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PROJECT DELIVERABLE REPORT

NAIADES

Greening the economy in line with the sustainable development goals

DELIVERABLE 2.2

WATER MANAGEMENT LANDSCAPE ANALYSIS

A holistic water ecosystem for digitisation of urban water sector

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Digital solutions for water: linking the physical and digital world for water solutions

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1. Contents

1 Summary

This report provides a holistic overview of the public and private actors involved in water management processes and highlights the role and use of "*smart water*" management in their general practices.

The report presents an exploration of the history and daily activities in two water utilities – *Aguas de Alicante*, in Alicante (Spain) and *Compania de Utilitati Publice Dunarea* SA, in Braila (Romania). Some information is also presented on the municipality of Carouge (Canton of Geneva, Switzerland) and on the ways in which it manages the watering of the city's public gardens. The reason why the city of Carouge deserves a different treatment, has to do with the fact that in this case it is not the utility that is presented as a pilot in the framework of the NAIADES project. The Carouge pilot focuses on possible smart technologies that will make the watering of city gardens more water and labor effective.

Since the three locations and study cases are diverse, the report first introduces the three municipalities and water supply contexts. It then focuses on each separate case study, documenting: 1) the urban socio-economic context; 2) the utility's institutional structures 3) the ways in which water is obtained, treated, and discharged; 3) routines and details regarding operation and maintenance; and 4) the ways in which water is supplied for domestic, administrative (and ornamental), industrial, and agricultural uses.

2 Introduction

This report presents an in-depth exploration of two water utilities – Aguas de Alicante, in Alicante (Spain) and Compania de Utilitati Publice Dunarea SA, in Braila (Romania). Some information is also presented on the municipality of Carouge (Canton of Geneva, Switzerland) and on the ways in which it obtains and manages the water for the irrigation of the city's public gardens. Since the three locations and study cases are diverse, the report first introduces the three municipalities and water supply contexts. It then focuses on each separate case study, documenting: 1) the urban socio-economic context; 2) the utility's institutional structures 3) the ways in which water is obtained, treated, and discharged; 3) routines and details regarding operation and maintenance; and 4) the ways in which water is supplied for domestic, industrial, administrative, agricultural and ornamental/leisure uses.

Alicante, Spain is the capital of the province of Alicante and a Mediterranean port. The population of the city of Alicante is around 332,067 inhabitants, however this value varies according to the season and can double during the summer. Population numbers increased from the 1960s and 1970s as the tourism sector grew, holiday houses and hotels were built, and water consumption rose (Instituto Nacional de Estadística, 2016) . The 2000s started with the so-called residence-construction boom which reached an end during the 2008 economic crisis. Presently, Alicante's unemployment rate is around 15% and its economy depends on services and public administration (Carrizosa, 2019). Water consumption in the city fell during the last decades due, not only to the property bubble burst and the economic crisis, but also as a consequence of the installation of new appliances and saving devices, the increase of environmental awareness, the price of water, and the use of reclaimed water for watering private outdoor and public areas (Morote, Hernández, & Rico, 2016).

The climatic characteristics make it one of the most arid places in Spain with episodes of droughts. The average rainfall in Alicante is 277 mm per year (Agencia Estatal de Meteorología, 2019). Although the area does not have major local water resources Alicante experiences irregular and torrential rains –two thirds of the annual rainfall can fall in one day. Historically Alicante relied on groundwater wells. Since the mid-20th century the city relies heavily on inter-basin water transfers. Moreover, in the 1990s and 2000s the construction of desalination plants allowed them to have an extra source of water (Morote et al., 2016). According to World Bank data, Aguas de Alicante became the "first international example of a successful water company of mixed (public and private) capital" in 1953 (Castro & Janssens, 2011).

Brăila, Romania is the capital of Brăila County a city in Muntenia, eastern Romania and a port on the Danube River. During the first part of the 20th century, the city had commercial activity and was also an important industrial centre, with metalworking, textile, food-processing, and other factories. However after 1989, the end of the communist leadership coincided with a process of de-industrialization in the region and as a result, the city's population moved to bigger cities to seek better job opportunities (Negru, 2018). Migration from Brăila to other countries increased after entering the European Union and population of the city went from 234,110 in 1992 to 180,302 according to the last 2011 census. Presently, the city's unemployment rate is around 9% and its economy depends mainly on services (National Institute of Statistics, 2016).

The region has a moderate continental climate with great variation between summer and winter are very significant and winters frequently bring strong snowstorms. The level of precipitations in one year is around 500 mm. Water consumption has fallen over the last 20 years due to population loss and to the departure of industrial consumers. Historically they have relied on water from the Danube River and also, but to a lesser extent from some available groundwater wells. Dunarea is a public corporation and has historically provided water and wastewater services to the city (Negru, 2018).

Carouge has a population of approximately 22,458 inhabitants. The city is part of the Geneva canton, which in itself is a financial center and hosts companies, financial institutions and industries. Carouge's population has grown significantly in the last decades and it went from 15,036 in the1990s to 22,458 in 2018. The unemployment rate is around 4.9% and as of 2008, 37.7% of the population are resident foreign nationals (Federal Statistical Office, 2019).

The climate of the city is moderately continental, with cold winters and warm summers. Precipitation amounts to about 1,000 mm per year, distributed over the seasons. Carouge receives its water supply (and also its public gardens' irrigation water) from the public multi-utility Services Industriels de Genève SIG. They, in turn draw the water from Lake Geneva (90%) and deep wells (10%) (Services Industriels de Genève, 2019).

3 Methodology

To write this report, two water utilities – *Aguas de Alicante*, in Alicante (Spain) and *Compania de Utilitati Publice Dunarea* SA, in Braila (Romania) were visited. During these visits, different staff members were interviewed, including technical and engineering executives/operators, as well as financial and customer service teams. The data obtained in these interviews was complemented with relevant literature in order to give context to the everyday operation of the utilities. In the case of Carouge, information was obtained through skype interviews with Laurent Horvath, the municipal manager for the Smart City initiative.

4 Urban water service: Alicante

4.1 Urban Socio Economic context

As was mentioned in the introduction Alicante experienced economic prosperity throughout the late 1990s and early 2000s, characterized among other things by a construction-boom. The economic crisis that affected Spain from 2008 was felt in the city through the decline in construction and an increase on unemployment. Currently, although the country has recovered, the city experiences high levels of inequality as high-end tourism coexists with still significant unemployment rates and with dynamics of migration across the Mediterranean. Thus, the city's GINI coefficient which quantifies income inequality levels (0 in case of perfect equity and 100 in case of perfect inequality) is 35,5 – five points above the national one.

> In the case of Alicante, housing ranged from old, deteriorated homes of unimaginable extremes, with minimal facilities, sometimes shared by immigrants or inhabitants with a reduced economic capacity, with very high levels of unemployment, in areas that have been significantly affected by the current economic crisis, through to splendid mansions in the areas where the higher-income population resides (Morote et al., 2016, p. 7)

In the city of Alicante since the year 2000, there has been a general decrease in water consumption. However, this decrease has been more significant in high/middle income detached houses and apartment blocks (located across the city's northern sector) than in low income households (located mostly in the urban core). This, according to the interviews and relevant literature, can be due to the acquisition of saving devices to use with taps, baths, and toilets and by using domestic appliances that are more water-efficient (March, Morote, Rico, & Saurí, 2017; Morote et al., 2016).

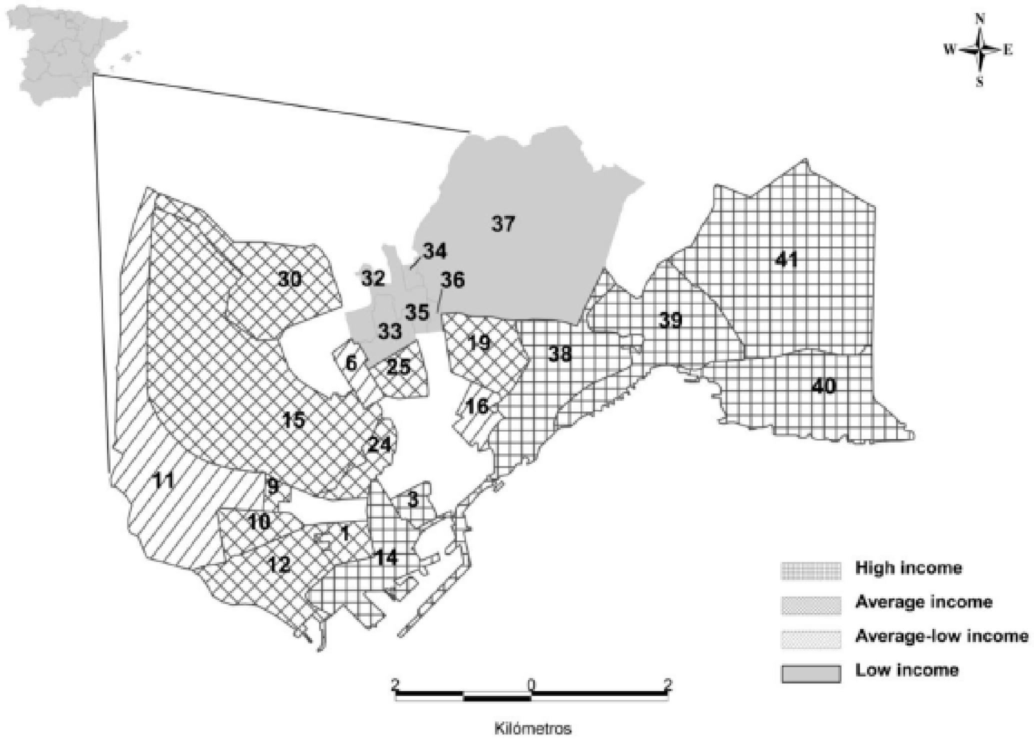

Figure 1. Alicante: different socio-economic sectors. Source: (Morote et al., 2016)

4.2 Utility's institutional structures

In September 30, 1952, the municipality agreed to create a commission for the study of the municipalisation of the water service. Subsequently, the Company "Aguas Municipalizadas de Alicante, Mixed Company" was established with 50% of the company owned by the municipality of Alicante and 50% by *Hidraqua, Gestión Integral de Aguas de Levante S. A.* (Suez). Aguas de Alicante provides water supply and distribution services in Alicante, but also in the municipalities of Sant Vicent del Raspeig, Sant Joan d'Alacant, El Campello, Monforte del Cid and Petrer. In these municipalities the utility has concession contracts, renewed until 2036, which has meant being able to work with long-term plans. They supply treated water, untreated water from wells, and reused water to different customers. They also manage the sewerage of the municipalities of Alicante, Sant Joan d'Alacant y Monforte del Cid.

There is a management board chaired by the mayor of Alicante and has equal representation from its private and public owners: "*The public partner works with a vision of public service, the private partner presses on the accomplishment of efficiency. In general, the municipality is really satisfied with the services. There has not been any complaints*".

4.3 Water Supply and Discharge

4.3.1 Sources

Traditionally, water scarcity has been a vitally important problem in Alicante, and negatively influenced the socio-economic development of the city for a long time: *"this is, mainly, due to weather conditions: in the area a semi-arid climate predominates, with low rainfall and high temperatures, in which there are no river networks, or large surface or underground water reserves"*.

The solution to this natural deficit involved the collection of water outside the region, through various projects which in turn entailed planning, development and exploitation, and a complex water infrastructure system. This system was characterized in the beginning by the search, capture and transport of water from springs, fountains and wells, as well as, subsequently, with surface waters from distant basins, such as those from the Taibilla River or the Tagus River.

This struggle to alleviate water scarcity and secure resources is a recurring and determining fact from the origins of the city, although the water scarcity problem really arose in Alicante from the industrial and demographic development of the 19th century. In this context, the municipality continued with the attempt to definitively solve the city's supply, which at the end of the century already had 30,000 inhabitants. Thus, in 1871, a new project emerged: the municipality adopted the first agreement to sign a contract with the society "Canal de Alicante", in order to supply the city from artesian wells located in the municipality of Sax, 48 km from Alicante.

Currently, what allows the company not to be startled by scarcity is the variety of sources: **1)** they continue to use the initial sources that they used 125 years ago that are aquifers: **underground deep wells** (300-400 meters deep) which currently provide between one third and half of the supply. They currently manage 20 underground deposits, extracting 16 cubic hectometres per year. Planning is done especially around the catchments of the wells, since they are so deep and therefore energetically very expensive: *"we try to fill the deposits at night because at night the electricity rate is lower. As far as possible, water is extracted only at night. This makes the process efficient"*. Also, the demand is predicted so that there are enough deposits in the city.

2) There is also a supply from the **Tagus-Segura Water Transfer**. The Tagus River is the longest in the Iberian Peninsula and the water transfer is made from the surroundings of Madrid, through several reservoirs and incorporates water from other rivers (such as the Taibilla River, the Segura River). This water ensures a third of the city's supply. And finally, **3)** a third source comes from **desalination plants**. These two sources (from the water transfer and the desalinisation plants) are received by the utility as a mixture: *"We do not buy separately desalinated water and the water from the transfer water because there is a public entity called Mancomunidad de los Canales del Taibilla MCT that manages these two mixed sources and sell the utility around 21 cubic hectometres of water per year"*.

Figure 2. Transvase Tajo Segura. Source: Alejandro Navarro López. creative commons

Therefore, Aguas de Alicante has its own managed source, which is groundwater and another source acquired from public sources. For the production of the wells: there are two counters one mechanical and one electromagnetic to measure the flow. They are trying to verify with external ultrasonic meters that both are calibrated and if there is one that is out of calibration, it is repaired or replaced.

These measurements are visible in the remote control room. In this area, the utility staff consider it would be desirable to have verifiers that realize that the meters are working well.

Much progress has been made in the re-use of urban water. For this, an investment of 9 million euros was made, most of which is already executed, in the "reused water master plan" to improve treatment and extend a new network: "what we call the double network that goes through the city and reaches all street irrigation points for trees and gardens and charging points for street cleaning". This double network already covers around 70% of the city. It also supplies customers with private gardens in the northern part of the city and they have an extension of the reused water network to also supply other private customers. All of the irrigation of golf courses is done with reused water. Re-used water consumption has been growing and has had an impact on the image of the city, since due to the scarcity of water resources this city had no green areas. This has already changed a lot, now there are more gardens. Green areas have tripled but at the same time less water is consumed in the city. The utility has also been using the reused water to cool a plant: the heat exchanger is cooled with reused water, instead of standard cooling towers.

4.3.2 Treatment

Aguas de Alicante does not manage any treatment plant as such. The water they buy has already passed through a treatment plant managed by MCT. MCT treats the water and supplies both the province of Alicante and Murcia. When it comes to water quality, utility members feel that the water with "worst quality" would be the one that comes through the transfer because of the amount of organic matter as it is surface water that covers a very large surface area. The desalinated water has a fairly high quality. However, they acknowledge that it is not so easy to discern the exact sources of water because they are sold already mixed.

Groundwater on the other hand has a high degree of hardness, but since it is water from very deep aquifers it has very good quality because it has no contact with any source of contamination, it is far enough from the sea so there are no problems with saline intrusion, it is an almost fossil water. This water only needs chlorination treatment as it enters the network, but this is done for conservation purposes rather than to solve any problem. Being hard it has a special flavour and for this reason there are perception problems when it comes to people drinking it. Dissemination exercises are being carried out with the community: panels, events with chefs, water tasting events in schools. Citizens have a tendency to buy bottled water or install water purification devices (household filters) due to a problem of appreciation: "*although there are no real quality problems there are problems with perception of taste. Alicante water has a particular flavour (due, among other things, to the hardness of deep well water) and this influences perception*".

The mixture between the three types of water is produced in the Alicante network.

The company has modelled the drainage network and has also modelled the marine network of coastal waters. These modelling exercises allow them to prevent saline intrusions when there is an episode of rains that finally produces a discharge into the sea of sanitation pumping. In these cases they create an immediate alert: because there are web camps at some key points, the alert is given and the behaviour is modelled. If necessary, citizens are informed and the beaches are closed.

There is a comprehensive water quality control system. For some years the company has had its own accredited laboratory and controlled its water quality. Thus they comply with all national and European quality standards and strictly comply with the national legislation. Aguas de Alicante performs more controls than the legislation mandates. The sampling is also accredited and in all points of the network there is also quality control.

There is a computerized management system in the laboratory. All technical managers have access to this system and when some quality parameter exceeds the value required by the legislation an alert automatically activates. The company publishes quarterly analyses of water quality, made from water in the network and in the deposits. The citizen can see the analysis of water quality made at the point where he/she resides. The citizen can also request the report of the water that comes out of its household tap. There is also a national coordination system for drinking water: this is an online platform to which the citizens can access and visualize the analyses made in the water.

There are quality meters in the deposits and at the exit of the deposits and in those strategic points of the network. Recently turbidity meters have been purchased. In Spain there is a sanitation decree that incorporates European parameters. Each company must have a self-control protocol. They do their analysis and any incident is communicated: "*Laboratory equipment is used every so often. There are also field values, in which turbidity, conductivity and residual chlorine are measured continuously. When there is affordable technology to measure organic carbon or to continuously measure trihalomethanes, we could establish it but for now this is done in the laboratory*".

PH and temperature are also measured in deposit tanks and in network. In the network water pressure is also measured. This is done with very robust equipment, which seldom breaks down. The pressure is monitored with a pressure sensor that is in the field and the main values come by remote control with which you have values at real time: "*What would make this work better would be a reliable, low maintenance chlorine sensor that is not affected by pressure changes and its adjustment easily verified. That is also easy to calibrate*".

A platform shared with the MCT has also been developed to unify the information of Alicante's water quality sensors with theirs and offer everything in a single platform that allows them to understand what is happening in the whole Tagus-Segura Water Transfer network: this way if there is an episode of turbidity in the water the system will allow the company to see how it extends and anticipate and make early decisions. The turbidity episodes are not frequent.

Something that would be good, if possible, is to acquire technology to monitor the water that arrives from the desalination plant, from the Tagus-Segura Water Transfer and from the wells allowing the company to measure / evaluate greater parameters (real-time microbiological parameters, for example). This would help the utility to have a greater ability to react, anticipate early warnings and perhaps close the deposit tank gates.

4.3.3 Distribution Network

The supplied population figures are difficult to estimate because the fixed population, that is, the registered population, is half a million but during the summer it is very difficult to have reliable figures and population can increase to 700,000 inhabitants. Aguas de Alicante has good network efficiency. Water loss is less than 10 percent, counting both physical and commercial losses. This, together with citizen awareness and the use of reclaimed water, has led to the persistent reduction of consumption of drinking water per capita in the city in the last 20 years. The total amount water supplied to the city has been reduced despite the fact that the city has grown.

They manage the sewerage of the municipalities of Alicante, San Juan and Monforte. In Alicante the network, of 200 kilometers of drainage and sewer pipe, with large drainage channels in Alicante. There were floods with fatalities in the past and large infrastructure was built to control them. They have a unitary network that of wastewater with rainwater. But there are some separate networks.

In order to avoid the contamination of seawater, they built a retention tank in the southern part of the city that keeps the water, which evidently, the sewage treatment plant would not be able to treat in case of torrential rain, to avoid an overflow and it would then reach the sea. As the episodes of rain in general are fast/short water it is sent progressively, from the retention tank, to the treatment plant so that everything is treated or reused or sent to the sea but already it has been treated.

There is another reservoir, exclusively for rainwater in the north, which is an area without slopes. There were many floods in the past because the area has no rapid exit path to the sea. Then they build a drain path that takes water to a park with a storage capacity of 40,000 cubic meters, which allows you them to send the water through a double outlet: either directly to the sea or pump it to the treatment plant to be treated. The exuberant vegetation of this park has brought many new species to inhabit it naturally, as many native bird species have arrived.

The utility wants to advance with sustainable urban drainage solutions to integrate urban drainage systems into the natural drainage systems or a site as efficiently and quickly as possible.

4.3.4 Operation and Maintenance

Aguas de Alicante has a control center. Remote reading tele meters are being installed for household consumption and also for the few industrial customers there are. They have full coverage of a radio system in the city with a low power system. They have a number of information and communication technologies to deal with is leaks, asset management, network renewal, and demand prediction.

The company is not in its 100% in what concerns tele-reading (around 90 percent of the users have these meters). This facilitates the control of each zone. The network is divided into *zonas* (zones). They study night-time *minimums*. Therefore, leak control is very thorough. The utility is able to stop instantaneous leaks of very small flows. This has to do with the fairly dense network of sensors installed throughout the network. To search for leaks a device is located on the sidewalks (in contact with a water rush) and these are left two or three days (to capture night-time values) and if they detect a permanent noise at night they mark it. The next day someone patrols around with a team and records the points where there is noise concentration. At that point another device is introduced that allows to locate the point where the noise is produced. This *detects the problematic water rush(s). Technological innovations could make this work more precise: "It would locate leaks exactly, because today, due to the amount of materials that are grouped on the network, the leak has ways to go unnoticed. One factor that must be taken into account is that there is currently a lot of night noise in the city, which makes the job more difficult. If we had a dense network of conductivity meters, perhaps this work would be easier to prioritize and make searches for leaks shorter".*

It is important to mention that leaks inside buildings or are very important and there is a great degree of difficulty in detecting them due to access to the apartments. There are micro meters per home, but there is no general meter for the whole building. Therefore, invisible leaks are very difficult to detect from the entrance of the building to the apartments because the company cannot enter the building to inspect. This becomes problematic when, for example, the building has internal gardens.

This is of importance since, as Morote and Hernández-Hernández (2018) explain, unauthorised consumption is recorded in all social classes and neighbourhoods, including those ones that are home to the better-off social classes. In the latter, residents commit unauthorised consumption to reduce the high levels of water consumption, aggravated by droughts and by increases in the price of water.

The city has a very large network density compared to other European cities. The average age of the distribution network is around 25 years old and the yields are a correlation between the ages of the network and the performance: "*A very old network that has many leaks will produce losses, no matter how much you dedicate yourself to finding them. This is a problem that is ignored because it is unpopular for a municipality to renew things that are invisible".* In addition to keeping the network relatively young, they have systems to decide on the renewal of the networks in the most intelligent way possible, deciding for the renewal of networks of both distribution networks and sanitation networks.

During the last 30 years they have only installed ductile iron networks. Before that, fiber cement was the preferred material. Plastic pipes are not installed except in domestic connections due to some past problems of oxidation of plastic pipes. The fiber cement pipes do not give them many problems because the water is very hard, not acidic, so there is no phenomenon of corrosion or attack on the cementitious part of the fiber cement. However, fiber cement pipes are being replaced because they have a certain fragility and it is no longer a material that is considered standard. The proportion is currently 1/3 of fibro-cement pipes and 2/3 of ductile iron.

One of the main tasks for the staff is maintenance planning. The network is divided into the elements that are considered susceptible to breakdown. They have maintenance of high-voltage overhead lines, high-voltage midlines, transformer centers, electrical panels, pumps, and tanks. Three types of maintenance are done in all the deposits: semi-annual maintenance (inspection of the surroundings), annual (it goes beyond checking the valves and what looks defective is repaired), and the biennial which implies the cleaning/ emptying of the deposit. The so-called "DDD" is also carried out in the tanks: disinfection, dis-insection, de-ratization.

In addition to this, a preventive protocol is carried out in the zones in order to reduce costs by assigning priorities: this seeks to prioritize maintenance in places where predictably leaks may appear: this system takes into account the age of the network, the material of the network (according to the percentage that it has of one or another material it is prioritized), the number of leaks that each zone has (the active leaks are valued since the repaired points are always problematic points). Special attention is also given to network connections, which are problematic points due to the coexistence of multiple materials.

As for flood prediction, they have their own system for predicting rainfall events. Flood risk predictions' information is provided to the police and the municipality. Information is also provided to citizens in real time about infrastructure works and their durations.

There is a line of innovation projects on issues of occupational risk prediction. With regard to the equipment for measuring water flow, pressure and quality, preventive and corrective maintenance is carried out. The company makes a measurement of network performance: there are inputs and outputs, and a comparison is made. For this, they work with an annual value, with the water billed/read annually to the subscribers and the water introduced annually to the network and that ratio is the best approximation. Sometimes there is water that is lost and this may be due to meter malfunction or leakage, misuse and fraud. In the networks the yields are of the order of 96, 97 percent and in the city of 87 percent. Meters are read and billed every three months.

4.4 Water Uses

4.4.1 Domestic

Domestic users are the biggest consumers in Alicante. There is a constant growth in the number of homes and despite this the total amount of drinking water consumed / supplied has been reduced. Citizen's new practices, technology/appliances are much more efficient.

There are many ways in which people have driven efficiency. Even as it is a tourist area, there is an efficient use of water for example in the pools: since those pools are never completely emptied. Water is reused, evaporation may be compensated, but those pools are not completely filled.

Consumption is recorded with hourly frequency. It is stored in the meter itself and sent approximately once a day. The data is thus produced hourly and sent to the central system is daily. There are macro meters by sector and also throughout the city. Within the framework of the TAYAD research project, the utility collaborated with a Swiss start-up that developed a system to monitor consumption in domestic showers in real time. A pilot associated with a mobile application was made to see the impact that long showers had on users.

Aguas de Alicante uses a system of Block tariffs or volumetric charges. Under this block tariff scheme, users pay different amounts for different consumption levels. Block tariffs have a step-wise structure. The water charge is set per unit (e.g. cubic meters) of water consumed and remains constant for a certain quantity of consumption (first block). As the water use increases, the tariff shifts to the next block of consumption and so on for each block of consumption until the highest one.

Besides block tariff there is also a Social Fund. In 2018, the Social Fund approved by the Board of Directors was € 513,000. This fund aimed at alleviating the serious economic situation of people and / or family units especially affected by the economic crisis, which in 2018 has been 1,642 families. These are social rates for disadvantaged families. They contribute the fund with their profits but an external entity, *Caritas Internationalis*, is the one that decides on the beneficiaries of this social fund.

There is also an official (municipality) fund for large families, which in the case of Spain are those with more than five members. This fund it is progressive, the greater the number of family members the bigger the reduction is. Where consumption has decreased the most is within the middle classes. In the lower classes it has not decreased so much: *"What sometimes happens is that, paradoxically, a family of high resources will renew their washer machine and dishwasher every 5 years and today's washing machines or dishwashers have an incomparably low consumption compared to those of 20 years ago"*.

Extensive social training is done especially in schools on efficiency measures. There is a water museum. Children and adults can also visit the remote control center.

4.4.2 Administrative and decorative

The consumption of water in public/administrative (*Ayuntamiento)* buildings rises substantively during the summer months. When it comes to the water used by the city in street and building cleaning and watering of city parks and plants, the staff explained: *"there is enough reclaimed water to cover the urban area: that is, reused non-potable water that is used for urban public gardens and for fountains. Also for all activities of street cleaning"*. The city pays for all decorative uses of water: these clients pay always on time.

Likewise, hotels and resorts use re-used water for irrigation of golf courses.

4.4.3 Industrial

Alicante is not an industrial city. It is a city mostly of services.

The sewage sludge reuse project was developed for this sector. A thermal sludge drying system was installed in the CEMEX cement plant using the residual heat generated by the cement plant. When the sludge is already completely dry using the residual heat it becomes fuel for the cement plant, which closes the circle.

For industrial users the meters have a mobile telephone system, which allows taking a measurement every 15 minutes. The hotels, because they are large consumers, have been given priority when installing the tele reading meters because they allow greater control and allow to locate internal leaks. Depending on the level of consumption hotels can be in hourly control or in more permanent control, every 15 minutes.

4.4.4 Agricultural

Aguas de Alicante manages two treatment plants with water-reuse percentages that have not reached 50 percent in their use. Alicante is not an area with a lot of agriculture, therefore the most classic application of reclaimed water, which is agriculture, is significant but not enough. There is also a salinity problem especially in the southern zone due to several causes, especially due to saline water infiltrations.

In the area where we have better potential for agricultural use, which is in the southern zone, they have a problem because they cannot treat all the water. They have an osmosis plant that consumes an important amount of energy. In addition, that osmosis plant cannot treat the entire water inflow. If they have a real capacity right now of around 45 thousand cubic meters a day of discharged water, the osmosis plant can treat approximately half of that amount. Then they can mix to reach degrees of acceptable salinity. But they have a problem there:

“This is why one of the things we are considering is to attack that problem in the networks where infiltrations occur and identify them, monitor them and ultimately of course eliminate them. But first you have to know the problem, identify it and locate it in order to solve it”.

Farmers in the area are also using sewage sludge. However, in recent years this use is becoming saturated because they have more sludge than necessary.

5 Urban water service: Brăila

5.1 Urban Socio Economic Context

There is a Romanian popular saying: "nothing takes longer than a blind man's journey to the city of Brăila". This popular saying summarizes, in a way, the situation of Brăila, as a municipality isolated from the capital of the country and from the largest production centres due, among other things, to the absence of fast roads and nearby airports. Paradoxically, the city is at the same time situated on the banks of the Danube River and during the past it served as an important port and a node for the shipping industry.

After Romania's 1989 revolution, communist regimes felt and industries were privatized. In this vein, the deindustrialisation of Eastern European countries took place much more abruptly than in Western countries and it stretched over a longer period (Bănică, Istrate, & Muntele, 2017). The reduction in production capacities led to the dismissal of a significant part of the labour force in the late 1990s and as a consequence, municipalities like Brăila showed low levels of development in the public infrastructure, environmental pollution, and low attractiveness for investment (National Institute of Statistics, 2016). In this context the overall population of the city has lost about 20.000 inhabitants in the last 20 years and the age distribution pyramid is showing also a trend of aging in the remaining citizens.

5.2 Utility's Institutional Structures

SC Compania de Utilitati Publice Dunarea SA Brăila is the regional water and wastewater operator for the County of Brăila, located in south-eastern Romania, and is responsible for the management of water resources including the distribution and treatment of water and wastewater services. This company is public, owned by the municipality of Brăila and has been providing water and wastewater services to the City of Brăila for 130 years. After the utility started receiving European funds it became a public corporation through Ordinance 109 regarding corporate governance: it works as a private entity but the majority of its shares (83 percent) are owned by the city. Other shares are owned by the county. All members of the administration board are elected by public contest with representation from the city and the regional bodies.

From 2009 the activity covers almost the entire county except for two localities that do not have infrastructure yet. They serve 22 territorial entities. They serve 300.000 inhabitants in the county. That is, three other localities (Ianca, Faurei and Insuratei) and 41 smaller rural communities in the county.

During the last decades it has received funds from the European Union, such as the Investment Programme which aimed to extend and rehabilitate the water and wastewater infrastructure in 45 administrative territorial units representing nearly two-thirds of the population of Brăila County: *"As a result of the project more than 300,000 inhabitants in the area will gain access to safe water supplies and to sanitation services".* Since 2017 their standards for water quality, water connections and sewerage treatment in the city of Brăila are in line with European requirements.

5.3 Water Supply and Discharge

5.3.1 Sources

The source of water is the Danube River. Dunarea also extracts water from six deep-wells. On average they extract from the Danube 1,666 m3 of water per hour. They measure this inflow with SONOFLO ultrasonic flowmeters.

There is variation a 40 percent variation between the winter and summer. This value is given also taking into account the rural villages served by the utility. The villages have variation up to 300 percent. They report the overall water network inflow through a SCADA transmission schedule

If the flow is low they do not have any difficulties and are available of meeting all national performance indicators. With high water demand they sometimes can offer the right pressure in the pumps. This is for the regional area supply. The station that supplies the rural towns was financed by European funds in 2007-2013 and it designed for an average annual consumptions. However the capacity of the infrastructure is not meeting its actual demand.

In the specific city of Brăila they do not encounter major problems in what concerns the production of water. They have more problems in what concerns the networks.

Figure 3. Danube River catchment. Danube Research. Creative commons.

5.3.2 Treatment

They have two drinking-water plants. To produce potable water they do four procedures: predesinfection, settling, filtration through quartz sand and disinfection. Water from the wells water is treated with disinfection for iron and manganese removal. They monitor water treatment processes with semi-automated monitoring and qualified personnel. They have a regional SCADA system and an individual local SCADA system supervised by the operators locally.

To make sure the water leaving the treatment facility complies with national and international water quality guidelines and standards, they do daily and hourly monitoring of chemical and biological parameters. They have their own laboratory accredited by the Romanian water regulator.

They face difficulties in the treatment process in what has to do with aluminum values, since sometimes these values have been above the standard. For this they changed the flocculating agents. They also try to avoid the entry of residual water (from filters) into the plants. They are not recovering this filter water (that is, water to operate and residual from the whole process) as it exceeds aluminum values, but dispose it with waste-water: *"We don't know if there are other technical solutions for this problem, but we have solved it for now"*.

Population in Brăila drink faucet water. However bottled water consumption is also related to status and the consumption of bottled water is seen as a symbol of economic prosperity.

They have 3 waste-water treatment plants: one in Brăila and the others in nearby towns.

5.3.3 Distribution Network

There are two pumping stations and they measure their flows. They measure their overall operational efficiency by performing monthly water balance for each locality. They have a Water Loss Strategy with the purpose of decreasing losses to 700 littles per hour per kilometer. The average of losses today amounts to 750 per hour per kilometer. They aim to reduce 50 l/h/k of water losses per year. In 2018 they had 41percent of losses/non-revenue water. They have a street network with low pressure and the network for the apartment blocks is served by station that increases the level of pressure. 60 percent of the water is supplied to apartment blocks: 4/10-story buildings.

To monitor warnings/events on faults (leakages, bursts) and unusual water consumption they do a thorough network inspection and rely on the damages reported by dispatchers. They have historical values of consumption per sector and they monitor if this value goes above average (above a threshold calculated on the basis of historical data) and then detect a possible leakage. They are monitoring the nightly consumption from midnight to 6 a.m. The water that is consumed on that time is classified as technical losses. They are currently monitoring pressure in 40 points of the city. They use the SCADA sensors in these points. In the future they would like to organize all city neighborhoods into *sectors* (street metered areas) that can be supervised. Today the sectors in the city centered are well monitored: they have micro-meters and they compare this consumption with internal consumption. They want to expand this system to monitor other parts of Brăila. They want to expand the technology that they have already.

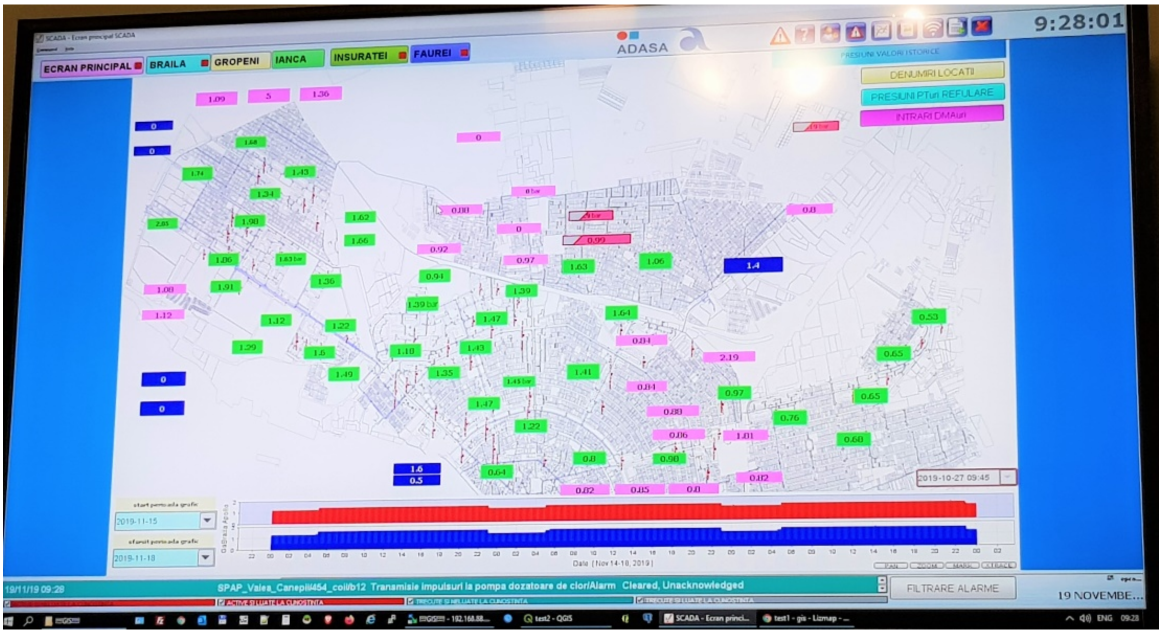

Figure 4. City of Brăila : Pink (metered/delimitated sectors), Blue (main pumping points of water into Brăila), green (pressure stations inside sectors and all over Brăila). Source: Dunarea 2019.

They are already working in 10 other areas that they would like to transform into sectors and are currently seeking for founding. In the context of the NAIADES project, they would like to monitor flow as well as pressure in the sector of Radu Negro. They prioritized this area because it is residential and has many building blocks, schools, and government institutions.

Figure 5. Radu Negro area, Brăila. Source: Google Maps.

Networks have old materials (steel, cast iron, cement, HDPE) that need to be rehabilitated and changed. The major problems in the network are related to the smaller valves operation: therefore they have to close large areas in order to be able to intervene and repair by changing pumps and the valves. There is now a project with European funds, to replace the network. This project runs from 2014 to 2020.

They a project funded by the European Union that entails a strategy to develop the water and waste water network at the regional level in 33 localities. This project will ensure the compliance of the European water directive. They have also a strategy to operate with their own funds once the European funding ceases. They have a prioritization of the important of assets and the risks involved, the quality of service, like this they determine the optimal placement of valves, water quality, and flow meters on pipes in the network. If an asset's repair is more expensive than the asset, they will replace it.

5.4 Water Uses

The average total of monthly water consumption is around 1 million cubic meters of water, including all categories of consumers, which are: state/public clients (*budgetary*); private companies *(Ag. Economici)*; homeowners associations formed by the inhabitants of groups of buildings (*Asoc. De Propr.)* and individual households (*Casnici)*. Water consumption has decreased in all this groups. In 2010 a total of 110.000 cubic meters was supplied in 2018 they provided 45.000 cubic meters.

Situatia comparativa privind productia raportata in anii 2017, 2018 si 2019

MC APA FACTURATI

	Ian. 2017	Febr. 2017	Mart.2017	Apr.2017	Mai 2017	Iunie 2017	Iulie 2017	Aug.2017	Sept.2017	Total 2017
BUGETARI	51,589.00	51,945.00	54,285.00	57,302.50	69,909.60	83,908.00	88,487.20	108,428.80	108,658.30	674,513.40
AG. ECONOMICI	48,771.00	56,567.00	62,928.00	78,408.54	86,047.90	131,798.00	98,741.90	98,632.70	94,445.10	758,340.14
ASOC. DE PROPR.	374,260.00	341,400.00	343,549.00	359,822.00	360,965.00	355,890.00	354,309.00	375,862.41	362,943.00	3,229,000.41
CASNICI	197,239.10	222,950.58	269,408.38	309,635.42	305,135.10	452,354.86	392,917.68	386,216.85	423,956.40	2,959,814.37
TOTAL	671,859.10	672,862.58	730,170.38	805,168.46	822,057.60	1,023,950.86	934,455.78	969,140.76	990,002.80	7,619,668.32
	Ian. 2018	Febr. 2018	Mart.2018	Apr.2018	Mai 2018	Iunie 2018	Iulie 2018	Aug.2018	Sept.2018	Total 2018
BUGETARI	56,166.54	48,513.14	43,997.59	49,942.77	74,884.79	101,713.60	68,523.70	102,490.00	100,088.10	646,320.23
AG. ECONOMICI	91,427.00	90,556.60	97,089.80	105,784.50	127,903.20	122,501.66	112,909.71	130,127.00	126,135.10	1,004,434.57
ASOC. DE PROPR.	380,722.00	331,692.00	342,624.97	333,055.00	380,634.00	358,390.00	342,908.00	381,603.00	352,000.00	3,203,628.97
CASNICI	286,998.07	268,850.02	266,521.30	343,497.76	425,010.48	511,465.63	418,945.77	454,450.63	437,814.06	3,413,553.71
TOTAL	815,313.61	739,611.76	750,233.66	832,280.02	1,008,432.47	1,094,070.89	943,287.18	1,068,670.63	1,016,037.26	8,267,937.48
	Ian. 2019	Febr.2019	Mart.2019	Apr.2019	Mai 2019	Iunie 2019	Iulie 2019	Aug.2019	Sept.2019	Total 2019
BUGETARI	57,843.15	49,052.00	53,541.20	64,492.93	61,204.00	71,225.00	55,927.30	93,969.30	112,194.10	619,448.98
AG. ECONOMICI	100,394.57	104,002.03	108,372.60	115,533.00	113,366.35	116,849.30	134,180.50	124,661.14	131,190.40	1,048,549.89
ASOC. DE PROPR.	405,412.00	330,698.00	334,187.00	325,124.31	392,106.00	345,802.00	362,425.00	349,474.72	355,357.72	3,200,586.75
CASNICI	255,623.47	305,784.26	298,392.09	360,286.00	386,844.65	404,970.37	436,901.14	520,339.59	504,325.66	3,475,467.23
TOTAL	819,273.19	789,536.29	794,492.89	865,436.24	953,521.00	938,846.67	991,433.94	1,088,444.75	1,103,067.88	8,344,052.85

Figure 6. Billed cubic meters of water 2017-2019.

They make sure their bills are accurate and flexible (adaptive) to the type of use by making radio-readings with their block meters. To modernise the current water infrastructure, the utility has also decided to install Itron's Flodis/Flostar M meter equipped with smart radio modules, to replace the utility's lower precision meters. With the support of local Itron partner Vestra (Elsaco Group), these meters will be deployed for residential, commercial and industrial customers. Mobile data collection allows the utility to reduce meter reading time and cost, and avoid manual reading mistakes. Smart meters store and transmit enhanced, advanced data.

According to Dunarea, In Brăila 80 percent of the consumers already have smart meters. Next year they will have a full coverage of smart meters to record real time consumption. They are also going to implement metering with daily sending the data so they can see leakages on daily basis. They have special meters for big consumers to monitor all atypical consumption.

There is a department that records complaints and communicates with the technical or commercial staff members.

5.4.1 Domestic

Domestic consumption is divided two groups: homeowners associations formed by the inhabitants of groups of buildings and individual households.

The data for total water consumption is obtained after the reading of the classical and distance reading meters (ITRON) by our field operators. Field operators are employees of the utility. Costs are recorded by cost elements, by their nature. The cost of the water and the sewerage services is not calculated differentiated by categories of users, there is a unitary tariff based on full-cost recovery (household, associations, economic agents, public institutions). There are not any subsidies for low-income residents. There is not a block tariff structure: *"This tariff strategy was imposed by the European Union and we have to maintain these full-cost recovery structures."*

Direct and indirect expenses are collected on consumption places (localities, operational centers) on the basis of internal management accounting. The distribution of indirect costs is achieved by using algorithms depending on the nature of the expenses.

In comparison with historical consumption levels in the 1970s and 1980s, current consumption has decreased. This has to do not only with the fact that the city has lost population, but also with the tariff increases (full-cost recovery and better and smart metering), and with the deindustrialization of Brăila, as industrial clients left. Before the 1989 revolution, domestic water was not metered and they started implementing full-cost recovery once they started doing projects with European funds. Utility staff also mentions that the decrease of water consumption also has to do with the aging of the population, as they have noticed that sectors of the city with older population tend to consume less water.

The change of the price is brought to the notice of users with a minimum of 15 days before billing. The explanations and legal base can be found by the users on the website and on the invoice. The operator practices the approved price according to the legal provisions in force: *"- art.35 par. 4,5,6,7,8 and art. 36 para. 1,2 of Law no. 241/2006 on the water supply and sewerage service, republished, with the subsequent modifications and completions; - Contract for the delegation of the management of public water and sewerage services; - according to article 8.1 of the contract for the supply of drinking water and article 9.1 of the Contract for the provision of the public sewerage service, the modification of the price shall be notified to the user at least 15 days before the start of the billing period at the new price, through the media or display to users".*

Full cost-recovery is achieved with most efficiency with homeowners associations (groups of buildings): 60 percent of Dunarea's of their treated water is delivered to these associations. In this vein, the least efficient sector is definitely the surrounding rural towns, as the maintenance costs (investments) are higher than those in Brăila. Inside the city there are also areas where the utility records great technical losses. One of this is Lago Duce, an area that has recently been converted into a sector and metered. The population in these area is low-income and experiences high levels of unemployment. To communicate with households that are on arrears they first send a notification and the household can pay or make a payment plan. It there is no payment they disconnect them from the service (and they have to pay a disconnection fee). If the household does not pay after the disconnection, the utility sues them for nonpayment.

There is a high level of debt among domestic clients in general. Currently (November 2019) 836 clients have been notified of imminent disconnection.

They can forecast the next water bill by a mathematical calculation based on an average of consumption.

5.4.2 Administrative and decorative

Municipal (state) buildings consumption is 100.000 m3 in average per month. In the summers these clients consume more. Specifically, consumption rises by 30 percent. They have an irrigation system for parks inside Brăila. This consumption is 30.000 m3 per month on average during the summer months. In the past, gardens and streets used untreated water from the Danube. Since they have started providing treated water for these uses recently, they cannot make historical comparisons. The city pays for all decorative uses of water: these clients pay always on time.

5.4.3 Industrial

Industrial water consumption decreased greatly as the five major industries in the area closed in the last decades: paper, naval, and iron industries. The existing industry consumes an average of 120.000 m3 per month.

The biggest consumer in the city today is the supermarket Carrefour. Therefore today services are more important than industry. Full cost-recovery is achieved with most efficiency in the services sector. However, there are some industries that have accumulated debts.

5.4.4 Agricultural

There is another company that provides water for agricultural users. However in towns from rural areas some users use Dunarea’s water to irrigate small plots of crops and vegetable gardens.

6 Forty Urban Gardens: the Watering of Public Gardens in Carouge

As was mentioned, Carouge is a growing city. Historically industrial, the city has now become also service oriented as multiple fashion boutiques and gadget shops have opened. It receives an important number of tourists during the summer: "The city is growing, we went from 20.000 inhabitants to 30.000, and there are now lots of new apartment buildings".

In order to support a strong citizen demand, the municipality, in partnership with the group of environmental activists created 180 garden boxes at different points in the city. The city invites residents to plant and use the gardens: "*It they want to contribute to improving their environment by bringing nature to the city, to cultivate, share and eat seasonal fruits and vegetables, to exchange knowledge on organic gardening, food and biodiversity, and meet their neighbors*". This project responds to a growing demand from residents to "*have more nature and biodiversity in the city and supports the development of ecological gardening practices accessible to all. Places of meetings and exchanges, these bins also participate in strengthening links between inhabitants*".

Figure 7. Public gardens: plant and vegetable boxes, Carouge. Source: Municipality of Carouge.

Everyone can grow and harvest freely and without registration the plants and vegetables of their choice, in an ecological way. All expenses for the boxes are taken from taxes. The City of Carouge provides the water in trucks with cisterns. Workers from the city go to each of the 180 vegetables/flowers, boxes: *"They have to water them manually, they do not have pipes or automatically systems because these are artificial boxes".*

The water comes from the multi-utility company SIG. It is treated water and charged by the number of thousand litters. They pay for supply and also treatment. These activities are supervised by the One *Departement de la Voirie* (department of roads). This department is in charge of cleaning the streets, removing solid water and watering all public gardens and boxes between 1 or 2 times per week. If it is extremely warm, they have to water them more. The activity is not only time consuming for the city workers but also water inefficient: "First of all we are wasting water and during the summer they are using more and more underground water therefore they have less and less rain. It is not sustainable. The city is growing very fast and we don't have the budget to hire more people, so the load of work for city employees is bigger and bigger".

However, the municipality is proud of the garden boxes program and wants to continue expanding it since it is highly regarded by the population. For this it will be useful to count on technological solutions that can help same money and time.

7 Role and use of "*smart water*" management in general practices of utilities

7.1 Alicante

- There are two counters one mechanical and one electromagnetic to measure the flow for the production of Alicante's groundwater wells. The utility is trying to verify with external ultrasonic meters that both are calibrated and if there is one that is out of calibration, it is repaired or replaced. These measurements are visible in the remote control room. In this area, the utility staff consider it would be desirable to have verifiers that realize that the meters are working well.
- The utility has modelled the drainage network and has also modelled the marine network of coastal waters. These modelling exercises allow them to prevent saline intrusions when there is an episode of rains that finally produces a discharge into the sea of sanitation pumping. In these cases they create an immediate alert: because there are web camps at some key points, the alert is given and the behaviour is modelled. If necessary, citizens are informed and the surrounding beaches are closed.
- There is a computerized management system in the laboratory. All technical managers have access to this system and when some quality parameter exceeds the value required by the legislation an alert automatically activates. The company publishes quarterly analyses of water quality, made from water in the network and in the deposits. The citizen can see the analysis of water quality made at the point where he/she resides. The citizen can also request the report of the water that comes out of its household tap.
- Aguas de Alicante has a control center. Remote reading tele meters are being installed for household consumption and also for the few industrial customers there are. They have full coverage of a radio system in the city with a low power system. They have a number of information and communication technologies to deal with is leaks, asset management, network renewal, and demand prediction.
- The company is not in its 100% in what concerns tele-reading (around 90 percent of the users have these meters). This facilitates the control of each zone. The network is divided into *zonas* (zones). They study night-time *minimums*. Therefore, leak control is very thorough. The utility is able to stop

instantaneous leaks of very small flows. This has to do with the fairly dense network of sensors installed throughout the network. In addition to keeping the network relatively young, they have systems to decide on the renewal of the networks in the most intelligent way possible, deciding for the renewal of networks of both distribution networks and sanitation networks.

- As for flood prediction, Aguas de Alicante has its own system for predicting rainfall events. Flood risk predictions' information is provided to the police and the municipality. Information is also provided to citizens in real time about infrastructure works and their durations.
- Consumption is recorded with hourly frequency. It is stored in the meter itself and sent approximately once a day. The data is thus produced hourly and sent to the central system is daily. There are macro meters by sector and also throughout the city. Within the framework of the TAYAD research project, the utility collaborated with a Swiss start-up that developed a system to monitor consumption in domestic showers in real time. A pilot associated with a mobile application was made to see the impact that long showers had on users.

7.2 Brăila

- On average Dunarea extracts from the Danube 1,666 m3 of water per hour. Utility staff measure this inflow with SONOFLO ultrasonic flowmeters. They report the overall water network inflow through a SCADA transmission schedule.
- Utility staff are currently monitoring pressure in 40 points of the city. They use the SCADA sensors in these points. In the future they would like to organize all city neighborhoods into *sectors* (street metered areas) that can be supervised. Today the sectors in the city centered are well monitored: they have micro-meters and they compare this consumption with internal consumption. They want to expand this system to monitor other parts of Brăila. They want to expand the technology that they have already.
- To modernise the current water infrastructure, the utility has also decided to install Itron's Flodis/Flostar M meter equipped with smart radio modules, to replace the utility's lower precision meters. With the support of local Itron partner Vestra (Elsaco Group), these meters will be deployed for residential, commercial and industrial customers. Mobile data collection allows the utility to reduce meter reading time and cost, and avoid manual reading mistakes. Smart meters store and transmit enhanced, advanced data.
- According to Dunarea, In Brăila 80 percent of the consumers already have smart meters. Next year they will have a full coverage of smart meters to record real time consumption. They are also going to implement metering with daily sending the data so they can see leakages on daily basis. They have special meters for big consumers to monitor all atypical consumption.

8 Conclusions

All three locations, Alicante, Brăila, and Carouge share the hope for more efficient and smart technologies. However all three cities are situated in very different contexts. Carouge is a growing city in need of smart technologies to manage its decorative irrigation. The city's main concern is to continue with the "vegetable boxes" program, as it fosters trust and integration among residents. However, the city wants to do this while keeping with sustainability. In the case of Alicante, which already uses many existent smart technologies, one of the biggest challenges comes not only from water scarcity but also from inequality. Despite the existence of block tariffs and of some social funds (collected from the profit made by the utility) to alleviate debt and the weight of tariff payment among low-income households, smart technologies should not broaden the inequalities:

> "Affordability of water (and also of energy) will likely be a major challenge for cities in the developed world and may involve growing social and economic inequities. Thus it is urgent that moves towards sustainable uses of water in cities fully incorporate notions of water justice, so that the conservation burden does not fall disproportionally on the more vulnerable" (Saurí, 2019, p. 13).

In Brăila, access to smart technologies in the last decade has allowed the utility to access situated detailed information on water use at the household scale, identifying patterns of consumption, reducing losses and improving efficiency of the water network. The challenge then has to do with the shrinking of the city's population due to accelerated deindustrialization. Another challenge might come from the fact that a number of the population is unemployed. Middle and low income households affected by unemployment may accumulate debt.

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