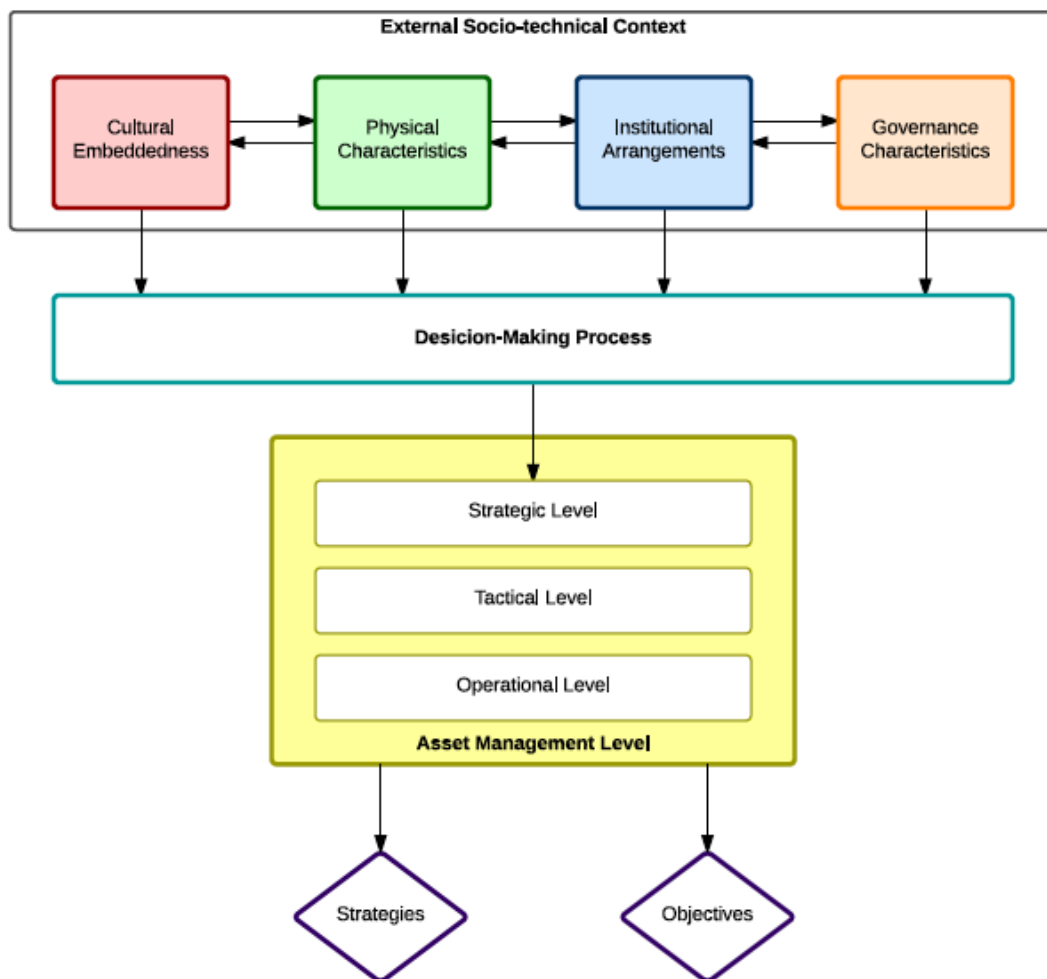


Figure 9: Theoretical Framework for the analysis of the interrelations and influences between the external socio-technical context and the decision-making process

To summarize, it is important to clarify that, from the perspective of an asset management system, the asset management strategies are considered as the tool to determine investments and activities in an efficient and effective way, as the strategy formed influences the investment planning for reaching the organization's strategic objectives. The external factors that constitute the socio-technical environment influence these decisions and as a result the development of the asset management plan. In that sense, the decision-maker does not have control over these factors, but does have control on the level of consideration within the decision-making process

2.4. Theoretical Framework – Summary

As it was illustrated already in the first section of this chapter, an asset management plan is a complex process to be developed and implemented. Although, asset management can follow different standards that have been evolved over the years by various organizations in order to standardize the process of asset management in the industries applied, its implementation relies on the asset manager and the decision-making process of each organization. Changes in any of the four categories defined in the previous section, influence the decision-making process and the development of asset management practices (strategies and objectives).

CHAPTER 3

Case study: Aigües de Barcelona

3. Analysis of the Socio-Technical Context in Aigües de Barcelona

The socio-technical context that is considered influential for the decision-making process of Aigües de Barcelona is analyzed in this chapter. The objective of this chapter is to answer the sub-research questions:

What are the relevant elements of the Physical Characteristics that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona?

What are the relevant elements of the Cultural Embeddedness that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona?

What are the relevant elements of the Institutional Arrangements that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona?

What are the relevant elements of the Governance Characteristics that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona?

The analysis of the external elements influencing the decision-making process starts with the description of the physical characteristics of the area in which the area operates in and its responsibilities. The second part is constituted by the description of the cultural embeddedness factors in Section 3.3. Furthermore, the Institutional Arrangements are analyzed. The main actors involved; the regulations and legislations for the water sector in Spain and in Catalonia and the water rights are described. Finally, the governance characteristics that include the price of water; the expectations of the customers, shareholders and stakeholders; and the ownership structure of the company are illustrated. The chapter will conclude by answering the above sub-questions.

3.1. Introduction

Droughts, quality issues and urbanization of the city have been the main key drivers to understand the current situation of the water supply system in the Metropolitan Area of Barcelona. The city represents a peculiar case of very early privatization, since the water cycle has been managed by the private operators and mainly by the Societat General d'Aigües de Barcelona (later known as Agbar) for 150 years.

3.2. Description of the Physical Characteristics

Aigües de Barcelona is responsible for the water supply in the urban Barcelona, which extends covers 635 km² and has a population of 4.5 million, accounting for approximately 44% of the population in Catalonia. The city, as well as its urban area (referred to as

Metropolitan Area of Barcelona, MAB), draws its water supply from the Ter and Llobregat Rivers. These two rivers have a combined reservoir capacity of $612 \times 10^6 \text{ m}^3$. The surface water constitutes around the 85% of the total water supplied in MAB, while the last 15% of the water comes from sea water and groundwater resources (Raich-Montiu, et al. 2014).

The water cycle in the Metropolitan Area of Barcelona follows a typical Mediterranean pattern: long, dry periods during the summer season but extending also throughout the year, and short, heavy rainfall episodes in autumn and spring producing important flash flood episodes. Thus climate constrains water availability in the MAB in important ways despite efforts in increasing the quantity of regulated water. Residential water demand constitutes some 60% of total water demand in the region. At the end of the 1990s, the average balance between water supply and water demand was in equilibrium but a succession of dry years has stressed the system to the point that new management alternatives (be these the increase of supply via conventional or alternative means or the reduction of demand via water conservation) need to be explored.

Metropolitan Area of Barcelona is formed by Barcelona and 26 other municipalities and represents a territorial entity with important executive powers regarding water management. In Figure 10 the area is separated in three regions: 1) the Barcelona country 2) cities outside this country and with a population greater than 50,000, and 3) the rest of the region. The first two units roughly represent the “compact city” whereas the latter is the “diffuse city”. In recent decades, and as in many other Mediterranean cities, important economic, social and territorial changes have occurred within the MAB. These changes have stimulated (and have been stimulated by) the dynamics of de-concentration of population, jobs and economic activity in general. Residential mobility, in particular, has been intense with people moving from the denser metropolitan core and partially from the first periphery to the second periphery (Domene and Saurí 2006). This is a major driving force for the future of the residential water sector since the change in the urban form towards a greater presence of low-density housing may produce an increase in residential water consumption (Monica 2002).

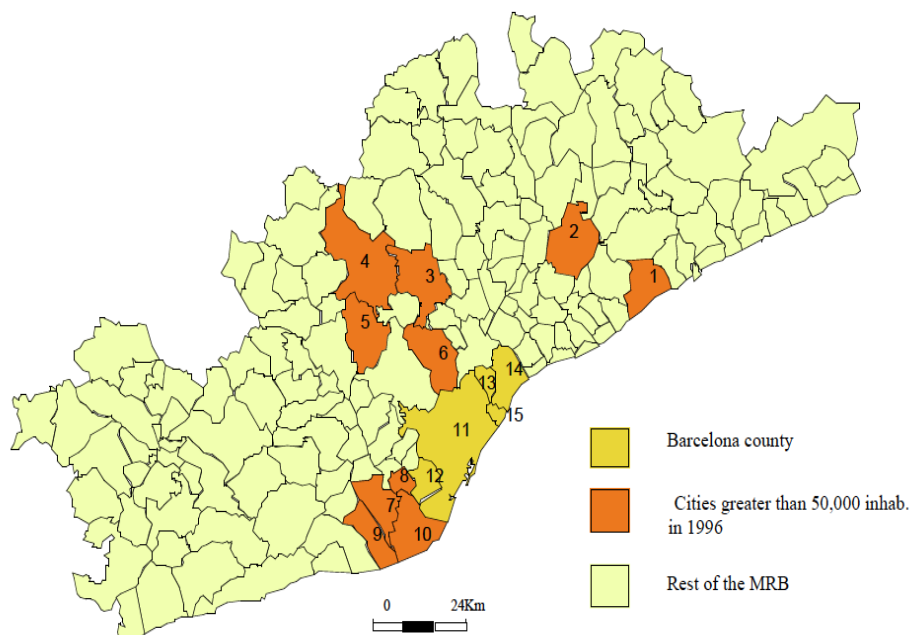


Figure 10: The Metropolitan Area of Barcelona, (Saurí 2003)

The biggest distribution company in the area is Aigües de Barcelona, a holding company for a number of different companies operating in the water industry, providing water to 23 municipalities and contributing 87.3 percent of total supply to the urban area of Barcelona. Aigües de Barcelona, a company of the Agbar group, is the retail water supplier that operates in the city (CETaqua and Fife-Schaw 2010). The rest of the municipalities are supplied either by public water suppliers or by other private companies that do not belong in the Agbar Group. Until recently Aigües de Barcelona was responsible only for the water supply in the city, but after the 21st of May 2013 the company will operate all retail sewerage and wastewater services in the MAB. Based on a valuation of the joint companies assets a new company was formed with the name "Aigües de Barcelona, Empresa Metropolitana de Gestio del Cicle Integral de l'Aigua"³ which integrates the current services of water provision or home water supply, the public sanitation in 'alta'⁴ and the waste water purification and also includes the regeneration service of waste water for other uses (Aigües de Barcelona 2013).

The new company is a public-private collaboration between Aigües de Barcelona that will have the 85% of the joint company and the public company Empresa Metropolitana de Sanejament, S.A.⁵ (EMSSA) will retain the rest of the 15% of the shares. The new company will be in charge of the whole water cycle in the area until 2047 (Aigües de Barcelona 2013).

The map in Figure 11 shows the operational area of the 23 municipalities that Aigües de Barcelona serves with drinking water while Figure 12 shows the operational area of the new joint company.

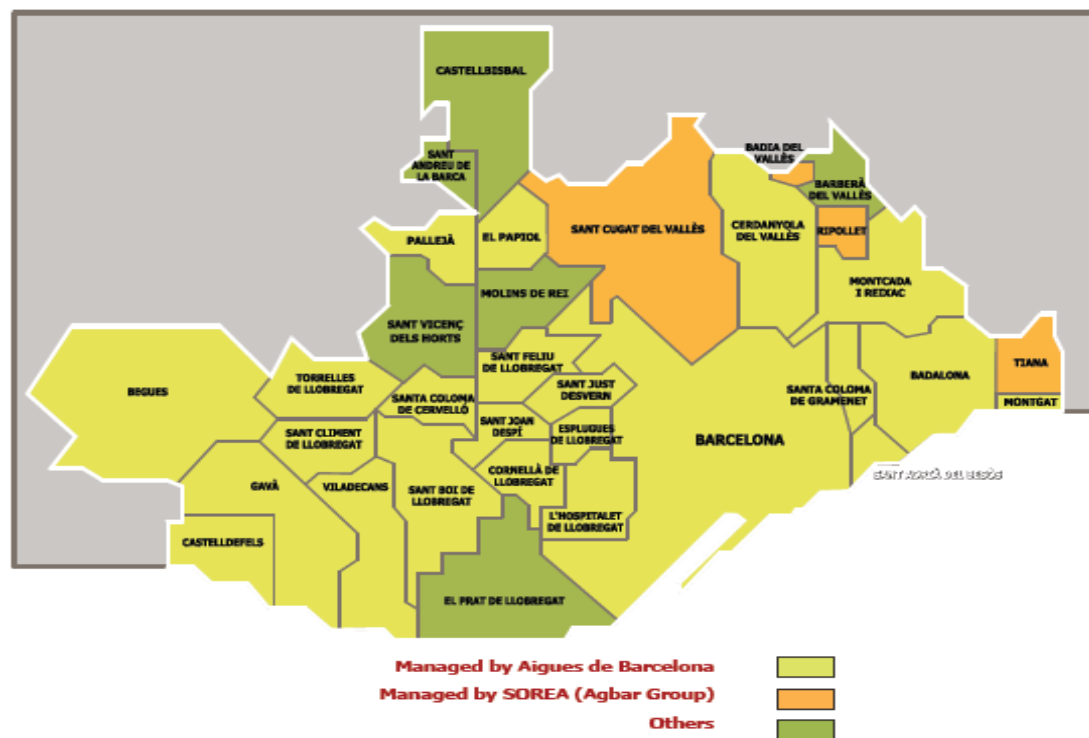


Figure 11: Municipalities served drinking water by Aigües de Barcelona and other retailers, (Aigües de Barcelona 2009)

3 English: "Aigües de Barcelona, Metropolitan Company for the Management of the Integrated Water Cycle"

4 Alta, which could be translated as 'high', is the part of the water cycle going from the water extraction, i.e. in the river, to the city tank.

5 English: "Metropolitan Company for Sanitation, SA"

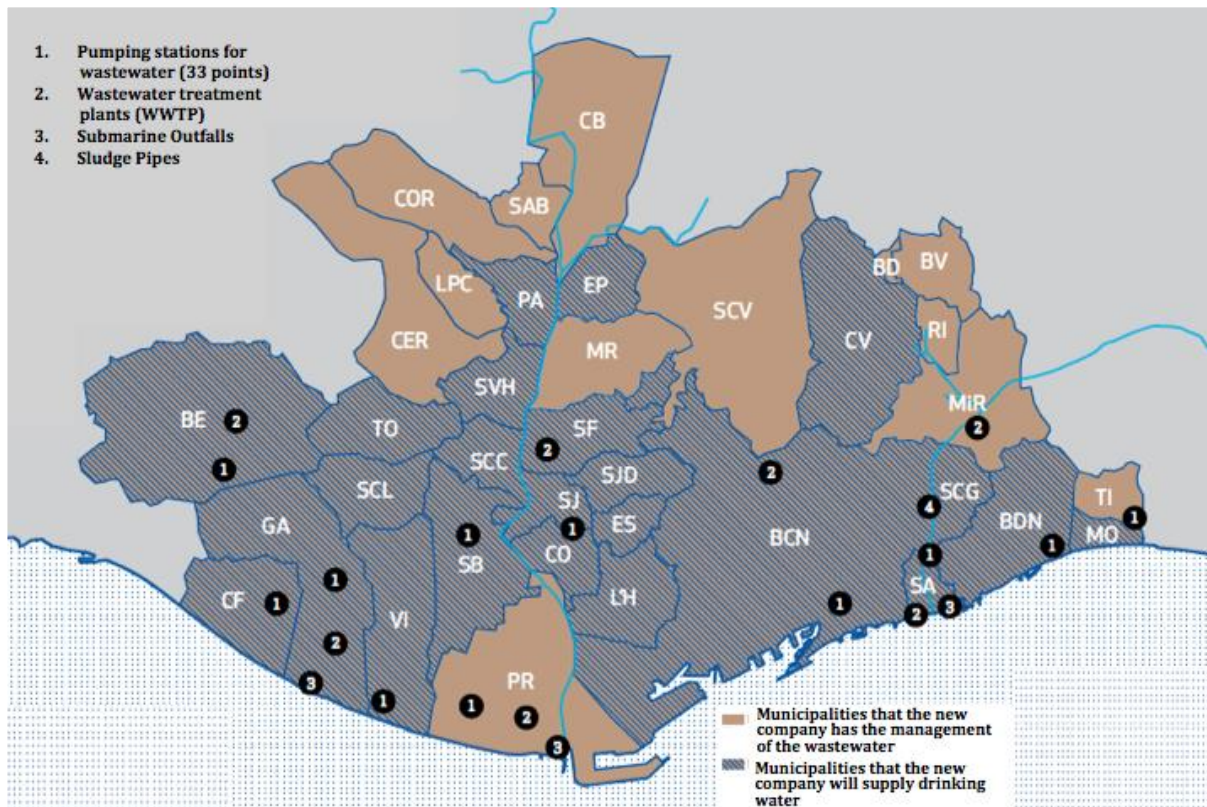


Figure 12: Municipalities served by the new company responsible for the whole water cycle, (Aigües de Barcelona 2013)

Water quality problems were always a big issue in the Metropolitan Area of Barcelona. High salinity content, including halogenate ions (bromide and iodide), combined with the presence of dissolved organic matter and chlorination induces the formation of trihalomethanes (THMs), with concentrations close to the legislated values in the surface water of Llobregat river (Raich-Montiu, et al. 2014). In addition to this at the upstream point, the river receives effluents from industrial and urban wastewater treatment plants, as well as pollution from agricultural and mining activities. This has a big effect in the water consumption, since by 2000 almost half of the population did not drink tap water because of its bad taste. Consequently, new infrastructure was built to improve the drinking water quality and to ensure the availability of the resources in recent years. Furthermore, high levels of pollution in the main groundwater source turned useless most of it, but because of the need for extra water resources the quality of the water is being reclaimed.

3.2.1. Influences of the Architecture of the system

The Metropolitan Area of Barcelona has an historical lack of water resources to ensure a permanent guarantee of water supply. Additionally there is a quality problem due to the high hardness and salinity, coming from the salt mines. Finally the lack of flexibility in the distribution network has not facilitated the optimization of resources management in Ter and Llobregat basins (Sanz and Miguel 2013).

The water supplied to the MAB comes from two main origins: the Ter and the Llobregat rivers with a ratio of 35/65. The description of the supply is illustrated in Figure 13 and is analyzed in more detail in the following sections.

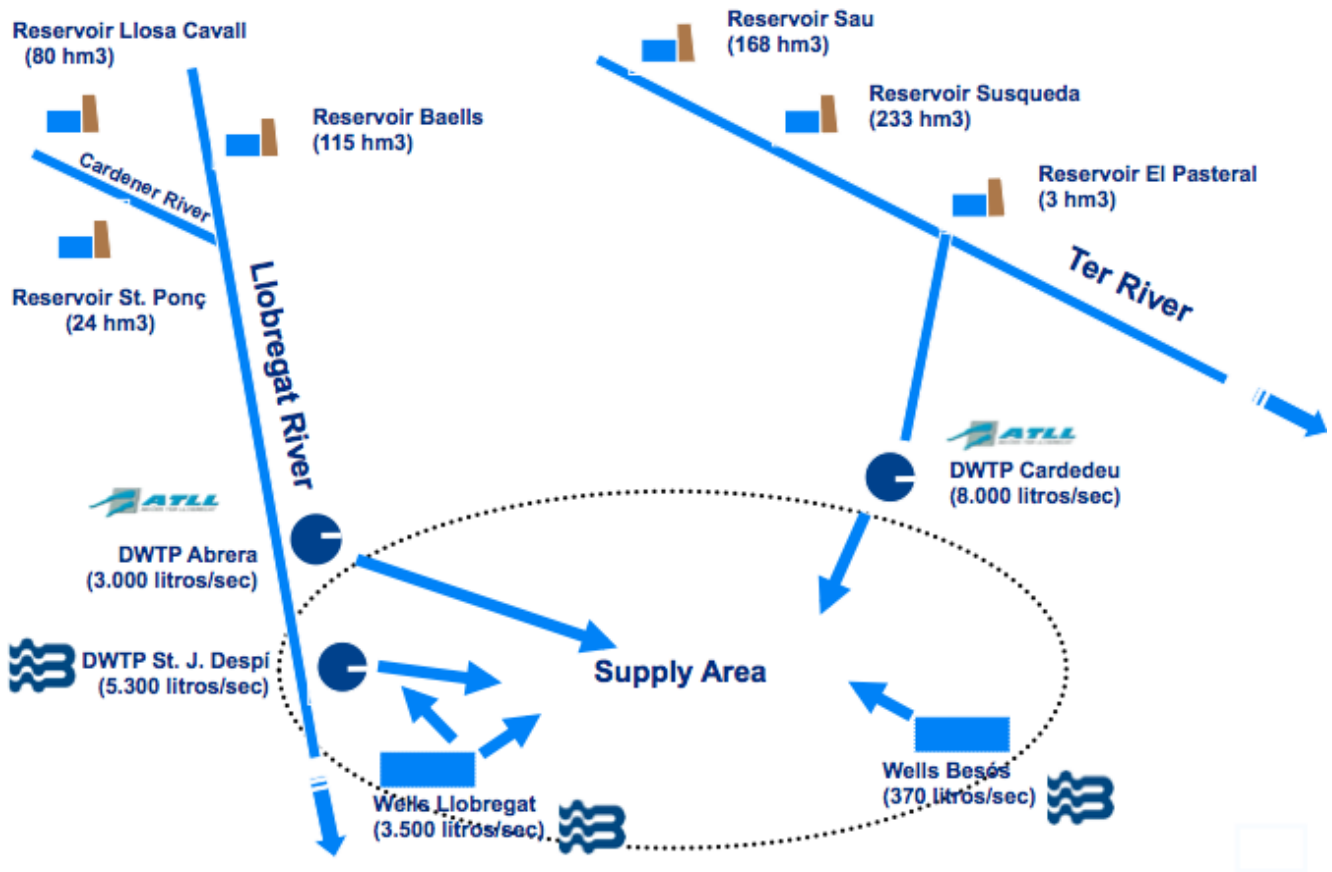


Figure 13: Water Supply Overview before the desalinization plant, (Aigües de Barcelona 2009)

3.2.2. Description of the water resources system

The drinking water in the distribution network system (WDS) of Barcelona is distributed by Aigües de Barcelona in Barcelona city and 22 municipalities. Until 1954, water consumed in the city of Barcelona came from the groundwater of the nearby Besòs and Llobregat river valleys. The Besòs catchment area was the traditional source of supply from Roman times until the beginning of the twentieth century, when the first wells in the Llobregat area were opened. The gradual growth of the demand made the water resources used until then insufficient and Aigües de Barcelona started thinking of the necessity of extending them with the use of the surface water of the same Llobregat River. For that reason, in 1953 a first concession of 2.2 m³/s was requested, which was later extended to 5.3 m³/s of the present concession (Aigües de Barcelona, 2014). In 1955, the first surface water intake was inaugurated in the town of Sant Joan Despí, on the Llobregat river. Despite the new water supplies from the Llobregat, the constant growth in water demand together with some drought periods encouraged again both public powers and the Aigües de Barcelona to search for additional solutions to the problem of water supply.

One of the most important proposals was the plan to bring water from the Ter River. The company took an active role in planning and offered their services not only to manage local supplies but also to build the infrastructure to provide bulk water supply. In 1965 the municipality and Aigües de Barcelona sealed an important agreement by which the latter would distribute across Barcelona the water coming from the Ter River and the water supply network grew to incorporate the inter-basin transfer, some 100 km north of Barcelona. Later, an increase in the regulation of the Llobregat River enhanced surface water supplies by the reservoir of La Baells, since 1976, and the smaller reservoirs of Sant Ponç, and La Llosa de

Cavall, since the 1990s, shown in Figure 13. The decrease in consumption brought about by the crises of the 1970s permitted to leave unused the groundwater from the Llobregat and Besòs reserved for emergency situations. However, the high levels of pollution of the Besòs basin turned useless much of its groundwater. By the end of the 1980s the aquifer of the Llobregat delta was in a poor situation, due to the years of overexploitation and the subsequent problems of saline intrusion or pollution from all type of discharges. Then it was just used for emergency when Llobregat waters were too polluted. However, even until now the different raw water sources show great physicochemical differences in the water quality before and after treatment processes. Another possible cause of variation in the water quality is due to the different treatment processes implemented (Platikanov, et al. 2011). Brief description of the different processes that are used in the three water treatment plants are:

- *Sant Joan Despí water treatment plant:* this facility treats water from the Llobregat River. At that point the river has received effluents from industrial and urban wastewater treatment plants, as well as pollution from agricultural and mining activities. The high anthropogenic influence on the water quality made it necessary to add an ozone treatment to remove several organic and inorganic compounds that cannot be efficiently removed with the more common treatments. The plant has a maximum treatment capacity of 5.5 m³/s, and provides almost 50% of the annual drinking water in MAB. The improvement in water quality achieved has been noted as an important improvement on the physicochemical parameters and a decrease in the trihalomethanes (THMs) concentration.
- *Abrera water treatment plant:* treats water from the Llobregat River and up-stream of the Sant Joan Despí treatment plant. It has a maximum treatment capacity of 4.3 m³/s. Except from the conventional treatment line a reverse electrodialysis step has been added in order to reduce the saline context and the formation of THMs. Origin of sources are 75% river water and 25% groundwater.
- *Cardedeu water treatment plant:* this facility treats water from the Ter River after it has been transported to the plant through a pipe originating at the Pastoral dam. This plant has a maximum treatment capacity of 8 m³/s and utilizes conventional treatment process (Raich-Montiu, et al. 2014).

Llobregat River is a typical Mediterranean River, highly dependent on climatic conditions and the seasonality of precipitation. The river emerges in the Eastern Pyrenees in North West of Catalonia (Spain), at 1,400 m of altitude and flows during approximately 160 km coming into the Mediterranean Sea, 10 km south of the city of Barcelona. The average discharge near the river mouth reaches 700×10^6 m³/yr, representing around 20% of the total rainfall. Due to the seasonal variability of the rainfall, only a fraction can be used to satisfy the demand, which is controlled by the reservoirs near the headwaters and the river base flow downstream. There are three reservoirs in the basin, which are crucial for the water supply. The basin also contains five aquifers, two of which are located in the upstream part of the basin and the other three connected to the river in its downstream part. Upstream aquifers regulate river flow, whilst downstream aquifers are used for supply and as strategic reservoirs in case of drought (Pouget, et al. 2012).

Cardener and Anoia Rivers are the main tributaries of Llobregat River. In the lower medium course of the Llobregat and Cardener Rivers there is an important concentration of industries, agricultural activities and densely populated areas with important demands of water. On the

other hand, Anoia River is mainly influenced by agricultural area (vineyards) and industries. During summer the flow can decrease considerably leading to a worse water quality due to the increase of effluent wastewaters in the total flow of the river. This river is also characterized by the salinity from salt mines located in the upper course of the river and from the geological formation present in the basin. Although in nineties a brine collector was built with the aim of collecting the mining lixiviates, the salinity problems in the Llobregat River Basin were not totally solved (González, López-Roldán and Cortina 2012). To improve the water quality of Llobregat River and its tributaries more than 30 Wastewater Treatment Plants (WWTPs) treating a mixture of urban or industrial wastewaters have been set up along the river. The main industries sited along the Llobregat River are tannery, food products, textile, pulp and paper industries discharging a broad spectrum of organic chemicals to the river. Therefore the river receives effluents from these WWTPs and surface runoff from agricultural areas.

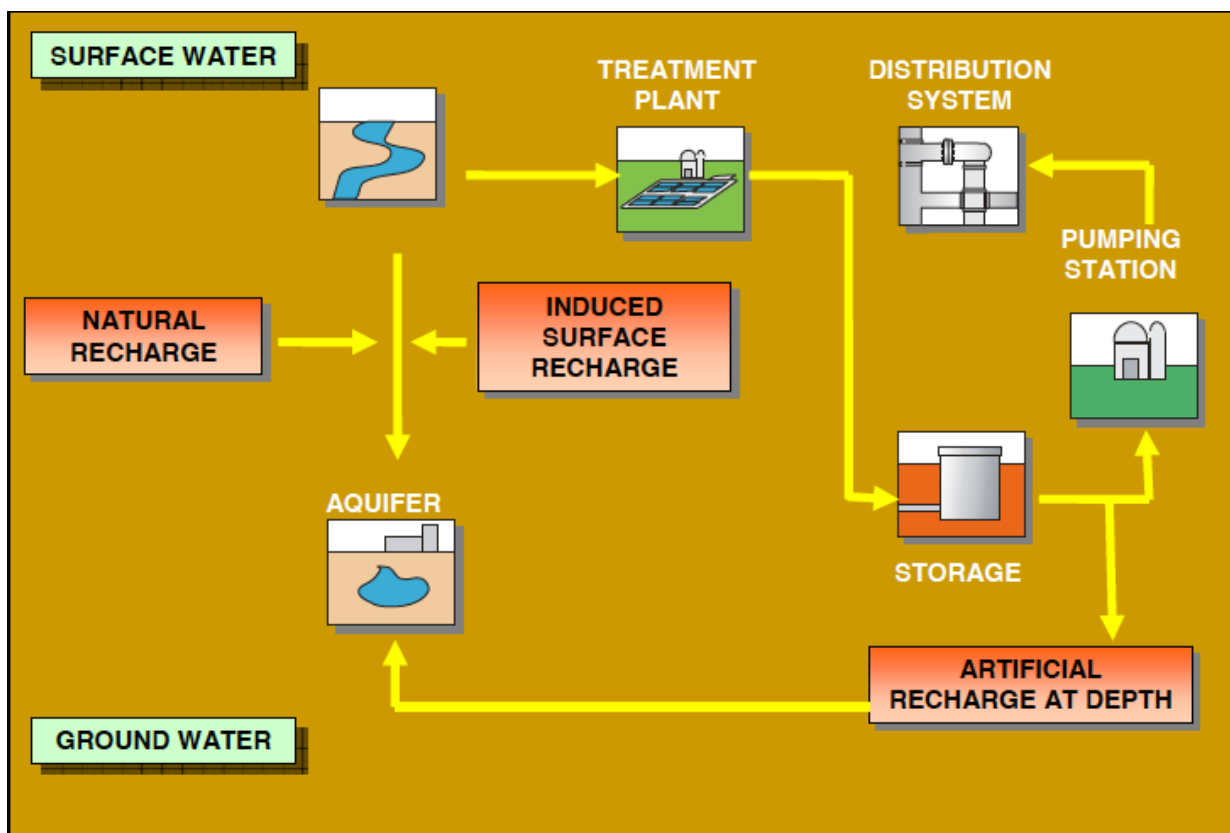


Figure 14: Simultaneous use of ground and surface water and artificial recharge, (Cortés 2012)

Aigües de Barcelona uses with priority the surface resources from the Llobregat River, maintaining a strategic reserve for the groundwater resources. In case of problems in quality or quantity of the surface water, they can capture up to 25,000 m³/day of groundwater, which represents more than 30% of the average daily demand for the supplied area. For this reason, the groundwater resources of the Llobregat River are of vital importance without which the city of Barcelona and the Metropolitan Area could have serious supply problems. In times of drought, the groundwater can satisfy up to 20% from the total demand. Taking into account these data, Aigües de Barcelona has been carrying out operations of artificial recharge of these valuable aquifers in the Llobregat River for more than thirty years. Their main objective is to provide good quality groundwater as an alternative to the surface water. The joint exploitation of the resources has enabled the extraction of up to 30* 10⁶ m³ of groundwater in dry years and the net recharge up to 7* 10⁶ m³ in wet years (Recharga,

Luque Montilla). The artificial recharge process and the concurrent use of ground and surface water are presented in Figure 14, (Cortés 2012).

Another alternative source of water gained momentum due to the drought period of 2008 is groundwater from the Barcelona subway network. Though not drinkable, since 2005 it had been used for public purposes such as watering public gardens or street cleansing. The remainder water was diverted to the sewer system and to the Besòs to increase the environmental flow of this river, as an example of how a river could be 'artificially' improved to restore its 'natural' characteristics.

3.2.3. Non – conventional water sources

As it has been mentioned before the extensive exploitation of the Llobregat River as a water source for urban, industrial and agricultural uses, high population density of the Metropolitan Area, and the water quality deterioration of the Llobregat River, have resulted in qualitative and quantitative water deficits in most of the areas supplied from that water source. Two main actions that have been implemented to correct the overall water scarcity:

1. Operation of the Water Reclamation Plant of El Prat de Llobregat to provide $50 * 10^6$ m³/year, since 2006;
2. Construction of a Seawater-Desalination Plant, completed in 2009.

3.2.3.1. Reclaimed Water

Since 2006, the Water Reclamation Plant (WRP) of El Prat de Llobregat has been using biologically treated secondary effluent from El Prat de Llobregat Wastewater treatment plant to produce reclaimed water. By the end of 2010, it had contributed $67.8 * 10^6$ m³ of reclaimed water, saving an equivalent volume of surface and groundwater that has been made available for the exclusive use of human consumption (Mujeriego, et al. 2008). Since its start-up, the WRP of el Prat de Llobregat has been operated by EMSSA, a MAB's public company responsible for wastewater treatment and water reclamation and reuse.

The project started in 2002 with the objective of producing $50 * 10^6$ m³/year of reclaimed water with quality levels suitable for different beneficial uses:

- a. In-stream river flow substitution,
- b. Restoration of natural wetland areas,
- c. Alternative supply for agricultural irrigation and
- d. Supply of high quality water for injection into a seawater intrusion barrier.

All water demands are seasonal, but they are satisfied on a regular basis during the summer period, except the seawater intrusion barrier water supply that is satisfied on a permanent basis (Gullón 2011).

Although Spain had no official limits for reclaimed water quality in 2003, when the project was initially approved, and in 2006, when the Water Reuse Project began, the Catalan Water Agency had developed quality criteria for reclaimed water suitable to different uses; those criteria covered a range of qualities including the limits established by Title 22 of the California Water Code, the water reuse criteria proposed by the US Environmental Protection Agency in 2004, and the health guidelines recommended by the World Health Organization in 1998. Since 2007, Spanish regulation RD 1620/2007 defines the quality requirements for reclaimed water suitable for a diversity of uses (Mujeriego, et al. 2008).

3.2.3.2. Llobregat Seawater Desalination Plant

Barcelona-Llobregat Desalination Plant is actually the largest seawater desalination plant in Europe producing potable water from the seawater of the Mediterranean Sea. The plant is

able to supply approximately the 20% of tap water of Barcelona Metropolitan area having a maximum capacity of 200,000 m³/day. This project was developed by Aigües Ter-Llobregat (ATLL), to face the lack of water resources and to improve the water quality in Barcelona's south area. A Joint Venture (JV) of three companies, Degrémont, Aigües de Barcelona and Dragados Drace built the plant during a severe drought period in a extremely tight delivery time of 24 months. The plant was inaugurated on July 2009 and from this date the same JV is operating it. The desalination plant has been taken as a new dam; it will be a complement to the rest of the dams. The re-mineralized water is introduced to the MAB distribution system after being mixed in a reservoir with water from the drinking water plants in the Llobregat River. In the first months of its operation the was running from 10% to 50%, but from April 2010 the plant is running at minimum production since the year 2010 and the beginning of 2011 were very rainy (Sanz and Miguel 2013). In Figure 15 there is an overview of the amounts of water from the different origins as well as the responsible company for the treatment of the water.

Amounts of water treated and distributed by Aigües de Barcelona:

- 10% from wells in the Llobregat aquifer
- 37% from the Sant Joan Despí ETAP
- 2% from wells in the Besòs aquifer

Total 49%

Water treated by ATLL and afterwards bought by Aigües de Barcelona in order to meet the overall supply:

- 5% from Abrera ETAP (in Llobregat river)
- 23.6% from Cardedeu ETAP (in Ter river)
- 22.4% Desalinization plant

Total 51%

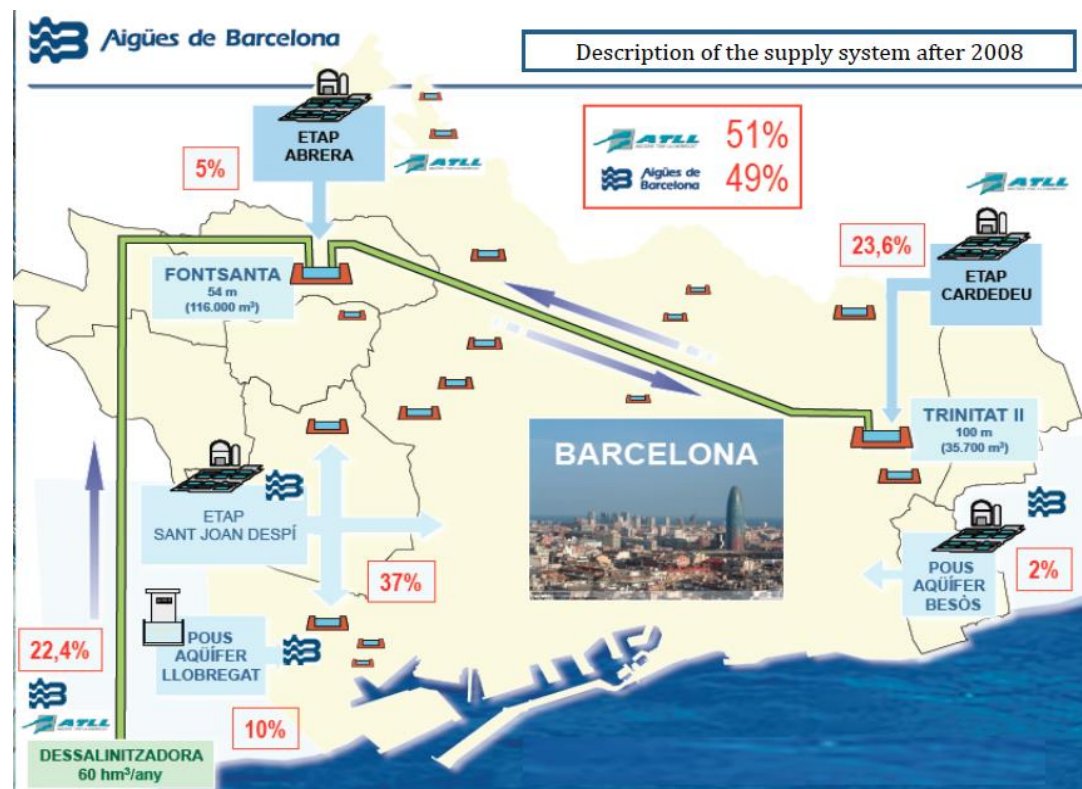


Figure 15: Description of the water supply system, after the incorporation of the desalinization plant in 2008, (Aigües de Barcelona 2009)

3.2.4. Distribution Network

The water delivered to the unitary distribution system in the area of Barcelona must reach all the customers with the adequate conditions of quality and quantity. For that reason, the pressure available at all the delivery points must be enough but it cannot be too high in order to make good use of it. The distribution system in the area of Barcelona has quite an irregular orography, from the wide plane level with the sea until the most peripheral areas of the Collserola Mountain with a maximum height 515 m on the sea level. This has forced to the implementation of 78 subsystems, called floors of distribution, which are piping systems in a defined territorial field that normally have a regulating tank, which establishes the piezometric level of the water supply and in many cases, furnish water to other subsystems.

The necessary infrastructures to give service to all the territory with an extension of 425 m², are composed of more than 4,200 km of piping system, with diameters between 40 mm and 2,000 mm; more than 100 tanks with capacities from 10 m³ the smallest, until the 60,000 m³; pumping stations, with elevating groups and regulator valves which allow the adjustment of pressures and water conveyance among subsystems.

The upstream supply systems in Catalonia lose between 2% and 4% of the flow transported, values that are close to the acceptable technical minimums. It is estimated that leaks in municipal distribution systems lead to the loss of between 5% and 7% on average for the well maintained systems, while in some specific cases the difference between the volume billed and that supplied may be greater and up to 20% or 25%. This difference is the result of other reasons, such as unregistered usage, under metering, fraud etc. The higher percentage of loss is a result of the fact that municipal networks are normally longer, older, and operate at a working pressure, which tends to cause greater losses. Improvement work is underway in order to reduce such losses in the transportation and distribution of water to a minimum (Agència Catalana de l'Aigua 2008).

3.2.5. The performance control of the distribution system

The knowledge of the hydraulic performance of the supply water system and its improvement in time is for Aigües de Barcelona is a constant concern. The objective is double: on the one hand, to improve the exploitation costs decreasing the volume of produced water and, on the other hand, to remove the unnecessary charges of a scarce good such as water. The performance evaluation is carried out through the Integral flow method and its evolution as well as the actions to take for its improvement are periodically analyzed by the System Performance Committee.

The most common way to measure losses is through the difference between the volume of water delivered to the system and the volume invoiced to users. However, and given the erroneous interpretations which are often made, it is to highlight that the main component of the water supply system losses is the under-measurement of the customers' meters which because of a lack of sensitivity of small flows, do not measure correctly no deliberate consumptions due to losses in the inner facilities (tap dripping, losses in the toilet and others). Other components, usually considered as losses but which really are not, are due to proper consumptions and uncontrolled ones carried out by third people, as works in the public way, cleaning of sewer systems, frauds and others. Finally, there are losses in the strict sense, which consist of the volume lost by the lack of tightness of the distribution facilities (leaks in pipes, tanks, elevation facilities, valves and other facilities).

The actions carried out by Aigües de Barcelona systematically to improve the performance are:

- Leak exploration
- Renewal of pipes and branches
- Renewal of the meter park
- Installation of meters with a greater measurement sensitivity
- Maintenance of tanks
- Inspection of inner installations
- Pressure regulation
- Sectorization of the distribution system and night flow analysis
- Campaigns of frauds detection

The network has a centralized tele-control system, organized in a two level architecture. At the upper level, a supervisory control system installed in the control center of Aigües de Barcelona is in charge of controlling the whole network by taking into account operational constraints and consumer demands. This upper level provides the set points for the lower-level control system. The lower level optimizes the pressure profile to minimize losses due leakage and to provide sufficient water pressure, e.g. for high-rise buildings (Ocampo-Martínez, et al. 2009).

3.2.6. Maintenance Policy

The company is following three types of maintenance:

- a. Predictive
- b. Preventive
- c. Corrective

Until now their strategy was based on the corrective maintenance meaning that when something failed by taking into account the whole life-cycle of the assets then they replace it. This type of maintenance includes also the day-to-day operations. This strategy is usually performed if failure consequences are low and the failed item is inexpensive. The company wants to make a database with the different failures as it will help them in identifying which are the most important and the most urgent to be done mainly for when is to conduct the annual meeting with the regulator. In order to achieve this goal the company is currently working with Data Mart software in which all the failures are registered and everybody in the system has access on these data. The objective of the company is to move from the corrective to the predictive maintenance as the preventive is already in quite high levels. The preventive maintenance is performed to reduce unplanned and disruptive system failures. A start is been done by using model-based methods in order to check the consistency of sensor data.

Concerning the maintenance there are three types of investments:

1. Renew: is about the life of assets. The company knows the properties of all the assets that are under its property and in which phase of its life cycle are. By this they get the opportunity to invest when is needed in order to replace (renew) an asset. The company is working with Suez Environment, the shareholder company, and with a use of software to know the age of the assets.
2. Reinforce: in this case the asset doesn't have to be replaced but it has to be reinforced as for example more water is going to pass from a certain pipe than the amount of water that it was designed for.
3. Extension – Enlargement: by building new infrastructure in order to meet a new higher demand.

3.3. Description of the Cultural Embeddedness**3.3.1. Influence from the Southern Europe – Spain Culture****3.3.1.1. Droughts**

In the Mediterranean countries, water resources are increasingly stressed, due to climate change and growing water demand. Water scarcity is one of the major problems the Mediterranean countries are facing (Kanakoudis, Tsitsifli, et al. 2011). Catalonia, because of its Mediterranean climate, typically has an irregular rainfall pattern; in particular in terms of inter annual variations. Over the last 20 years (1988-2007) there have been 6 drought alert periods in the internal basins, leading to the adoption of exceptional measures in order to guarantee supply. These episodes have become increasingly severe to the point that during the last drought 2007-2008, Barcelona had to be supplied partially, by sea tankers transporting water from Marseilles in France and other Mediterranean ports (March, Saurí and Perarnau 2012). Aigües de Barcelona entered into scene as it was designated to build a pipe connecting the port of Barcelona where the ships would unload the water, with the water supply network. The frequency of such episodes is symptomatic of the existence of a structural deficit, as demand is very close to the available level of resources. A structural deficit is defined as an inadequacy in the infrastructure systems for the distribution of water in circumstances of limited resources (Agència Catalana de l'Aigua 2008).

In Catalonia and Spain, the declaration of drought alerts is based on the amount of water stored in reservoirs supplying the main agricultural, industrial, and urban users. Depending on the water stored, certain uses may be prohibited. The first uses to be curtailed are those of agriculture and of certain municipal services, such as ornamental fountains. If water levels in reservoirs continue to decline, a new set of uses are targeted. For instance, in the drought regulations of 2005 and 2007-2008 (Decrees 93/2005 and 84/2007), garden irrigation and the filling of swimming pools were temporally banned. Together with these prohibitions, authorities have also launched vast education and awareness campaigns urging citizens to use water in 'rational and responsible ways'. Moreover, during this period, water-efficient retrofit kits for taps were freely distributed to the population by the Catalan Water Agency. In June 2008, the MAB reached an all-time-low figure of 113 liters/capita/day (lpcd), one of the lowest levels of consumption of any urban area in the developed world. The water authorities attributed this decrease in per-capita consumption to the campaigns carried out and the commitment of people to overcome the scarcity (March, Saurí and Perarnau 2012).

3.3.1.2. Sub-urbanization

In southern Europe and Spain, in particular, changes in urban growth, the consolidation of new urban lifestyles as well as changes in the size and composition of families are leading to a more complex water scenario where consumption tends to grow in the expanding suburbs and to diminish in the central cores. These trends are relevant for southern European countries and other Mediterranean contexts where water resources are subject to strong pressures (Domene and Saurí 2006).

Before the mid-1970s the MAB had witnessed the highest rates of population growth recorded in the history of the region when large numbers of immigrants from other areas of Spain arrived in Catalonia searching for jobs. Urban development took the form of high density, low quality housing blocks built to accommodate immigrants and their families. Between 1960 and 1975, population in the MAB grew from 2.5 to 4 million people. From 1975 onwards a new socio-demographic and spatial pattern began to emerge. Immigration from

other Spanish areas declined sharply and fertility rates entered a downward phase. Also, the increasing presence of women in the job market, and young people's relatively late age of emancipation from their parental home (in 1996, 60% of persons between 25 and 29 years of age still lived at home).

The poor quality of much of the housing stock built in the 1960s and 1970s in the center of Barcelona, motivated a lot of residents to improve their conditions of habitation by moving to the periphery. Until 2000, nearly 400,000 people left Barcelona county whereas the population of the rest of the region increased by almost exactly the same amount. The compact city is characterized by a predominance of smaller households, and also by a larger ageing population, unlike the diffuse city where the population tends to be younger. In sum, data at the municipal level and data at the household level appear to confirm the association between low-density urban patterns and greater levels of domestic water consumption in the MAB. Given the higher rates of population and housing growth in the metropolitan periphery, water demand is likely to increase in the future (Saurí 2003). One attractive aspect of detached housing is the possibility of having a garden. Gardens are linked with the ideas of stress avoidance, recreation and social positionality. However, a new type of garden with large areas of turf grass not adapted environmentally to the Mediterranean context is growing in popularity. In fact, gardens can be considered a positional good for some people who strive for status and social distinction. These factors contribute to explain the booming Spanish real estate market during the past decade. In 2004, for instance, more new housing units were built in Spain than in France, Italy and Germany combined (Domene and Saurí 2006). The growth and diversification of the housing stock has led to urban sprawl, which is relatively new in Mediterranean cities.

Consequently, concerns have been raised over the environmental impacts of low-density urbanization. These impacts, already recognized in Anglo-Saxon countries, include growing energy consumption and emissions (Anderson, Kanaroglou and Miller 1996); an increase in travel distances (Giuliano and Narayan 2003); and the loss of agricultural land, open spaces and environmentally valuable areas (Heimlich 1989). However, as it has been mentioned already in a Mediterranean context, other impacts are worth studying, especially the rising water consumption observed in the suburbs as compared with the denser city cores. This is important given the situation of potential water crises affecting many southern European metropolitan areas (Kallis and Cocossis 2003).

What has been analyzed until now can be seen in the average water consumptions noted in 2008. The citizens in the denser-core of the MAB consumed around 107 lpcd during 2008, with minimums of 90 lpcd. Some 8.9 kms southwards, the municipality of Sant Cugat del Vallès presented an average consumption of 182 lpcd for the same period of time. Others had even higher consumptions: 273 lpcd in average of Sant Andreu de Llavaneres (north-east of Barcelona) or Matadepera with 230 lpcd in 2008. As a result there is a high inhomogeneity in the consumption depending on the where the municipality is (in the denser-core or in the suburbs) (H. March Corbella 2010).

Figure 16 represents the daily water consumption per capita, in the Metropolitan Area of Barcelona. The graph shows a decline trend as it has been mentioned before, due to the shortage of water the last years but also because of the bad quality of water in small areas. This is an important cultural aspect in the Metropolitan Area of Barcelona, as the perception of the citizens is that the quality of the drinking water is very poor and as a result the consumption decreases, while the consumption of bottled water increases. Drinking water

taste is normally determined by public opinion as an indicator of its quality, although the company is trying to improve the water quality by introducing new technologies, this belief is hard to change since it is a fact that the surface water from Llobregat River has a very different composition than does the Ter River and it is more accepted than the water coming from the Llobregat River. Therefore, especially the municipalities supplied with water from Llobregat River complain about the poor quality of the water coming out from their tap. On the other side municipalities supplied with water only from Ter River have a higher consumption due to the better quality of raw water. Aigües de Barcelona for this reason has studied optimal blends between both sources (Fabrellas, Devesa and Matia 2004). Pipes interconnecting the infrastructures and water reservoirs to increase the blending options were built as an alternative to distribute the best water quality with the highest taste uniformity (Raich-Montiu, et al. 2014).

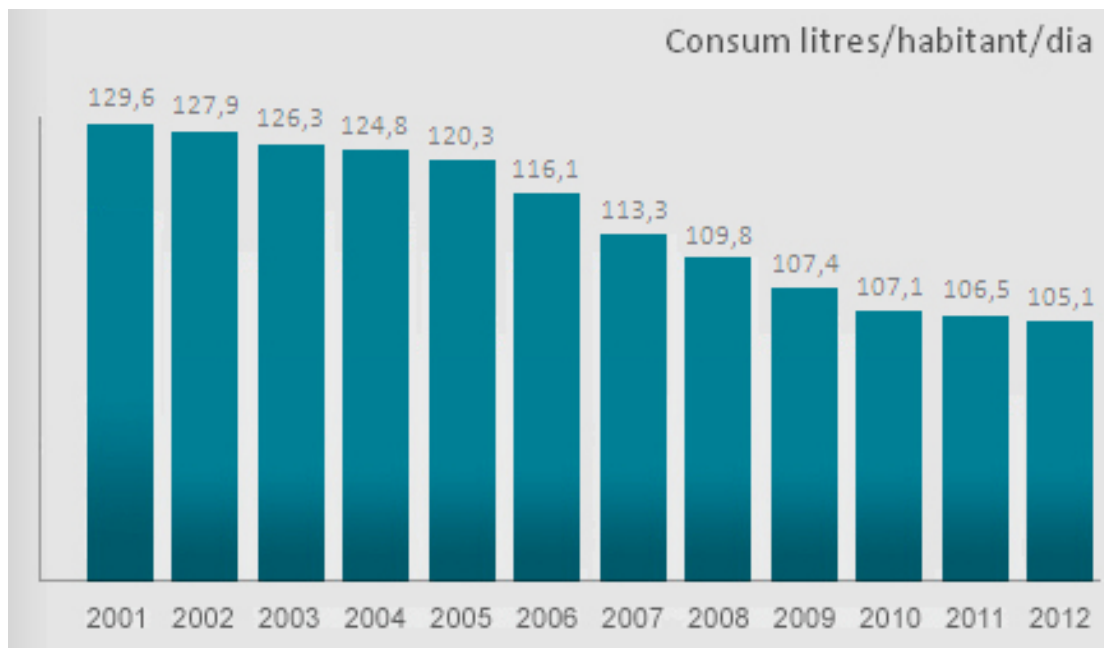


Figure 16: Water consumption, per capita, per day (2001 - 2012), (Aigües de Barcelona S.A. 2013)

3.3.1.3. Influence from the French Culture

After 2009 that the water company Suez Environment took over the majority of the shares of Agbar a new culture influenced by the French company was introduced in Aigües de Barcelona. One of the first aspects that got recreated was the importance of the Health and Safety department not only for the employees but also for the subcontractors.

Another essential point was the improvement of the efficiency of the system. The shareholders are interested in investments that will make the system perform better and in turn they will increase their profits.

3.4. Description of the Institutional Arrangements

3.4.1. Main Intervening Actors

There is a large array of institutions involved in the water supply chain in the Metropolitan Area of Barcelona. The most important ones are listed below.

➤ ***Catalan Agency for Water⁶, (ACA)***

The highest authority on regional water policy is the Catalan Water Agency (ACA). Negotiations with the regional authorities culminated in the institutional and legal change brought about by the law of 1999 on Water Planning, Management and Taxation of Water. The law constituted a fundamental piece of a larger reorganization process of the water sector in Catalonia, which began in December 1998 with the creation of the Catalan Agency of Water (ACA) (Saurí 2003). As a result ACA, is a public firm owned by the regional government of Catalonia and attached to the Regional Ministry of Territory and Sustainability. Its creation reflected the purpose of the regional government of Catalonia of concentrating all water-related issues in a single regulatory body. The ACA is in charge of the design and implementation of the Water Management Plan of Catalonia, based on the principles of the Water Framework Directive (CETaqua and Fife-Schaw 2010).

The most important responsibilities of the ACA are:

- a. Planning water policy – this includes planning global water delivery in the region, as well as any other water resources;
- b. Management of reservoirs in Catalonia;
- c. Control and supervision of the core network of water supply, including the basic Ter-Llobregat system;
- d. Preparing the planning proposal for wastewater treatment in Catalonia and implementing planning, including both infrastructure replacement and improvement. Moreover, the ACA also performs functions in public sewage systems. In this regard, it is responsible for promoting, building and operating waterworks that are under the jurisdiction of the regional government;
- e. Tax and revenue functions – the ACA manages, collects, administers and controls the revenues accrued by the agency;
- f. Designing the projects and actions associated with the water cycle, including infrastructure and environmental improvements.

Besides these functions, the ACA has created the Catalan Water Price Observatory⁷. The observatory is designed as a tool for raising public awareness of the essential elements that make up water prices in the different areas and municipalities of the region, including those related to urban water delivery. This committee is dependent on the regional ministry with responsibility for consumer-related affairs, while any changes in tariffs and the prices of various public services – urban water delivery among them – need to be approved by the committee in line with the decision made, in the case of water urban delivery, by the local governments (Bel, González-Gómez and Picazo-Tadeo 2013).

➤ ***Àrea Metropolitana de Barcelona (AMB)***

With the Water Act of 1985, the supply of raw water (“agua en alta”) was envisaged as a public duty, regardless whether urban water supply was private or public. In the urban area of Barcelona though, many municipal services are handed over to a inter-municipal entity responsible for providing municipal services to a wider area. The Corporación Metropolitana

⁶ Agencia Catalana de l'Aigua

⁷ Observatori del Preu de l'Aigua a Catalunya

de Barcelona, now known as Àrea Metropolitana de Barcelona (AMB), is one such entity, responsible, in collaboration with town councils, for the local water supply service, wastewater treatment, control of industrial dumps and waste disposal in 33 municipalities of the urban area of Barcelona.

After the Water Law in 1985 the Àrea Metropolitana de Barcelona was split into two metropolitan bodies: one to plan and manage public transportation services (Entitat del Transport) and the other one appointed to be in charge of water-related and waste treatment issues. Regarding water resources, the dissolution implied the fragmentation of the ownership and responsibility of water supply services. Thus, while ACA was empowered with jurisdiction for water planning, the metropolitan body was to coordinate municipal water and wastewater services, to forecast future demands and to carry out hydraulic works to ensure these demands.

Finally, according to the article 4 of Law 6/1999 the tasks that correspond to the local water bodies, as AMB are:

- a. The supply of drinking water;
- b. The drainage and treatment of wastewaters;
- c. Sanitary controls of wastewaters;
- d. The exercising of functions established by this Law (Casado and Pardos 2000).

The AMB acts as a regulatory body, monitoring the quality of service and approving the tariffs that retailers charge to their customers. It also authorizes investments and supervises their actions (CETaqua and Fife-Schaw 2010).

➤ ***Aigües Ter Llobregat (ATLL)***

Aigües Ter Llobregat (ATLL) was created in 1990, by the Law 4/1990, as a state-owned company by the Government of Catalonia to be in charge of the primary water supply network in most of the municipalities in the Metropolitan Area of Barcelona. ATLL distributes water to more than 110 municipalities, including the city of Barcelona. The upstream water supply covers initial water capture, from the rivers Ter and Llobregat and desalination plants, and its storage in municipals tanks, from where the local water authority or concessionaire of the upstream water supply distributes the water directly to end-users. The company owns a water distribution network that carries raw water from reservoirs to water treatment plants where drinking water is produced. This water is then transferred to service reservoirs through a transport network consisting of large pipes and various elements of control. ATLL also sets the prices at which water is sold to municipalities and private water companies.

In 2012 a private joint venture lead by the Spanish company Acciona was awarded from ACA the contract to manage ATLL for a 50-year contract. Acciona and its partners will run ATLL until 2061. ATLL's partially privatization has been a part of the Catalan Government's austerity plan in order to reduce the public deficit and meet the imposed deficit targets (Catalan News Agency 2012).

➤ ***Aigües de Barcelona***

The biggest distribution company in the area is Aigües de Barcelona, a company of the Agbar Group, providing water to 23 municipalities and contributing 87.3% of total supply to the urban area of Barcelona. The company has its own water production facilities, as they own a drinking water treatment plant that gets water from the Llobregat River and a groundwater treatment plant that draws water from the aquifer of river Besòs. These two plants supply about half of the city's water demand, the rest coming from the ATLL network (CETaqua and Fife-Schaw 2010). Therefore, Aigües de Barcelona has to buy the rest of the treated water

needed from ATLL's network in order to meet the demand of the system.

➤ ***Other smaller entities***

Sewerage and sanitation is the responsibility of municipalities too. In Barcelona, the city awarded a concession contract to Clavegueram de Barcelona (CLABSA), a public-private partnership. CLABSA is in charge of the planning and development of urban drainage systems as well as the implementation and maintenance of the necessary elements for the control of sewers and regulation of drainage systems.

Wastewater and rainwater collected in urban reservoirs is driven to two wastewater treatment plants (WWTPs). As stated earlier, the AMB has responsibilities over wastewater treatment. The operation of the two WWTPs, which are located by the sea in rivers Besòs and Llobregat, are under the responsibility of Empresa Metropolitana de Sanejament (EMSSA), a public company owned by the AMB (CETaqua and Fife-Schaw 2010).

The different actors as well as how they interact and their competences can be seen in Figure 17.

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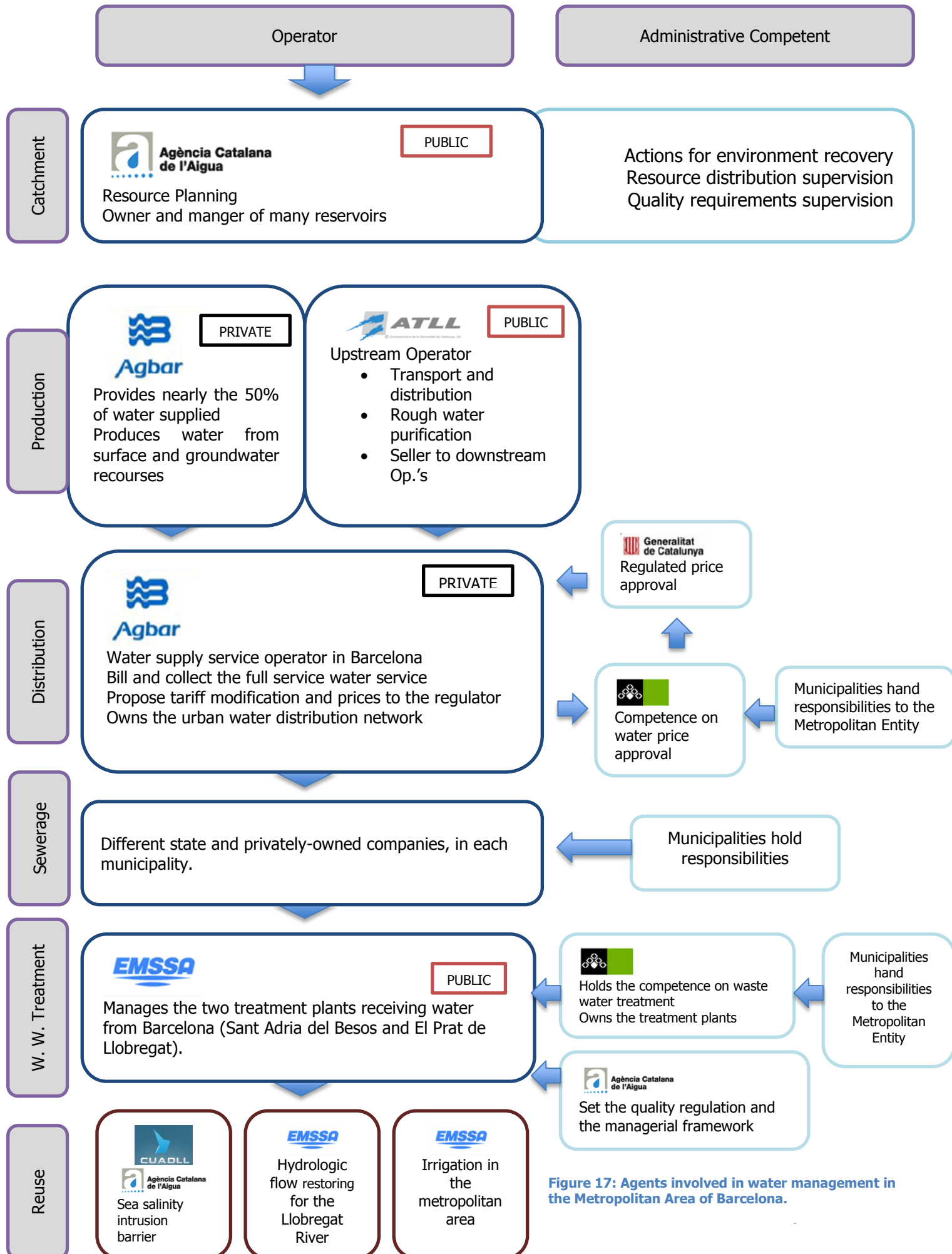


Figure 17: Agents involved in water management in the Metropolitan Area of Barcelona.

3.4.1.1. Regulations and Legislations

3.4.1.2. Spain

The basic law regulating water management in Spain is the 1985 Water Act that was partly amended in 1999. Both acts were put together in 2001, and this legislation has been adapted to the European Union's Water Framework Directive. In addition to these laws, water management is also affected by related legislation for the regulation of public works, water pollution or wastewater treatment.

The key principle of the 1985 Water Act is that all the continental water, either surface or groundwater, is of the public domain with some exceptions for groundwater. There are no water rights in the strict sense, but rather temporary public concessions that grant the holder the right to use a given amount of water. These concessions can be cancelled and reallocated to other users by the basin authority, in the event of inadequate or unjustified use of water. The Spanish Water Act grants an important role to public administration. Each basin authority (Confederación Hidrográfica) is the main administrative body, largely responsible for water management at basin level. They are responsible for the elaboration and monitoring of the basin hydrological plan, the administration and control of the water public domain, and for all the water uses. They are in charge of projects, construction works and management of public hydraulic works, which may be financed by the central or state governments, local councils, or even private entities. The basin hydrological plans are integrated in the National Hydrological Plan, approved by the central government. According to the Spanish Water Act, the objectives of hydrological planning are to satisfy all water demands, to attain an equilibrated and harmonious water sector, and to further regional development. This is achieved by increasing resource availability, maintaining water quality, and by rational and sustainable usage (Albiac, et al. 2006).

Over the past 20 years, the Spanish State has gone from a very centralized political organization to quite the opposite: the configuration of a quasi-federal state formed by 17 Autonomous Communities (AA.CC.) with legislative and executive powers (Sauri and Moral 2001).

As it was established in the Constitution all AA.CC. have their own Government and Legislative Assembly, which assume the executive and legislative in their own field of authority. According to the Spanish Constitution the State assumes competences regarding legislation, arrangement and concession of resources and hydraulic exploitation when water passes through more than one Autonomous Community, otherwise the AA.CC. have these competences. It also establishes that the AA.CC. assume competences regarding projects and construction of hydraulic exploitations, canals and irrigations when these are of interest for the Autonomous Community.

The 1999 reform of the Water Act introduced the legal possibility of voluntary water exchanges, but with many restrictions. Water exchanges among different basins are also allowed, provided that water transfer facilities are in place and exchanges are permitted by the National Hydrological Plan that was formed in 2001.

Municipalities are recognized as entities in the world of administrative and constitutional law, but they don't have competence to promulgate their own laws, so they have to assume the existing ones, at the Autonomous Community level and Central State level. Although the municipal authorities have important power and assume shared and exclusive competences in

environmental issues and in water management (drinkable water supply and wastewater sewer system and disposal). This is established in the Local Regime Regulation Law, 1985⁸. Also the amount of population makes obviously a difference in the kind of ordinances a municipality has (Observatorio de los Servicios Públicos 2004). This decentralization to the municipalities enables a higher capacity to integrate local elements and sensibilities and gives more flexibility to municipalities to manage and cope with their local requirements on a yearly basis, and also for using different public partnership forms according to their needs, always following the European Framework Directive (AQUAE Foundation 2013).

To summarize, Spanish legislation establishes two forms of management of the local public services:

- Direct management, carried out by the municipality itself or by entities belonging to the same
- Indirect management, in which private companies assure the provision of local services under a contract system on behalf of the municipality.

As shown in Figure 18, indirect management (through private companies) allows, in turn, different forms: concession, interested management, arrangement system or public-private companies (Cañete and Menéndez 2009). A Joint venture lease/concession is a well-known model in Spain. In fact, the World Bank qualifies Spain as the country par excellence in this respect (World Bank 2006).

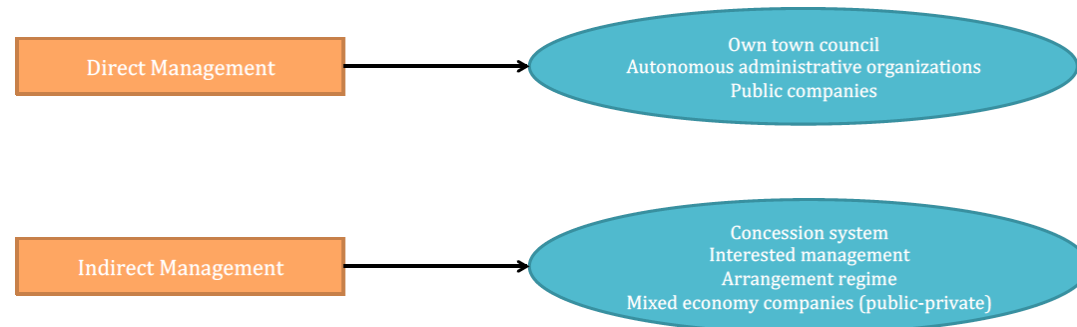


Figure 18: Management modalities in the provision of water (Cañete and Menéndez 2009)

Indirect management dominates in Spain as it accounts for more than 85% of the total market. The distribution of the market among major private operators shows two incumbents: FCC Group and Agbar Group (Cañete and Menéndez 2009).

The Spanish National Hydrological Plan, passed in 1998 and approved by the National Parliament in Act 10/2001 sanctioned in July 2001, divided public opinion. The Plan detailed the transfer of $105 \cdot 10^6$ m³/yr of water from the Ebro basin in Catalonia, and was intended to balance national water 'abundance' and deficits (Downward and Taylor 2007). The main objective of the Plan was to solve Spain's hydrological imbalances between water rich and water poor regions. Hence, water to be transferred had to be defined as "surplus water" in the basin of origin. Nevertheless, criteria to define "water surpluses" became a hotly contested issue in the debate since the belief of the exporting basis was that surpluses existed not because they were not needed, but because these basins lacked the hydraulic infrastructure necessary to put them to productive uses (Sauri and Moral 2001). As a result, asking one region to relinquish their value water resources to serve the demands of another is seldom popular with the conceding region, and disputes between regions outburst.

⁸ Ley reguladora de las bases del régimen local, 1985

Another blow to the Ebro transfer was the reluctance of the European Union (EU) to provide European funding for the project, because of its shaky economic and environmental foundation. Serious environmental concerns were highlighted, particularly with respect to compliance with European Union environmental directives, such as the EU Habitats Directive and the EU Water Framework Directive, the latter of which requires Spain to maintain the good ecological status of the Ebro River (Ibanez and Prat 2003). Opponents also noted that the Ebro transfer would further accentuate the already apparent economic disparities that exist between the conceding and recipient regions, claiming that agriculture in northern Spain would suffer to support the seemingly unsustainable thirst for development in the south (Boné 2003).

In 2004, Spain's newly elected socialist government cancelled the National Hydrological Plan and launched a new water policy named the Program AGUA, (Actuaciones para la Gestion y la Utilizacion del Agua⁹). The Program AGUA is forthright in stating its compliance with EU environmental legislation and makes specific reference to the EU Water Framework Directive in its stated aim of promoting water savings through full-cost recovery by 2010. However, recognizing that water savings alone will not be sufficient to meet changing demands for water in the Mediterranean regions, it emphasizes desalination as the means to 'better guarantee its availability and its quality'. So, it can be noted a fundamental policy shift in national water management from large inter-basin water transfers to a commitment to desalination.

The 21 proposed desalination facilities, including Barcelona, allow the Spanish Mediterranean regions to maintain their hydro-independence and remove them from their neighbors' changing political alliances and environmental attitudes.

Controversially, the Program AGUA challenges the geographical ideology of the river basin: whereas the National Hydrological Plan of 2001 sought to balance basin deficits in the Mediterranean region by transferring water from distant basins, the Program AGUA's vision extend the geographical boundaries of the river basin itself beyond its coastal limits to tap the marine waters and littoral saline aquifers of the Mediterranean coast. Nationally, Spain has over 1500 km of coastline and numerous coastal aquifers for desalting brackish groundwater. Furthermore, unlike the Ebro transfer, supplies of desalinated water can be predicted independently of climate changes and drought. In theory at least, the opportunities to supply desalinated water to recipient basins are limitless (Downward and Taylor 2007). However, the replacement Program AGUA, is also controversial and not immune from environmental criticism.

3.4.1.3. Autonomous Community of Catalonia

The privatization of Barcelona water in the 19th century and its current situation is very different from the privatization process undergone in England and the current status of water utilities. In the British case, water went through different stages during the 20th century (private, municipal, stated owned) until the full privatization in 1989. In the Barcelona case, what was privatized during the third quarter of the 19th century was not the water resources but the municipal delivery of water. In that sense, it can be said that Barcelona constitutes a case of the "French Privatization Model" (lease, contract, etc.) (H. March Corbella 2013).

The concession contract is a common type of contract in the Autonomous Community of

⁹ Actions for the management and the use of water

Catalonia between private companies or mixed public-private companies and the municipalities. The concession contract is an institutional arrangement that has all the characteristics of the lease contract, but with the significant addition that the concessionaire also finances a detailed investment programmed for expansion and/or rehabilitation of the urban water supply system (Nickson and Franceys 2003). In other words, a concession gives the private partner responsibility not only for the operation and maintenance of a utility's assets but also for investments (World Bank 2006). In the urban water sector the term concession is used to describe a citywide contract with a private operator for the commercial management of abstraction, treatment, financing and constructing new assets, sale of water and distribution (Nickson and Franceys 2003). In the case of Barcelona, government agencies supply bulk water and the private company Aigües de Barcelona is responsible for the treatment, the distribution and for financing new projects like the desalinization plant that was built by the company in 2009.

Concession contracts pass full responsibility for operations and investments to the private sector with the aim of providing incentives for efficiency. Still, asset ownership and full use rights to all the assets remain to the public administration. This arrangement requires strong regulation of prices, quality of services, drinking water quality, environmental quality and customer care. The operator assumes full risk, and pays a fee to the 'asset holding authority', generally a state owned company or a government department. In the case of Barcelona, the Aigües de Barcelona has to buy the raw water from the state-owned company ATLL and the Àrea Metropolitana de Barcelona (AMB) is the regulator that decides the prices and the sets the indicators for the quality of service.

Theoretically and ideally it is the pressure of a competitive market, in the form of competition for the market rather than competition within the market, which finally delivers the benefits of private sector involvement (Nickson and Franceys 2003). The goal of private companies that operate concession contracts is to maximize the financial return to their shareholders by providing what customers want at a price that they are willing to pay.

3.4.1.4. Water Supply Assets

Aigües de Barcelona is considered the owner of the assets related to the water treatment plant of Sant Joan Despí downstream of the Llobregat River, as it was built in 1952 with funding from the company and remained in their operation thanks to a concession granted by the Ministry of Public Works in 1953. The company also owns some facilities of the secondary and municipal network. In 2013 the assets owned by the company were valued at 286,45 M€. Moreover, in 2008 the company won the Built, Own and Transfer (BOT) contact for the desalinization plant including a two-year management of the plant that began to operate in 2009.

As it was mentioned before with the Water Law in 1985 groundwater flows as well as the supply of raw water¹⁰ ("agua en alta") would be considered part of the public domain from then on, and concessions from the public administration would be needed to exploit them. The Water Law was incorporated in the Catalan law "Llei 8/1987". In article 63 of this law, the municipality was endowed with the duty of water supply, sewerage, and wastewater treatment. The article 64 added that the municipality alone or associated must provide these services; the Generalitat could perform these services in extreme cases (article 65).

¹⁰ Raw water represents the flow of water before it is distributed within the urban network. Thus, raw water supply includes the extraction and the treatment of water to turn it drinkable.

Thus, the legislation makes the public entity Àrea Metropolitana de Barcelona the asset owner of the infrastructure related to the groundwater sources and Aigües de Barcelona the company in charge to manage them. Furthermore, the other two water treatment plants, one upstream of the Llobregat river in the location Abrera and another one in the Ter river in the location Cardedeu, as well as the network that brings the bulk water to the treatment plants and then is stored to reservoirs in order afterwards to be distributed to the urban network are owned and managed by the state-owned company ATLL. The supply system and the owners of the various assets that are considered in the distribution system of the Metropolitan Area of Barcelona are showed in Figure 19.

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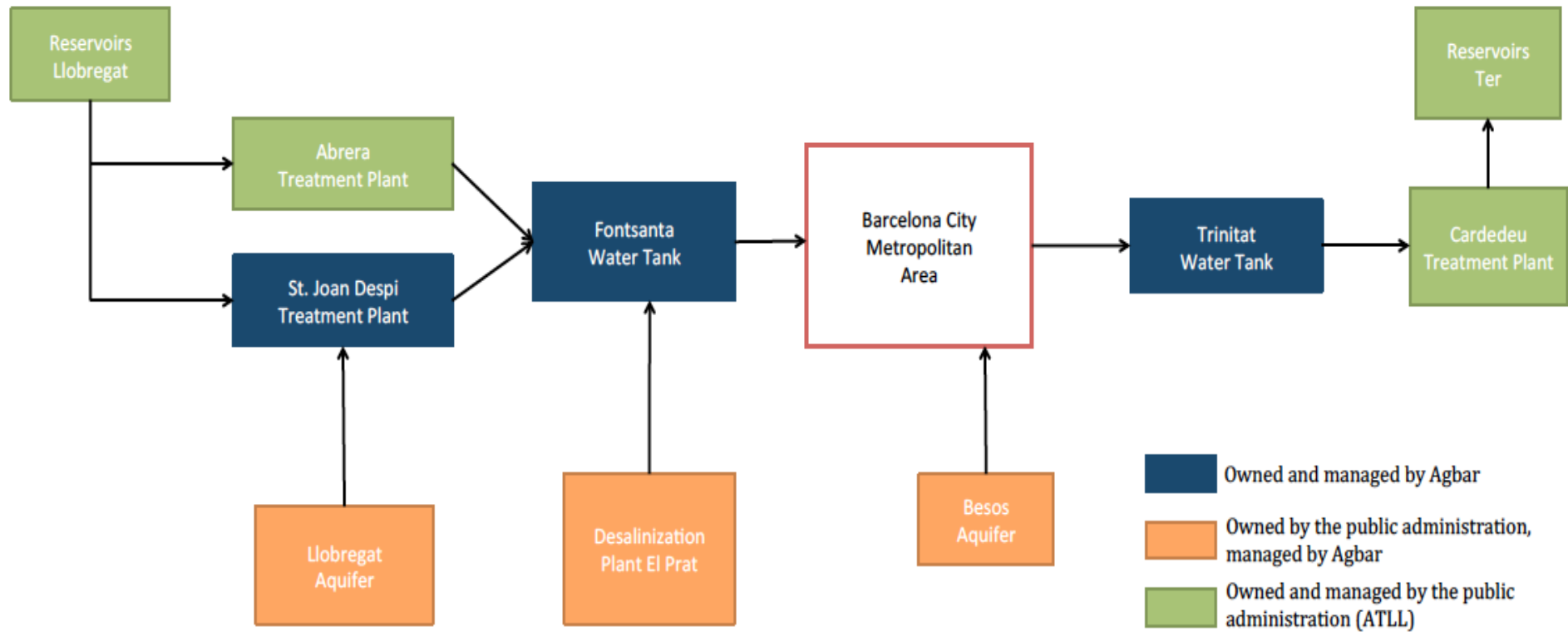


Figure 19: Water supply system in the Metropolitan Area of Barcelona, ownership and management

3.4.1.5. Regulations on the Water Companies

As it was analyzed in the previous section in Spain there are different entities that take part in the management of the water cycle.

Each company should hand in its price proposals to the regulator, based on the cost recovery principal and the local regulators will decide the price based in the proposals. Nonetheless, proposals have to meet environmental goals and comply with the regulation of European Union services on a national and regional level. There is no centralized price regulation model imposed by a national regulator, due to the municipal competition of the supply and sanitation services established by law. Therefore no uniform price model, price review process and tariff can be found at national level, but this fact does not hinder the existence of good levels of efficiency in the industry. Service concession contracting with municipalities is a tough competitive process where efficiency and operational excellence are key and the contract defined under competition is in itself a regulatory framework in terms of performance, determination of efficient costs, tariff model, return on investment, allocation of risks. The market competition determines the quality standards and promotes operating excellence above the minimums required. Spain is a good example of successful competitive policy in which some private companies have developed internationally, exporting know-how and efficiency in their operations worldwide. The price is usually reviewed once a year. There is no uniform deadline for the price review process. When disputes in price setting arise between water companies and regulators, no third party has been appointed to solve the discrepancies (AQUAE Foundation 2013).

At present there are important tariff differences between the water services of the different towns, due to various reasons such as the origin of the resource, the quality of the service provided and the level of investments executed, in addition to the different levels of subsidy by the public sector or, in other words, the different degree of recovery of costs of the services. It should be added that the water bill is sometimes used as an instrument to collect other items not related to the complete water cycle, the most common being the charge for the collection of solid urban waste. All these make the water bills of the different municipalities very different and as a result the end consumer does not know the real price of the water.

The most common residential water-billing model in the MAB consists of a fixed component or service fee, which may range from 2–7 euros per month and several increasing block rates. Every municipality in the MAB negotiates with the water company, which may be public or private the service fee, the block structure if this is used, 2–4 block rates, depending on the municipality and the threshold quantity and price of each block. Therefore, the variety of water prices in the MAB may be quite high.

To give just one example, the company supplying the city of Barcelona uses a service fee and up to 3 blocks, the last of which is set at 36m³ per 3 months, while another municipality, Sitges, also uses a service fee, but 2 tariff blocks, the last of which is set at 90m³ per 3 months. In 2003, the price for the last block in Barcelona was 1.065 euros per cubic meter, while in Sitges; the price for the last block was 0.806 euros per cubic meter. Contrary to water prices, water taxes, the so-called Canon de l'Aigua, are the same for all the municipalities in the MAB and also follow a block system (Domene and Saurí 2006).

3.5. Description of the Governance Characteristics

3.5.1. Ownership

3.5.1.1. History

The water cycle in the Metropolitan Area of Barcelona is under private control since the mid 19th century by the "Societat General d'Aigües de Barcelona" (S.G.A.B., later known as Agbar). In 1878, the city council acknowledging the increasing needs of water to feed the population growth of Barcelona initiated a search for new water resources in the Besòs River, which until the fifties was one of the basic elements of water supply in the field of Barcelona. The local government granted a concession to the water company "Compañía de Aguas de Barcelona" to excavate more wells in the Besòs basin. This company later would monopolize the water supply of Barcelona.

The "Compañía de Aguas de Barcelona" (CAB) was constituted in Liege (Belgium) on the 19th June of 1867, with Belgian and French participation (Voltes 1967).

By the time the CAB began to operate, other private companies existed in Barcelona and in the towns of the Barcelona Plain, which were mostly bought by the CAB later on.

In January 1882 the "Compañía de Aguas de Barcelona" was dissolved and some days later the "Societat General d'Aigües de Barcelona" was established in Paris (Voltes Bou 1967, Jove 1995). It should be mentioned is that this company had not only a Barcelonan perspective but also the scope of their business was the whole of Spain and the duration of the society was established for 99 years. By the end of the 19th century the company had already a globalization mentality.

Despite private initiatives to supply water to different parts of the city, the public administration was also interested in controlling the flows of water.

Water supply problems were obvious even back then. The SGAB after the acquisition of the second largest private company in the area – "Empresa Concesionaria de Aguas Subterraneeas del Rio Llobregat" – in 1887 started to focus in finding new source of water: the Llobregat valley groundwater (Voltes 1967). Apart from Barcelona, the S.G.A.B. started to extend its agreements with other neighboring municipalities to supply them.

During 1920, an attempt to buy and convert the S.G.A.B. into a Spanish company was carried out. That was under the nationalistic and patriotic trends that started appearing in Spain after the World War I. However, by nationalizing the company it was meant the takeover of the company by the Spanish capital, but not the transference of the company from private to the public sphere. Until then, the company's shares had been owned by French-Belgian capital (Voltes 1967). The financial crises of the 1920s changed definitively the mind of the bankers, and eventually, the municipality desisted from undertaking such adventure so that in 1923 the process was revoked (Pascual 2007).

Two key elements took place in the 1970s that changed forever the scope of business of Aigües de Barcelona: the creation in 1975 of the Coporación Financiera Agbar, S.A. and the entrance of French Capital. First, the new firm, owned by Aigües de Barcelona, became a holding company controlling the shares of 40 subsidiary companies of the water group. From then onwards, there would be just one subsidiary company: the Corporación Financiera AGBAR. This operation was aimed at enhancing the development and diversification of the water corporation, not only in water supply services but also in related fields, such as pollution control or construction.

The second turning point was in 1981 when the "Société Lyonnaise des Eaux et de l'Éclairage"¹¹ bought 40% of the shares of Corporación Financiera Agbar; another 40 percent were held by SGAB and the remainder 20% by banks. At the beginning of the 1990s, a major event that would deeply influence the trajectory of the water group took place. Because of an imminent merger between Aigües de Barcelona and the gas company Catalana de Gas, the Catalan bank La Caixa decided to enter the water company becoming the second major shareholder of Aguas de Barcelona, just behind Lyonnaise.

In 1992, the Corporación Financiera Agbar, S.A. gave birth to the Agbar Group. Apart from the core water sector operations, this group would extend its business to the health insurance sector (Adeslas), the car emissions control and certification (Applus), waste management and treatment (Cespa), building (Acsa), installations and computing maintenance, telecommunications, wastewater treatment (Degrémont), leisure activities and even the bottled water sector in a move that some may consider rather cynical.

The next turning point in the reconstruction of the ownership of Agbar was in 2007. The bank La Caixa sold their participation in the Suez Environment Group and Suez and la Caixa launched a takeover bid for the remaining part of AGBAR they did not control (50.3%). The objective of Suez was to convert Agbar in a pillar of the water sector in Europe, and also to increase its participation in the energy company Gas Natural. La Caixa and Suez agreed the "joint management" of Agbar. At the beginning of 2008 La Caixa and Suez controlled over 90% of the capital of Agbar (Figure 20).



Figure 20: Shareholders of Agbar Group (Agbar Group 2012)

Finally in Table 3 there is a summary of the key moments in urbanization of water in Barcelona, with the main actors as well as the predominant discourses showed in sections before.

¹¹ Suez Environment

Table 3: Key moments in Barcelona water urbanization, (H. March Corbella 2010)

Period	Key actors	Dominant discourse	Institutional Social Outcomes	Scalar networks
Late 19 th and early 20 th century	Landowners and industrialist/Urban popular classes	Water as a private good	Privatization, quest for new supplies beyond the city limits	Transnational – local
1920s	Bankers/Municipality, French and Belgium owners	Water to speculate	"Nationalization" of the SGAB (takeover by Spanish private capital)	National – local
Spanish Civil War (1936-39)	Bankers/Urban popular classes	Water as an essential good	Collectivization of "Aguas de Barcelona"	National – local
Franco's dictatorship (1950-1975)	Political and economic elites/Water donor Regions	Water as an strategic good (still private managed)	Construction of dams distance water transfers, Transfer from the Ter River, Dismissal of the Ebro Transfer	Transnational – National – local
1980-1990s	Metropolitan and Catalan Administration, rich neighborhoods/Working classes, lower income families	Water as an economic good a key factor for the expansion of the urban continuum	"Water Wars", Creation of the Catalan Water Agency, National Water Plan	Transnational – National – Metropolitan
2000-onwards	European Government, Spanish Government, Catalan Water Administration	Water as an economic, and eco-social good	Desalination plants instead of Ebro water transfer. Drought increasing social awareness for conserving water	Transnational – National – Metropolitan

3.5.1.2. Innovation

In 2007, Agbar joined with the Polytechnic University of Catalonia (UPC) and the Spanish National Research Council (CSIC) to found CETaqua. CETaqua contributes to research and development of technologies linked to the integral water cycle, striving for synergies between the business, research, and education sectors to meet pressing water-related challenges at national and global levels. Agbar made a strategic decision to consolidate its research efforts under one roof for improved coordination and broader societal impact. Early in the development of CETaqua, it was agreed by CETaqua's high-level, appointed Scientific and Technical Committee, which advises the Board of Directors, that climate change – under the broader umbrella concept of global change – should be incorporated in the center's mandate as one of the main lines of research. Agbar provides core financing for CETaqua (United Nations Environment Programme; United Nations Global Compact 2012).

Agbar takes the innovations developed at CETaqua, analyzes their market potential and uses them to expand its service offerings and strengthen its business position to generate profits. These products are aimed at increasing operational efficiencies and reducing costs. The respect CETaqua has gained for its strategic, innovative projects also provides Agbar with positive reputational benefits.

Agbar created Aqualogy in 2011, a dedicated water solutions and technologies brand, in order to transfer water management knowledge and innovations to markets worldwide, including to lower- and middle-income countries. Aqualogy benefits from the knowledge accumulated over 150 years and uses this experience to address the challenges of society and meet each customer's needs. The water management techniques and technologies are being developed by CETaqua and marketed through Aqualogy. The company is acquired in four main areas of activity: solutions, infrastructure, environment and knowledge.

As a result after 2011, Agbar is divided into two lines, in one side there are the different concessions in Spain and all around the world and on the other side there is Aqualogy, also with an international activity, which provides services to companies inside and outside the Agbar Group.

Agbar began to introduce changes in the business model before the crisis began, as since the middle of the last decade they have been aware that the traditional concessions model could not last forever. On the other hand, the company saw huge possibilities of growth from their own capabilities. They are confronting the current situation of economic uncertainty, with the new brand Aqualogy. This change represents above all going from infrastructure management to knowledge management. One of the biggest objectives set by the company is Aqualogy to contribute 50% of Agbar's recurrent profit by 2015 (Agbar Group 2011). It's a big challenge to sell Aqualogy's operations in companies outside the Agbar Group due to big competition entre this fields.

3.5.1.3. Expansion Inside and Outside Spain

Nowadays, Agbar operates as a holding company for over 150 companies that provide water supply and other related services. The group is also engaged in various operations like treatment and purification of wastewater and liquid water. The Group carries out its operations in United Kingdom, Chile, China, Spain, Algeria, Colombia, Cuba and Mexico. The international character of the company is noted also in their vision: "To be the benchmark business group in our fields of activity and one of the largest service companies".

Taking advantage of the disarray affecting many municipal water companies and of the financial need of the city councils, from 1980 onwards, Agbar began to expand its operations in Spain, gaining concessions for supplying water to an increasing number of cities either alone or in partnerships. At the end of the 1990s, the holding supplied to more than 750 municipalities and 11 million people (some 25% of the Spanish population). At the same time, Agbar invested in the Latin American water market; in the European market with the UK Company Bristol Water that was acquired in 2006 and Asian market (Sauri, Olcina and Rico, he State of Urban Water Supply and Sanitation in Spain: Issues, Debates and Conflicts 2009). Main world cities and regions supplied by the Agbar Group in 2009, with the approximate population are presented in Figure 21.

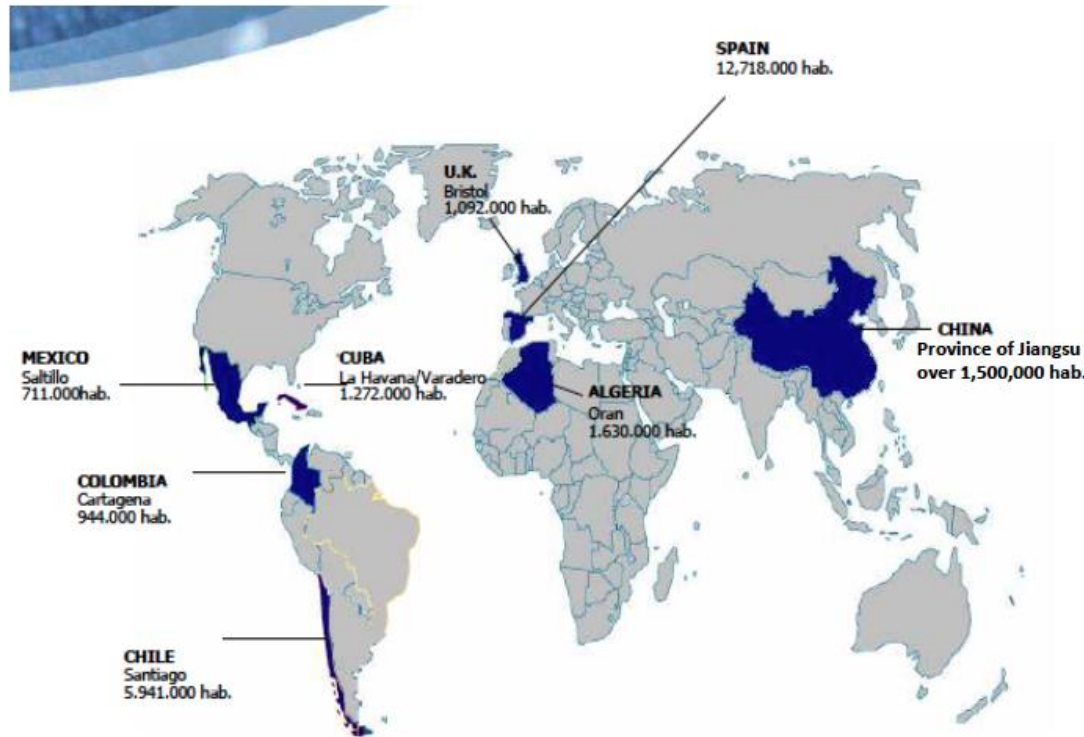


Figure 21: Agbar around the Globe, (Cortés 2012)

3.5.2. Regulatory Structure

3.5.2.1. Influences on Regulations and Stakeholders Requirements

Agbar has identified the expectations of its strategic stakeholders, which are constituted by: clients, employees, public administration, suppliers and the dual aspect of society covering the environment and the local community. The company has set a series of specific commitments for satisfying the expectations of its stakeholders. All these commitments make up overall Agbar's Corporate Responsibility Policy. Corporate Responsibility is one of Agbar's strategic pillars. As such, its objective is clear: *"to guarantee the continuance of the company over time, basing its model of action on the generation of value for all of the stakeholders"*. Agbar considers that it is necessary to maintain an open dialogue with its stakeholders on their needs.

Table 4: Commitments to the strategic stakeholders (Agbar Group 2011)

Clients - Quality - Innovation - Effective Communication	Employees - Training and Development - Communication - Occupational Health & Safety - Work – life Balance and Equality	Public Administrations - Transparency - Anticipating the Regulations - Quality Service
Environment - Sustainable Management - Environmental Management - Quality and Health - Biodiversity - Energy Efficiency	Local Community - Quality of life - Communication and Awareness – Raising - Experience	Suppliers - Integrity and Honesty - Transparency - Sustainable Practices

For each of the commitments acquired with the stakeholders, Agbar has defined, in its Medium-Term Corporate Responsibility Plan, a series of actions to be developed which include objectives and indicators to measure their evolution. Each year it carries out a follow-up of the progress of the objectives set (Agbar Group 2011).

The regulator in the Metropolitan Area of Barcelona is the public entity Àrea Metropolitana de Barcelona (AMB). As it will be described in more detail in the water price section, the company has to sit once per year with the regulator and discuss the water tariffs and the investments for the next year. Except from that the company has to provide a long-term contract called “Acuerdo Marco” every 5 years that includes restrictions as Key Performance Indicators (KPI’s) set by the regulator. These indicators are updated according to the needs of the system and possible changes in regulations from the European Union. So, in the annual meeting between the regulator and the company what it also discussed is the level of compliance to these indicators.

During these meetings the requirements set by the regulator depends on different things. Sometimes, are based on personal objectives and other times their objectives are based on legislations from the European Union. An example for the current year is that the company has to replace some pipes in the distribution system in order to eliminate the percentage of plumb. Furthermore, a recent restriction concerning the decrease of trihalomethanes in the water was appointed by the regulator according to European limits. The company had to introduce more effective treatment methods for complying with the new acceptable percentages. After the annual negotiation and the final agreement, the company has to send monthly reports to the regulator describing the level of progress.

3.5.2.2. Shareholders

Aigües de Barcelona as a private company should always take into account profits in return to the shareholders. For this reason, before the annual agreement with the municipality the company has to discuss the planned expenses first with the shareholders. So, a balance should be achieved for the needs of both parts.

3.5.3. Price of Water

3.5.3.1. Pricing Policy

In Spain, the responsibility of retail water tariff regulation is held by the municipalities and autonomous communities, consistent with the existing decentralized political regime (AQUAE Foundation 2013, Bru Angelats and Albiol Omella 2013). The supply of drinking water to the consumers is a service which forms part of a broader activity, made up of a series of actions linked in a sequence which covers water catchment and impoundment, drinking water treatment and adaptation for consumption, supply to the end user along the distribution networks, the subsequent sewerage works, treatment and final discharge to the public domain, that it to say the complete water cycle. Each of the activities which make up the complete water cycle has a tariff or price, and they are all fundamental to guarantee quality supply for the customer and, in turn, to maintain a balance with the environment, especially as regard the sewerage and wastewater treatment activities which take place after the supply of the water and its use by the consumer. The different items included on the bill are summarized graphically in Figure 22.

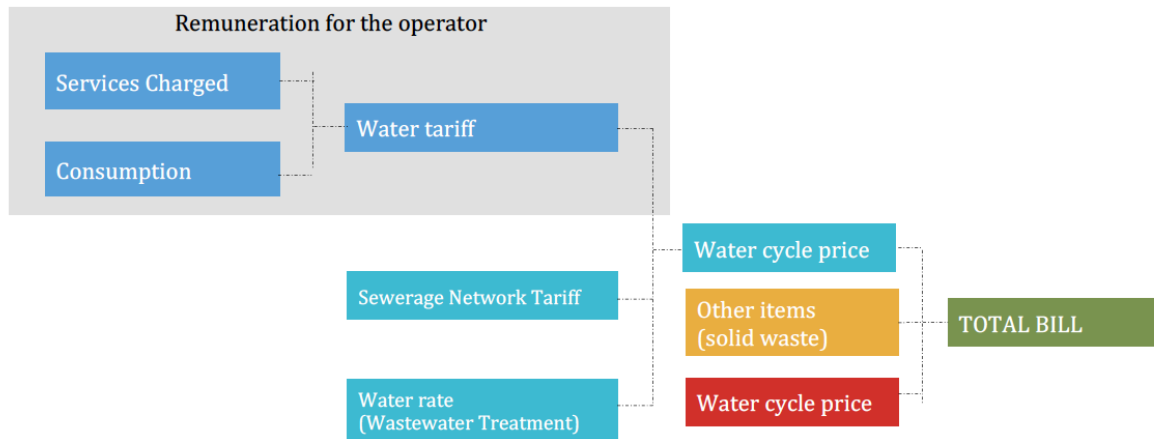


Figure 22: Items included on the water bill, (Bru Angelats and Albiol Omella 2013).

Also an example of a bimonthly water bill for a consumption of 20 m³ is shown in Figure 23.

Bimonthly Water Bill	Volume (m ³)	Unit Price (€/m ³)	Import (€)	VAT (%)
Service Fee				
Consumption				
Band up to 12 m ³	12	0.5870	7.04	
Band from 12 to 20 m ³	8	1.1742	9.39	
Water Supply Service (Aigües de Barcelona)	20		29.27	10%
Band up to 18 m ³	18	0.4469	8.04	
Band from 18 to 20 m ³	2	1.0294	2.06	
Water Rate (Aigües de Barcelona)	20		10.10	10%
Band up to 20 m ³	20	0.1529	3.06	
Sewerage Tax (Municipality of Barcelona)	20		3.06	
Solid Waste Tax (Metropolitan Area of Barcelona)			24.03	
VAT for Water Supply Service and Water Rate, 10% at the 39.37€			3.94	
Total Amount			70.40	
Total Consumption: 20 m³		Total Amount: 70.40 €		

Figure 23: Example of a water bill charged by Aigües de Barcelona, (Aigües de Barcelona n.d.)

3.5.3.2. Procedure for setting the water price

The next for the adaptation of the water price is the approval of the water rates from the regulator, which in this case is the Àrea Metropolitana de Barcelona (AMB).

In Spain each company should hand in its price proposals to the regulator, based on the cost recovery principal, and the local regulators will decide the price based on the proposals. Nonetheless, proposals have to meet environmental goals and comply with the regulation of the European Union services on a national and regional level.

More specifically, prices of urban water supply and sanitation service are subject to a two-step approval process, in the context of an authorized tariff regime. Firstly, the water operator, in this case Aigües de Barcelona, should hand in their annual price proposal to the local regulator. Then, the prices are provisionally approved by the municipality, with the autonomous regions, through their Price Commissions providing the definitive approval of the prices proposed by local governments. The second step enables a common approach to the price setting process among the municipalities within the same region, thus providing the Autonomous Water Body, in case of Catalonia is Agencia Catalana de l'Aigua (ACA), with valuable information to properly control and approve the tariffs, taking into account also the particular circumstances of each municipality (AQUAE Foundation 2013). The two-step procedure followed for the approval of the price is showed in Figure 24.

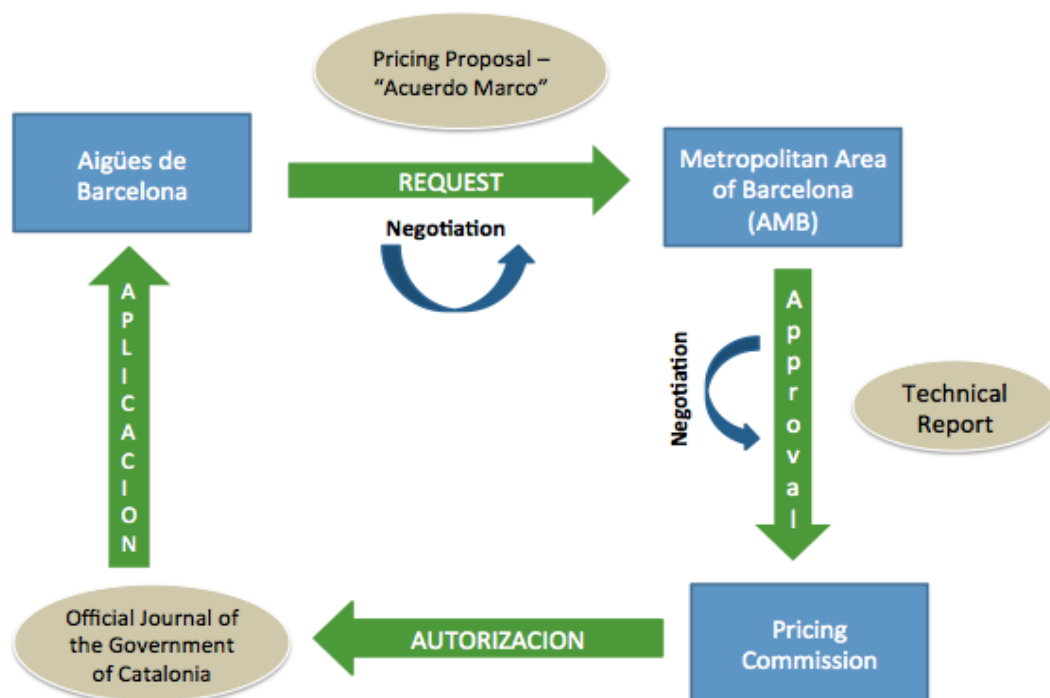


Figure 24: Process for approving the tariffs (Aigües de Barcelona 2009).

The final document of this agreement called "Acuerdo Marco" is the representation of the commitments between the regulator and the company, in order to achieve funding for the infrastructure that will ensure the quality of supply, a stability in the evolution of the tariffs, a better service to the citizens/clients and minimize the waste of water. As a result for the update of the tariffs that Aigües de Barcelona charges to its customers, important elements are considered, as follow:

- A polynomial formula for tariff revision, showed in Table 5 that takes into account past water acquisition costs as well as other costs, but which is also affected by a series of indicators that reflect the extent to which certain goals have been accomplished;
- Performance indicators to continuously measure the level of service;
- Commitment letter from the company to its clients.

A regular investment commitment during the term of the agreement is of about 150€ million according to data from the year 2005-2006 (Albiol and Demessence 2006).

3.5.3.2.1. The Polynomial Equation

The increase of the service fee, as corresponds to a service provided by a company mature and stable and in an environment not favorable for experimenting with increases, moves closely linked to the Consumer's Price Index (**IPC_n**). A possible increase of the component **ΔPA_{n+1}** is decided by the Board of the Directors of the company that sells the water to Aigües de Barcelona, in this case ATLL. Another component, **INV_n**, is formed as a prevision for covering possible necessary improvements that were not planned for improving the quality of service, or for advanced funding for strategic investments in water administration, with strict interest and benefit to the citizens who pay this fee.

The performance indicators are grouped into four different categories: water quality, environment, quality of service and customer's service. In Table 6 all the indicators that are taken into account as well as the relative weight of each different indicator are listed for the year 2005-2006. The most important, among the others, are the efficiency of the distribution system, minimizing water losses and the response time to the customers. A positive result in this set of indicators impacts the **IAM_n** factor in the equation. At the same time, for a negative result the company gets penalized (Albiol and Demessence 2006).

The analytical polynomial formula that is used for the tariff revision with all different components that are taken into consideration is showed in Table 5.

Table 5: Polynomial equation for tariff revision, (Albiol and Demessence 2006)

$$\Delta T_{n+1} = [(0.24 * \Delta PA_{n+1}) + (0.76 * IPC_n)] * IAM_n + INV_n$$

T_{n+1}: Price Increase application for the year n+1

PA_{n+1}: Average price for purchasing the predicted amount of water for the year n+1

IPC_n: Increase in the Consumer's Price Index (CPI) over the last 12 months (from July in year n-1 to June in year n)

IAM_n: Index of compliance to the Framework Agreement (Acuerdo Marco) of year n, based on the level of service indicators

INV_n: Costs for financing exceptional investments (including operational expenses) (€/m³)

3.5.3.2.2. Performance Indicators

The performance indicators are updated whenever something new important comes up. For this reason currently a new indicator in the water quality group has been added for the presence of trihalomethanes in the water, as the quality has to comply with the standards set by the European Union.

Table 6: Indicators referred in the Acuerdo Marco, 2005 – 2006, (Albiol and Demessence 2006)

Service Indicators	Relative Weight
Water Quality	25%
Quality of Disinfection	10%
Turbidity	8%
Smell	7%
Environment	20%
Amount of waste generated in WWTPs	4%
Elimination of pipes	6%
Elimination of unmetered users	6%
Efficiency of treatment processes	4%
Service quality	35%
Continuity (unsuccessful runs)	5%
Continuity (time without service)	5%
Efficiency of the distribution network	7%
Pressure	5%
Accuracy of installed meters	4%
Remote meter reading	4%
Time of installing new meters	5%
Customer support	20%
Complaint response time	5%
Waiting time in offices	5%
Waiting time on the phone	3%
Attended phone calls	4%
Quality of billing	3%
Total	100%

3.5.3.2.3. Commitment Letter

The letter of Commitment from the company to its clients, is a way for strengthening the quality of service performed by the company and at the same time target their activities focused on a more integrated quality in order to acquire a commitment of responsibility, efficiency and accuracy. Finally, is a procedure that ensures the quality of service with an economic compensation for the client in case of non – compliance. In agreement with the Àrea Metropolitana de Barcelona – the regulator – the company has established some very specific commitments about the quality of service as it is shown in Table 7. These information are open for the public in the website of the company so the customers can be well informed for their rights.

Table 7: Commitments from the company to its clients, (Aigües de Barcelona 2013).

Commitments	Explanation
Claims on water quality in a maximum of 24 hours	The company promises to contact the clients within 24 hours after making the claim. Otherwise, they will receive a compensation of 12 euros
Compliance appointment agreed	Commitment to make the necessary tasks at the client's installation (high supply and changes or counter checks, etc.) on the day and time arranged in advance by phone or in person. If not, the client gets a compensation of 10 euros. Cases in which the customer canceled the appointment are excluded.
Water in a maximum of 4 days	Once the customer's request is placed, the measuring equipment should be installed in a maximum of 4 working days. If not, the client is compensated with 15 euros.
Complaints in a maximum of 10 days	The complaints should be analyzed and the customer should get a response in a maximum of 10 days. If this doesn't happen then they get compensated with 12 euros.
Error in reading the meter	If the bill contains an error from reading the meter, the customer gets 15 euros back.
Immediate warning of excess consumption	Whenever the company detects consumption above the usual, they should communicate personally the client by leaving a note in the mailbox or by message on the bill. If the client doesn't get notified by any of these methods, will receive a compensation of 12 euros.
Immediate customer's arrangements	The most common customer's requests: change in ownership, duplicate invoices, update data... are conducted immediately. Otherwise, the client gets a compensation of 10 euros.

3.6. Description of the Socio-Technical Context in Aigües de Barcelona – Summary

The sub-questions defined in beginning of the chapter, were intended to be answered by the conducted analysis. The description of the socio-technical context of Aigües de Barcelona is a first step for answering the main research question about the interrelation between the socio-technical context and the decision-making process. In order to understand this interrelation, four different categories were analyzed in this chapter.

Because of the concession contract of the company with the regulator, the company has the responsibility not only for the operation and maintenance of the system but also for investments. Although there is no centralized price regulation model imposed by a national regulator, service concession contracting with municipalities is a tough competitive process where efficiency and operational excellence are important. The company has to discuss once per year with the regulator a price proposal. In this proposal, costs for financing exceptional investments are also included. Therefore, the company makes a 5-year in which investments are counted based on the company's needs as well as requirements of the regulators. The performance indicators provided by the regulator are based on outcomes that they are expecting on the society. The compliance of the company to these indicators is taken into account when setting the price tariff.

The ***physical characteristics*** of the system, describe the conditions in which the company operates. The Mediterranean climate of the region is a restricting factor for the water resources, since the area is suffering from long periods of droughts. Therefore, the company is continuously in search for new water resources. For a water utility located in an area of water scarcity in Europe, such as Aigües de Barcelona, issues related to the efficient use of water are more relevant than for a water utility located in an area where water quantity is abundant. Techniques for leak detection and smart metering are been used for the improvement of the system. Current pressures are a determinant for the performance of European water utilities and future pressures are marking the path for the transition from the present situation to a more sustainable future.

The ***cultural embeddedness*** analysis has shown that there is a strong perception in the customers about the quality of the water. This has a result, the decline in the water consumption of tap water the increase of bottled water. The company's objective is to improve the water quality by introducing new treatment techniques. In the long-term this decrease is possible to affect the company, since it's main financial resources are coming from the water tariffs. Furthermore, the company's strategies are influenced by its main shareholders. The importance of Health and Safety is a characteristic not so common in the Spanish culture, but common in the French culture introduced by the shareholders.

The ***institutional arrangements***, as a result of privatization and the actors included in the region, have created a complex structure of regulations. The municipal authority has important power and assumes shared and exclusive competences in Spain and in Barcelona in particular. The decentralization model that Spain follows enables a higher capacity to integrate local elements and sensibilities and gives more flexibility to cope and manage with local requirements on a yearly basis. The new public-private company responsible for the whole water cycle, operating from August 2013, shows new an integrated character.

The main ***governance characteristics*** show a short-term perspective due to the price review period. Moreover, Aigües de Barcelona as a private company should always take into account profits in return to the shareholders. For this reason the company has to discuss any planned expenses first with the shareholders. The company is a part of a big company group with an international vision, with involvement in different sectors. The strategic decisions are defined by the shareholders and the company has to align them in its program. Finally, there is an important innovation department that not only advises the Board of Directors of Aigües de Barcelona, but also markets new water management techniques and technologies all around the world.

Table 8 shows a small summary of the analysis carried out in the previous sections.

Table 8: Summary of the analysis

Level	Main Characteristics
1. Cultural Embeddedness	• Decrease in water consumption – poor water quality belief • Health and Safety introduced by the French Culture • Increase consumption in the suburbs – gardens are linked with social positionality
2. Physical Characteristics	• Water availability, continuous search for new water resources • Good performance of the system – Techniques for leak detection and smart metering • Application of innovative technologies – Advanced desalinization techniques
3. Institutional Arrangements	• Early privatization of the drinking water supply • Strong power of municipal authorities • Concession contract – competitive process with efficiency and operational excellence
4. Governance Characteristics	• Annual price review period • Strong Shareholders influence • International Vision • Innovation department • Marketing activities

CHAPTER 4

Case study: Athens Water Supply and Sewerage Company

4. Analysis of the Socio-Technical Context in Athens Water Supply and Sewerage Company (EYDAP)

The socio-technical context that is considered influential for the decision-making process of Athens Water Supply and Sewerage Company (henceforth EYDAP) is analyzed in this chapter. The objective of this chapter is to answer the sub-research questions:

What are the relevant elements of the Physical Characteristics that are taken into consideration in the strategic decision-making process about asset management by EYDAP?

What are the relevant elements of Cultural Embeddedness that are taken into consideration in the strategic decision-making process about asset management by EYDAP?

What are the relevant elements of the Institutional Arrangements that are taken into consideration in the strategic decision-making process about asset management by EYDAP?

What are the relevant elements of the Governance Characteristics that are taken into consideration in the strategic decision-making process about asset management by EYDAP?

The analysis of the external elements influencing the decision-making process starts with the description of the physical characteristics of the area in which the company operates in and its responsibilities. The second part is constituted by the description of the cultural embeddedness factors. Furthermore, the Institutional Arrangements are analyzed. The main actors involved; the regulations and legislations for the water sector in Greece and the water rights are described. Finally, the governance characteristics that include the price of water; the expectations of the customers, shareholders and stakeholders; and the ownership structure of the company are illustrated. The chapter will conclude by answering the above sub-questions.

4.1. Description of the Physical Characteristics

Greater Metropolitan Athens' population is estimated at around 4,300,000 million. It holds 35% of Greece's population. Attica's water service is under the supervision of EYDAP (Athens Water Supply and Sewerage Company Inc). The company is a legal entity of private law but of public purpose. EYDAP uses state-of-the-art technology, equipment and facilities to supply water to residents in the Attica region through an extensive network of almost 2,060,000 water meters and a 9,500 km of water pipes. The sewerage sector serves 3,500,000 residents with sewers spreading at almost 8,500 km.

Athens is located on the peninsula of Attica in the central-southern part of Greece. Greater metropolitan Athens extends today through almost the whole of the peninsula of Attica (427

km²). Typically Mediterranean, Attica's basins average rainfall in the center of the city is 368 mm/year (760 mm/year average for Greece). Most of the – on average – 60 rainy days are between December and March (Kallis and Coccossis 2003).

The Athenian agglomeration and its current structural characteristics is a succinct case of rapid urban and industrial growth, in a region with limited natural resources, without systematic planning and management. In addition to the absence of city planning, environmental problems are compounding their impacts to the area.

The Attica sector is the only water sector in Greece where urban water supply exceeds by far any other uses. In describing the water resources of Greece, the key element seems to be the uneven distribution, both in time and space, of precipitation, activities and population. Western Greece is by far richer in water creating water crescent from the north to the south than the eastern part of the country, where the majority of the population is concentrated. This spatial and temporal imbalance led to the development of a very long distance water conveyance system.

Most of Attica's city water sources are not available for potable use; surface sources are buried under concrete and groundwater aquifers under the central city are polluted or those close to the coast, salinized. Relatively abundant and remaining clean sources of groundwater are located in the mountainous outskirts of the city. Therefore, to obtain its water supply, Athens has resorted to a series of surface hydraulic works and transfers (Kallis and Coccossis 2003).

According to the existing legislation EYDAP is solely responsible for the water supply and the wastewater works to perform studies, construction, maintenance, repair, operation, financing, revenue etc. However, for flood protection and pollution control works, the Ministry of Environment, City Planning and Public Works, now Ministry of Environment, Energy and Climatic Change, has the responsibility of studies and construction, whereas EYDAP executes the remaining functions. The Ministry of Economics supervises the budget of EYDAP (Karavitis 2002).

EYDAP's area of service is the greater metropolitan area of Athens, as determined by Law 1068/1980 and it has the exclusive right to provide water supply and sewerage services in the geographical area of its jurisdiction. More specifically, EYDAP's area of service covers the municipalities shown in Figure 25, either directly (retail) or through bulk water supply. A number of municipalities, the majority in the metropolitan periphery, run their own distribution networks, receiving treated water in bulk from EYDAP, whereas a few supplement their supply with water from local sources. Finally, EYDAP supplies water to certain islands that belong to the Cyclades prefecture, as well as to various towns in prefectures along the Mornos and Yliki reservoirs.

The main water sources and reservoirs of EYDAP are located in pure areas, free from industrial and agricultural activity, resulting in the natural supply of the Greek capital city with water, which requires minimum consumption of energy. EYDAP, responsibly, with know-how and mainly stable human centric approach, successfully manages since 1980 the water cycle, which provides to all citizens without discrimination and returns it back to the environment clean. EYDAP remains committed to the optimal customer satisfaction by maintaining good quality of the supplied water and by providing high quality services. The company is also

committed to undertake continuous initiatives and actions to protect the environment (EYDAP S.A. 2014).

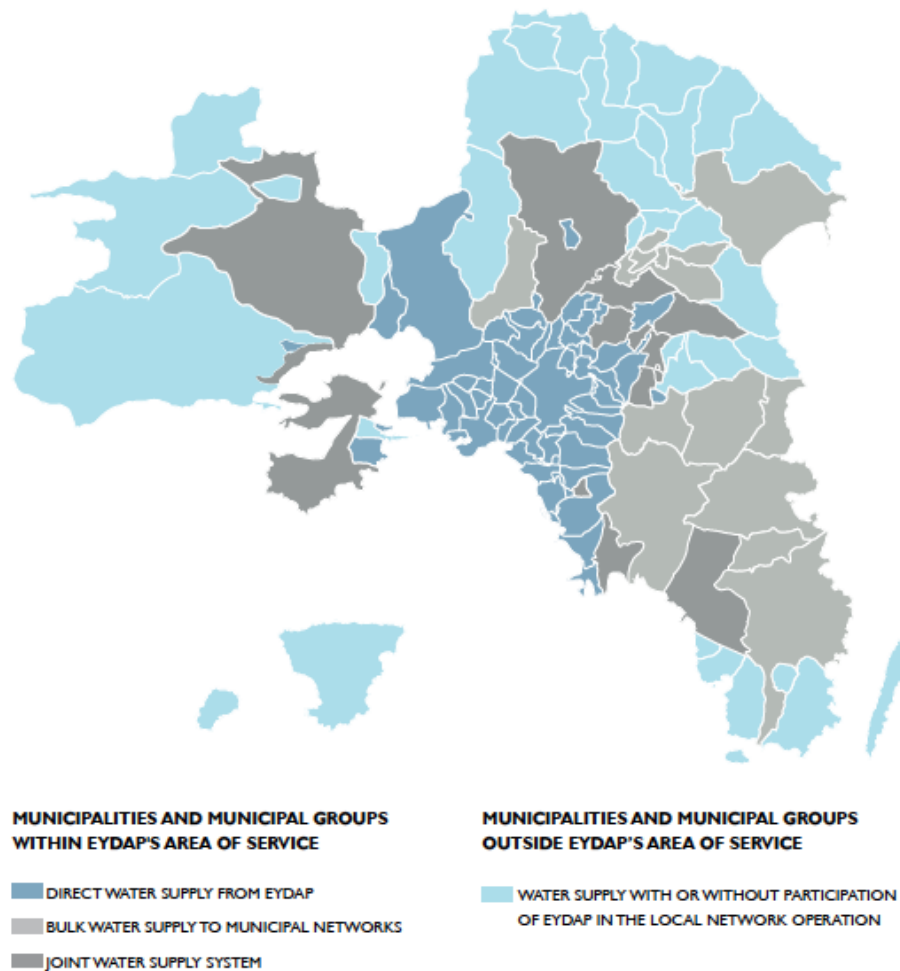


Figure 25: EYDAP's Area of service, (EYDAP S.A. 2014)

To meet its obligation and provide water-supply services in the greater metropolitan area of Athens, EYDAP obtains, under certain agreements, raw water from adequate resources that belong to the Greek State.

Athens's raw water supply depends predominantly on surface water sources. In years of drought, the groundwater wells play an important role in the raw water supply system of Athens. EYDAP operates about 100 groundwater wells. These wells comprise a safety reserve for the water supply of Athens.

Finally, the water delivery network of Athens satisfies the daily needs of its effective population who live and/or work in the greater metropolitan area of Athens, resulting in a daily per capita consumption of 280 liters (Figure 26). The altitude of its jurisdiction areas ranges from 0m to +600 m. The WTPs operational water levels range from +159 m to +248 m (V. Kanakoudis 2004).

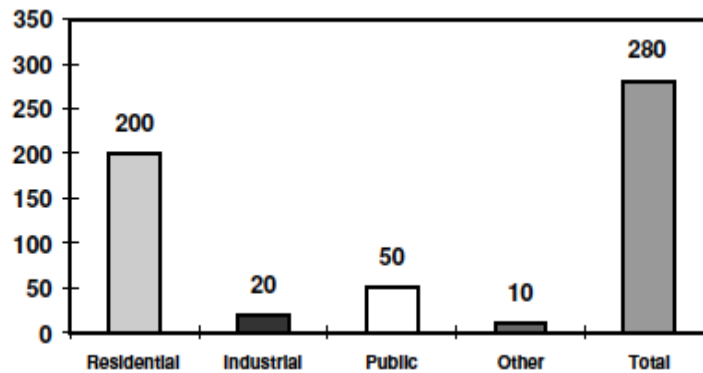


Figure 26: Daily per capita water consumption in liters, (V. Kanakoudis 2004)

EYDAP's largest class of customers, after the class of common consumers, both in terms of consumption and in terms of revenue and debts, consists of municipalities supplied with bulk water supply. In most of the cases though the municipalities do not have the money to pay back the company, this has resulted in big debts of the municipalities to EYDAP. Given the unfavorable economic conditions and the incapability of Municipalities to meet the operational requirements of their networks and their financial obligations towards EYDAP, EYDAP aims at the implementation of an extended program of Concession Contracts Networks with Municipalities that own and operate water distribution network. According to that:

- a. EYDAP will take over the management of the above-mentioned network, while the network remains at the property of the municipality,
- b. The customers of the municipalities will enjoy the upgraded services provided by EYDAP.

In this framework, in February 2013, the Management of EYDAP handed the draft concession contracts for the municipal water supply networks, to 7 Mayors in Eastern Attica. One of the municipalities has approved the concession contract with EYDAP for the water distribution network of the city, for a period of 20 years, starting on the date of signature.

Finally, about the wastewater services that EYDAP provides the company has submitted a project proposal for financing for reusing of treated sewages of Psytaleia and Thrasio Wastewater Treatment Plant for industrial and agricultural uses, reforestation, irrigation of urban green and enrichment of aquifer.

4.1.1. Influences of the Architecture of the system

The Athens water resource system is an extensive and complex system that includes surface water and groundwater resources. It incorporates four reservoirs, 350 km of main aqueducts, 15 pumping stations, more than 100 boreholes and four drinking water treatment plants (DWTP). Two of the reservoirs, the Mornos reservoir and the natural lake Yliki, hold 88.5% of the overall storage capacity, which approaches $1400 \times 10^6 \text{ m}^3$. Although the storage capacity of the latest constructed Evinos reservoir is quite small in comparison, inflows to this reservoir are the largest. Therefore, water from the Evinos reservoir is diverted through a tunnel to the neighboring Mornos reservoir, which stands as the main storage project for the Evinos River flow as well. The smallest reservoir, Marathon, is the oldest and the nearest to the city of Athens. Today the Marathon reservoir is kept at a high water level and it is used only as a backup for emergency situations and as a complement for the peak water demand during the summer season. The water of some aquifers, lying mainly in the northern part of the hydro-system, is used as a backup resource (Figure 27) (Koutsoyiannis, Karavokiros, et

al. 2003).

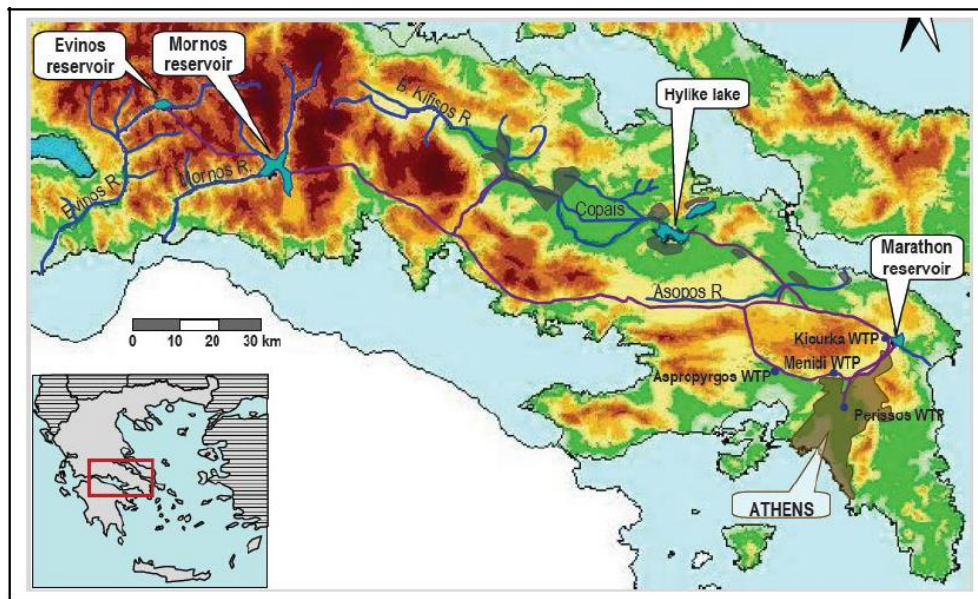


Figure 27: Athens water supply system – the four water sources, (Koutsoyiannis, Karavakios, et al. 2003)

Two main aqueducts transfer water from lake Yliki and from the Mornos reservoir. Interconnections of these allow alternative routes of water to the DWTP. Although the Mornos aqueduct carries water via gravity, water is carried through the Yliki aqueduct only via pumping with considerable cost. Another characteristic of lake Yliki is the significant leakage due to its karstic underground. Analysis of historical data established two distinct leakage-elevation relationships, one for the dry period and one for the wet period. It is estimated that about 50% of the overall inflows to the lake end up to the underlying aquifers and finally from there to the sea. Some minor leakage has also been observed from the Mornos reservoir. Moreover, water losses occur along some of the main aqueducts. Projects of EYDAP are under way, which will help specify the exact location and extent of losses and minimize them. Reservoir spills are another significant loss of the system. Due to the several losses, less than $500 \times 10^6 \text{ m}^3$ per annum can be available to the water supply of Athens; although the mean natural inflows are about $840 \times 10^6 \text{ m}^3$ per year and the groundwater resources in theory can contribute another $90 \times 10^6 \text{ m}^3$.

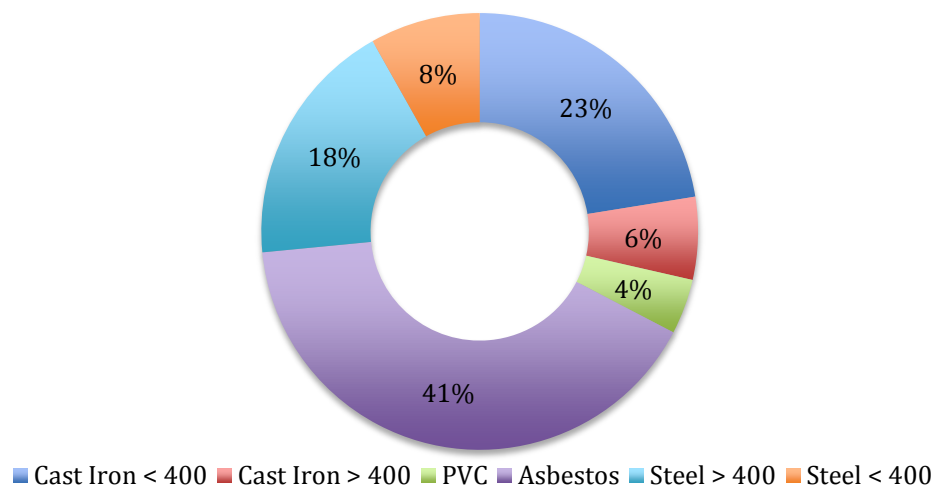


Figure 28: Pipe Material in Athens, (V. Kanakoudis 2004)

Initially the water supply system (510 km long) carries water from the Attica water resources (rivers: Evinos and Mornos, lakes: Yliki and Marathon, showed in Figure 27 to the four water treatment plants located just outside the city limits. From there, the delivery system, through mains (diameters > 400 mm of 1,250 km total length) and 'delivery' pipes (diameters < 400 mm, of 5,750 km total length), services 1,600,000 customers' connections (98.75% of them refer to domestic and 1.25% of them refer to industrial uses). The water distribution system is divided into the sections of Athens (2,150 km), Piraeus (1,950 km) and Heraklion (2,600 km). The pipe materials are cast iron, steel, asbestos and PVC (Figure 28). The delivery pipes are of all kinds of materials and the mains are made of cast iron and steel. The cast iron pipes are not lined in contrast to steel mains (V. Kanakoudis 2004).

The network has been divided into pressure zones for its stable operation and control. Pressure zones are designed to service areas differing in altitude by 30 m intervals. They are supplied either from the regulating/storage tanks via gravity flow, or from a pumping station, or from a zone of higher pressure. Based on the water network operational guidelines (as published in the Government Gazette No. 1396/22-10-2001), EYDAP has the responsibility to supply potable water based on Greek and European standards. EYDAP is required to provide its customers with a continuous operational pressure of at least 2 atmospheres at the water meter, and never higher than 12 atm. EYDAP's goal is for the water supply pressure zones to operate at a pressure of 6 bars (Chatzisavva and Arampatzis 2007).

4.1.2. Description of the water resources system

During the Roman period, the most important water supply work for the city of Athens was the 25 km long Hadrian aqueduct (commenced in the times of emperor Hadrian, 117–138 AD) carrying water from the mountain Parnes. This was also a long lasting work, as it provided water to Athens until the beginning of 20th century (with periods of deterioration and abandonment through the centuries). During the 20th century, the water consumption in Athens displayed an explosive increase as depicted in Figure 29. From $5 \times 10^6 \text{ m}^3$ in 1927 (population 800,000), the annual water consumption reached $400 \times 10^6 \text{ m}^3$ in 2000 (population 3,200,000). To provide this amount of water, the Greek State had to develop an extensive and complex water resource system comprising four major works that were built at the times depicted in Figure 29. The current percentage breakdown of water consumption is shown in Figure 30.

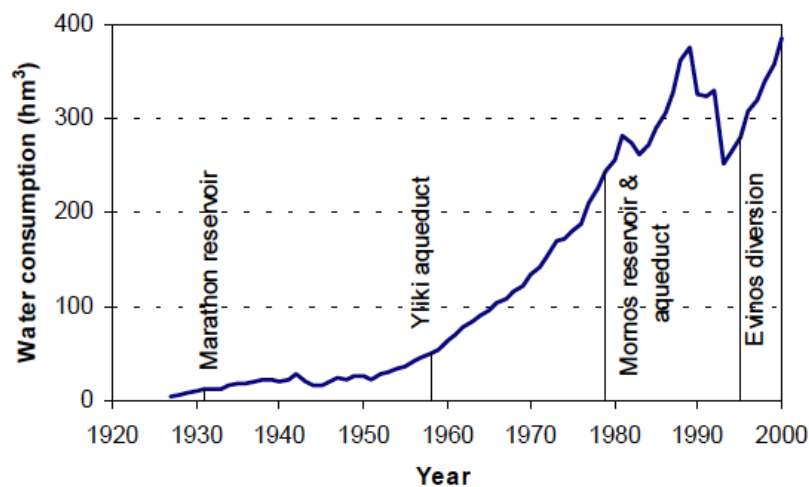


Figure 29: Evolution of water consumption in Athens and years marking commence of the different water supply projects, (Xenos, et al. 2002)

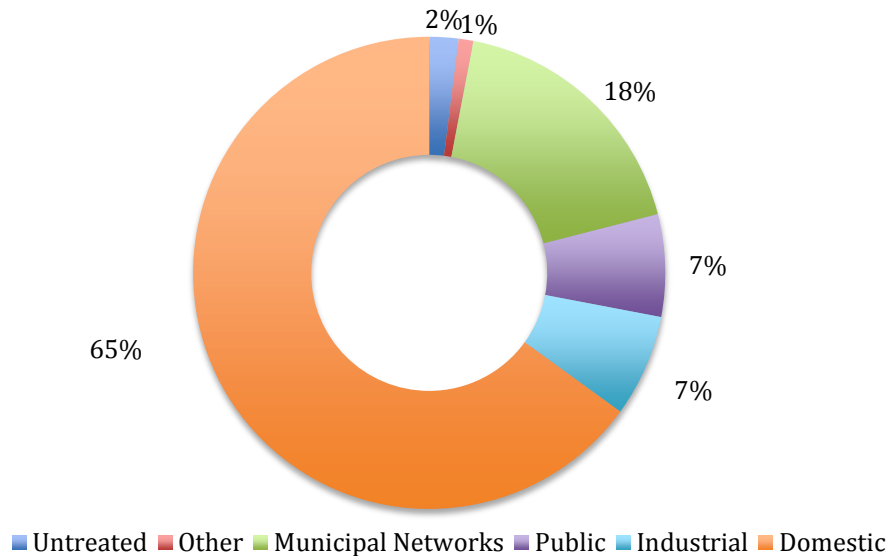


Figure 30: Percentage breakdown of water use in Athens in 2000, (Xenos, et al. 2002)

As clearly indicated in Figure 29, the urban water development of the 20th century, apart from the last decade, was supply oriented, aiming at providing structurally induced water abundance to Athens. The early 1990s is a transition period where both supply and demand are taken into consideration. Although, the 1990s was a period with an increase in the population and as a result an increase in the water consumption was identified, lately the population growth has been stabilized and as a result the water consumption is steady. Figure 31 shows the total water consumption from 1990 till 2012, where the last 10 years a stable volume trend is identified. The decrease in consumption is attributed to the lower number of connected households due to the repatriation of economic immigrants, as well as to the per capita consumption due to conservative use of water by the population following the economic crisis.

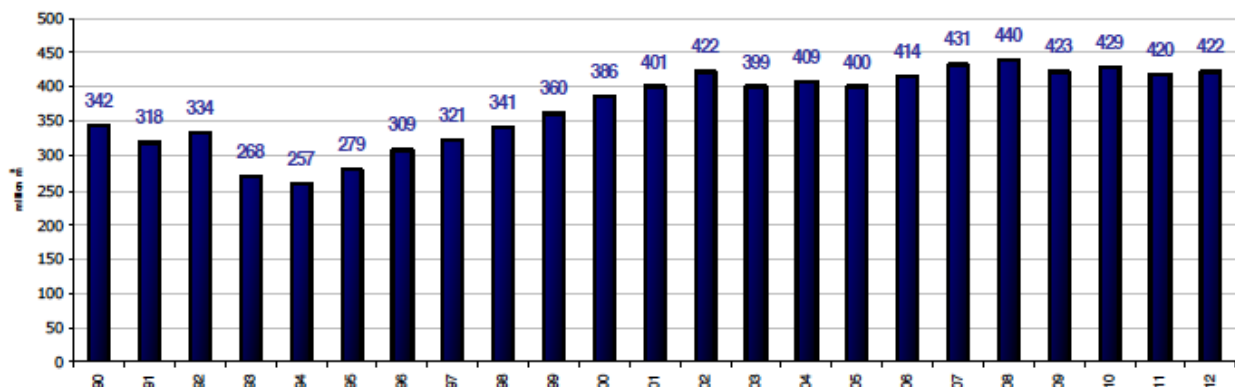


Figure 31: Total consumption in 10^6 m^3 , (EYDAP S.A. 2013)

The system's main objective is to provide water to the Greater Athens area through the four Drinking Water Treatment Plants (DWTP), which lie in the surroundings of Athens, Figure 32. Each DWTP (Kiourka, Menidi, Aspropyrgos, Perissos) serves mainly one sub-area of Athens, but there is a limited possibility of water transfer between the DWTP's, which increases the availability and security of the system in case of a malfunction. The annual water demand of Greater Athens had been continuously increasing until the early 1990s. Then, a persistent drought period almost vanished every surface water resource available. Today, after the end

of the drought period, the construction of the Evinos reservoir has been completed and put into operation, and the annual water demand of Greater Athens has reached again, if not exceeded, the pre-drought period level ($386 \times 10^6 \text{ m}^3$ in the year 2000). The water resource system also supplies other uses such as irrigation and water supply of nearby towns and also provides an environmental preservation flow of $1.0 \text{ m}^3/\text{s}$ in the Evinos River.

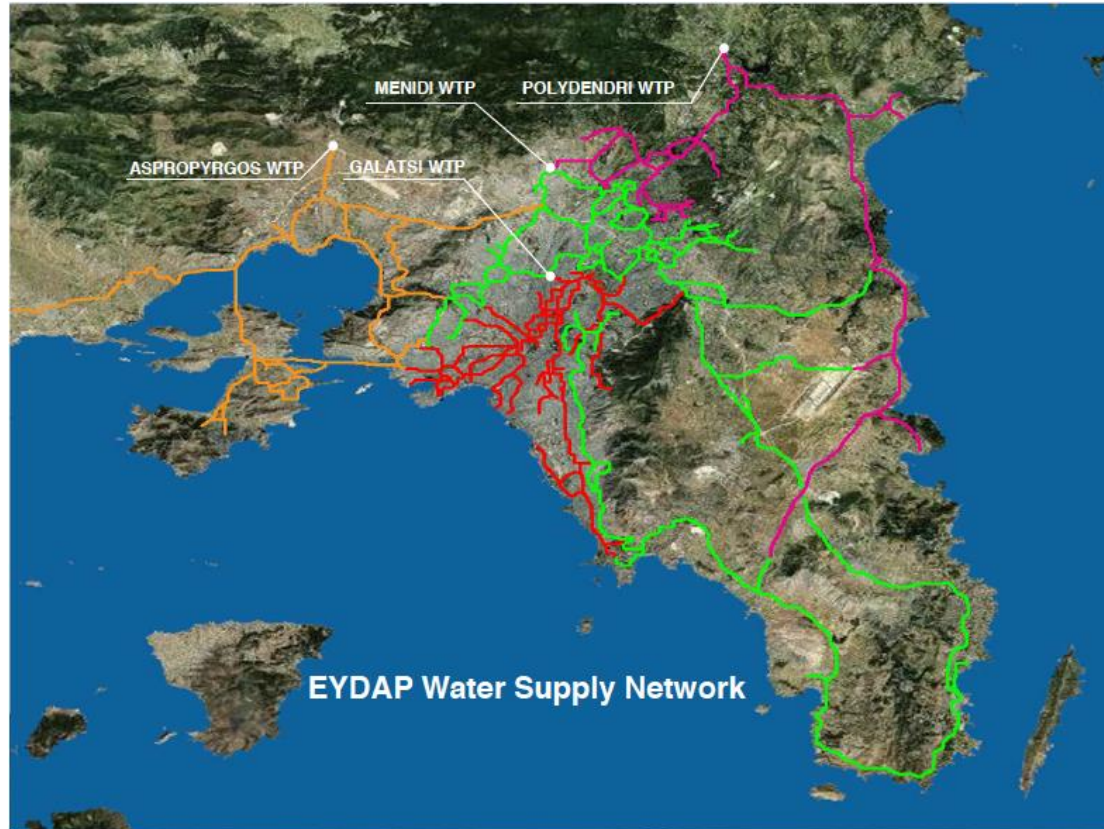


Figure 32: Water supply network under the responsibility of EYDAP, (EYDAP S.A. 2013)

The system's sources of water are:

- Marathon Reservoir: has a maximum capacity of 41 million m^3 of water and an operational volume of 34 million m^3 . The reservoir operates mainly as a backup source and as a primary regulating reservoir.
- Yliki lake: is a natural lake with a maximum volume capacity of 590 million m^3 of water. The lake is situated on a lower altitude to Athens and for that reason, the lake water intake structures depend on the operation of various pump units and as a result that consumes large quantities of electricity. Furthermore, the lake poses a problem of a high rate of water loss, due to the pervious areas in the lakebed. In order to alleviate the negative aspects of this problem, water levels of the lake are kept within a certain range so as to minimize water losses. This delicate balance is achieved in conjunction with the maintenance of the necessary volume in the remaining reservoirs.
- Mornos Reservoir: has a maximum capacity of 780 million m^3 of water, while its operational volume is 670 million m^3 .
- Evinos Reservoir: is the last reservoir and its construction was finished in 2001. Its maximum capacity is 140 million m^3 of water, while its operational volume is 113 million m^3 . The project also included the construction of a tunnel (total length of 29,4 km), which transfers Evinos' water to the Mornos reservoir when the first one reaches its maximum capacity.

- Boreholes: except from the four Reservoirs, there are also a large number of wells and boreholes that can provide 800,000 m³ of water daily. These sources are an auxiliary source of raw water and are to be used in the event of emergency.

The everyday normal operation of the hydro-system relies upon several decisions, which are concerned with the allocation of withdrawals to the different reservoirs or groundwater resources and the conveyance of water through the different aqueduct branches. In emergency situations, other issues such as activation of backup resources and storages, and measures to restrict consumption are also considered (Koutsoyiannis, Karavokiros, et al. 2003).

4.1.3. Decisions related to the efficient operation of the water system

A software called Hydronomeas has been developed by the National Technical University of Athens that it's been used by the company since 2003 as a decision support system (DSS), in order to determine the releases from the reservoirs so that their sum equals the total demand and enhance the demand management of the system. A schematic layout of the hydro-system, along with some technical characteristics, is showed in Figure 33. The DSS, now in its final stage of development, uses simulation and optimization techniques combined with database and geographical information systems (GIS). The DSS explores alternative management practices and locates optimal solutions for the operation of the water resource system (Koutsoyiannis et. al., 2002).

In general terms, taking into account only financial criteria, it is preferable to maximize the abstractions of the system Mornos – Evinos, since it's a gravitational system and as a result with zero energy costs. In contrast, the operation of the Yliki aqueduct and groundwater extractions involves significant costs due to pumping expenses. On the other hand, the decision of not using water from Lake Yliki, which is the second biggest reservoir available for the system, constraints significantly the security of the system in case of a big drought, mainly because of the physical underground leakage of the lake that can reach up to 50% of its annual reserves. Therefore, from the standpoint of safety it is preferable to maximize the abstractions from Lake Yliki in order to minimize the physical water waste. This decision though involves high-energy costs as in period of intensive use of Lake Yliki, 'EYDAP Fixed Assets' is the second largest consumer of electricity in Greece. The problem that arises concerns to when and at what volume should be integrated to the system the water from Lake Yliki as well as the water from auxiliary wells, so as to ensure the reliability of the system and at the same time to retain the operational costs from energy consumption within reasonable limits. This process influences the cost of bulk water, as it depends on the extractions costs from the water resources and the transport to the aqueducts.

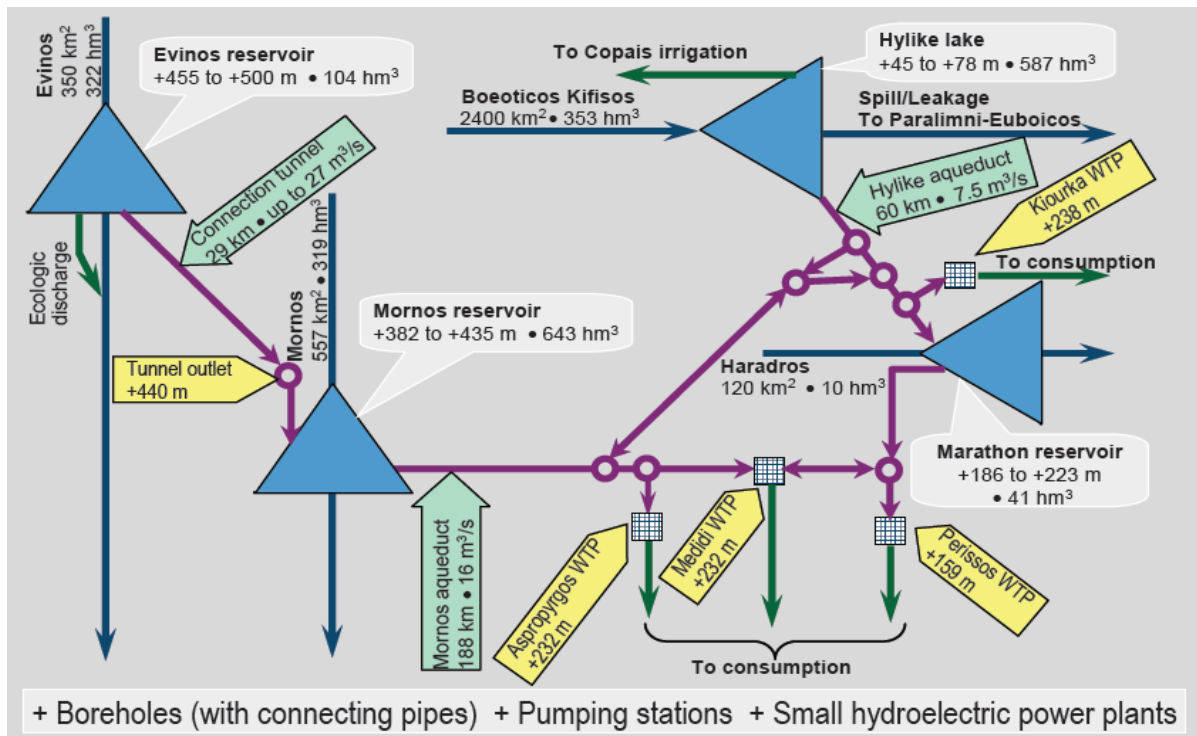


Figure 33: Schematic layout of the hydro – system of Athens, (Koutsoyiannis, Efstratiadis and Karavokiros 2002)

The mathematical framework of Hydronomeas, which is the decision-making module of the DSS, follows the parameterization – simulation – optimization scheme where simulation and optimization are effectively combined to derive the optimal management policy for the problem stated before.

The model that determines the general management of the hydro-system follows an operational rule, namely a law that specifies the desirable amount to be released from each source as a function of the actual state of the system. Usually, operational rules are empirical or heuristic (and consequently pre-defined) mathematical expressions that are incorporated into simulation models, where the aim is to faithfully represent the real-world system's performance rather than locate an optimal policy. The problem is formulated so that the following hierarchies of requirements are fulfilled (Efstratiadis, Koutsoyiannis and Xenos 2004):

1. Strict satisfaction of all physical constraints;
2. Satisfaction, if possible, of the operational targets and constraints, preserving the user-defined priorities;
3. Minimization of departures between the actual and the desired releases, so as to ensure that the management policy imposed by the optimized operational rules is implemented as much as possible;
4. Minimization of the system's operational costs

4.1.4. Performance of the water supply system

In 2013 total water consumption (billed or not) decreased by 2.4% compared to 2012. Moreover, in 2013 billed consumption decreased by 4.1% over 2012. Thus, in 2013 an increase of the non-billed consumption occurred that reached the 24.2%. The progress of the percentage of the non-billed consumption is shown in Figure 34 (EYDAP S.A. 2014).

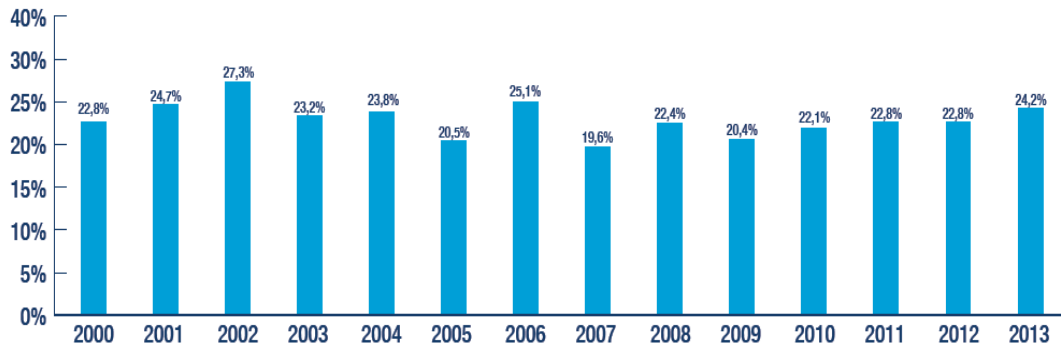


Figure 34: Percentage of non-billed consumption progress (%), (EYDAP S.A. 2014)

Due to the obvious significance of leaks a specific department of EYDAP is responsible for keeping continuous leakage records. These records include data gathered from customers' complaints reports and data collected by experienced personnel through leak detection techniques using portable sonic devices. From the complete leak data record it is apparent that 43.3% of the leakage occurs in pipe bodies, 24.1% in the customers' connections and the rest (32.6%) in other system devices such as valves, joints and gates. Figure 35 and Figure 36 demonstrate the allocation of leaks and breaks according to pipe material (V. Kanakoudis 2004). In Athens, EYDAP uses a troubleshooting manual along with a simulation hydraulic model and a SCADA system, under either abnormal operating conditions, to detect, identify and solve operational problems, or normal operating conditions, to determine the time and place that any preventive maintenance action must take place (Kanakoudis and Tolikas 1999). Furthermore, customers complains are used for leak detection. It should be noted that the data used in Figures 35 and 36 are from previous years, as a result the percentage of leakage is higher than the one measured by the company according to the non-billed water in 2013. Although, actions have been taken the leakage now is in the limits set by the European Union about the non-revenue water. Furthermore, in the appendix it can be found a more detailed approach taken by the company now in order to reduce the percentage of leakage. Finally, the percentage of leakage in the rest of Greece is much higher and in some regions reaches even 37%, (Chatzisavva and Arampatzis 2007).

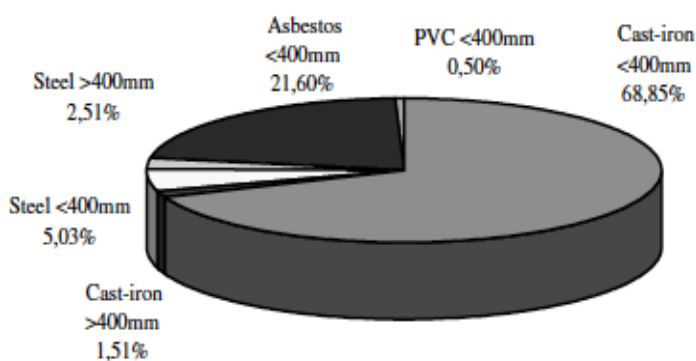


Figure 36: Leaks allocation according to pipe material

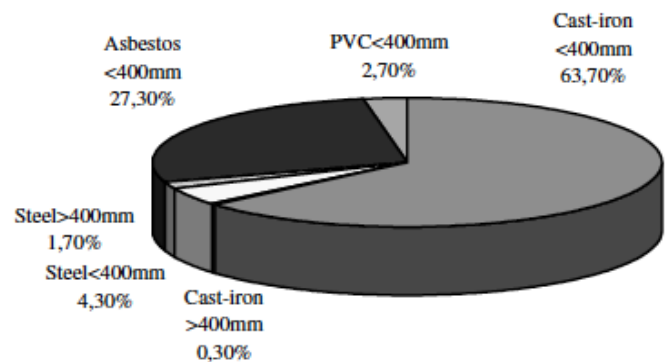


Figure 35: Breaks allocation according to pipe material

Company's strategy is to retain the good performance of the systems by making smart, targeted and rational operational investments. For this reason, the company is following a corrective maintenance, which as it was mentioned already in Chapter 3 in Aigües de Barcelona case study, this means that something is replaced or maintained when a break occurs. This is due to an attempt of a try for minimizing company's investments over the operational part. The company is following some Key Performance Indicators (KPI's) formed by the International Water Association (IWA) related to customer's complains and the performance of the distribution system, but are currently in a procedure of updating these KPI's by adding more in order to improve the performance of the system by introducing international indexes. Finally, the EYDAP's strategy for dealing with problems arising in the system is done with three different methods: by repair; by renovation and by a new project.

Table 9 summarizes the key physical data of the drinking water and wastewater distribution systems in Athens.

Table 9: Key data for drinking water and wastewater for Athens, (Cunha Marques and van Leeuwen 2012)

Drinking Water		Wastewater	
System input volume (Million m ³ /year)	420	Number of properties connected (x 1000)	400
Population coverage (%)	100	Collected sewage (m ³ /inhabitant per y)	78.9
Authorized consumption (million m ³ /year)	328	Length of combined sewers (km)	250
Consumption m ³ per person per year	105.8	Length of storm water sewers (km)	1200
Service connections x 1000	2036	Length of sanitary sewers (km)	7550
Water losses (m ³) per connection and year	45	Wastewater treated (Million m ³)	268
Water losses (%)	22	Total sludge produced in STPs (ton DS/y)	40410
Quality of supplied water	99.5	Sludge going to landfill (ton DS/y)	0
Average water charges (€ / m ³) 0.72 (ex VAT)		Sludge thermally processed (ton DS/y)	40410
Mains length (km)	8777	Sludge disposed by other means (ton DS/y)	0
Average mains age (y)	55	Energy costs (million €)	7.845
Main failures per 100 km per year	3700	Average age of the sewer system (y)	20

4.2. Description of the Cultural Embeddedness

4.2.1. Droughts – Decrease in water consumption

A persistent drought started in the late 1980s almost vanished every surface water resource available. At that time, the new Evinos project was studied and its construction began. Simultaneously, severe water conservation measures were studied and implemented. These included two drastic increases in water price, with simultaneous discount for significant water conservation. The pricing measures were accompanied by massive water saving information campaign. At a later stage, severe restrictive regulations were also introduced, which (a) prohibited and fined the use of treated water for irrigation, car and road wash, and swimming pools, and (b) restricted the private consumption to an upper limit, which was 70-100% of the consumption of the previous year, and fined heavily the exceedance of this limit (Christoulas 1994). The results of these measures were impressive as water consumption was reduced by a third (Figure 29). At the same time, individuals and municipalities searched for alternative local water sources, mostly groundwater from lower quality local aquifers to irrigate private and public gardens, to wash roads and cars and to use in industry. The entire experience shows the significant elasticity of water demand and its clear relation to water pricing (Figure 37).

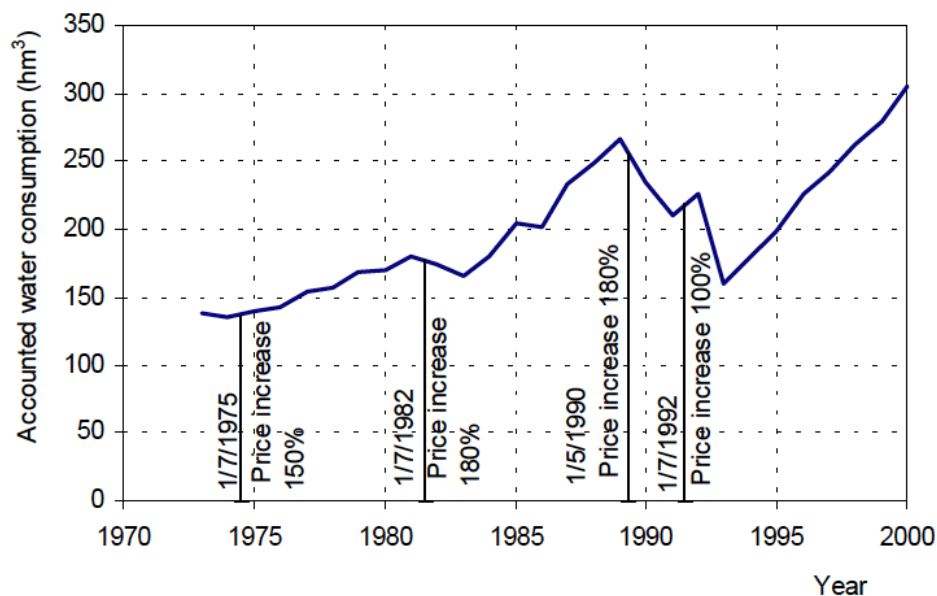


Figure 37: Schematic representation of the effect of price increase to water consumption, (Xenos, et al. 2002)

The rate of demand increase has become too high, exceeding 6% annually, although in 2001 as a result of a water conservation campaign it became 3%. A significant part of the rising trend is explained by the expansion of the supplied area and the trend of people to move from apartment buildings to houses with gardens at longer distances from Athens. This marks an improvement of living standard, but simultaneously is a threat for the water supply system. Detailed studies (A. Efstratiadis, et al. 2001) show that if this increase continues, the system will run out its capability in a few years. The potential for augmenting the water supply system by building new water resource projects is limited and extremely expensive, as both lower elevation rivers would have to be utilized and the conveyance, treatment and distribution infrastructure enlarged (Kallis and Coccossis 2003). Regional and environmental groups also have an increasingly louder voice, although they have not yet affected Athens

water policy. Parliamentarians from Western Greece have raised a petition for the creation of a fee to be paid by Athens for exploiting the regions water sources. Therefore, demand management appears to be the only viable solution for Athens for the years to come.

4.3. Description of the Institutional Arrangements

4.3.1. Main Intervening Actors

Until the mid-1960s, Greece's water policy regime was quite simple and had few actors involved, in administration and coordination. Later, the institutional context in the water sector became quite complex and fragmented, decreasing the prospect for coordination (Kampa and Bressers 2008). Today, the distribution of power among administrative structures about water protection and water resources management is divided into several levels (ministry, decentralized administration, regional administration, municipal administration, and others), as shown in Figure 38.

According to the Law 3199/2003 a ministerial National Water Committee (NWCT) has the following duties: determines the national policy on water protection and management; ensures policy implementation; approves national water programs; defines river basins and competent regional authorities; and submits to Parliament and the National Water Council (NWC), an extended representative board with consulting role, annual report concerning water resources status in Greece and compliance to European policy.

According to the official website of Ministry of Environment, Energy and Climate Change (YPEKA), the prime competent agency, the Special Secretariat for Water (SSW), former Central Water Agency is responsible for the development and implementation of all programs related to the protection and management of the water resources in Greece and the coordination of all competent authorities dealing with the aquatic environment. The implementation of the Water Framework and the Marine Strategy Directives, as well of the related Directives, fall within the scope of the activities of the Secretariat. The Secretariat is headed by a Special Secretary, appointed by the Ministry of Environment, Energy and Climate Change and Government. The Secretariat, in collaboration with the Regional Water Authorities (RWA), formulates and upon approval by the National Council for Water, implements the River Basin Management Plans (RBMP) and the national monitoring program upon the approval by the National Council for Water (Ministry of Environment, Energy & Climate Change n.d.).

The Regional Water Councils that are consisted of regional representatives are responsible for consulting about the formulation RBMPs. Even though, Law 3199/2003 establishes competent authorities in water policy, as shown in Table 10, the responsibilities of these authorities dealing with water management are not clearly stated and fully clarified (Alexopoulou, Makropoulos and Voulvoulis 2005); (Koutiva, Makropoulos and Voulvoulis 2007). Moreover, fragmentation, overlapping of similar responsibilities, lack of cooperation and bureaucratic functions impose barriers in water planning and hinder the implementation of RBMPs. Horizontal fragmentation of responsibilities among government agencies is also considered as a basic reason for the persistent failure of Greek governments to enforce an effective regulatory framework in environmental policies, in general (Koutalakis 2011). Although, several administrative tasks have been transferred to local authorities, the truth is that regional authorities have little experience in self-governance and have not succeeded to become fully operational and autonomous. The transfer of new competencies was not accompanied with fiscal and administrative capacities. Actually, theirs competence is related to the enforcement and application of regulatory standards defined by national legislation or

the environmental impact assessments of economic activities. Providing of management services in local authorities with closed nature and lack of significant financial resources and qualified personnel is not expected to have directly fruitful results (Koutalakis 2011).

Table 10: Established new administrative units by Law 3199/2003, (Podimata and Yannopoulos 2012)

Administrative Unit	Abbreviations
1. National Water Committee	NWCT
2. National Water Council	NWC
3. Special Secretariat for Water (former Central Water Agency)	SSW
4. Regional Water Authorities	RWA
5. Regional Water Councils	RWC

As it can be seen from Figure 38, there is a strong hierarchy in the institutions on water sector according to the latest law.



Figure 38: Institutional regime on water sector according to Kallikrates Law and Law 3199/2003, (Podimata and Yannopoulos 2012)

4.3.2. Regulations and Legislations

In Greece, water sector has been for a long time the major responsibility of the Central State. However, in the 1980s and mainly in the 1990s, regional administrations and local authorities acquired major responsibilities and competencies through a process of decentralization (Kampa and Bressers 2008). These waves of decentralization have challenged centralized regime of Greece, which is considered as one of the most centralist European states (Hlepas and Getimis 2011). Nowadays, several administrative tasks have been transferred to local authorities. Water sector has experienced institutional fragmentation at several levels of government. The extent of power, defined responsibilities and competences of these levels form the main characteristics of Greek water policy.

Greece is considered to be a country with a complicated administrative and legislative framework. Water Framework Directive (WFD) 2000/60 requirements about IWRM at basin level led to authority decentralization on water sector. Until then, there had been a restricted central state control about water resources and the decision-making powers were distributed by the highest levels of public administration. The current state of water resources management is defined by the existing legislative and administrative framework of Greece. The basic and main points of this legislation and administration follow next.

4.3.2.1. Greece

The basic frame of legislation on water resources management, besides the Law 1650/1986 on environmental protection that imposed the application of Environmental Impact Assessment Studies, also includes Law 1739/1987 on 'Water Resources Management' and Law 3199/2003 on 'Water Protection and Sustainable Management of Water Resources'. In fact, many law articles are repealed in Law 1739/1987 and other ones have never actually been put into practice. However, Law 1739/1987 remains a basic regulation specialized in water resources management. It characterized water as 'a natural good', established an institutional framework for the management of water resources in 14 defined water districts and introduced a license system for water exploitation, with various permit-issuing authorities, in order to overcome water use inconsistencies and rivalries (Podimata and Yannopoulos 2012). Thus, the Greek territory is divided into 14 regional water departments, corresponding to hydro-administrative units aggregating river basins. Although the regional water departments were initially designed to be autonomous units, they were later incorporated as "water offices" within the administrative structures of the existing regional authorities. These water offices are supposed to draft a regional water resource strategic and master plan, allocating water to the different users (including environmental uses and the maintenance of a minimum flow). The plans should provide the basis for the authorization of new abstractions (competency of the water offices) and the planning of the necessary water-works to satisfy anticipated needs [(Ministry of Development 1996); (OECD 2000)].

Competent ministries for each water use were defined. Ministry of Development former Ministry of Industry, Research and Technology, had the major competence for coordination-elaboration of national water policy, monitoring activities and the supervision for water development programs. Until then, the Ministry of Agriculture had been the main actor in water resources management. Every water usage needed to get official permission and license record, where water abstracted quantity and quality and other terms were defined. Law 1739/1987 also provided for balancing competing water uses (resolution of differences) by trying to coordinate the allocation of rights to water users (Stefopoulou, et al. 2008). Presidential Decree 256/1989 defined the water-use license procedure and imposition of fines.

Law 3199/2003 on 'Water Protection and Sustainable Management of Water Resources' is the incarnation of WFD goals and was put into force at the end of 2003. By giving priority to the ecological status of water bodies and emphasizing water environmental protection, Law 3199/2003 defines river basin as the spatial area where water management measures will be implemented. The development of a six year River Basin Management Plan (RBMP), including programs of measures, monitoring and specific measures, is introduced by Law 3199/2003. It defines new forms of competent water agencies where the Ministry of Environment has had the prime competence about national water coordination and monitoring. The law also determines representation in water councils for enhancing public participation in decision-making. Presidential Decree 51/2007 transposed more articles of WFD referring to RBMPs and to public participation in decision-making process (Podimata and Yannopoulos 2012).

In Greece the provision of water supply and sewerage is treated as a public service and that there are 214 companies of water supply and sewerage services in the country. The competent bodies/companies of water supply and sewerage are divided into three categories (Safarikas, et al. 2006):

- In the cities of Athens and Thessaloniki there are state-owned companies (nonprofit making corporations) for water supply and sewerage but function as private enterprises with a 20 – year concession contract. In Athens, as mentioned already there is the Athens Water Supply and Sewerage Company (EYDAP SA) while in Thessaloniki, is the Thessaloniki Water Supply and Sewerage Company (EYATH SA). Both companies come under the jurisdiction of the former Ministry of Environment, Physical Planning and Public Works (MEPPW) now Ministry of Environment, Energy and Climatic Change (YPEKA), which approve their water pricing policy. Overall, the objective of the above companies is the supply of water and sewerage services in their territory as well as the research, construction, establishment, operation, exploitation/use, management, maintenance, expansion and renewal of the systems of supply and sewerage. The population served by EYDAP and EYATH is estimated to be 53% of the total population of Greece.
- Cities with more than 10,000 inhabitants are managed by the Municipal Enterprises for Water Supply and Sewerage (DEYA) operating as private companies, but owned by the municipalities, as enacted by Law 1069/1980. Every DEYA, has as an objective the supply of water and sewerage to the customers while is responsible also for the quality of water, the early respond to a likely water shortage, the good condition of the water supply and sewerage system and the construction of water supply projects. Population served by DEYA is estimated to be 35% of the total population of Greece.
- In the rest of the areas (towns/municipalities with less than 10,000 inhabitants) the competent bodies of water supply and sewerage services are the Municipalities. These account for only the 12% of the total population served.

In conclusion, in Greece the water and sanitation services are public. The private sector can participate through the conclusion of contracts for the construction of projects or the conduct of studies. Such participation is regulated by a national legal framework and the companies bear limited responsibilities to the extent that concerns the competition of the project. However, since the project (or study) is completed, the public sector and in particular the local authorities, take over its utilization or operation. Thus, the public sector is responsible for the operation of the project and the function of the water and sanitation services. By retaining control, the price of water and sanitation services for the consumers does not increase and, therefore, they are easily accessible by everyone. The public sector takes into account issues of social equity and basic human needs, as well as issues of national security,

directly related with the protection of the quality of the services provided. It is important that the private sector participation is regulated by a legal framework, which emphasizes, even indirectly, the fact that water is a public good and the prices of water and sanitation services remain reasonable. The law, which governs the conclusion of contracts between the private entities and the public authorities, take into account the protection of the public interest and the reassurance of social equity.

4.3.2.2. Institutional Framework in Athens

The Athens Water Supply and Sewerage Company (EYDAP S.A.) bears the responsibility for water and sanitation services in Attica and it is the largest company in Greece operating in the water market. EYDAP was founded in 1980 under the "Incorporation of a Single Water Supply and Sewerage Company for Greater Athens" Act 1068/1980, pursuant to a merger of the incumbent water supplier in Athens and Piraeus 'Hellenic Water Company S.A.' (EEY S.A.), and the 'Greater Athens Sewerage Organization' (OAP S.A.). In 1999, after the adoption of Law 2744/1999, EYDAP S.A. took on its current legal form, with the primary fixed assets of the company passing into the ownership of the newly formed "Fixed Assets Company EYDAP NPDD"¹², a company remaining in the public sector. The Fixed Assets Company EYDAP NPDD owns the dams, the reservoirs, the external raw water aqueducts and pumping stations, as well as all other installations that ensure the secure transfer of water until it reaches the Drinking Water Treatment Plants (EYDAP S.A. 2014).

The Company operates under the authority of the Ministry of Infrastructure, Transportation and Networks and in accordance with the clauses of the Corporate Law 2190/1920 and establishment Law 1068/1980 as amended by Law 2744/1999. Until the enactment of Law 2744/1999 the Company operated as wholly state-owned utility. In 1999 the Hellenic State decided to partially privatize the Company by passing the 39% of the shares of the company to an Initially Public Offering in Athens Stock Exchange. With respect to this privatization, it was introduced and enacted the 2744/1999 Law, the main clauses of which are as follows, (EYDAP S.A. 2014):

- The legal duration of EYDAP is set to 100 years commencing as of 25th of October 1999, date at which the Law 2744/1999 was published. The aforementioned period can be expanded by an individual resolution of the General Assembly.
- EYDAP has the exclusive right to provide supply and distribution of water and sewerage services in the Attica region for 20 years commencing as of date of which the Law 2744/1999 was published in the Government Gazette. This exclusive right is not transferable and it can be renewed following a written agreement between the Greek State and the Company. It is noted that due to the nature of the product and existing infrastructure, the provision of water supply and sewerage services its a natural monopoly.
- EYDAP may also expand its operations to other areas within or outside the Attica region. Before each attempted expansion, EYDAP is required to investigate and ensure the feasibility of the effected investment, as well as to secure all necessary funds. The enactment of Law 4053/2012, whereby EYDAP may provide the full range of services specified in the Law 2744/1999 also outside its area of responsibility, through subsidiaries and through signing of framework agreements with local authorities, establishes a new growth framework for the company, expanding the market in which it can operate and develop. At this case the subsidiaries are

¹² NPDD is a Greek acronym which translates as "Legal Entity – Public Sector"

governed by the same legal and regulatory framework as effective for EYDAP with the exception of the tariffs policy which is defined by the programmatic contracts.

EYDAP's object is also stipulated in Law 2744/1999. The company's object is:

- a. To provide water-supply and sewerage services, as well as to design, construct, install, operate, manage, maintain, expand and upgrade water-supply and sewerage systems. These activities and projects include the pumping, desalination, processing, storage, transfer, distribution and management of all kinds of water, as a means of serving EYDAP's object. Other activities and projects include the collection, transfer, process, storage, management and disposal of wastewater treatment products.
- b. To provide telecommunications-related, energy-related, and sundry other services, and to exploit the water supply and sewerage system for other parallel objects, such as the deployment of telecommunications-related and energy-related operations, as an exception to the prohibitions of article 11, par. 8 of Law 2744/1999 and upon condition that the safe and reliable operation of the system is not jeopardized.
- c. To explore and exploit natural springs and water resources, produce bottled water and sundry other refreshments or beverages that contain water.
- d. To utilize know-how and offer technical support.
- e. To undertake investments related to the scope and object of the company.

It should be noted that in 2005 the "State Companies and Organizations (DEKO)" Act 3429/2005 was passed, stipulating specific provisions for such entities. More precisely, publicly held companies (listed on a stock exchange) in which the State holds majority or minority stakes are not considered as 'State-Owned'. Those companies are managed, organized and operate under Companies Act 2190/1920 and "Corporate Governance" Act 3016/2002. In 2012, the enactment of Law 4053/2012, whereby EYDAP may provide the full range of services specified in the law 2744/1999 also outside its area of responsibility, via subsidiaries and via the signing of framework agreements with local authorities, establishes a new growth framework for the Company, expanding the market in which it can operate and develop (EYDAP S.A. 2014).

The legal entity Fixed Assets Company EYDAP NPDD was established with purpose mainly the management of the operation and maintenance of the dams, reservoirs and the main transfer channel of water. These assets were transferred to EYDAP NPDD with a decrease of the Special Untaxed Reserve of Equity. The Greek State through EYDAP NPDD, is obliged to provide adequate quantities of raw water to EYDAP in order to the company to be able to meet the demands for water supply. The aforementioned maintenance of the infrastructure transferred to EYDAP NPDD has been assigned and is carried out by EYDAP. The annual cost of maintenance and the proper of operation of these installations continue to be counter-balanced against the cost of the raw water, which is provided by EYDAP NPDD to the company (EYDAP S.A. 2014).

Finally about the wastewater treatment plants, as of 2009 after the signing of the deliverance-acceptance protocol by EYDAP and the Ministry of Infrastructure, Transportation and Networks concerning the management of the dehydrated sludge desiccation unit of Psitalia, the company has under its jurisdiction the total facilities of Psitalia sewerage processing center (Phase A, Phase B, desiccation and CETHE). The company has also the responsibility and management cost (transfer and energy development) of the desiccated product (EYDAP S.A. 2014).

4.4. Description of the Governance Characteristics

4.4.1. Ownership

In the early 1900's, Athens' rapidly increasing population demanded that immediate actions should be taken regarding water supply. In 1922 with the huge influx of refugees from Asia Minor, Athens underwent a sharp increase in population that had a devastating effect on the city's water supply. An American Company by the name Ulen Company was commissioned to renovate and increase the water supply capacity of the existing aqueduct system, as well as to construct a new water supply system in two areas (Athens and Piraeus). Under a Build-Operate-Transfer contract, the New York based Ulen Co. assumed the task of financing, constructing and operating Athens water system for a period of 22 years, until the Greek Government would repay the loan. A private company, the Hellenic Water Company Inc. (EEY), was set up by Ulen for this purpose, assuming the ownership of the infrastructure and operating on behalf of the Greek State.

Athens became the first Greek city with a modern water supply system and the only, up to this day, Greek city for which water management is directly controlled by the central government (Coccossis and Kallis 2000).

Keeping the cost of water low for the end-users was an essential goal in the states approach to water management. The State maintained the right to determine water charges and EEY collected them on its behalf. Although, the formal agreement between the State and Ulen imposed that the charges should be determined so as to pay both premium and interest of the loan and to cover all capital, operational and maintenance expenditures, in practice prices were set at a level that was not even high enough to cover annual expenditures. A few years later, the loan was not repaid on time, but in 1974 the State bought Ulen's share of the company. As the State had guaranteed to cover any of EEY's operational deficits, this meant that the low price of Athens water was subsidized by public funding drawing from general taxation.

EYDAP was it was mentioned in Section 4.3.2.2, was founded in 1980 under Act 1068/1980, pursuant to a merger of the incumbent water supplier in Athens and Piraeus "Hellenic Water Company S.A." (EEY S.A.) and the "Greater Athens Sewerage Organization" (OAP S.A.). the Ministry of Environment, Spatial Planning and Public Works retained responsibility for the company, appointing its presidents, director and the majority of its board, and for the planning, financing and executing Athens's large water works as well as for setting water prices.

The quest to reduce public deficit over the short-term, a crucial criterion of Greece's late entry into the Economic and Monetary Union of the European Union in 2001, through proceeds from public sector privatization the company fitted well with the dominant view of the drought period 1989-1993. Although, Kaika, 1999 provides evidence for the reverse argument and more specifically that the drought was used as an instrument as part of the privatization-agenda of the non-liberal government (Kaika 2003). Since the costs of environmental and basic urban infrastructure in Athens are generally financed by the EU, it was not so much the high costs faced by the public sector for renovating the supply infrastructure and meeting the EU environmental requirements that drove water sector privatization, as it was the Commission's unofficial pressure for efficient managerial and planning structures as a pre-requisite for its financial support. Given the political failure of the neo-liberals agenda of full-privatization, the social democrats replacing in power followed a

milder policy of modernization, selling a minority of the shares in public utilities, but maintaining strategic control. Therefore, in 1999, under the Act 2744/1999, EYDAP took its present legal form and a concession was signed with the Greek State, in which the company has the exclusive responsibility of the water supply and sewerage services for 20 years. The main shareholder was the Greek State and as a result although the company was listed on the Main Market it remains a state-oriented company.

The Hellenic Republic Asset Development Fund (HRADF) owns the majority of the shares. The HRADF was established on 1st July 2011 (Law 3986/2011)¹³, under the medium-term fiscal strategy with the aim to restrict governmental intervention in the privatization process, and its further development within a fully professional context. The HRADF is operated by 100% from the Greek State. The plan is that the 61.33% of the shares transferred to HRADF will be sold through an international open tender. In the aforementioned transaction it should be mentioned that the percentage of the Greek State in the capital share of EYDAP is consequently formed to 0.00%. The Greek State controlling 100% of the HRADF controls indirectly the voting rights.

The shareholders composition on the 31/12/2013 is shown in Figure 39.

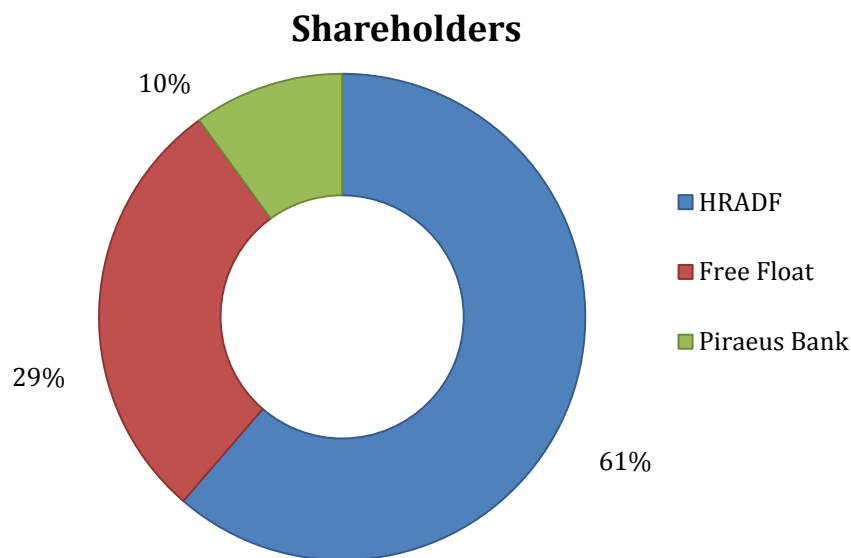


Figure 39: Shareholders of EYDAP, (EYDAP S.A. 2014)

By Decision No, 1960/2014 Case, of the Council of the State, Greece's highest administrative court, annulled the government's decision to transfer the 34.033% of the share capital of EYDAP, from the Greek State to the HRADF. According to the decision of the Council of the State, the privatization of EYDAP is in contrary to Articles 5 and 21 of the Constitution Law, which requires the attention of state for public health, and also ensures the right to health protection.

Finally, EYDAP established in 2011, a subsidiary company called "EYDAP Nison S.A." were the company participates with 100% in the share capital. The scope of the new company is to provide water and wastewater services as well as a variety of activities related to water, in

¹³ In article 1.2 of Law 3986/2011 is stated that, "The product of the assets utilization is used exclusively to pay off the country's public debt" and all public percentage is to be managed by this fund.

the Greek islands territory. The aim of this initiative is to exploit the expertise of EYDAP in order to provide water services in other territories outside Athens.

4.4.2. Regulatory Structure

4.4.2.1. Influences on Regulations and Stakeholders Requirements

The direct stakeholders of the system are the three ministries that are set by the government as responsible for the operation of the company:

- Ministry of Environment, Energy and Climate Change (YPEKA)
- Ministry of Economics and Finance
- Ministry of Infrastructure, Transport and Networks

Also the municipalities that the company supplies with water are part of the system not only as users but also as collaborators for implementing projects for the maintenance, rehabilitation and the renovation of the system when needed. In general, the company can be characterized as customer-oriented.

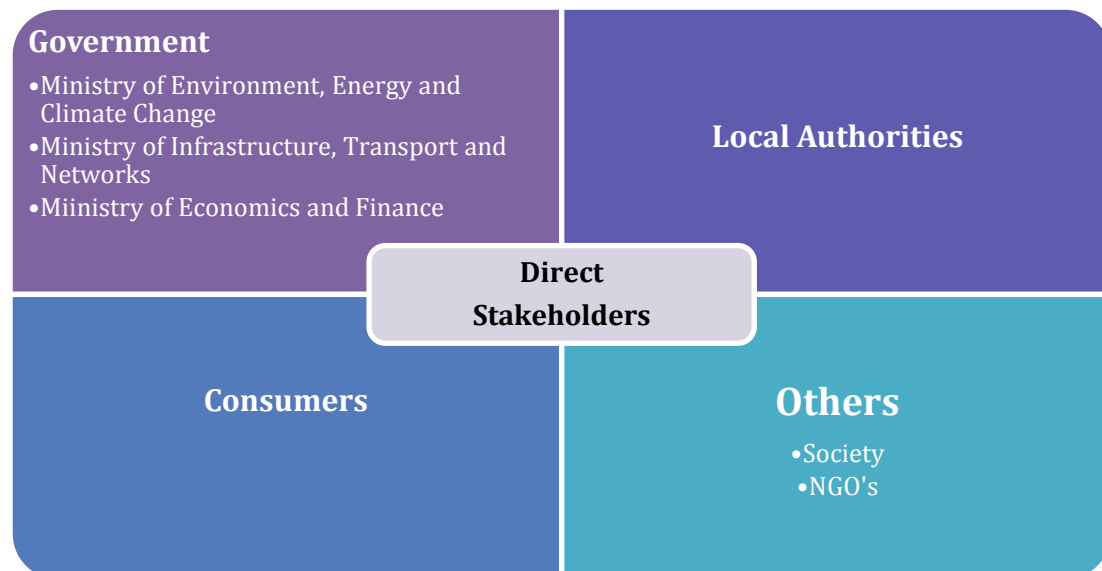


Figure 40: Stakeholders of the system

The Greek State is the main regulator of the company through the Ministry of Environment, Energy and Climate Change and more specifically through the Special Secretariat of Water. The Special Secretariat of Water monitors and, if not defined otherwise in the law, supervises the proper implementation of existing managing contracts for compliance with the envisaged terms and conditions of the agreement signed between the EYDAP NPDD and EYDAP about the standards set for potable water and the effluent of the wastewater treatment plants. The Greek State has the power to appoint the chairman of the Board of Directors of the company. The Ministry of Infrastructure, Transport and Networks is in charge for inspecting the fulfillment of the agreement signed between the company and EYDAP NPDD about the quality and the supply method of the raw water from the second to the first.

The Board of Directors is the supreme administrative body of the company that primarily formulates the corporate growth policy and strategy while supervising and overseeing the management of the corporate property. The Board of Directors has authority to decide on all matters with respect to the management of the corporate property, the administration and representation of the company and the corporate business in general, and proceeds with all

action and decisions aimed at the fulfillment of the Corporate object; the Board of Directors also monitors the course of the Company and the implementation of its activities. Excepted are those issues and matters, which, under the provisions of the Law or the present Articles of Association, fall within the exclusive authority of the General Meeting (EYDAP S.A. 2014).

The Board of Directors consists of:

- Two representatives of the Company's employees, elected (along with their alternate members) by direct universal suffrage, in accordance with article 17, par.1, of Law 2469/ (Government Gazette A' 38), as in force whenever.
- Two members representing minority shareholders, in accordance with the provisions of article 18, paragraphs 3 and 5 of Codified Law 2190/1920, elected as per the provisions of article 36 hereof.
- Representatives of the shareholders, elected by the General Meeting; shareholders who participated in the Special Meeting provided for in article 36 hereof (concerning the election of the remaining members of the Board) may not participate in the said General Meeting.

The company's last business plan was conducted 10 years ago. The usual time period of a business plan is 5 years, but the situation the last years remains the same and as a result it wasn't needed a change. Company's current strategy is "business as usual". The last big infrastructure investment was included in the latest business plan and it was the wastewater treatment plant in Thriassion. In general, new potential projects have an implementation frame of 2-3 years.

The budget allocation is accepted from the bottom to the top. More specifically, once per year each department has to ask for a certain budget for the following year, mainly according to the expenses occurred in the running year. This proposal has first to be accepted from the head of each department and then from the executive directors. The final proposal is discussed in the Board of Directors meetings and they are the ones that are going to accept or reject the economic proposal.

The company is responsible for the water quality of both the raw and treated water according to the Ministerial Ordinance A5/288/1986 "Quality of potable water", following the EU Directive 80/778 and the Health order YM 5673/4-12-1957, about potable water disinfection. The Ministerial Ordinance A5/288/1986 sets distances for the activities done close the water resources in order to ensure a good quality of the raw water. The treated water is tested every day according to EU Directive 98/83/EC. The Greek State is responsible for the water quality, but EYDAP on behalf of the Greek State, as an indirect responsible, checks the water quality and provides the results to the Greek State. Every 3 years the corresponding department sends an analytical report to the Ministry of Health with all the data recorded.

4.4.2.2. Shareholders

The General Meeting of shareholders of the Company is the supreme body of the Company, being entitled to decide on any matter in connection with the Company; its resolutions, passed as prescribed by law, are binding on all shareholders, even absent or dissenting ones. The General Meeting of shareholders, convened by the Board of Directors, holds its ordinary sessions at the place where the registered office of the Company is located, once every year, within six months at the latest after the end of each business year.

The Greek State attends the General Meeting represented by the Minister of Finance or his representative authorized in writing by the Minister of Finance. The General Meeting may also be attended, without voting right, by the Minister supervising the Company or his representative authorized in writing by the said supervising Minister. Specifically for the election of the members of the Board of Directors, the State, as a shareholder, is represented at the General Meeting by the Ministers of Economy and the supervising Minister or the official authorized by them.

4.4.3. Price of Water

4.4.3.1. Pricing Policy

Water supply prices vary considerably throughout the country and are set by municipalities, whereas in Athens are approved by the Ministry of Economics and Environment, Energy and Climatic Changes. Water charges are based on volumetric rates and are progressive, with the price per cubic meter increasing with the level of consumption; however, a ceiling exists for large families. The big cities of Athens and Thessaloniki have a combined water billing system covering both water supply and wastewater collection & treatment charges. Volumetric rates for industry are generally higher than for households with charges including also flat rate pollution charges and wastewater charges. Four protection areas have been designated for vulnerable drinking water sources, in the framework of a program to protect drinking water resources.

In general terms, the present regulatory framework approach entails setting a binding revenue requirement so that the reasonable costs of providing water and sewerage services can be recovered by the regulated entities or service providers, consistent with the requirements of the European Union (EU) Water Framework Directive, as transposed into Greek law (Law 3199/2003 and Presidential Decree 51/2007, and as amended by Law 4117/2013) (Special Secretariat for Water 2013).

Nowadays, the water bills in Greece consist of mainly increasing tariffs (separation of the consumed m³ in scales with different price per scale) including a fixed charge (calculated either in monetary units or in water volume). The water bill of municipal water utilities consists of various charges (Papadopoulou, Tsitsifli and Kanakoudis 2013):

- I. Value of water consumption,
- II. Fees related to the connection to the water and sewage pipelines (well, water meters, fittings),
- III. Connection fees to the water network,
- IV. Sewer usage fee,
- V. Connection fees to the sewerage network,
- VI. Fee for the design and construction of water supply and sanitation
- VII. Discounts and
- VIII. VAT, varying between the water utilities, depending on the region a water utility belongs to.

EYDAP's tariff policy is renegotiated every 5 years in accordance to Law 4177/2013 with the corresponding ministries after considering the Company's Board of Directors opinion. This is consistent with similar regulatory environments elsewhere that generally specify control periods of between four and eight years. A particular benefit of a relatively long multi-year regulatory period is that it is less burdensome on both the Secretariat (regulator) and the service providers because a detailed review of costs only occurs every few years. Depending on the incentive mechanisms that might be developed, a longer period may also provide

stronger incentives on operators to outperform ex ante assumptions for costs and outputs (Special Secretariat for Water 2013). Negotiations involving the tariff policy take into consideration the inflation index as well as the European Union Water Framework Directive 2000/60/EC, which includes an article on the recovery of costs for water services.

The present system involves a marginal block structure for domestic consumers and a flat block structure for all other consumers, comprising a total of eight categories. There is also a fixed charge applied to each connection related either with the total water consumption of the latest 3 months period for domestic users or the diameter of the water meter for all other users. Sewerage services are charges in four categories as a proportion of the water tariff. Domestic users are charged an additional 75% of their water consumption for sewerage services. The annual tariff increase is based on the evolution of inflation, and the general government policy concerning utilities. On December 16th 2013, the Joint Ministerial Decision of the Ministers of Finance, Infrastructure, Transport and Networks and of Environment, Energy and Climate Change, who accepted the decision of the Board of Directors of EYDAP of March 28th 2013 and decided the tariff readjustment of water supply and sewerage services provided by the company as referred to the J.M.D., was issued in GG B' No. 3188/16-12-2013, setting into effect the adjusted tariff from the date of publication, the 16th of December 2013. The new tariff policy includes reductions in consumption prices, within its social responsibility policy. The current water and sewerage new reformed tariff structure is presented in Table 11. The bill comes to the consumers every three months.

Table 11: Tariff structure charged after 16/12/2013, (Athens Water Supply and Sewerage Company (EYDAP SA) 2013)

Tariff Categories	Water Supply		Sewerage Services
	Consumption (m ³) /Month	Price (€) / m ³	% Water Price
Domestic Minimum Mandatory Consumption of 2 m ³ /month	0 – 5	0.35	75% (30% discount for gardens > 200 m ²)
	5 – 20	0.64	
	20 – 27	1.83	
	27 – 35	2.56	
	35+	3.2	
Industrial – Professional	0 – 1000	0.83	75% (50% discount for special industries)
	1000+	0.98	
Public Services – Municipalities	Independent	0.98	75%
Social Charity	Independent	0.23	75%
Ships Supply	Independent	2.4	
Municipality Network Support	Independent	0.488	
Fire Protection	Monthly charge	11.01	
Raw Water	Independent	0.1804	
Fixed Monthly Tax			
Domestic Consumption (Depending on the Diameter of the water meter)	Independent	1	
Industrial and Municipalities (Depending on the Diameter of the water meter)	Independent	4.5 - 35	
Law 1068/42	1% on the total water consumption		

VAT	13% on the water consumption
VAT	23% for the rest (Sewerage + Fixed Monthly Tax)

Furthermore, except from the new reduced tariff the company applies since June 2013 a new claim settlement program, which includes specific social arrangements to better serve the Greek household, which is affected by the crisis. Since September 2013 and for one year, EYDAP, due to the unfavorable economic conditions that have affected the Greek households, after the unanimous decision of the Board of Directors and within its social responsibility policy and continuing social contribution, has set into effect the Social Tariff. Specifically, for specific social groups, families with many children, single-parent families, elderlies with low income, a discount up to 60% on water - sewerage bills is set (EYDAP S.A. 2014).

The main objectives of the tariff policy are:

- To provide adequate incentives for users to use water resources efficiently and to discourage waste
- To accommodate special groups with a diversified tariffs
- To maintain high standards in water quality
- To preserve the social character of EYDAP S.A. as a utility (the average price of water supply and sewerage is only a small percentage of household income)
- To partially finance EYDAP's investments
- To accomplish EYDAP's economic goals

Bulk Water Supply to municipal networks, which represent the second biggest customer class, in 2012 increased by 4.6% compared to 2011, versus a 2.1% decrease in 2011 compared to 2010 as it can be seen in Figure 41.

BREAKDOWN OF BILLED CONSUMPTION PER CUSTOMER CLASS

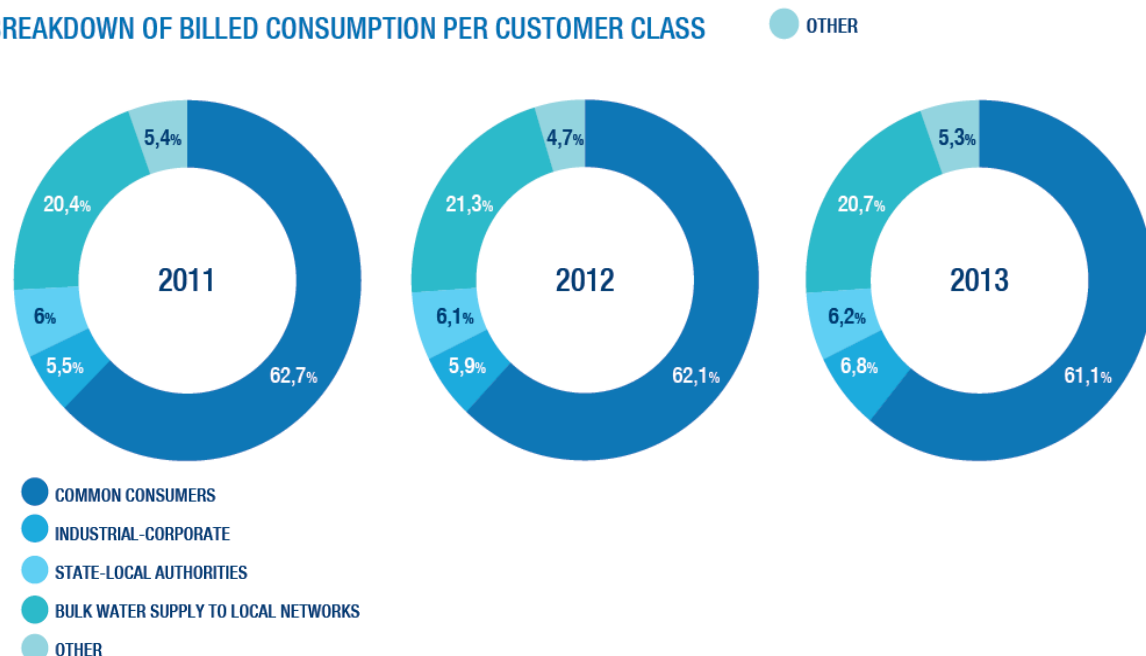


Figure 41: Billed consumption per customer class, (EYDAP S.A. 2014)

It should be mentioned that the municipalities that EYDAP is selling the water for the support of the system are using their one tariff system. They resell the water to the consumers charging different prices. EYDAP is responsible only for supply the needed amounts of water, the municipalities are in charge for the rest. So, the prices even inside the Metropolitan Area

of Athens are quite heterogeneous. The municipalities should pay the company for the water that they receive but there are a lot of cases that either they don't pay on time or they don't pay at all. As a result, the company had to go to court and solve these types of problems. Therefore, one should also consider the adverse effects imposed by the dire financial context wherein EYDAP operates, the high amount of receivables from State and Municipal Authorities, and the absence of a tariff policy regime that would serve the company's business plan, due to its ownership status. It is obvious that in such a volatile financial and business context, it is hard to forecast long-term business developments. It is certain, though, that the company's strategic choices and actions ensure its sustainable development and set the ground for further profitability and growth, upholding the interests of its customers and shareholders.

In line with its recently established responsibilities (Law 4117/2013 and JMD 322/2013), the Special Secretariat for Water is developing a new regulatory framework for the pricing of water and sewerage services in Greece across the entire value chain, from 'catchment to tap'. This will be an evolutionary process, given the absence of a single pricing policy framework at national level.

A few new ideas that the Secretariat for Water is thinking to implement in the tariff structure are (Special Secretariat for Water 2013):

- Incentives for service providers to maintain or improve service quality levels as well as to reduce costs. This would ensure that improvements in cost efficiency are not at the expense of quality of service.
- Introduce a performance regime for service providers. This performance regime, would initially be limited to a small number of factors that concentrate attention on those aspects that are likely to be important to consumers and for which there is going to be reliable and useful data. Once key performance indicators are established, rewards and penalties would be developed for their achievement or failure. These rewards and penalties would then be applied as adjustments to the allowed revenues.
- The cost of raw water is an important input cost for all urban water and sewerage service providers, the price of which is likely to be administratively set and outside the control of the urban service providers. For the purpose of developing allowed revenues and tariffs for these providers, therefore, the cost of raw water will be treated as a pass-through parameter that is recoverable from end-use customers. Specifically, the Secretariat will be developing principles and estimates of the cost of raw water for the country as a whole, taking into account the competing uses of water (irrigation, industry, household, electricity production) consistent with Article 9 and Annex III of the EU Water Framework Directive.
- Another important aspect is whether or not is appropriate to leave service providers with volume risk, and a corresponding incentive to maximize consumption. For environmental purposes, the introduction of incentives to maximize consumption is considered undesirable, for this reason a revenue-based control is planning to be adopted rather than a price-based control.

4.5. Description of the Socio-Technical Context in EYDAP – Summary

The sub-questions defined in the beginning of the chapter, were intended to be answered by the analysis conducted in the previous sections of this chapter. The description of the socio-technical context in which the water company EYDAP is forming its decision-making process about the management of its physical assets is the second step for answering the main research question of this thesis. In order to understand the interrelation between the socio-technical context and the decision-making process of the company four different categories were analyzed, like in the case of Aigües de Barcelona.

The ***physical characteristics*** of the system, describe the conditions in which the company operates. Athens is characterized by a Mediterranean climate, which means that there is not a lot of rainfall and at the same time with an uneven distribution between the Western Greece and Athens where the majority of the population, about 40% of the Greece's population, is concentrated. Furthermore, the city doesn't have clean water sources and for that reason an extensive and complex system was created and a number of hydraulic works and transfers were needed in order to obtain its water supply. The population growth is constant the last years and as a result the company is concentrated more on the demand management of the system and more specifically on ways to expand its services and minimize the leakages of the system by making smart, targeted and rational operational investments.

The ***cultural embeddedness*** analysis has shown that in the early 1990s there was a big drought period and the company along with the government had to take severe measures in order to reduce water consumption. A drastic increase in the water price, some administrative measures and a massive water saving campaign reduced the water consumption by a third. Today, after the latest water transfer the water doesn't suffer from water availability problems. The period of after the drought initiated for the company a change of culture from a supply-oriented management to a demand-oriented management.

The analysis of the ***institutional arrangements*** has shown a complex relation between the company and the Greek State. A lot of actors are involved and not a single regulator authority makes the regulation of the water sector quite fragmented. The water sector in Greece is managed by the Municipal Enterprises for Water Supply and Sewerage (DEYA) operating as private companies, but owned by the municipalities. The only exception to that are the two water companies operating in Athens and in Thessaloniki, the two most populated cities in Greece, where state-owned companies are operating that function as private enterprises with a 20-year concession contract. The main regulator in the water sector on behalf of the Greek State is the Ministry of Environment, Energy and Climate Change through the Special Secretariat for Water.

The ***governance characteristics*** show a confusing regulatory structure because of the amount of Ministries involved. Furthermore, the uncertain future and the scenarios of full-privatization of the company by foreign capital don't allow them to make long-term plans. The company because of the economic crisis introduced a readjusted tariff of water and sewerage services that included reductions in consumption prices, within its social responsibility policy. The tariff policy is renegotiated every 5 years with corresponding ministries after considering the company's Board of Directors opinion. The relatively long multi-year regulatory period shows a less burdensome character for both the regulators and the company because a detailed review of costs occurs only every few years.

Table 12 shows a small summary of the analysis carried out for EYDAP in the previous sections.

Table 12: Summary of the analysis carried out for EYDAP

Level	Main Characteristics
1. Cultural Embeddedness	• Decrease in water consumption, because of the drought in the early 1990's • Increase of water tariff as a method for decreasing water consumption • Supply oriented culture until the drought period
2. Physical Characteristics	• Limited water resources close to Athens had as a result water transfers • Stable water consumption pattern almost the last 10 years • Focus on the demand management – decrease leakage in the water distribution system
3. Institutional Arrangements	• Strong power of the Greek State • Semi-privatized in 1999 • 20-year concession contract with an exclusive responsibility • No innovative behavior
4. Governance Characteristics	• Price review period every 5 years • Not a strong regulatory structure • Long-term periods of strategic plans

CHAPTER 5

Comparison of the External Socio-Technical Context

5. Comparison of the External Socio-Technical Context

The objective of this chapter is to compare the two case studies presented in the previous chapters in order to find similarities and differences on the ways that the external socio-technical context influences the strategic decision-making process of the companies about the management of their physical assets.

The analysis will try to bring together the different social and physical-technical factors that form the external socio-technical context of the two companies under study by identifying the ones that influence the most the strategic decision-making and as a result the layout of the infrastructure. In this process similarities and differences in the two systems under evaluation are going to be determined that will help in understanding on what extent these elements are taken into consideration on the strategic decision-making process and why specific external elements are more important than others. Finally, the outcome of the analysis will help in order to give an answer to the main research questions as defined in Chapter 1.

5.1. Comparison of the Physical Characteristics

5.1.1. Water Resources Availability

To start with this comparison both companies are operating in cities with a typical Mediterranean climate with heavy rainfall episodes in autumn and approximately 60 rainy days per year. Furthermore, the population served from the two companies is approximately the same and around 4 million people that make them large drinking water companies. The water company operating in the Metropolitan Area of Barcelona, Aigües de Barcelona has to deal with water availability problems and a continuous search for new water resources. The main river that serves the area is a typical Mediterranean river, highly depended on climatic conditions. At the same time the area suffers from big droughts with the last one occurring in 2007-2008. The company's main policy about water resources is to use with priority the surface water coming from the two rivers and maintain a strategic reserve for the groundwater resources. As a result in cases of drought events the groundwater resources can provide up to the 30% of the average daily total demand for the supplied area. This makes the groundwater sources of vital importance and explains the strategic decision of the company to proceed in operations of artificial recharge of these aquifers especially during the wet years.

Another aspect that shows the influence that the water resources availability has on the company's strategic decision-making process is the construction of the Llobregat Seawater Desalinization Plant (SWDP) in accordance with the regulatory authority of the area. The desalinization plant can supply approximately 20% of the average daily water demand. The years flowed the drought period of 2007-2008 were wet and as a result currently is running at minimum production. It should be mentioned though that producing desalinated water is an expensive procedure so except from the fact that the last years were considerably more

wet it is also less costly to operate the plant in high capacity as the company can produce drinking water by taking advantage of the surface water coming from the two rivers. Moreover, the strategic decision of incorporating the SWDP in the system was influenced also by an external factor coming from the institutional arrangements. A new water policy named Program AGUA introduced in 2004 as was presented in more detail in Chapter 3, section 3.4.1.2., emphasizes the commitment to desalination in Spain and mainly in regions suffering from fresh water resources availability problems. Finally, the impact of the drought on water resources availability in Barcelona is also shown by the strategic decision to supply fresh water to the city from other Mediterranean ports by sea tankers.

Thus, it can be seen that the availability of water is a very crucial external factor that influences the strategic decisions of the company about the layout of the infrastructure. More specifically, since the surface water resources are not always enough to cover the average daily demand the company has found innovative ways to provide extra water to the supplied area in order to secure the supply. The following Figure 42, shows the priority of the alternative water resources that the company uses to cover the average daily water demand after taking into consideration the amounts of water from the different origins as were presented in Figure 15.

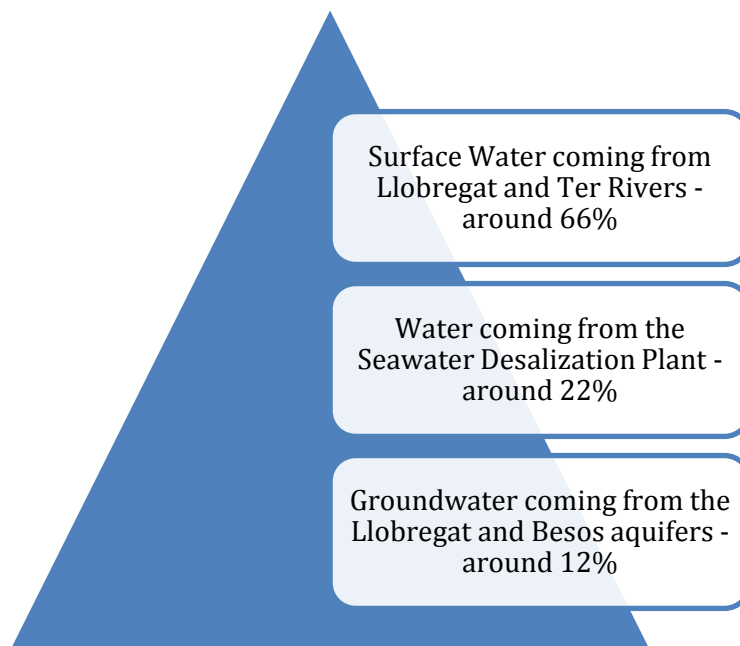


Figure 42: Strategic decisions by Aigües de Barcelona for covering the average daily water demand of the supplied area

In the case of EYDAP the physical characteristics are influencing the strategic decision-making on the layout of the infrastructure through the absence of clean water resources that can be used for potable water in the city of Athens. Because of that a series of surface water works and transfers had to be obtained in order to provide the supplied area with the required amount of water. Similar to case of Barcelona the company operating in Athens uses water that includes surface and groundwater resources. Furthermore, in the case of Athens the groundwater resources are usually preserved for drought years as it was seen in Barcelona. As it was mentioned before, both companies are operating in cities with a typical Mediterranean climate, which means that they have to be aware of dry years and more important of sequent dry years since one year with less precipitation cannot cause very

serious problems. So, both companies have taken the strategic decision to reserve the groundwater resources in cases of emergence and depend mainly on surface water sources.

Another similarity that can be identified between the two water systems influenced by the physical characteristics of the system is the continuous search for new water resources. However, the way the two companies are trying to accomplish this goal is different. Aigües de Barcelona, in order to deal with the last drought period introduced an innovative technique such as desalinization. EYDAP, in order to overcome the persistent drought that started in the late 1980s (1988-1993), started to study the construction of a new dam. This difference in the character of the strategic decision-making process of the two companies can be explained by the influence that the institutional arrangements have on this specific decision. More specifically, EYDAP's decisions are influenced by the supply-oriented character of the company and of the Greek State in general. While Aigües de Barcelona decision is influenced by the change in the legislation that introduced the concept of desalinization instead of the water transfer coming from Ebro River. So, it's a difference coming from the different mentality of the governments in charge during the years that the legislations were approved.

In the case of Athens there are also operational decisions that have to be taken on a daily basis about the allocation of the available water resources affected by a strategic decision coming from the minimization of the operational costs. For the efficient operation of the water system, the company tries to manage the system by optimizing the desired amount that has to be released from each source as a function of the actual state of the system and by minimizing the operational costs. This is being done daily in order to cover the demand of the supplied area in the most efficient way.

Therefore, as Figure 43 shows there is a preference of extraction between the different water sources in order the company to ensure the reliability of the water supply in the most efficient way.

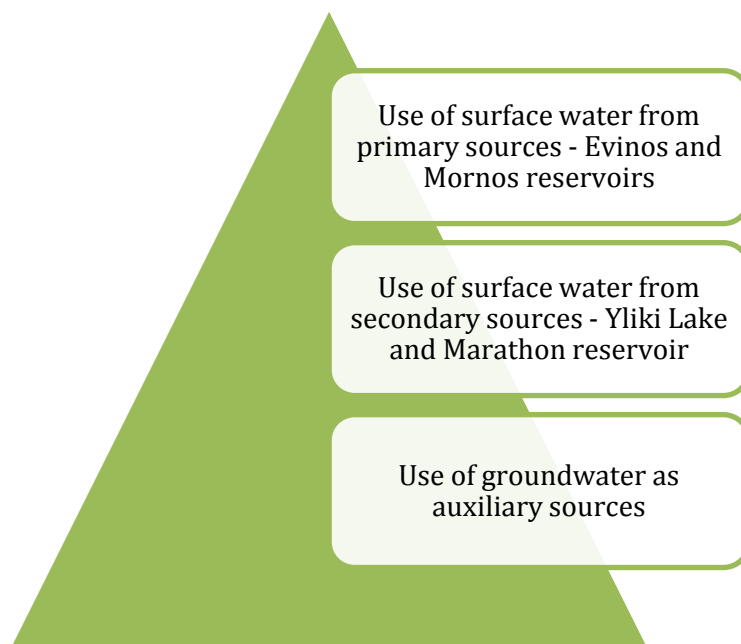


Figure 43: Strategic decisions by EYDAP for covering the average daily water demand of the supplied area

5.1.2. Raw Water Quality

The second important external factor that influences the strategic decision-making process of the two water companies is the quality of the raw water. This is a major problem in the Metropolitan Area of Barcelona, as the quality of the Llobregat River is poor because of industrial activities and salinity problems. Due to that the company had to introduce innovative techniques in the Drinking Water Treatments Plants that receive water from the Llobregat River in order to improve the quality of the water and make it potable. The effect that the quality of the water has on the strategic decisions of the company can be seen also when comparing the DWTPs operating in the two rivers. More specifically, the DWTP that operates in Ter River uses conventional treatment processes as the water is of better quality, but the DWTPs operating in the Llobregat River are using ozone treatment and reverse electro-dialysis in order to remove compounds that cannot be removed with common treatments. Moreover, the municipalities served with water from the Llobregat River, between them the city of Barcelona, have lower water consumption rates than the municipalities served by the Ter River. This shows that improving the water quality is an important objective of the company as its main revenues are coming from selling water to its customers. As a result, investing in improving the quality of the water by introducing expensive but more effective treatment techniques is a way the company to increase its revenues.

On the other hand, EYDAP has the advantage that its water sources are of good quality for two reasons. First, the origin of the water is rain and second there is a law that prevents raw water contamination in the environment by reducing the impacts of human activities on water resources in the environment. Thus, a combination of physical and institutional characteristics enables the company to use conventional treatment methods and at the same time to ensure cost-effective drinking water quality with low treatment costs.

5.1.3. Transaction Cost of Raw Water

This external factor is again influenced by two categories coming from the physical characteristics (raw water) and the institutional arrangements (transaction costs).

Aigües de Barcelona as it was described in detail in Chapter 3, Section 3.4.1., is the biggest distribution company in AMB. The company although owns water production facilities the demand cannot be met only with water coming from its system. For this reason the company has to buy treated water from Aigües de Ter-Llobregat (ATLL) network in order to meet the demand of the system. This is considered one of the biggest annual operational expenses for the company, as the amount of water originating from ATLL's network is about 50%.

For EYDAP the raw water is bought from the state owned company EYDAP NPDD that is considered the asset owner of the reservoirs and the dams. The Greek State through EYDAP NPDD is obliged to provide adequate quantities of raw water to EYDAP in order the company to meet the daily demands. However, EYDAP is assigned by the Greek State to maintain the infrastructures owned by EYDAP NPDD. So, the cost of the untreated water sold to EYDAP is set off against the cost incurred by the company for the maintenance and operation of the assets that belong to EYDAP NPDD. As a result compared to Aigües de Barcelona doesn't have this operational expense.

The way these expenses influence the strategic decisions of the two companies can be explained first for Aigües de Barcelona, as a constraint in their strategic decision-making

process as because of that they have less money for further investments. At the same time, in the long-term it can be an initiative for new investments for the company by either buying the treatment plants from ATLL, or building an extension that can increase the amount of treated water coming from their system. Second, in the case of EYDAP this agreement saves money for the company that can be spent for the maintenance, upgrade or expansion of the system.

5.1.4. Performance of the Water Supply System

The knowledge of the performance of the water supply system is a constant concern for both companies. Their objective is to decrease losses of a scarce good, such as water. The strategic decisions taken by the two companies in order to reach this objective are different. Aigües de Barcelona is trying to cope with this high importance problem by using the common way to measure losses – through the difference between the volume of water delivered to the system and the volume invoiced to users. Aigües de Barcelona also introduced innovative leakage detection techniques like smart metering, the sectorization of the distribution system and night flow analysis. These techniques are used as a tool in order the company to reach its higher objective, which is to move from a corrective maintenance strategy to a predictive maintenance strategy. Finally, the vision of the company is to be a benchmark in the water sector, so to achieve this the company itself should be a good example for its market-driven policy. Therefore, the strategic decision of using predictive maintenance for the management of its physical assets is a way to accomplish this vision by implementing innovative techniques in its operating water system that can be practiced in other water systems inside and outside Spain. Finally, the investment plan of the company includes replacement of assets by taking into consideration exploitation.

In case of EYDAP the objective is the same but the realization is less active. More specifically, the leakage of the distribution system is around 24% but the plan of the company is to act correctively. Thus, the decisions taken by the company about making investments on this field are only for replacement of assets when a problem occurs and are not predictive. The strategy of the company is to make smart, targeted and rational operational investments in order to reduce operational expenses. It is worth mentioning though that there is a clear change of strategy from supply-oriented to demand-oriented.

Typically, in developed countries when the society enters a situation of “water scarcity” where the resources become increasingly inadequate, this problem has been remedied by increasing water supply via engineering solutions such as construction of dams and transfers of water from other locations. This situation has been called the “supply-phase” and results in the so called “structurally-induced water abundance”. Where water demand continues to increase, but the amount of water that can be obtained by conventional engineering solutions is soon exceeded; a situation of “water deficit” ensues and any further growth in water demand worsens the degree of water deficit.

Water Demand Management (WDM) can be defined as those activities, which aim to provide the greatest possible amount of services using the least possible volume of water. In a more general perspective, WDM refers to activities that aim to reduce demand, improve water use efficiency and avoid the deterioration of water resources. Usually, WDM is considered an obligatory solution in cases where the best supply opportunities have been exploited, and the marginal opportunities are much more expensive economically and environmentally. Furthermore, WDM marks the implementation of a paradigm shift from the traditional orientation of increasing supply towards sustainability of water resources and the

environment, as well as economic efficiency and social development. Technological means related to WDM that aim at more efficient water use are the repairing of leakage from water supply systems, the adaptation of systematic metering of all water facilities, the control of distribution network operations (e.g. to avoid high pressures which increase water consumption and leakage) and the technical modifications of installations with the use of better hydraulic and sanitary equipment (low-flow plumbing devices).

The situation in Athens water supply system is a common example of that. EYDAP with the Ministry ¹⁴ responsible for planning, financing and constructing for Athens' water infrastructure, until 2001 whenever Athens' supply-demand balance narrowed and water reserves fell, new water works were planned. As a result, the decisions made were waterworks-driven, aiming at providing structurally induced water abundance to Athens. After reaching this objective and with the water demand having a stable trend the last 10 years, but still close to the supply limits gave the opportunity to the company to change and turn its decisions on water demand management. One of the ways that EYDAP is using to implement WDM is through leakage detection techniques. Finally, the company has the know-how after operating since 1980 the drinking and wastewater system of the area to help other municipalities to deal with similar problems.

For a water utility located in an area of water scarcity in Europe, issues related to the efficient use of water are more relevant than for a utility located in an area where water quantity is abundant. This sentence characterizes the two companies under evaluation. When comparing them though it can be seen that Aigües de Barcelona has taken this factor into consideration more actively into its strategic decision-making by incorporating Water Demand Management techniques such as the smart metering, the sectorization of the distribution system and night flow analysis. These methods come in combination with water-supply driven strategic decisions like water reuse and use of desalinated water. Therefore, the company is using an integrate way for managing the water recourses mainly because the danger of on reaching the supply-demand balance substantial. EYDAP lately is making steps for improvements, since the supply-demand balance is stable, but the performance of the water system is poor with high percentages of leakage. So, the objective remains the same "*the good performance of the water supply system*", but the actions taken are different as it was illustrated.

Consequently, comparing the strategic decisions taken affected by this external factor from the two companies under study there is a clear difference on the time horizon of the process. Aigües de Barcelona has a long-term asset management plan for the replacement of physical assets while EYDAP a short-term asset management plan. A short-term replacement plan has shown that companies can save money by reducing the operational expenses in the short-term, but after some years this strategy can cause different results in the future. This is a common problem identified in European water utilities that are too concerned with the current pressures and solve problems associated to them instead of looking at the urban water cycle system in an integrated and holistic way. This confirms the main objective of Vitens.

It should be noted that although this external factor drives operational decisions that is out of the scope of this research as it was mentioned in Chapter 2, Section 2.3 it is considered as an important part for the asset management plan of the two companies as it affects their annual investment plans that is part of the research and more specifically is included in the third

¹⁴ Ministry of Environment, Energy and Climatic Change

layer of the theoretical framework. Furthermore, it helps to understand the way that the two companies are making their business plans and what are their priorities when it comes to the performance of the water system.

5.2. Comparison of the Institutional Arrangements

After describing the institutional structures governing each case there are considerable differences implied.

The Greek territory is divided into 14 regional water departments, corresponding to hydro-administrative units aggregating river basin. Although the regional water departments were initially agreed to be autonomous units, they were never incorporated as “water offices” within the administrative structures of existing regional authorities. Therefore, it is more accurate to talk about a centralized water resource management organization in Greece, decisions taken at the central government level, instead of decentralized, integrated river basin management as foreseen in the 1987 national water law. The key difference of the institutional structure of the water sector between Spain and Greece is that in Spain there is a strong tradition of planning and management at the level of river basin (since 1930s). The regional authorities – Autonomous Communities – have considerably more power than in Greece. Although national government remains powerful and centralistic, many competencies have been transferred to the autonomous communities as part of a decentralization move. This decentralization to the municipalities enables a higher capacity to integrate local elements and sensibilities and gives more flexibility to municipalities to manage and cope with their local requirements on a yearly basis. In addition, decentralized systems are an opportunity to reduce intermediary bodies and costs of tariff review and reporting procedures, thus eliminating duplicities in functions and supervisory activities.

Another aspect identified is the Program AGUA that notes a fundamental policy shift in national water management from large inter-basin water transfers to a commitment to desalinization. The new program is a way for exploitation of the 1500 km of coastline that Spain has, combined with an attempt for water supplies independently from climate changes and droughts since desalinated water can be produced at any time.

The concession contract between Aigües de Barcelona and the regulatory authority Àrea Metropolitana de Barcelona, introduces competitive aspects by passing full responsibility for operations and investments to the private sector, in this case Aigües de Barcelona. Hence, it is the competition for the market and not within the market, which finally delivers the benefits of private sector involvement. The goal of Aigües de Barcelona, as a private company, operating in a concession contract is to maximize the financial returns to their shareholders by providing what customers want at a price that are willing to pay. The competitive market exposure has allowed the sector and the Spanish companies to become a worldwide benchmark and to open up new markets.

More specifically, the Program AGUA was implemented with success in the case of Barcelona and currently provides the 22% of the average daily demand as was described in the physical characteristics section. Moreover, Aigües de Barcelona started by operating the drinking water supply system of Barcelona and currently is one of the major water companies around the world not only for water, but also in other sectors. This shows that the competitive Spanish model has transformed regional water companies into worldwide benchmarks. To add to this, it can be mentioned that the state-owned water company that operates in the city of Madrid has also an international character.

In Greece, although the mentality of the water law enacted in 1987 was the same, to make water resources management more decentralized didn't succeed. The government has strong power and especially about decisions for the water supply of Athens. There are a lot of Ministries involved in the decision-making process and that makes the procedure even more complicated since depending on the type of work/decision a different Ministry is in charge. A new attempt has been made to change this situation by establishing the Special Secretariat of Water (SSW) as a regulatory authority. Furthermore, the power of the government over the company can be seen by the right of the first to appoint the Chairman of the Board of the Directors of the second. That influences the decisions of the company in the sense that each Chairman has different views and visions that affect the strategies of the company. As a result, the goals of the company can change in a short time and specific plans made for a certain period can be put back.

The political decisions in Greece are in general connected with the political party in head. This means that depending on the political party that forms government the Ministers change and as a result the SSW gets also affected. Government reshuffle is a common phenomenon since the economic crisis burst in the country, which influences all the related Ministries to the company. Because of that the company has to form plans and implement its strategies in an unstable political environment since the Greek State through the HRADF is the main shareholder of the company.

Additionally the company was partially privatized in 1999, but the Greek State maintained a strategic share, which makes the company state-oriented. EYDAP through this semi-privatization signed a 20-year concession with the Greek State that at the same time gives them the exclusive right to supply and distribute water and provide sewerage services in the Attica region, as well as to expand its operations to other regions outside Attica. This fact influences EYDAP's decisions by the fact that eliminates any type of competition for the market, like in the case of Aigües de Barcelona. Water sector is a natural monopoly, but as it has been described in the case of Barcelona the Spanish institutional structure introduces competition for the market that in the case of Athens doesn't exist since the company has the exclusive right. The second part of the privatization agreement though, which has to do with the expansion of the services of the company outside the region of Attica, gives a growth initiative to the strategic decision-making process. The company has taken this opportunity by incorporating additional municipalities of Attica in the water supply system of EYDAP and by applying consulting services to other municipalities. Finally, the establishment in 2011 of the subsidiary company called "EYDAP Nison S.A." with the scope to provide water and wastewater services in the Greek islands territory is a part of this expansion strategy while taking advantage the gained know-how by operating the biggest water system in Greece.

In the same agreement the company is assigned by the Greek State to undertake the construction of flood protection infrastructure for the account of the Ministry of Infrastructure and Networks. Hence, the company has the chance to increase its revenues by this part of the agreement.

5.2.1. Influences from Privatization

An example of the reflection of privatization in the public authorities can be contemplated by comparing the vision and the mission from Aigües de Barcelona with Vitens. Aigües de Barcelona vision and mission statement are: *"To be the benchmark business group in our fields of activity and one of the largest service companies"* and *"To reach all citizens with good quality water and pressure, 24 hours a day 365 days a year as well as to manage water*

efficiently to improve people's quality of life, in balance with the environment". On the other hand EYDAP's vision and mission are: "To remain the largest and most reliable company in the management of water cycle, always oriented towards Man and the Environment" and "To provide quality and affordable water to an increasing number of citizen and to return it pure back to the environment through the effective management of all available resources with social sensitivity and with our contribution to social welfare taken as basis".

First it is important to highlight that the clients/customers are not referred in Aigües de Barcelona vision, although their mission includes both the improvement of customers' and the environment's quality. The company's vision shows the market-oriented character of the company as well as the competition for marketing their services in the water sector. Moreover, the profitability can be reflected in the use of the phrase "To manage the water efficiently".

In the case of EYDAP, the company counts on its relationship with the clients/customers, as it is clear in both the vision and mission. The customer-oriented character of the company is confirmed not only in the vision as it is explicitly said, but also in the mission by the use of the words: affordable, social sensitivity and contribution to social welfare. These type words are missing from Aigües de Barcelona statements and can be translated as the difference between a private company with a profit-maximization behavior to a semi-private company with a human-centric behavior. However, both companies care about the quality of the supplied water as well as on the implementation of environmentally friendly processes.

Furthermore, the expansion of customer base by the increase of geographical coverage can be reflected by the use of the word "largest" in both cases. Finally, effective management is important also for EYDAP, which indicates the change to demand management strategies.

To conclude, all the aspects indicated in this section reflected on the companies' visions and missions are aspects already observed during the comparison procedure.

5.3. Comparison of the Governance Characteristics

5.3.1. Regulation

A very important factor that influences the strategic decision-making process of Aigües de Barcelona is the strength of the regulator authority. Firstly, this guarantees to a private company, legal certainty and stability to investors and enables the development of the water industry. It is fundamental regulatory framework enable the level of investment that the system requires to improve the services to customers, that encourages innovation and technical development and an efficient use of resources. Additionally, the price review in Spain and in Barcelona specifically, is annual. Furthermore, towards the implementation of an efficient goal-oriented system, annual compliance agreements have been adopted, in Aigües de Barcelona and in other Spanish cities, where, in accordance with the holder/regulator – Àrea Metropolitana de Barcelona – the companies have goals related to water quality, environment and customer management.

The annual price review meeting with the regulator influences the strategic decisions of Aigües de Barcelona in different ways. The company hands in a long-term proposal called "Acuerdo Marco" that represents the commitments between the regulator and the company, in order to achieve funding for infrastructure projects that will ensure the quality of supply, a stability in the evolution of the tariffs, a better service to the customers and minimize the waste of water. This long-term proposal is reviewed in the annual price review meeting by

the regulator in order to check whether the company is on track with the set commitments and the regulator has the power to penalize the company in case of spending the funding for different investments than the ones discussed. This procedure as a result affects the strategic decisions of the company, as it is a serious commitment that has to be implemented on time. Furthermore, during the annual review meeting the company sets annual – short-term strategies – that includes the level of compliance to the KPIs set by the regulator, about water quality, the environment, the quality of service and the customer support. Thus the company has to keep a high level of compliance on a regular basis as they get annually supervised.

In the case of EYDAP a similar procedure doesn't exist. The tariff policy is renegotiated every 5 years but no KPIs commitments are included only the inflation index and the recovery of costs and services policy set by the Water Framework Directive 2000/60. The company has a customer-oriented character that influences its pricing policy decisions as it is clear from the reduction of the tariffs during the last price review that was held in the end of 2013. Moreover, the regulator authority and more specifically the SSW, wants to introduce a performance regime system for the service providers similar to the one described in the case of Aigües de Barcelona. Initially a small number of factors that are considered important to customers are going to be included, but the idea is to establish KPIs where according to the level of compliance of the company is going to be rewarded or penalized. A more strict regulation would help EYDAP set specific strategic goals and improve the level of service.

Furthermore, it was mentioned that Aigües de Barcelona hands in long-term strategy plans, for a time period of 5 years. In the case of EYDAP, the company's policy is to update its business plan every 5 years, but the last business plan was enacted 10 years ago. Since then the company is working under the strategy "Business as usual". This verifies that the strategic decisions of the company are mainly reactive. Although the last business plan was updated 10 years ago, EYDAP knows about new works and big infrastructure projects that need to be done. This shows on the one side that there are no big changes on the system, such as the stability of the water consumption rates in the last 10 years. So, there wasn't an urge for the company to revise the already existing business plan. On the other side, it shows a short-term oriented policy and low response to future uncertainties.

William et al., (2003) argues that efficiency reached by privatization is not necessarily due to increased competition, but by the evolving relationship between the firms and the economic regulators. It can be concluded that for the case of EYDAP, currently this relationship is very weak compared to Aigües de Barcelona.

5.3.2. Innovation

A big part of Agbar Group is dedicated on marketing of new innovation techniques. CETaqua is the part of the company that contributes to research and development of new technologies, related to the integral water cycle and at the same time advises the Board of Directors of the company for important external issues such as the influence of the climate change. Agbar takes the innovations developed at CETaqua, analyzes their market potential and uses them to expand its services. The decision of Agbar to establish a new company in 2011 called Aqualogy shows the market-driven and international vision of the company. The concept of a market-driven company is that the organization sees continuous change as a way of life and not as an exception. The implementation of this strategic decision was influenced by two factors. First, the economic uncertainty worked as an initiative for the beginning of the idea of Aqualogy as the company realized that the traditional concessions

contracts could not last forever. Second, Agbar has over 150 years of experience on the water sector inside and outside Spain. Hence, the company saw possibilities of growth through its own capabilities, by marketing this over the years gained know-how. As a result a change of mentality can be identified in the strategic decision-making process of the company, from infrastructure management to knowledge management.

In the situation of EYDAP there is not a strong innovation behavior recognized. The big difference between the two companies is their scale not in the sense of the clients served, but in the sense of the range of activities and the investments. Aigües de Barcelona has the economic support of the mother company of the group Agbar. This gives them the opportunity to make strategic decisions such as the one made in the 2013 to operate as an integrated water cycle company responsible for the whole water cycle by taking over the 85% of the new mixed public-private participation company.

EYDAP, created the Research & Development Department in 2011. With this decision the company aims to strengthen applied research in order to improve and resolve issues concerning the operation of the company. Thus, there is one more difference between the two companies concerning innovation. EYDAP is using innovation in order to resolve issues on its own operation system, while Aigües de Barcelona is using innovation more as a showcase in order to retail these innovations in other markets outside Barcelona.

5.3.3. Shareholders

Aigües de Barcelona as a private company should always take into account the profits in return to the shareholders. The shareholders review the annual reports that Aigües de Barcelona discusses with the regulator in order to give their permission about the budget expenses of the coming year. That shows a big influence on the decision-making process of the company, as the annual expenses except from the regulator requirements should also satisfy the shareholders demands. Another issue with a high rank on the company's list that influences their decision-making process and is introduced by the shareholders is the health and safety of the workers and the sub-contractors. It's a very important aspect for the company to ensure its employees by making investments in order to minimize any possible risks. Finally, efficient of the system should always be one of the major objectives of the company as it saves money for the shareholders.

In EYDAP the shareholders is also the supreme body of the company and representatives are present during the meetings of the Board of the Directors. There is no information available about the influence of the shareholders in the strategic decision-making process of the company and as a result no conclusions can be made. It can only be said that for now it supports the customer-oriented character of the company by the decision to reduce the tariffs since the proposal of the Board of Directors was approved.

5.3.4. Financial Crisis

The current economic situation of the countries that the companies are operating in has also an important effect on the strategic decisions on the asset management of the infrastructure. The unstable economic situation in Greece has effects on the strategic decisions of EYDAP as the company is highly connected to the Greek State. The company has a customer-oriented character. As it was mentioned before during the last tariff review the Board of the Directors decided reductions in the consumption rates, within its social responsibility policy. Furthermore, the company due to the unfavorable economic conditions that have affected the Greek households has set into effect the Social Tariff, which is a discount up to 60% on water-sewerage bills for specific social groups.

Another aspect that has been identified during the analysis part and demonstrates the effect of the financial crisis in the strategic decision-making process of the company is the big debts of Municipalities to the company. In Section 4.1.2., Figure 30 shows that the largest class of customers, after the class of common consumers, both in terms of consumption and in terms of revenue and debts, consists of Municipalities supplied with bulk water. The company has chronic problems with accumulated overdue debts that constricted the smooth growth of the company. The fiscal year of 2013 ended with positive results for EYDAP as most of the overdue debts were repaid. The Board of Directors of EYDAP, formed the "Relation Development with Local Authorities Division", not only for better monitoring but also for more effective management of this specific customer class.

Given the unfavorable economic conditions and the incapability of Municipalities to meet the operational requirements of their networks and their financial obligations towards EYDAP, the company aims at the implementation of an extended program of Concession Contracts Networks with Municipalities that own and operate water distribution network. According to that:

- a. EYDAP will take over the management of the above-mentioned network, while the network remains at the property of the Municipality,
- b. The customers of the Municipalities will enjoy the upgraded services provided by EYDAP and
- c. Specific Municipalities will have debts settlement, based on a specific repayment timetable.

Aigües de Barcelona's main shareholders are from France, a country with currently no financial problems. Still, the establishment of Aqualogy, as it was noted in Section 3.5.1.2., shows a change in the mentality of Agbar Group from infrastructure management to knowledge management driven by the economic uncertainty. This strategic decision shows that Agbar Group transformed the economic uncertainty of the future to an initiative by introducing Aqualogy to the market. This idea of a company marketing worldwide their water management knowledge and innovations is a way to unbound from the traditional concession contracts that cannot last forever. One of the biggest objectives set by the company is Aqualogy to contribute 50% of Agbar's recurrent profit by 2015 (Agbar Group 2011). It's a big challenge to sell Aqualogy's operations in companies outside Agbar Group due to big competition in this field.

Therefore, it can be seen that both companies have taken strategic decisions in order to overcome the uncertainty of the current economic situation. Both companies are taking advantage of the knowledge accumulated over the years that are operating in their regions and use this experience to address the challenges of society and meet each customer's needs. However, there is a difference in the range of this strategic decision that is explained by the size of the companies under study. In the case of EYDAP, it's an expansion within the country while as it has been mentioned already Aigües de Barcelona has an international vision that is reflected also on this strategic decision.

5.4. Comparison of the Cultural Embeddedness

According to Hofstede one of the dimensions that characterizes the culture of a country is the "Long-term versus Short-term Orientation" related to the choice of focus for people's efforts: the future or the present and past (Hofstede 2011). Therefore, the influence of the cultural

embeddedness in the strategic decision-making process of the two companies is evaluated through their reaction on a drought event focusing on the time horizon of their decisions.

First, in the case of EYDAP during the drought years of 1989-1993 the main decision in order to overcome the supply problem was to reduce the demand by increasing the price of the water. This decision helped in the short-term, as when the prices were put back into normal, the demand increased. The second decision was to build an extra reservoir that will increase the available water resources. Again this decision has a short-term view since the actual incorporation of the new reservoir to the existing system was postponed since 2001 because wet years followed before the final implementation of the project.

The last drought event that affected the system of Aigües de Barcelona, which was the most severe one, was in 2007-2008, but over the last 20 years (1988-2007) there have been 6 drought alert periods. This shows that compared to Athens in Barcelona drought events are of more importance. On of the most crucial decisions during the last drought event was to build the seawater desalinization plant introduced by the Aigües Ter-Llobregat (ATLL) and developed by a Joint Venture of three companies between them Aigües de Barcelona. Moreover, the company built a pipe that connected the port of Barcelona where sea tankers coming from France and other Mediterranean ports were uploading water to supply the system. These decisions taken by Aigües de Barcelona have a long-term view by making capital expenses since the company is aware that the demand is very close to the available level of resources and as a result drought alerts can occur any time.

Furthermore, in both situations certain uses were prohibited, such as garden irrigation. Awareness campaigns urging citizens to use water in rational and responsible ways were introduced by the authorities. As a result, it can be said that EYDAP is characterized by a short-term orientation culture while Aigües de Barcelona by a long-term orientation that takes into account more the challenges of the future.

5.5. Comparison of the External Socio-Technical Context – Summary

The objective of this chapter was the analysis of the different strategic decisions made by the two companies about the layout of the infrastructure under evaluation. Also, how these decisions were influenced by the social and physical-technical factors that form the external socio-technical context. The outcome of this analysis will help to give an answer on the main research questions in the following Chapter. The following figures (Figure 44; Figure 45; Figure 46; Figure 47) summarize the results that were presented in the previous sections in order to gain a more clear view of the impact that each external factor has on the layout of the infrastructure. The figures show the external factors that are included in each of the four categories under investigation and the strategic decisions that were taken by each company influenced by them. Thus, the last column in each figure represent the strategic decision and the lines (blue, light orange, purple) show from which company each decision was taken.

Chapter 5 – Comparison of the External Socio-Technical Context

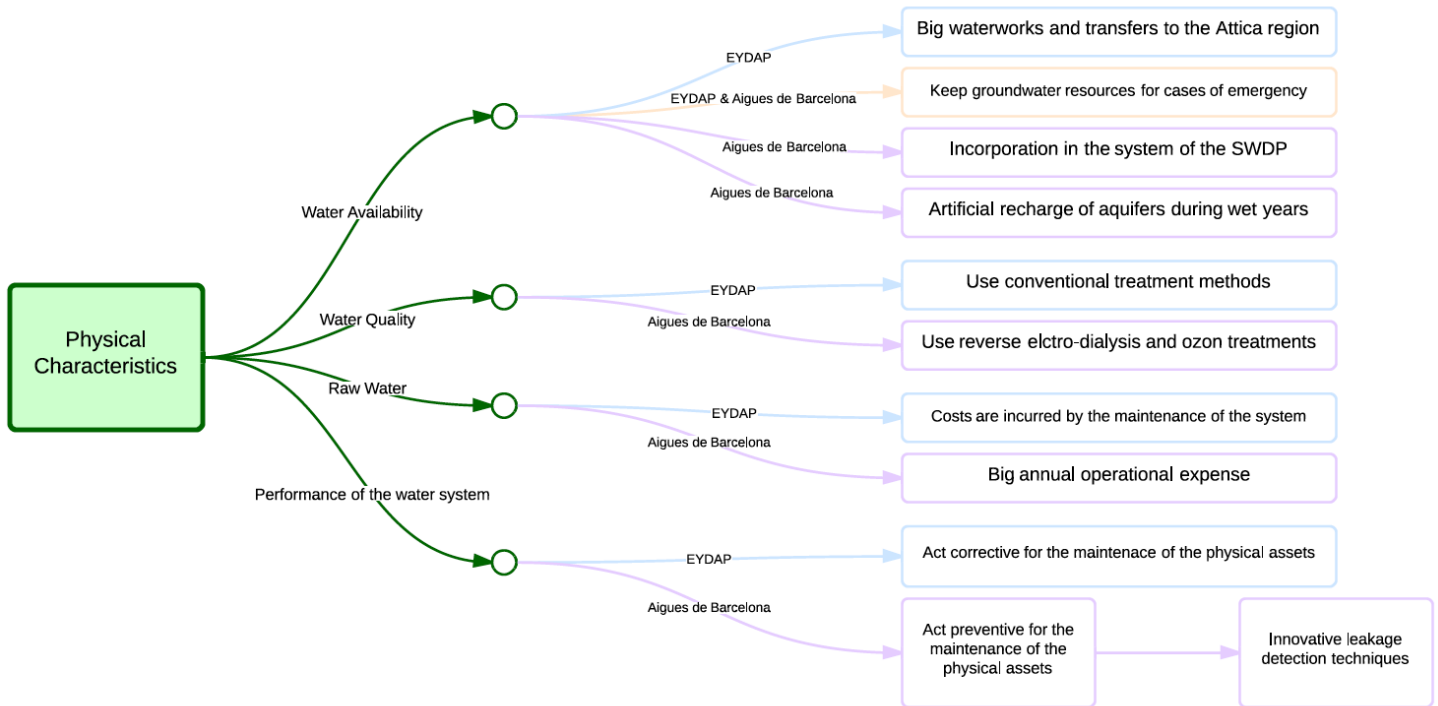


Figure 44: Decisions made by the two companies influenced by the Physical Characteristics

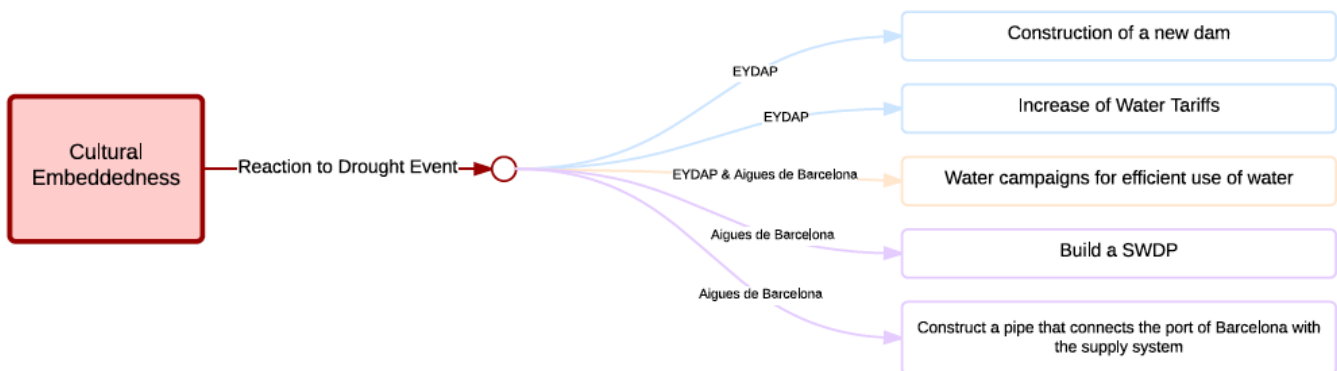


Figure 45: Decisions made by the two companies influenced by Cultural Embeddedness

Chapter 5 – Comparison of the External Socio-Technical Context

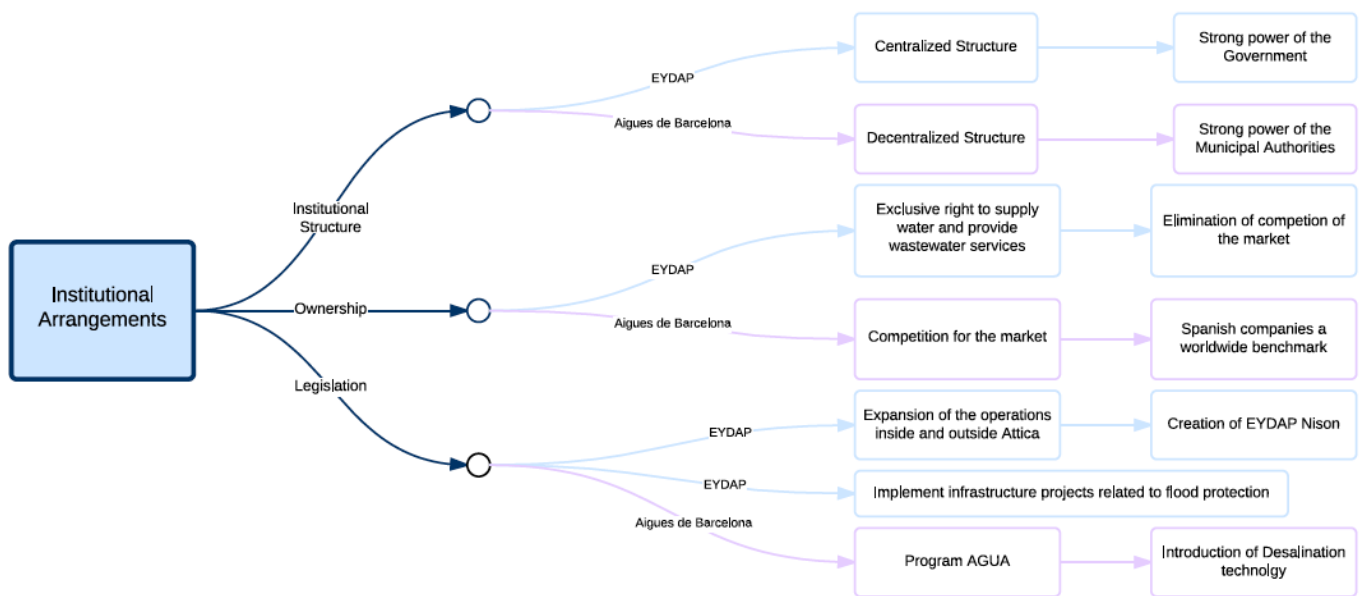


Figure 46: Decisions made by the two companies influenced by Institutional Arrangements

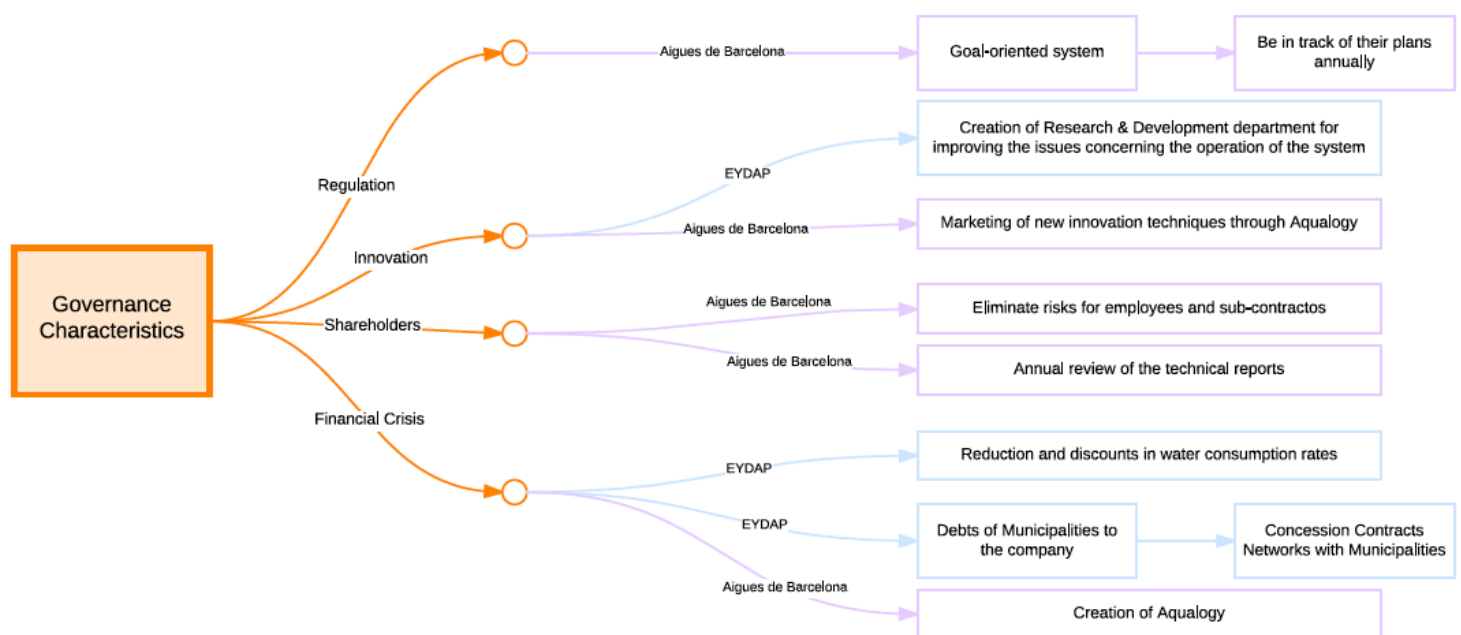


Figure 47: Decisions made by the two companies influenced by the Governance Characteristics

CHAPTER 6

Conclusions

6. Conclusions

The main objective of this chapter is to present the conclusions of the research by answering the following main research questions:

What are the interrelations between the strategic decision-making process about asset management and the socio-technical context on the water companies under study (Aigües de Barcelona and EYDAP)?

How does the ownership rights influence the strategic decision-making process about the management of the physical assets in water companies?

The main objective of this research was to understand on what extend external elements are taken into account in the strategic decision-making process on the management of the physical assets and why specific external elements are more important than others. In order to come to a conclusion the research was divided in sub-questions that helped in gradually reaching the main objective. This chapter focuses on answering the main research questions by concluding on the findings of the previous sections. Furthermore, an evaluation of the applied methodology is made.

6.1. Conclusions on the Main Research Questions

6.1.1. Research Question 1

What are the interrelations between the strategic decision-making process about asset management and the socio-technical context on the water companies under study (Aigües de Barcelona and EYDAP)?

It can be concluded that after comparing the case studies there are interrelations between the strategic decision-making process on the asset management of the infrastructure and the external socio-technical context.

The external factors that were discussed and were shown to influence the strategic decision-making process of the two companies are shown in Figure 48. All of these external factors were proven to have an influence on the strategic decision-making process, but on a different scale.

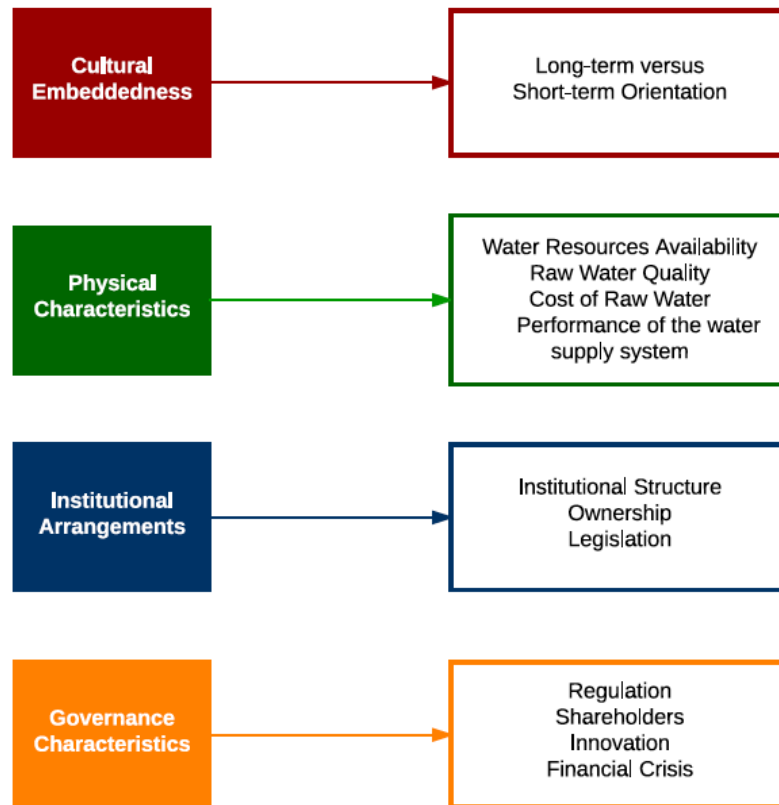


Figure 48: Influential external factors

To come to this conclusion the strategic decisions driven from the external factors shown in Figure 48 were evaluated. More specifically the found results were described below.

The influence of the ***cultural embeddedness*** in the strategic decision-making process of the two companies is evaluated through their reaction on a drought event focusing on the time horizon of their decisions. It was shown that Aigües de Barcelona in combination with influence from the institutional arrangements and the governance characteristic confronted the drought event with long-term strategic decisions trying to give a permanent solution to this problem. An example of a strategic decision taken during the last drought event is the construction of a seawater desalinization plant. This shows as it was mentioned before that because the company understands the persistence of the problem searches for long-term ways to solve it. However, EYDAP took short-term decisions since the problem wasn't so persistent. The strategic decision of the company to increase the water price in order to decrease the water demand verifies this. This strategic decision helped on the short-term as when the prices went back to normal the demand increased. As a result, it can be said that EYDAP is characterized by a short-term orientation culture while Aigües de Barcelona by a long-term orientation that takes into account more the challenges of the future.

The ***physical characteristics***, describe the operating environment of the water companies and the assets characteristics. External factors such as the water availability, the quality of the raw water and the performance of the water system are complications that arise in the strategic decision-making process. In both cases, these factors were taken into account. The strategic decisions originating from these external factors are fundamental for the operation of the two water companies. Water availability is a big problem for both companies.

Although, both companies are keeping groundwater resources for cases of emergencies, in the case of Aigües de Barcelona the problem was tried to be solved with more active ways. The integration of a seawater desalinization plant that produces the 22% of the average daily water demand for the system is a long-term strategic decision. This decision was created by the water availability problem, but the final implementation came in combination with the change in the legislation of the country in 2004 that introduced the desalinization technology. The water availability problem in Athens was solved with short-term strategic decisions mainly based on inter-basin water transfers. The knowledge of the performance of the water system is a constant concern for both companies. Furthermore, in both cases the percentage of leakage detection in the distribution system is quite high. In specific places in Barcelona is about 20% and in Athens about 24%. Therefore, there is an interrelation between the condition of the assets – coming from the performance of the water system – and the strategic decisions focused on repairing leaks. Aigües de Barcelona is aware of this problem and its strategic decision is to act long-term by investing in preventive maintenance. While EYDAP is following a short-term investment plan by acting correctively. As a result, the impact of previous decisions in investment and maintenance are reflection of the leakage problems that the two companies are currently confronting.

The external factors that come from ***institutional arrangements*** category such as the institutional structure, the ownership and the legislation also appear in the strategic decision-making process about asset management. Especially for the case of EYDAP the institutional structure of the water sector is of vital importance. The water resources management plan of the country is centralized and as a result the Greek State has a big influence on the strategic decisions taken on this field and especially for the water supply system of Athens. There are a lot of Ministries involved in the decision-making process and that makes the procedure even more complicated since depending on the type of work/decision a different Ministry has to give the final approval. Finally, the influence of the Greek State on the strategic decisions of the company is shown by the fact that they have the right to appoint the Chairman of the Board of Directors. As a result, certain goals of the company can change in a short time and specific plans can be put back. In Spain the institutional structure of the water sector is decentralized. A lot of competences are given to the Municipality level. In the case of Aigües de Barcelona the Municipal authority is also the regulator. That gives to the company the opportunity to make strategic decisions with less intermediate bodies involved.

Furthermore, the ***governance characteristics*** show an effect on the strategic decision-making process of the two companies with the regulation being the most crucial. A strong regulator authority guarantees to a private company like Aigües de Barcelona legal certainty and stability for investments. An example is the goal-oriented regulation system that Aigües de Barcelona operates. The company has to achieve annually goals related to water quality, environment and customer management. This imposes that these matters have to be annually incorporated to the strategic decision-making process of the company and certain investments have to be made in order to reach these goals. Another important factor that was shown to have an effect on the strategic decision-making process of the two companies is the difference in the level of innovation. Aigües de Barcelona has an innovative and market-driven character originating from Agbar Group. The research and development (R&D) center of the Group creates new techniques and Aigües de Barcelona works as a showcase for the ones that can be applied in their region that afterwards can be retailed by Agbar as successfully performed. As a result, the company has taken innovative strategic decisions for the improvement of the performance of the water system like launching smart metering. EYDAP as a company with smaller possibilities for investments is using its R&D department in

order to resolve issues on its own operation system. Hence, the institutional arrangements in Greece and in Spain show that they have a large influence in establishing interrelations between the socio-technical context and the strategic decision-making process. Finally, the financial crisis has an effect on the strategic decisions of both companies. The companies are trying to overcome the uncertainty of the current economic future, by taking advantage of the experience gained all these years operating in their regions. However, there is a difference in the range of this strategic decision that is explained by the size of the companies under study. In the case of EYDAP, it's an expansion within the country while as it has been mentioned already Aigües de Barcelona has an international vision that is reflected also on this strategic decision.

It can be seen that the biggest problems that the two companies have to face are coming from the physical characteristics category. However, the way that each company incorporates the effects on its strategic decision-making process as well as the value given varies.

Hence, it can be concluded that the external factors comprising the physical characteristics category are causing the same problems to the companies under study. While, the external factors coming from the governance characteristics and the institutional arrangements are the ones used in the strategic decision-making process in order the companies to find a solution.

However, the impact that the governance aspects have on the strategic decision-making process on asset management of the infrastructure is very big. The contextual factors coming from this category are highlighting the most the difference in scale between the two companies. This difference is caused not by the scale of operations and services provided, as the population served is the same, but mainly from the financial support and hence the opportunity of making investments. Furthermore, a strong relationship between the firm and the economic regulator is an important aspect that is missing from EYDAP as it was indicated in the governance characteristics category.

Finally, the cultural embeddedness reflects a substantial element that is relevant to the strategic decisions of the two water companies. As the culture of the long-term versus short-term orientation was reflected not only on the strategic decisions concerning the reaction to a drought event that flows from the physical characteristics, but also in the institutional arrangements and in the governance characteristics.

6.1.2. Research Question 2

The purpose of the comparison of the two case studies was to identify similarities and differences in the strategic decision-making process for the layout of the infrastructure of the two companies induced by the external elements. Conclusions concerning the research question that flows from the hypothesis of this study are going to be illustrated in order to check whether the hypothesis made is verified or rejected. As it was hypothesized in Chapter 1, the water companies under study are expected to have dissimilar strategic decision-making processes because of their different ownership regimes. Under this hypothesis the following question was formed:

How does the ownership influence the strategic decision-making process about the management of the physical assets in water companies?

The ownership was analyzed in the institutional arrangements category by comparing a private company with a semi-private state owned company. It was shown that the strategic decision-making process in the two companies is different. One of the reasons behind that conclusion is indeed the different ownership regime, but it's not the only reason and also not the most important one. There is a combination of factors coming from the governmental and institutional categories that cause this difference in the strategic decision-making process. Therefore, the ownership does influence the strategic decision-making process but relatively less compared to other factors such as the institutional structure and the regulation.

The private participation in the water sector can yield in differences in the strategic decision-making, but partly depends upon other interrelated factors. These factors do not operate independently of each other. The identified related factors in our case are:

- The form of private involvement (e.g. divestment, BOT, concession, contract);
- The competitive structure of the sector;
- The type of private company involved – this includes its technical and managerial competence, the range of its operations (e.g. diversified company or single output firm) and the characteristics of its owner/major shareholders;
- The regulatory regime – this includes all the continuing roles of the public sector and the institutions (contracts, regulatory agencies, laws, market tools, etc.) employed to influence, provide incentives for or directly control private sector behavior.

Therefore, the identified differences in the strategic decision-making process of the two companies originate not only from the different ownership regime, but also on a combination of factors. It was seen in the vision and mission of Aigües de Barcelona that as a private company has a profit-maximization behavior while EYDAP has a customer-oriented policy as a semi-private company with the Greek State holding the majority of its shares through HRADF. That is the biggest difference reflected from the different ownership regimes.

However, there are more aspects observed, such as the market-oriented character with the competition for marketing their services in the water sector, the scale of its operations, which is international, and finally the strong relationship between the company and the regulator. These three aspects were described in the governance characteristics and are different in the case of EYDAP. Since there is an expansion policy, but inside Greece (different scale of operations) and the existing regulator regime is quite weak.

As a result, the differences between the strategic decision-making processes on the asset management of the infrastructure are generated by a combination of factors.

6.2. Conclusions on the Applied Methodology

The theoretical framework that was used as a tool to give an answer to the questions addressed before was based on the extended 4-layer Williamson model. It can be said that the model was useful in order to make conclusions and analyze the data that were gathered during the in-person interviews and the desk research. Selecting a suitable framework to study the strategic decision-making process about asset management is depended on the content and objectives of the organization and the context and nature of the problems. Williamson's 4-layer expanded model gives the chance of evaluating two sub-systems simultaneously. The social and physical-technical sub-systems that consist the external socio-technical environment were described. By this description the strategic decisions on the layout of the infrastructure were easier to be identified and on the final step evaluated. Therefore, the theoretical framework used in this research is suitable for the evaluation of the

interrelations between the strategic decision-making process about asset management and the socio-technical context for water companies.

Williamson's model is an economic model. The economic elements included in the model are part of layer 4 (pricing, quantities incentives) (Table 1) that was neglected from the analysis part. However, economic elements were included in the government layer 3 therefore it can be concluded that it was a right decision to neglect layer 4. Furthermore, operation and maintenance are part of layer 4 as well (Table 2), but decisions that have to do with maintenance were included in the analysis as part of the investment plan. This was because there is an interrelation between the condition of the assets – coming from the performance of the water system – and the strategic decisions focused on repairing leaks. The impact from previous decisions in investments and maintenance are reflected on leakage problems that the two companies are currently confronting. As a result were considered as part of the analysis in the technical sub-system of the physical characteristics.

The method used to collect the necessary information in order to build the model was in-person interviews and desk research. The interviews were based on a questionnaire that can be found in Section 9.4 in the Appendix. The procedure followed during the interviews depended on the person that was interviewed. The problem faced during the interviews was the validation of the collected data. Therefore, information couldn't be validated afterwards from documents were left outside on the evaluation research. Furthermore, especially in Aigües de Barcelona as a private company information about more in depth decision-making procedures were limited due confidentiality. That limited the final outcome on a description of the internal environment of the company.

The questionnaire was a guideline for the interview and depending on the conversation more questions that weren't included were asked in order to make things more clear. The first company visited was the one in Athens. After having the experience of interviewing and collecting the necessary information on the first company the procedure was better organized for Aigües de Barcelona. However, a big problem faced during the second visit was the employee's availability due to workload. As a result compared to EYDAP the interviews in Barcelona were limited and further research had to be done afterwards in order to obtain the necessary information. Furthermore, the language was a problem in Barcelona since many of the official documents from the regulator authority where in Catalan and not in Spanish and as a result a translation was needed. Finally, these documents were outdated with the earliest being from 2006.

The research objective of this thesis originated from Vitens objective to improve its long-term asset management planning in line with the institutional environment. The final outcome has contributed to Vitens objective by gaining insight in the strategic decision-making about asset management of water companies working in different institutional environments. The socio-technical context might be different from the one that Vitens is working in and thus creates different influences, but as it was recognized in the beginning of this thesis, describing and evaluating the strategic decision-making process of a water company operating in a different institutional environment can provide valuable information that could be relevant to Vitens' decision-making process on asset management. Asset management decision-making is an important factor in order WCS to achieve societal and environmental needs. The future is uncertain and the challenges that of the future the need of understanding the interrelations and interdependence of WCS with the physical and social context is getting stronger. This

complexity seems that Vitens, Aigües de Barcelona and EYDAP have faced and have identified the importance of incorporating in their decision-making process.

This research tried to add to the scientific knowledge gap by linking the external environment with the strategic decision-making process on the asset management of the infrastructure. The socio-technical context was reviewed with the intent on characterizing its impact on the decision-making process. The socio-technical context has produced a way of thinking in the strategic decision-making process of the two companies, which is reflected on the structure of this process. In other words, the socio-technical context has been embedded in their way of thinking in regard to strategic decisions. The understanding of why specific strategic decisions were taken can provide a useful insight in the interrelation between these two worlds (asset management and socio-technical context).

Chapter 7

Recommendations

7. Recommendations

This chapter provides general recommendations for further research to Vitens and to the companies under study.

7.1. Recommendations Coming from Limitations During the Process

By describing the limitations and the obstacles that were faced during this thesis, they can be used as indicators for future research as well. The first intent of this thesis was to compare except from the two visited companies with a third one from the UK.

After completing the research part of the thesis that included the interviews it was seen that the available information wasn't the same and as a result the comparison wasn't possible. A comparison can be made in the future for the external environment. The three companies represent three different institutional ownership rights. In the UK the water sector is fully privatized, meaning that the physical assets are also passed to the private companies, while in Barcelona there is private company operating under a concession contract and finally in Athens a semi-private state owned company operating also under a concession contract. Furthermore, a comparison involving Vitens would have been interesting.

The questionnaire used was a good start in order to obtain the necessary information, but during the procedure it was found that maybe a few questions were too general and it didn't give the expected answers. What is recommended for further research is to collect information before visiting the company under interest and focus on trying to verify the collected information, while get answers and internal information that are not published.

A limitation coming on the analysis part is that the research is relying on interpretative methods. This means, that my level of analysis relies on my analytical capability and on my interpretation of the results from the conducted research. Therefore, the receptiveness of the factual determination of this analysis could be questionable.

Based on the comparison part of the case studies a possibility for further research can be by setting specific boundary conditions. More specifically, a pattern can be made in order to identify the cases that have similarities on their strategic decision-making process influenced by the same external factors, as well as differences. For example, in the case of Spain and Greece, both Southern Europe Mediterranean countries suffering from drought problems their strategic decisions had similarities. Therefore, maybe other Mediterranean countries suffering from drought problems might share the same strategic decisions.

It will be interesting to expand the research outside Europe. A water company operating in South America or in a big Asian market, such as China, India or Japan, where some of the world's largest cities are located.

The research can be applied in companies operating in other markets that the external environment influences the strategic decision-making process. The electricity or the telecommunications sectors are a few examples.

The interrelation between the strategic decision-making process on the asset management of the infrastructure and the socio-technical context has been showed in this research. Demonstrating this interrelation opens an opportunity for further research that focuses in characterizing and understanding the importance to act over this interrelation in order to reach certain goals.

The objective of this research as it was explained in the beginning of this thesis comes from Vitens objective on improving their long-term asset management planning. Recommendations from the final outcome of this research can be given to Vitens. The idea of gaining insight of the socio-technical environment is in order to be aware of possible threats (e.g. population growth, climate change, deterioration) and vulnerabilities (e.g. lack of information) of the future. That will help the choice of the decision-maker for reaching the strategic of the organization. Therefore, it is important to deal the threats and the vulnerabilities, with actions taken in the present beneficial to reduce the risk of uncertain effects on the strategic goals in the future. The uncertainties of the future should be reflected to the strategic objectives with specific actions in line with the strategic goals of the organization.

Chapter 8

Bibliography

8. Bibliography

Agbar Group. *Corporate Responsibility Report 2011*. Agbar, 2011.

—. "Shareholders." *Agbar Group*. 2012. <http://www.agbar.com/en/1630.html> (accessed February 20, 2014).

Agència Catalana de l'Aigua. *Water in Catalonia : diagnosis and proposed actions : significant water management issues raised within the compilation of the River Basin District Management Plan for Catalonia*. Pursuant to Article 14(b) of the Hydrological Planning Regulation (Decree 380/2006), Departament de Medi Ambient i Habitatge, Barcelona: Catalan Water Agency (ACA), 2008, 100.

Aigües de Barcelona. *Aigües de Barcelona*. <http://www.aiguesdebarcelona.cat/ca/la-factura> (accessed January 10, 2014).

—. *Aigües de Barcelona*. 2013. <http://www.aiguesdebarcelona.cat/compromiso-de-servicio> (accessed January 10, 2014).

—. "Gestio Integral." *Aigües*, October 2013.

Aigües de Barcelona S.A. *Evolució de la demanda i del consum diari*. 2013. <http://www.aiguesdebarcelona.cat/ca/evolucion-de-la-demanda-y-del-consumo-diario> (accessed February 20, 2014).

Aigües de Barcelona. "Water in Barcelona, Data updated until 2008." 2009.

Aigües de Barcelona. "Aigües de Barcelona, una realitat de futur." *Aigües*, October 2013: 23.

Aigües de Barcelona. "Water in Barcelona, Data updated until 2008." 2009.

Albiac, J., M. Hanemann, J. Calatrava, J. Uche, and J. Tapia. "The Rise and Fall of the Ebro Water Transfer." *Natural Resources Journal* (University of New Mexico School of Law) 46, no. 3 (01 2006): 729-757.

Albiol, C., and D. Demessence. "El Preu de l'aigua." *L'aigua a Catalunya. Una perspectiva per als ciutadans.*, 2006: 333-338.

Alegre, H., and S. T. Coelho. "Infrastructure Asset Management of Urban Water Systems, Chapter 3." In *Water Supply System Analysis - Selected Topics*, edited by Dr. A. Ostfeld, 149. InTech, 2012.

Alexopoulou, A., C. Makropoulos, and N. Voulvoulis. "Water Framework Directive: Implementation in Greece." *Proceedings of the 9th International Conference on Environmental Science and Technology*. Rhodes Island, Greece, 2005.

Anderson, William P., Pavlos S. Kanaroglou, and Eric J. Miller. "Urban Form, Energy and the Environment: A Review of Issues, Evidence and Policy." *Urban Studies* 33, no. 1 (1996): 7-35.

AQUAE Foundation. "International Overview of Regulation Frameworks for the Urban Water Cycle in the United Kingdom, Chile and Spain." *Aquae Papers* (AQUAE Foundation) 2 (September 2013): 31.

Athens Water Supply and Sewerage Company (EYDAP SA). "http://www.eydap.gr." *Athens Water Supply and Sewerage Company (EYDAP SA)*. 2013. http://www.eydap.gr/media/clientservice/timologio_16_12_13.pdf (accessed February 28, 2014).

Bauer, J. M., and P. M. Herder. "Designing socio-technical systems." *Philosophy of technology and engineering sciences*, 2009: 601-630.

Bel, Germà, Francisco González-Gómez, and Andrés J. Picazo-Tadeo. "The dynamics of privatization and regulation of water services: a comparative study of two Spanish regions." *International Journal of Water Resources Development* 29, no. 3 (2013): 373-384.

Boné, Alfredo. "Reasons for the autonomous community of Aragon's position against the Ebro transfer as envisaged in the National Hydrological Plan." *Water Resources Development* 19, no. 3 (2003): 413-435.

Brown, R. E., and B. G. Humphrey. "Asset management for transmission and distribution." *Power and Energy Magazine, IEEE* 3, no. 3 (2005): 39-45.

Bru Angelats, A., and C. Albiol Omella. "Study on the price of water in Spain." *Aquae Papers* (AQUAE Foundation) 1 (June 2013): 84.

Butenko, S., et al. "Asset Management Literature Review and Potential Applications of Simulation, Optimization, and Decision Analysis Techniques for Right-of-Way and Transportation Planning and Programming." Technical Report, 2007.

Cañete, Olga Ruiz, and Dolores Dizy Menéndez. *The Water Sector in Spain*. Working paper, Liège: CIRIEC, 2009.

Casado, Lucia, and Carlos Pardos. "Municipalities and the new Water Act." *Medi Ambient, Tecnologia i cultura*, January 2000.

Catalan News Agency. *The Catalan Government privatises Greater Barcelona's water supply to reduce the public deficit*. 2012. <http://www.catalannewsagency.com/politics/item/the-catalan-government-privatises-greater-barcelonas-water-supply-to-reduce-the-public-deficit> (accessed February 20, 2014).

CETaqua, and Chris Fife-Schaw. *Strategies for Addressing Water Shortages: Barcelona – A Case Study*. TECHNEAU, 2010.

Chatzisavva, E., and St. Arampatzis. "PROWAT Project - Planning and Implementing a Non-Revenue Water Reduction Strategy Improves the Performance of Water Supply and Distribution Systems." National Technical Report, 2007.

Christoulas, D. "Feasibility and potential for conservation of potable water." *Proceedings of the Workshop "The water supply problem of Athens"*. Athens: Department of Water Resources, Hydraulic and Maritime Engineering, 1994. 46-60.

Coccossis, H., and G. Kallis. *Metropolitan areas and sustainable use of water, The Case of Athens*. METRON project, University of Aegean, 2000.

Cortés, Pere Verger. *Management Experience of Agbar Group*. Presentation, Paris: Athens Week, 2012.

Cunha Marques, R., and K. van Leeuwen. "Current State of Sustainability of Urban Water Cycle Services. Part I – Towards a Baseline Assessment of the Sustainability of Urban Water Cycle Services." Deliverable 11.1, 2012.

Domene, Elena, and David Saurí. "Urbanisation and Water Consumption: Influencing Factors in the Metropolitan Region of Barcelona." *Urban Studies* 43, no. 9 (2006): 1605–1623.

Downward, Stuart R., and Ros Taylor. "An assessment of Spain's Programa AGUA and its implications for sustainable water management in the province of Almeria, southeast Spain." *Journal of Environmental Management* (Elsevier) 82 (2007): 277–289.

Efstratiadis, A., et al. *Master plan of the Athens water resource system - Year 2001-2002, "Modernisation of the supervision and management of the water resource system of Athens"*. Technical Report, Department of Water Resources, Hydraulic and Maritime Engineering, Athens: National Technical University of Athens, 2001, 200.

Efstratiadis, Andreas , Demetris Koutsoyiannis , and Dionysios Xenos. "Minimizing water cost in water resource management of Athens." *Urban Water Journal* (Taylor & Francis) 1, no. 1 (2004): 3-15.

Eilon, S. "What is a decision?" *Management Science* 16, no. 4 (1969).

EYDAP S.A. *Annual Bulletin & Annual Report, 2013*. Athens: EYDAP S.A., 2014.

EYDAP S.A. *Corporate Presentation EYDAP S.A. 2013*. Athens, 2013.

Fabrellas, C., R. Devesa, and L. Matia. "Effect of blending two treated waters on the organoleptic profile of Barcelona's supply ." *Water Science Technology* 49 (2004): 313-319.

Finger, M, J Groenewegen, and R. W. Künneke. "The quest for coherence between institutions and technologies in infrastructures." *Journal of Network Industries* 6, no. 4 (2005): 227-259.

Flintsch, G. W., and J. W. Bryant. *Asset Management Data Collection for Supporting Decision Processes*. U.S. Department of Transport-Federal Highway Administration, 2009.

Furubotn, E. G., and R. Richter. *Institutions and Economic Theory: the contribution of the new institutional economics*. Ann Arbor: University of Michigan Press, 2005.

Georgiadis, St. "Applied methodologies for optimal management in Athens water supply system (in Greek)." *Water: The Next Day*. Athens, Greece: EYDAP, 2009.

Ghorbani, A., A. Ligtoet, I. Nikolic, and G. Dijkema. "Using Institutional Frameworks to Conceptualize Agent-based Models of Socio-technical Systems." *Proceedings of the 2010 Workshop on Complex Systems Modelling and Simulation*. 2010.

Giuliano, Genevieve, and Dhiraj Narayan. "Another look at travel patterns and urban form: the US and Great Britain." *Urban Studies* 40, no. 11 (2003): 2259–2312.

González, Susana, Ramón López-Roldán, and Jose-Luis Cortina. "Presence and biological effects of emerging contaminants in Llobregat River basin: A review." *Environmental Pollution* (Elsevier) 161 (2012): 83-92.

Gullón, Martín. "Water reuse project of the Barcelona Metropolitan Area." *8th IWA International Conference on Water Reclamation & Reuse*. Barcelona: International Water Association (IWA), 2011.

- Gómez, F. González, and M. A. G. Rubio. "Efficiency in the management of urban water services. What have we learned after four decades of research?" *Hacienda Pública Española*, (IEF) 185, no. 2 (2008): 39-67.
- Haasnoot, M., H. Middelkoop, E. van Beek, and W. P. A. van Deursen. "A Method to Develop Sustainable Water Management Strategies for an Uncertain Future." *Sustainable Development* 19 (2011): 369-381.
- Harrison, E. F. *Policy, Strategy, and Managerial Action*. Boston, MA: Houghton Mifflin, 1994.
- Harrison, E. Fr. "A process perspective on strategic decision making." *Management Decision* 34, no. 1 (1996): 46-53.
- Heather, A. I. J., and J. Bridgeman. "Water industry asset management: a proposed service-performance model for investment." *Water and Environment Journal* 21 (2007): 127-132.
- Heimlich, Ralph E. "Metropolitan agriculture: farming in the city's shadow." *Journal of the American Planning Association* 55, no. 4 (1989): 457-466.
- Herder, P.M., and Y. Wijnia. "A Systems View on Infrastructure Asset Management." In *Asset Management The State of the Art in Europe from a Life Cycle Perspective*, edited by T. Van der Lei, P.M. Herder and Y. Wijnia, 31-46. Dordrecht: Springer, 2012.
- Hlepas, N. K., and P. Getimis. "Impacts of Local Government Reforms in Greece: An Interim Assessment." *Local Government Studies* 37, no. 5 (2011): 517-532.
- Hofer, Ch. W., and D. E. Schendel. *Strategy Formulation: Analytical Concepts*. St. Paul, MN: West Publishing, 1978.
- Hofstede, G. "Dimensionalizing Cultures: The Hofstede Model in Context." *Online Readings in Psychology and Culture* 2, no. 1 (2011).
- Hofstede, G., and G.J. Hofstede. *Cultures and organizations: Software of the mind*. London: McGraw-Hill, 2005.
- IAM and BSI. "Pas 55-2: 2008 Asset management, part 2: Guidelines for the application of PAS 55-1,." Institute for Asset Management and British Standard Institution, Bristol, United Kingdom, 2008.
- Ibanez, Carles, and Narcis Prat. "The environmental impact of the Spanish national hydrological plan on the lower Ebro river and delta." *International Journal of Water Resources Development* 19, no. 3 (2003): 485-500.
- Jonker, M. *Modernization of electricity networks*. Dissertation, Delft University of Technology, 2010.
- Künneke, R. W. "Institutional reform and technological practice: The case of electricity ." Delft, 2007.
- Kaika, M. "Constructing Scarcity and Sensationalising Water Politics: 170 Days That Shook Athens." *Antipode* 35, no. 5 (November 2003): 919-954.
- Kallis, G., and H. Cocossis. "Managing Water for Athens: From the Hydraulic to the Rational Growth Paradigm." *European Planning Studies* 11, no. 3 (2003): 245-261.
- Kampa, E., and H. Bressers. "Evolution of the Greek national regime for water resources." *Water Policy* 10 (2008): 481-500.

Kanakoudis, V. K. "A troubleshooting manual for handling operational problems in water pipe networks." *Journal of Water Supply: Research and Technology—AQUA* (IWA Publishing) 53, no. 2 (2004): 109-124.

Kanakoudis, V., and D. Tolikas. "Detection, identification, study and solutions for problems in urban water networks ." *Proceedings of the 4th National Conference of the Greek Committee of Water Resources Management, Water Resources Management in Sensitive Areas in Greece* . Volos, Greece, 1999.

Kanakoudis, V., S. Tsitsifli, P. Samaras, A. Zouboulis, and G. Demetriou. "Developing appropriate performance indicators for urban water distribution systems evaluation at Mediterranean countries." *Water Utility Journal* (E.W. Publications) 1 (2011): 31-40.

Karavitis, C. *Flood Events and Management Options in Metropolitan Athens in "NEDIES Project: Lessons Learnt from Flood Disasters"*. EUR 20261 EN, Italy: European Commission, Joint Research Center, 2002.

Koutalakis, C. "Chapter 9 Environmental policy in Greece reloaded: Plurality, participation and the Sirens of neo-centralism." In *Sustainable Politics and the Crisis of the Peripheries: Ireland and Greece (Advances in Ecopolitics, Volume 8)*, edited by L. Liam and I. Botetzagias, 181-200. Emerald Group Publishing Limited, 2011.

Koutiva, I., C. Makropoulos, and N. Voulvoulis. "Administrative challenges in implementing the Water Framework Directive in Greece: Stakeholder engagement." *Proceedings of the 10th International Conference on Environmental Science and Technology*. Kos Island, Greece, 2007.

Koutsoyiannis, D., A. Efstratiadis, and G. Karavokiros. "A decision support tool for the management of multi-reservoir systems." *Journal of the American Water Resources Association* 38, no. 4 (August 2002): 945-958.

Koutsoyiannis, D., G. Karavokiros, A. Efstratiadis, N. Mamassis, A. Koukouvinos, and A. Christofides. "A decision support system for the management of the water resource system of Athens." *Physics and Chemistry of the Earth* (Pergamon) 28, no. 14-15 (2003): 599–609.

Kroes, P., M. P. M. Franssen, I. R. Van de Poel, and M. M. Ottens. "Treating socio-technical systems as engineering systems: some conceptual problems." *Systems Research and Behavioral Science* 23 (2006): 803-814.

Linde, C. van der, A. Correlje, J. de Jong, and C. Tonjes. *The paradigm change in international gas markets and the impact on regulation*. The Hague: International Gas Union/The Clingendael Institute, 2006.

March Corbella, H. *Urban Water Management and Market Environmentalism: A Historical Perspective for Barcelona and Madrid*. Dissertation, Barcelona: Universitat Autònoma de Barcelona, 2010.

March Corbella, Hug. "Taming, controlling and metabolizing flows: Water and the urbanization process of Barcelona and Madrid (1850–2012)." *European Urban and Regional Studies*, 2013.

March, Hug, David Saurí, and Judit Perarnau . "Exploring the Links between Immigration, Ageing and Domestic Water Consumption: The Case of the Metropolitan Area of Barcelona." *Regional Studies* 46, no. 2 (2012): 229-244.

Ménard, Claude, and Aleksandra Peeroo. "Liberalization in the Water Sector: Three leading models." *Handbook of Liberalization*, 2011: 310-327.

Ministry of Development. *The 14 water departments of Greece*. Athens: Ministry of Development, (MDEV), 1996.

Ministry of Environment, Energy & Climate Change. *Ministry of Environment, Energy & Climate Change*. <http://www.ypeka.gr/Default.aspx?tabid=246&language=el-GR> (accessed May 14, 2014).

Monica, Rivera. "Case of the Barcelona basin in Hydrosocial Issues,– Report of Work Package 2 of the FIRMA project." 2002, 126-156.

Mujeriego, R., J. Compte, T. Cazorra, and M. Gullón. "The water reclamation and reuse project of El Prat de Llobregat, Barcelona, Spain." *Water Science & Technology* 57, no. 4 (2008): 567-574.

Nickson, Andrew, and Richard Franceys. *Tapping the water market: the challenge of reform in the urban water sector*. Basingstoke: Palgrave Macmillan, 2003.

Nordgård, D. E., E. Solvang, and G. Solum. "Developing and implementing a risk based maintenance strategy for distribution companies." *In Proceedings of CIRED – 18th International Conference on Electricity Distribution 6–9 June*. Turin, Italy: IEE, London, 2005. 55–59.

North, D. C. "Institutions." *Journal of Economic Perspectives* 5, no. 1 (1991): 97-112.

Observatorio de los Servicios Públicos. "D10k: WaterTime National Context Report – Spain." <http://www.watertime.net>. May 31, 2004. http://www.watertime.net/docs/WP1/NCR/D10k_Spain.doc. (accessed February 05, 2014).

Ocampo-Martínez, Carlos, Vicenç Puig, Gabriela Cembrano, Ramón Creus, and Meritxell Minoves. "Improving water management efficiency by using optimization-based control strategies: the Barcelona case study." *Water Science & Technology: Water Supply* 9, no. 5 (2009): 565-575.

OECD. *Environmental performance: Greece*. Paris: OECD, 2000.

Ottens, M. M., Kroes P. A., M. P. M. Franssen, and I. R. Van de Poel. "Modeling engineering systems as socio-technical systems." *International Journal of Critical Infrastructures* 2 (2006): 133-145.

Papadopoulou, A., S. Tsitsifli, and V. Kanakoudis. "Spatial analysis of the domestic water use pricing in Greece." *Proceedings of the 4th International Conference on Environmental Management, Engineering, Planning and Economics (CEMEPE) and SECOTOX Conference*. Mykonos island, Greece, 2013. 661-667.

Pascual, Martin M. *Aigua i societat a Barcelona entre les dues exposicions (1888-1929)*. Doctoral dissertation, Cerdanyola del Vallès: Universitat Autònoma de Barcelona, 2007.

Patil, A., and P. Herder. *Changing the Rules of the Game to Influence the Diffusion of Alternative Fuels*. Next Generations Infrastructures Foundation, 2010.

Platikanov, S., V. Garcia, E. Landeros, and R. Devesa. "Determination of water supply sources in the Barcelona distribution system by UV spectrophotometry and PLS." *Water Science & Technology: Water Supply* 11, no. 1 (2011): 45-54.

Ploeg, Tineke Ruijgh-van der. "Manifestations of adaptive capacity: An institutional analysis of adaptation of a local stormwater drainage system." *Climate Law* 2, 2011: 201–217.

Podimata, M. V., and P. C. Yannopoulos. "Kallicrates Scheme and Water Governance in Greece." *Protection and restoration of the environment XI*. Thessaloniki, Greece, 2012. 2385-2394.

Pollitt, C., and G. Bouckaert. *Public Management Reform: A Comparative Analysis*. 2nd Edition. Oxford: New York: Oxford University Press, 2004.

Pouget, Laurent, Isabel Escaler, Roger Guiu, Suzy Mc Ennis, and Pierre-Antoine Versini. "Global Change adaptation in water resources management: The Water Change project." *Science of the Total Environment* (Elsevier) 440 (2012): 186–193.

Raich-Montiu, Jordi, et al. "Integrating membrane technologies and blending options in water production and distribution systems to improve organoleptic properties. The case of the Barcelona Metropolitan Area." *Journal of Cleaner Production*, 2014.

Safarikas, N., N.V. Paranychanakis, O. Kotselidou, and A.N. Angelakis. "Drinking water policy in the frame of the Directive 2000/60/EC with emphasis on drinking water prices." *Water Science and Technology: Water Supply* (IWA Publishing) 5, no. 6 (2006): 243–250.

Saletha, R. Maria, and Ariel Dinar. "Institutional changes in global water sector: trends, patterns, and implications." *Water Policy* 2, 2000: 175 - 199.

Sanz, Miguel Angel, and Carlos Miguel. "The role of SWRO Barcelona-Llobregat Plant in the water supply system of Barcelona Area." *Desalination and Water Treatment* (Taylor & Francis) 51, no. 1-3 (2013): 111–123.

Saurí, David. "Lights and Shadows of Urban Water Demand Management: The Case of the Metropolitan Region of Barcelona." *European Planning Studies* 11, no. 3 (2003): 229-243.

Sauri, David, and Leonardo del Moral. "Recent developments in Spanish water policy, Alternatives and conflicts at the end of the hydraulic age." *Geoforum* 32 (2001): 351-362.

Sauri, David, Jorge Olcina, and Antonio Rico. "The State of Urban Water Supply and Sanitation in Spain: Issues, Debates and Conflicts." In *Water Supply and Sanitation: Public Policy and Management*, by Jose Esteban Castro and Leo Heller, 392. Taylor and Francis, 2009.
Special Secretariat for Water. *Regulating urban water and sewerage tariffs guiding principle and general approach*. Athens: Ministry of Environment, Energy and Climatic Change, 2013, 25.

Stefopoulou, A., K. Soulis, M. Papapetrou, S. Kyritis, and C. Epp. "Institutional and policy framework analysis in relation to the application of autonomous desalination systems - Greece." *Desalination* 220 (2008): 455-467.

United Nations Environment Programme; United Nations Global Compact. *Business and Climate Change Adaptation: Toward Resilient Companies and Communities*. UN Global Compact, 2012.

Valdés Cardona, J. Luis, and Jordi Castelló Rodríguez. "The management of distribution networks by sectors and the Barcelona experience." *II International Conference "Efficient Use and Management of Urban Water Supply"*. Tenerife, Spain: IWA International Water Association, 2003.

Valencia, V. V., J. M. Colombi, Al. E. Thal, and W. E. Sitzabee. "Asset Management: A Systems Perspective." *Proceedings of the 2011 Industrial Engineering Research Conference*. Air Force Institute of Technology, 2011.

Van der Lei, T. E., Y. C. Wijnia, and P. M. Herder. "Towards an Asset Management Framework of Asset Characteristics, Asset Environment, Lifecycle Phases, and Management." *Engineering Asset Management and Infrastructure Sustainability*, 2012: 543-556.

Velde, J. van der, L. Klatter, and J. Bakker. "A holistic approach to asset management in the Netherlands." *Structure and Infrastructure Engineering* 9, no. 4 (2013): 340-348.

Voltes, Bou. *Historia del abastecimiento de agua de Barcelona*. Barcelona: Sociedad General de Aguas de Barcelona, 1967.

Webster, Mike, and K. Sansom. *Public-Private Partnership and the Poor: An Initial Review*. Water, Engineering and Development Centre Loughborough University, 1999.

Wijnia, Y. C., and P. M. Herder. "The state of asset management in the Netherlands." *Proceedings of the 4th World Congress on Engineering Asset Management (WCEAM), 28-30 September*. Springer London, 2009. 164-172.

Williamson, O. E. "Transaction cost economics: how it works; where it is headed." *The Economist* (Kluwer Academic Publishers) 146, no. 1 (1998): 23-58.

Williamson, O.E. "The new institutional economics: taming stock, looking ahead." *Journal of Economic Literature* XXXVIII (2000): 595-613.

World Bank. *Approaches to Private Participation in Water Services : A Toolkit*. Washington, DC: World Bank, 2006.

Xenos, D., I. Passios, S. Georgiades, E. Parlis, and D. Koutsoyiannis. "Water demand management and the Athens water supply." *proceedings of the 7th BNAWQ Scientific and Practical Conference "Water Quality Technologies and Management in Bulgaria"*. Sofia: Bulgarian National Association on Water Quality, 2002. 44-50.

CHAPTER 9

Appendix

9. Appendix

9.1. Aigües de Barcelona

9.1.1. Regulations on the Water Companies

In sum, the water billing system in the MAB can be modeled as follows:

Block pricing

$$BP = MPB_0 \cdot q$$

$$BP = MPB_0 \cdot q_{B0} + MPB_1 \cdot (q - q_{B0})$$

where,

$$0 < q < q_{B0} \text{ and } q_{B0} < q < q_{B1} ;$$

and where q is the quantity consumed by the customer; MPB_n is the marginal price of each block; and, q_{Bn} is the threshold quantity between the $n - 1$ and n blocks.

Taxes

$$CP = MPC_0 \cdot q$$

$$CP = MPC_0 \cdot q_C + MPC_1 \cdot (q - q_C)$$

where,

$0 < q < q_C$ and $q_C < q$ and where q is the quantity consumed by the customer, MPC_n is the marginal price of each taxation block; and, q_C is the threshold quantity between the two existing blocks, that is, 12 cubic meters/month.

Therefore, the total cost of water is:

$$TP_i = FC_i + BP_i + CP$$

where, FC_i is the fixed component applied by the municipality.

9.1.2. Smart Metering

One of the main innovative solutions to which Agbar is committed is smart metering, which consists of remote meter –reading. The water consumption is thus obtained without the need for professionals from the company to personally read the figure on the meter. This solution allows the service and tariffs to be adapted, and the billing processes to be more flexible and more adapted to the users (Agbar Group 2011).

Aigües de Barcelona gives a smart metering service to large client or geographic areas as a first step toward mass extension.

Benefits of smart metering

End clients:

- Has more information on their water consumption on the website
- Knows billing in advance
- Controls consumption in rented accommodation and second homes

Community:

- Ensures availability of water
- Applies philosophy of urban development such as the Smart City, a philosophy based on energy saving and mobility, lifestyle and sustainable ways of working

Greater value in relations with the clients:

- Claims due to wrong reading
- Web communication promoted
- Travelling reduced
- Aids possible fraud detection

Efficiency in management of the network:

- Verification of the correct sizing of the meters
- Early identification of problems with meter
- Knowledge of water consumed with hourly and daily frequency etc.

9.1.3. Maintenance

The objective of the company is to move from the corrective to the predictive maintenance as the preventive is already in quite high levels. A start is been done by using model – based methods in order to check the consistency of sensor data. This consistency check is based on computing the difference between the predicted value from the model and the real value measured by the sensors. Then, this difference, known as residual, will be compared with a threshold value (zero in the ideal case). When the residual is bigger than the threshold, it is determined that there is a fault in the system. Otherwise, it is considered that the system is working properly.

In the following Figure 49, the maintenance scheme that is followed by the company is presented.

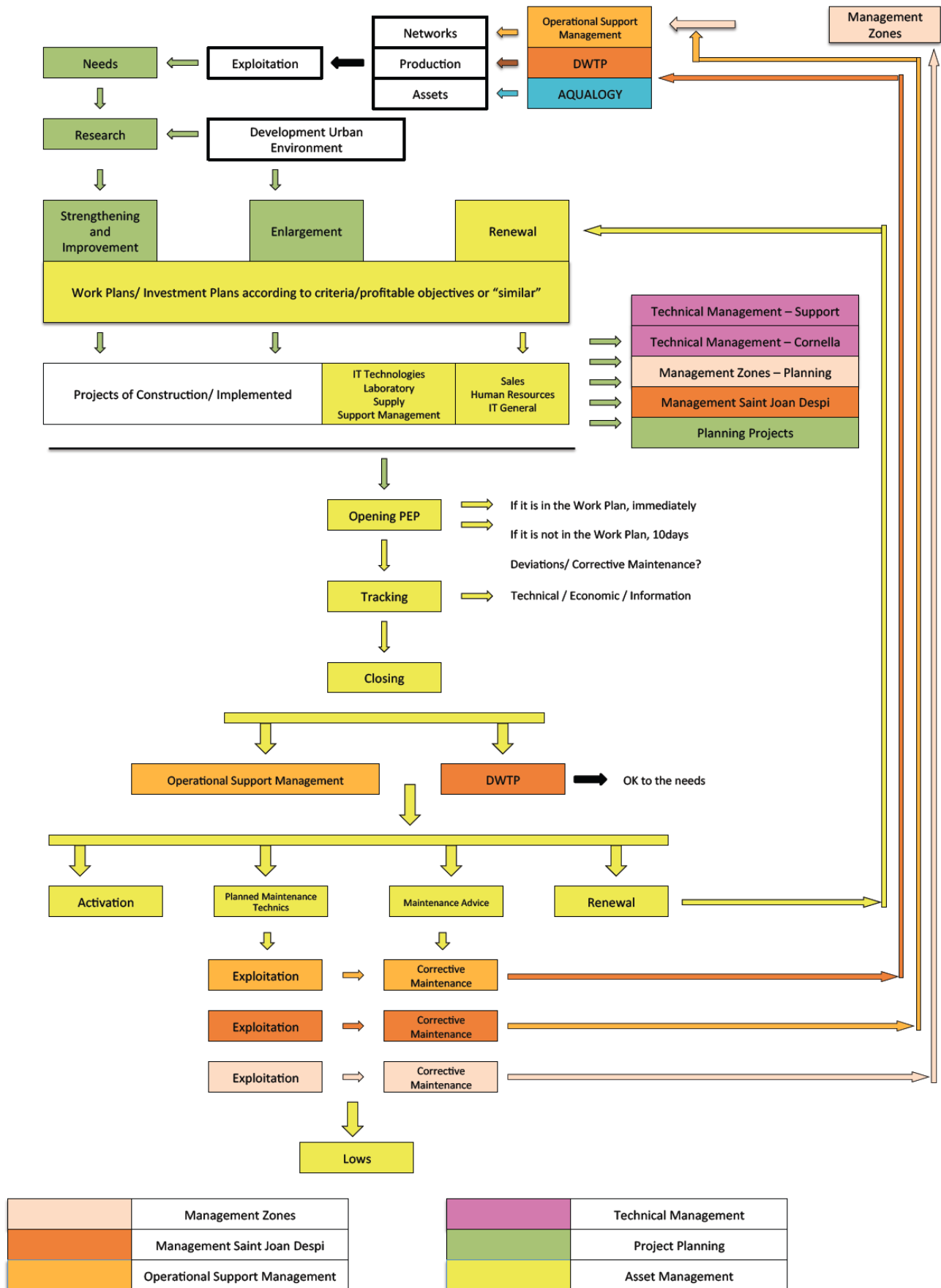


Figure 49: Maintenance scheme for the Asset Management department

Another indicator in which special emphasis has been given on is the minimum night flow (Q_{min}), since any variation may indicate a leak or an anomaly in the service. The night flow expected is formed by measurements, industrial night consumption and a flow of reference that gives an idea of the minimum volume of losses acceptable in the system. It depends on the length of the system, the number of connections, the number of supplies, the average pressure, the sampling interval and some coefficients that may vary according to the features of the system. Also, it takes into consideration possible internal leaks from consumers. The technical performance of the system is calculated as:

$$Performance\ Indicator = \frac{volume\ consumed\ by\ customers}{volume\ delivered}$$

So, by crossing the indicators concerning performance and minimum relativized flow, specific conclusions can be drawn about the state of the system and the improvements to be carried out. In this respect, four trends have been distinguished (Figure 50):

1. Good performance and low Q_{min} , "Optimum situation"
2. Good performance and high Q_{min} , "Night consumption"
3. Bad performance and low Q_{min} , "Under – metering by customer meter"
4. Bad performance and high Q_{min} , "The system is possibly in a bad condition"

Currently around 20% of the system is being using this inspection method and one of the company's objectives is to increase this number.

Concerning the maintenance there are three types of investments:

4. Renew. Is about the life of assets. The company knows the properties of all the assets that are under its property and in which phase of its life cycle are. By this they get the opportunity to invest when is needed in order to replace (renew) an asset. The company is working with Suez Environment and with a use of software to know the age of the assets.
5. Reinforce. In this case the asset doesn't have to be replaced but it has to be reinforced as for example more water is going to pass from a certain pipe than the amount of water that it was designed for.
6. Extension – Enlargement. By building new infrastructure in order to meet a new higher demand.

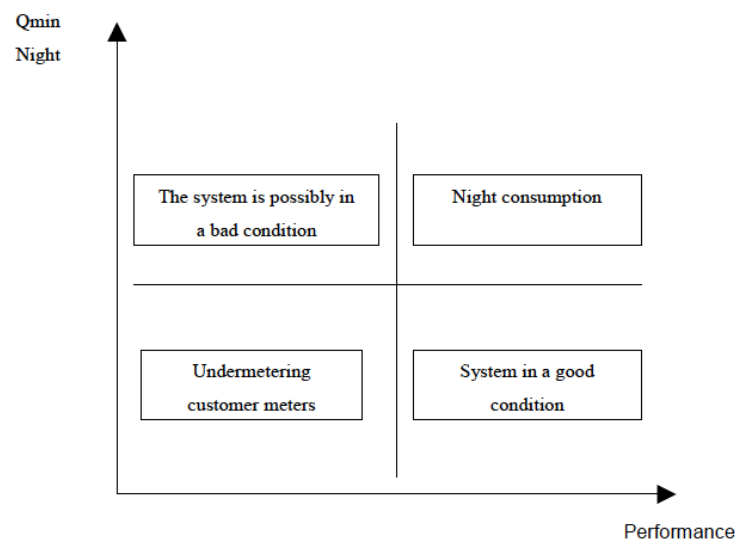


Figure 50: Performance versus Minimum night flow, (Valdés Cardona and Castelló Rodríguez 2003)

9.1.4. The control of water quality

The supplied water quality assurance with all the sanitary guarantees is essential in any supply system, for that reason Aigües de Barcelona has a Laboratory with a high qualification staff equipped with the most modern and complete equipment.

However, to assure the quality of the final product, all the process followed by the water from its origins in nature until the customer's tap has to be known and controlled.

For that reason, the Laboratory of Aigües de Barcelona, besides its analytical capacity, has put the emphasis on three basic aspects:

- The specialization in the realization, control and logistic of the sample collection and its transport and conservation until the moment of the analysis (the diagnosis begins with the sample collection).
- The use of equipment and analysis methodologies adequate to each particular case and internationally accepted to contrast the results with other expert laboratories.
- The specialization in the analytic capacity necessary to objectify the customer's opinions with regard to the quality of water they receive, besides, obviously the fulfillment of the sanitary norms in force (research of tastes and odors in water).

The analysis of the samples collected is carried out in the Laboratory of Aigües de Barcelona, using official methods of analysis and/or internationally recognized and the most advanced analytical technology. The two centers of the Laboratory work according the principles of Quality Guarantee, which govern the operation of the analytical laboratories in the European Union. Particularly since April 1996, Aigües de Barcelona has a quality assurance system, which includes the control and analysis of human consumption waters supplied by their system (ER 177/2/96 UNE-EN-ISO 9002).

❖ *Control of water in the origins*

Even if a previous control of the surface water is carried out in the Sant Joan Despi treatment plant and the rest of origins as a resource (ground water), the water of these origins is also controlled all along the basin of the Llobregat river. Once the water is in the ETAP (Drinking Water Treatment Plant), the quality of the water is followed all along the different treatment stages, including its point of departure.

This control is carried out depending on what the regulations in force establish for origins as for the frequency and number of analysis, which must be carried out in a certain period of time. However, the sampling plan applied by the Laboratory is even stricter, because analysis with more parameters than the regulated ones are also carried out.

❖ *Distribution system sampling plan*

To guarantee the quality of waters distributed to the different municipalities, Aigües de Barcelona applies a Sampling plan for the distribution system which allows to fulfill the requirements fixed by the regulations in force and which, moreover, is more strict and complete in many aspects because, besides the controls fixed by this legislation, it includes the realization of other analysis to have a more complete information on the distribution system.

The sampling points are strategically chosen in the distribution system of each municipality in order to be as representative as possible of the ones located at the outlet of tanks and/or elevating stations, they are also located in public fountains and irrigation outlets existing in different municipalities. This Plan establishes a cyclic sampling calendar that guarantees the control representativeness.

The frequency of the control corresponds, at the very least, to the ones established by the regulations in force and, with the collected samples, the corresponding analysis are carried

out with the determination of those parameters established by the legislation according to the type of analysis which must be done. Moreover, in a parallel way to this sampling, daily systematic controls on the level of chlorine are done in different points of the system which are necessary to guarantee the sanitary quality of the supplied water. Continuous information on the levels of residual chlorine in the distribution system is available through automatic experimental analyzers connected to a computer system of data collection. These analyzers are strategically distributed all over the distribution system.

In all the origin points and in the different sampling points of the distribution system of the municipalities, a bacteriologic control is made every day, from the collected samples. Determinations which are carried out systematically are the following: count of total aerobic bacteria to 37 C and 22 C, coliform bacteria (total and faecal), streptococcus, spore – forming anaerobic bacteria (sulphite – reducing clostridia) and classification of isolated species in previous trials.

9.1.5. The quality guarantee system

Aigües de Barcelona got for its quality guarantee system the certificate of Enterprise Register given by the "Asociacion Espanola de Normalizacion y Certification" (AENOR) according to the UNE-EN-ISO 9002 standard, and the certificate number is ER 177/2/96, of 25 April 1996. The certified activities are:

- The production, control and analysis of the quality of water for human consumption.
- The service of drinking water supply and customer attention.

In 1997, the activities related to the service of water analysis to customers were incorporated to the quality assurance system. For these activities, the certificate of the Enterprise Register given by AENOR according to the same standard was also obtained and the number of the certificate is ER 1007/2/97, of 30 December 1997.

The obtention of the aforementioned certificates of quality supposes for Aigües de Barcelona another recognition, in this case by a certifying independent organism, of the constant work that is being carried out on quality. This fact, of course important, is only one of the goals established inside the management strategy of quality management of Aigües de Barcelona.

This strategy includes three stages with their respective objectives:

- 1) Quality guarantee system.
Objectives:
 - Guarantee the requirements of quality of the customer service to be met.
 - Obtain the ER certification by AENOR.
- 2) Extension of the quality system field
Objectives:
 - Integrate in the quality system all the processes of Aigües de Barcelona.
 - Know the customers' opinion.
- 3) Continuous improvement.
Objectives:
 - Improve the processes efficiency and quantify it.
 - Eliminate the charges of non – quality.

The quality system filed has been designed from the point of view of the customer about three basic aspects:

- The water product
- The supply continuity
- The attention to customer

9.1.6. Information systems

To give the maximum efficiency to the water supply system in the area of Barcelona, Aigües de Barcelona has a whole of information systems which allow to operate in all the fields of responsibility which have been described, with the knowledge and tools essential to assure the quality of service to all the users of the system.

9.1.6.1. Control and information system for exploitation

During 1991, the present Exploitation Automatic System (SAE) came into operation. The new System guarantees the continuity of the service, the maintenance of the reference pressures and the control of the supplied water quality, by sending orders to the facilities, which are part of the system and with the continuous supervision of its characteristic parameters.

Aigües de Barcelona reaches with the Exploitation Automatic System the following objectives:

- Optimize the use of the facilities, that is to say, to make the best use of its capacity with a good manoeuvre program. For that reason, a prevision of the water demand must be done in every area of the system.
- Decrease the exploitation costs, that is to say, be in optimal conditions of operation all the time, with an overall view of the need of flows and choose the most adequate manoeuvre alternatives.
- Improve the service, that is to say, avoid pressure variations when the consumption varies, foresee anomalies, which can appear and limit leaks. With these parameters, a supply with an adequate quality is reached.

Each facility is equipped with an associated remote station, which is an element with a whole of electronic circuits inside (hardware), of elements that can be programmed, controls the operation of the associated facility, either tanks, impulsions, pump-motor units, flow meters or associated regulator valves, according to the established order values. All the remote stations send data from their associated facilities to the Control center. This way, all the information on exploitation can be concentrated in a specific place, which gives the operator an overall view of all the facilities operation.

The functions of the control center are:

- Actualization of the system state, by acquiring the data coming from all the remote units.
- Diagnosis of everything, which does not operate in ideal conditions according to the management criteria.
- Calculation of operation strategies for facilities.
- Control of anomalies and warnings.
- Elaboration of information.
- Communication operator-system.

This automatic exploitation system includes the information continually on the levels of residual chlorine as the main parameter of water sanitary quality control in the distribution system.

To complete the optimal strategy of exploitation, the system has knowledge of the variability of the resources in quantity and quality. On the other hand, a series of pluviographs have been installed which allow to foresee, in the short term, the evolution of the flow in the basin of the Llobregat river that, automatically, collect samples of the river and measure their parameters of quality. The objectives of these stations are:

- Warn about the accidental pollutions to be exploited that reach the Sant Joan Despí and Abrera treatment plants.

- Analyze variations in water quality and optimize the treatment.
- Contribute to the control of the quality of the river water, in order to check the effects of the treatment stations in operation and to make the localization of clandestine dumps easier.

Besides this automatic system, there are two more, one in the Sant Joan Despí water treatment plant and another in the catchment and pumping facilities of the aquifer in Sant Feliu and Cornellà.

9.1.6.2. Commercial information system

The Commercial Information System (SIC) is the computer mechanization of the information and decision systems (in its most formalized part) which requires the commercial management for the development of all its activities and functions. In the same way, it covers some activities of the technical management, intimately related to the commercial management, such as the ones corresponding to installations of branches or points of water collection, installations of sets of keys, meters and water posts, location of consumptions depending in zones in the distribution system, change operations and meter checking, cancellations or annulments of supplies, among others.

To carry out its tasks, the SIC needs a whole of structured information in a complex and voluminous mechanized database and a whole of mechanized processes, structured in computer applications or computer subsystems. With both components (Database and Applications), the SIC covers the following objectives:

- Obtain a favorable social and economical balance as for the previous situation.
- Improve the quality of the results, products and services and reduce the terms of execution of activities.
- Optimize the use of the available means.
- Increase productivity and improve the organization of the organic units responsible for the commercial management.
- Eliminate the manual activities, which are monotonous or undesirable.
- Help to the taking of decisions.
- Improve relations with third parts, specially the attention to customers.

The SIC is composed of a Decisional Subsystem (SSD) and the following operative applications:

CUSTOMER MANAGEMENT

1. Supply applications
2. Branches contracts
3. Divisionary meter contracts
4. Customers' consultation

BILLING

5. Maintenance of the Database
6. Meter readings
7. Supply billing
8. Billing summaries

PAYMENT

9. Supply bills payment management
10. Unpaid bills management

The SIC Decisional Subsystem is formed by a series of formalized processes for helping to the taking of decisions in the field of the commercial management. In short, it includes the following:

1. Database consultations
2. Database summaries
3. Lists at request
4. Commercial statistics
5. Tariff simulations

9.1.7. Ownership Models Inside and Outside Spain

A few examples of contracts within public and private management and ownership as shown in Figure 51 in which Agbar Group participates are listed below:

- a) Service contract, whereby the private company provides a defined technical or administrative task for a public operator. An example, is the administrative task of client management that Agbar has been carrying out for Sanego in Goiás (Brazil).
- b) Management contract, whereby a private company is contracted to carry out core responsibilities with a production unit. That would be the case for instance of the contract the group maintains with the Société des Eaux d'Oran (Argelia).
- c) Lease contract, similar to a management contract but this time the private contractor is the one bearing the legal responsibility for operating the service in exchange for payments to the public administration, who is the asset owner. An example is the Aguas de Varadero in Cuba.
- d) DBO (design, build and operate), a variant of a BOT contract (Build, own and transfer), could be observed with the desalination plant Agbar built and manages in Barcelona.
- e) Full ownership/Divestiture, where the entire infrastructure and assets of a publicly owned water utility are sold to the private sector. This extreme case could only be seen in England and Chile, where the legislation permits such kinds of arrangements. Agbar owns two important water suppliers: Bristol Water in the former and Aguas Andinas in the later one.

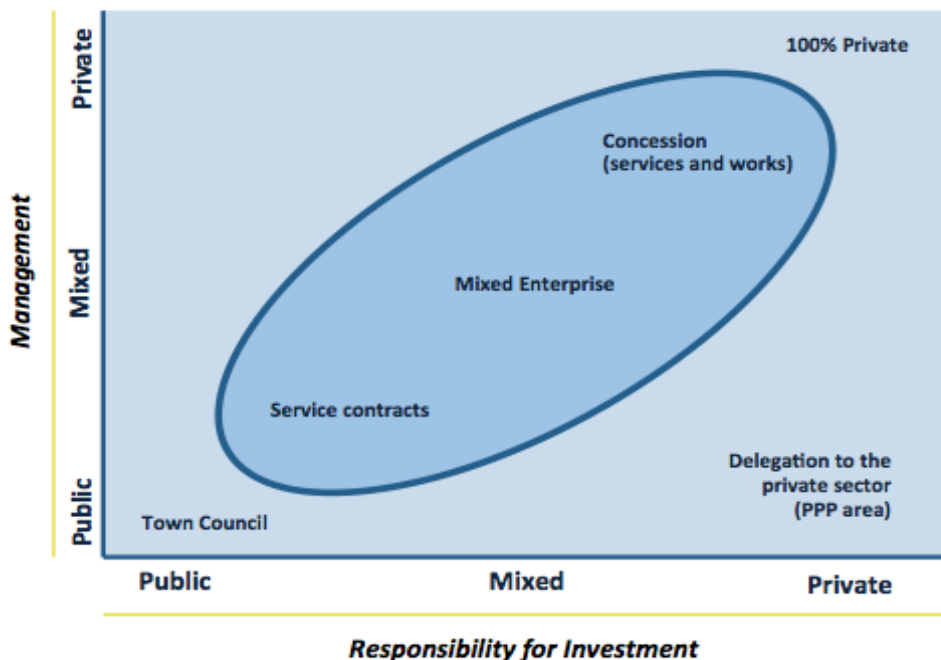


Figure 51: Public – Private Partnership (PPP) contracts within public and private management and ownership, (Webster and Sansom 1999)

9.1.8. Price of Water

Below are described in detail the items included on the water bill from Aigües de Barcelona, and are shown in Figure 51:

I. Supply Contract

The contract for the water supply to the water company (payment to Aigües de Barcelona). The supply contract with Aigües de Barcelona includes the rights and security of supply. It is an amount to be paid only once when the contract is signed: € 56.41 (VAT included) in 2013.

II. Water supply service

The water supply tariff is the remuneration for the costs of the services of catchment and impoundment, drinking water treatment and distribution through the distribution system.

The predominant tariff structure for drinking water is binomial named in the bill as “Subministrament d'Aigua”, that is to say it contains a fixed part and a variable part. The fixed part is the so-called service charge and guarantees the immediate availability and permanent access to the water service. It is a fixed amount, which in general, is calculated taking the caliber of the meter installed as a reference. The variable part is calculated in accordance with the water consumption and is generally applied by consumption bands with increasing prices in order to encourage responsible water use, increasing the price of the cubic meter in a phased and progressive manner as consumption increases. There is usually an initial consumption band, considered as vital, with subsidized price, in order to guarantee that is affordable for underprivileged groups.

III. Sewerage network service tax

This is the payment for the maintenance of the sewerage network and wastewater collection and transfer to the wastewater treatment plant. Is collected on behalf of the municipality in a few regions. It's aim is for the service and the maintenance of the sewer. The rates are published in the Official Journal of the Province of Barcelona. Is named in the water bill as “Taxa de Claveguram”.

IV. Charge for maintenance of the meter

This is the payment for the charge for the maintenance of the meter. It covers the costs to change and replace the meter due to age or breakage. Together with the supply contract, the customers have to purchase a measuring device by a specialized company that will be responsible for its maintenance also. According to Article 45 at the “Municipal Ordinance for the Integrated Water Cycle – Reglamento del Servicio Metropolitano del Ciclo Integral del Agua”, the consumption measurement in which the billed water supply is based on must be done by a measuring device. The model of measuring equipment according to Article 46, must be officially approved and selected by Aigües de Barcelona. In Article 47, Aigües de Barcelona determines the type of the measuring equipment, its features and its position. The customers can consult a document with the selection criteria according to their house. The owner of the water supply contract is free to choose the measuring device and hire the company that considers. Aigües de Barcelona doesn't get involved in the deal, purchase, rental and maintenance of the measuring device, however they can recommend specialized companies with who have reached an agreement and simplify the procedure.

V. Charge for collection of solid urban waste

This is the amount collected to finance the collection and treatment of rubbish and solid urban waste. Is collected on behalf of the Metropolitan Area of Barcelona (AMB). The tax is also published in the Official Journal of the Province of Barcelona and is showed in the water

bill as “Taxa Metropolitana de Tractament de Rsiduos Municipals – TMTR”.

VI. Autonomous rates

The autonomous communities have the power to create their own taxes under the terms foreseen in Article 133.2 of the Spanish Constitution. They normally count as an income of the autonomous community. In any case, the rates included on the water bills should be limited to the complete water cycle and not finance other aspects from outside it. This type of tax in the water bill of the Autonomous Community of Barcelona is called Water Rate, and shows up in the binomial bill as “Repercussio Canon Aigua”. It is a tax charged by the Catalan Water Agency (ACA). The water rate is a tax regulated in a general manner by Article 114 and the articles of the Royal Legislative Decree 1/2001 of 20 July approving the revised text of the Water Law, which is aimed at recovering a part of the investment and exploitation costs of hydraulic construction and infrastructures, in a similar fashion to the regulation rates.

VII. VAT

VAT is the main indirect tax of the Spanish taxation system, being levied on the consumption of goods and services produced or marketed in the development of business or professional activities. Businesses can deduct the VAT paid, while the end consumers cannot deduct the tax, effectively paying it on consuming goods or services. VAT is included among the taxes assigned to the Autonomous Communities in the ordinary regime without regulatory power, 50% of the tax yield generated in the territory of each autonomous community being assigned since January 1999. A tax of 10% is applied for the services in the water cycle.

VIII. Rebates and discounts

In some cases there are rebates or discounts on the water bill for different items, the most usual being the rebates for large families, for the retirees and pensioners, for people with low income, and the unemployed. The rebate can be with a special tariff for the group of users in question, or an extension of the band limits. It is recommended that these discounts be explained on the bill so that the subscriber is aware of the real cost of the service. In any case, subsidizing the costs of the service or certain groups of users is a decision for the regulator, which must make an informed decision in order to avoid possible perverse effects which discourage good water use.

9.2. EYDAP

9.2.1. Company’s Vision, Mission, Key Strategies

EYDAP’s vision is to remain the largest and most reliable company in the management of the water cycle, always oriented towards Man and the Environment. Furthermore, the company’s mission is to provide quality and affordable water to an increasing number of citizens and to return it pure back to the environment through the effective management of all available resources with social sensitivity and with our contribution to social welfare taken as basis. Their strategy is based on achieving a balanced and sustainable development for the benefit of the society, our customers, employees and shareholders and for parties involved (EYDAP S.A. 2014).

The main keystones of their strategy are:

- Increase of the operating efficiency of our Company
- Upgrade of the services provided
- Expansion of customer base – Increase of geographical coverage
- Development of new activities
- Take full advantage of human resources

- Utilization of technology and innovation
- Arrangement of the regulatory and contractual framework with the Greek State
- Strict implementation and compliance with all the quality and operational standards

To achieve these objectives, EYDAP has developed an integrated program of modernization, which main actions are focused on:

- Adoption of modern techniques of financial planning
- Restructuring and simplification of internal and external processes
- Application of modern techniques for remote monitoring and remote management for efficient network management.
- Implementation of crucial interventions in the network to avoid repeated costly failures.
- Implementation of modern techniques and tools of risk management
- Expansion of e-Government for customer service
- Adoption of modern systems for the development and management of human resources
- Implementation of a new cooperation model with the municipalities
- Empowerment of regulatory compliance and obtaining relevant certifications
- Elaboration of business plans for new activities and expansion in areas outside Attica region.

9.2.2. Actions for the Improvement of Service

Main Eydap's objective for the performance of the current system is the improvement of service to the customers without additional financial charge on the application. First the exploitation of the existing investments is an appropriate and already used economic way for the improvement of the current system. Since the system is already in use and investments have been made for its initial development what is important now is the good maintenance of the existing system and a better demand management. Building new infrastructure is not always the best solution. As a result, according to the company a way to achieve this objective is by increasing the flow capacity of the system as well as by taking advantage the life cycle of the existing investments.

1. Exploitation of existing investments:

- **Flow capacity:**
 - Eliminating local bottlenecks
 - Continuous monitoring the status of the valves in the network
 - Review operating conditions of individual elements of the system
 - Simulate of the operation of the network through specialized software
 - Exploit the possibility of demand management
 - Limit network leakages
- **Increase lifetime of investments:**
 - Recording – display of geometric and functional elements and network configuration
 - Ensure cartographic reference
 - Exploiting existing data file construction
 - Extraction of the available "human knowledge"
 - Emergence of visible data network
 - Exploiting information daily (daily cycle of work)
 - Disclosure of allocated data mapped network to other operators
 - Recording of hydraulic operating parameters (pressure)

- Pressure management of the network:
 - Nominal pressure adapted to the terrain
 - Minimize the sinking of the pressure peak hour with while improving discharge capacity of the network
 - Minimize night overpressures due to low consumption
 - Minimize – eliminate faults, due to errors on the operation of the network and due to intense and instant changes in demands of large consumers

2. Limitation of Leakage – two methodologies for the quantitative determination of losses with different accuracies

- Calculation of non-revenue water
- Evaluation of total volume offered water to consumers
 - Water used for human activities
 - Relationship between night flow and peak flow during the day
 - Social behavior “statistically measurable”

It gives an overview in order to estimate from the total volume of water that is distributed in the system, which corresponds to consumption.

Leakages are found both in the distribution system and in indoor customers facilities. Both are of the same importance. Ways to reduce the leakage:

- Processing of statistical files of consumption
- Replacement of water meters: will result in financial resources to fund the addressed leakage plan

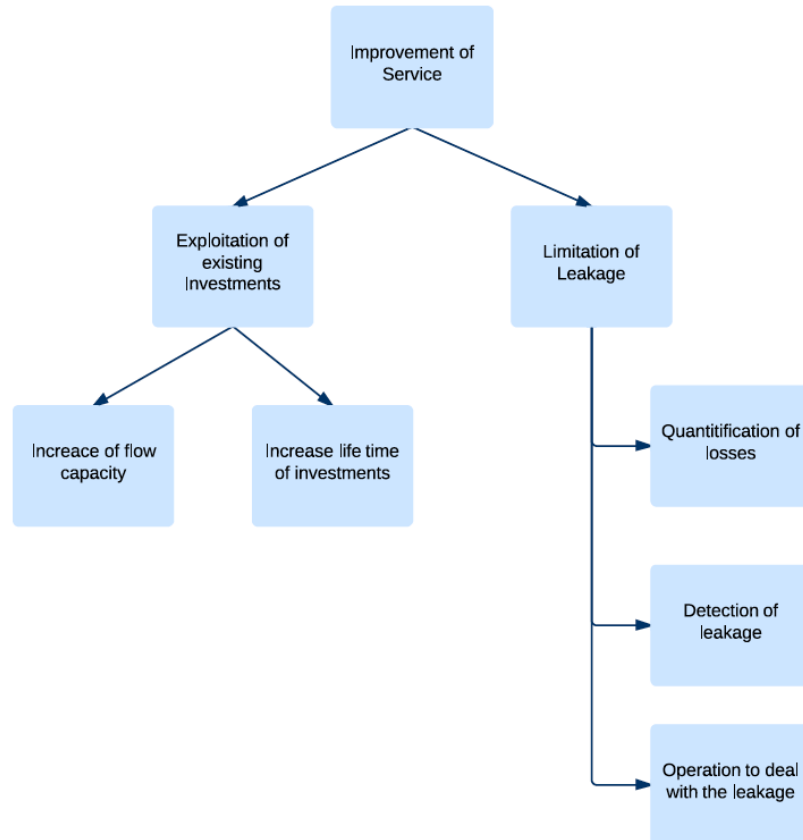


Figure 52: EYDAP's strategy for reaching its improvement objective, (Georgiadis 2009)

9.2.3. Corporate Social Responsibility

The commitment to the principles of sustainable development is a primary objective of EYDAP and basic prerequisite for long-term and sustainable business activity. In this context the principles of Corporate Social Responsibility (CSR) at each level of its operation are the cornerstone of any planned strategy with emphasis on environmental protection, social welfare, transparency, integrity and the quality of its services.

9.2.3.1. Environment

Environmental protection is a key pillar of CSR and in this context EYDAP incorporates procedures and actions to its activity to reduce its environmental footprint. The Company's strategy with regard to environmental protection is implemented with concrete practices in specific fields.

Less energy consumption – Lower environmental burden

- Exploitation of the biogas produced at the Wastewater Treatment Plant to generate thermoelectric power.
- Exploitation of the hydraulic energy produced during the transfer of water across aqueducts to generate electric power at small hydroelectric stations.
- Investment in more efficient – hence less energy consuming – equipment and facilities.
- Sludge treatment and exploitation at Water and Wastewater Treatment Plants.
- Research and planning for reuse of treated water from WWTP in Psytalia for irrigation and other secondary uses.

Protection of marine life

- Treatment of Athens sewage and wastewater and construction of new treatment facilities.
- Control of materials disposed in the Company's sewerage network.

Protection and optimal use of water resources

- Improvement and upgrade of the Company's water supply network to minimize leakage.
- Gradual water-meters replacement plan.
- Operation of a Central Water Resource Management System.
- Operation of a Geographical Network Information and Management System to ensure proper maintenance of the water supply network and prevent faults and leaks.

9.3. Interviews

Below there is a list of the different interview respondents in the two companies under study.

Table 13: List of Interviews conducted on July 2013

Rer. Num.	Name	Position	Organization
1	Dr. Dionysis Asimakopoulos	Ex-member of the Board of the Directors of EYDAP	National Technical University of Athens
2	Dr. Nikos Mamasis	Advisor of EYDAP for technical issues	National Technical University of Athens
3	Dr. Dimitris Koutsogiannis	Advisor of EYDAP for technical issues	National Technical University of Athens
4	Prof. Xristos Makropoulos	Advisor of EYDAP for water pricing	National Technical University of Athens
5	Mr. Ioannis Passios	Executive Director, Project Development and Production	EYDAP
6	Mr. Stefanos Georgiadis	Executive Director, Network Infrastructure and Operations	EYDAP
7	Dr. Efthimios Lytras	Research and Development Department	EYDAP
8	Mr. Ramon Ferrer Embodas	Head of Asset Management Department	Aigües de Barcelona
9	Mrs. Beatriz Beza Fredes	Health and Safety Department	Aigües de Barcelona

9.4. Questionnaire

What is the structure of the strategic decision-making process for asset management in Aigües de Barcelona and EYDAP?

<i>Structure of strategic decision-making</i>	<i>Questions</i>
<i>Company Objectives</i>	Who is considered to be the asset owner?
	What are the objectives of the company related to drinking water?
	How the shareholders, regulators or other parties influence these objectives?
	How the company takes into consideration the objectives of the shareholders?
	What mechanisms are placed in order to incorporate the shareholders objectives?
	Is there a method to weight the objectives?
	What are the struggles and constraints to implement strategies?
<i>Asset Management Policy</i>	What is the asset management process for Agbar and EYDAP?
	How much capital is assigned for innovation? How many PhD, R&D, etc.?
	Are innovation and technical conditions considered in the decision making process?
	How does Agbar set the criteria for the Risk Management Framework?
	How much the Risk Management Framework is controlled by the regulators, shareholders, etc.?
	How important is Financial and Safety aspects in the Asset Management Policy?
	How are the internal and external stakeholders opinions used in the evaluation process of the policy?
	How the company takes into consideration the objectives of the internal and the external stakeholders?
	Does Agbar/EYDAP distinguish between assets as systems and assets as objects?
	How the asset system is defined?
	Can I review business cases on new water resources; water reuse and desalinization plants?
	Is the decision-making process focused on solving current bottleneck issues?
	Does the decision-making process contemplate the next generation of infrastructure?
	What is the vision of the company?
	How is the vision of the company contemplated into today's decision-making process?
	What are the main factors considered when establishing criteria and priorities?
	Are the established criteria or priorities changed over time?

	If yes, how often these kinds of changes occur?
	How do they define the performance of the system?
	What are the key performance indicators taken into account?
	What kind of information is gathered for the performance indicators, related to asset management?
	What factors are considered in order to establish target values for the objectives?

What are the relevant elements of the Physical Characteristics that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

<i>Physical Elements</i>	<i>Questions</i>
	Is there guidance on the application of modeling tools (software or other) on providing decision-making support to end-users of model results and long-term strategies?
	Is there any kind of software used in order to identify possible failures of the system?
	For which phases of the water cycle is the company responsible?
<i>Physical Geology</i>	Is the water resources management scheme (groundwater vs. surface water) based on internal needs or is driven by the regulators?
<i>Hydrology System</i>	Is the hydrology system integrated in the development of long-term strategies?
<i>Water Availability</i>	How is the water availability considered as a factor in the decision-making process?
<i>Climate</i>	Is the effect of Climate Change considered in investment decisions?
	Is there a process/methodology to manage the uncertainties from Climate Change in the development of long-term strategies?
	Are there any other uncertainties beside the Climate Change used in the context of a model?
<i>Performance of the water system</i>	What is the likelihood of failure?
	Is there a leakage in the system? If yes, what are the actions to face the problem?
	Are there any preventive maintenance programs?
	How old is the distribution system?
	What is the decision-making process for maintenance?

What are the relevant elements of the Cultural Embeddedness that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

<i>Cultural Embeddedness Elements</i>	<i>Questions</i>
	Is there an interaction between the main regulators and the company? If yes, how can it be described?
	Are the regulators considered as part of the decision-making process for asset management?

	Are there specific guidelines for the decision-making process?
Managerial Background	What is the background (technical or managerial) of the people supporting the decision-making process?

What are the relevant elements of the Institutional Arrangements that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

<i>Institutional Arrangement Elements</i>	<i>Questions</i>
<i>Property Rights</i>	Are there concessions to extract water?
	Are the licenses temporary or permanent?
	What kind of licenses exists?
<i>Ownership</i>	Who is the owner of Agbar/EYDAP?
	What is the behavior of the owner?
	Want to earn money in a long-term with less risk or short-term with higher risk?
	Investment decisions are based on long-term vs. short-term?
	How long-term and short-term is defined respectively?
	Is there a relationship between efficiency and ownership?
<i>Regulations and Legislations</i>	What are the specific legislations that Agbar/EYDAP needs to consider for the asset management?
	How is considered the regulator?
	How expected changes on the legislation are considered in the long-term planning?
	Is there a general approach to incorporate these changes?

What are the relevant elements of the Governance Characteristics that are taken into consideration in the strategic decision-making process about asset management by Aigües de Barcelona and EYDAP?

<i>Governance Characteristics Elements</i>	<i>Questions</i>
<i>Price of Water</i>	How the water price is determined? Does Agbar/EYDAP have an influence in the price of water?
	How the price affects the decision for investments?
	How are the shareholders considered on the decision for the price?
	Is the price set the same for all the regions that the company is operating in? If not, what defines the difference in price?
	What's the role of the regulator considering to the set of the price?