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# Adaptation Strategies of the Hydrosocial Cycles in the Mediterranean Region

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**Abstract:** The Spanish Mediterranean region has been affected by several factors over the years (climatic conditions of aridity, high water demands, rapid and intense urban and population growth, climate change), that have generated a negative water balance whereby water resources are unable to meet the demand. Diversifying supply sources by resorting to new resources has been a necessity that has stimulated the expansion and integration of non-conventional water sources (desalination and reuse of reclaimed water) and sustainable solutions. The aim of this paper is to evaluate the adaptation strategies that have been developed in Alicante, Benidorm and Torrevieja in order to adjust their hydrosocial cycles to development and future scenarios. The theoretical analysis developed in this paper is corroborated by the study of the hydrosocial cycle evolution of three cities in the southeast of Spain, and the adaptive measures that the different stakeholders involved in the cycle have developed in each of them. The input and output of the systems are accounted for with information provided by the management companies in each of the phases (urban consumption; treated, reused and desalinated volumes), which highlight how the diversification of resources and the incorporation of non-conventional resources have been essential for adaptation.

**Keywords:** water deficit; hydrosocial cycles; adaptation; diversification; non-conventional resources; Mediterranean regions

## 1. Introduction

Despite the fact that water was conceived as being an unlimited, resurgent resource throughout history, since the middle of the 20th century it has been considered as a natural, economic and social asset of limited and limiting value [1,2]. Specifically, in the Mediterranean region of Spain, water has become remarkably important for the socio-economic development of the area, mainly for the tourism and agricultural sectors [3]. This scarce asset acquires greater importance in areas whose water contributions fail to meet the demands (urban and agricultural)—a situation that occurs in several countries. The combination of the growth of population along with the associated water demand, climate change, an increase in demand as a result of changes in economic activities (the intensification of agricultural practices and the diffusion of tourist uses and urban areas) has aggravated the decrease of resources in several places, leading to the need to diversify water sources. This situation occurs even though recent data on water consumption, at least in the developed world, indicates the end of the rising trend in water consumption [4].

Many examples of diversification can be observed in areas of the world marked by water scarcity. Israel, for example, combines inter-basin transfers, recycling, diversification of fresh water away from agriculture [5], and mainly desalination [6]. Australia is another country characterized by diversification of water sources in order to achieve self-sufficiency [7], as well as California [8]. Specific cases include Orange County (CA, USA) where recharge aquifers with reclaimed water are used, Singapore and

Southeast Queensland (Australia) where rainwater is collected [9], and the city of Tucson (AZ, USA) where groundwater, surface water, reclaimed water and grey water are combined [10,11].

Water scarcity is clearly manifested in the Spanish Mediterranean coast, the Balearic Islands and the Canary Islands, and various measures have been carried out in order to mitigate it [1]. Given the physical-ecological characteristics of Spain, over the centuries a large amount of infrastructure has been built to try and store water. An example is the large number of dams and reservoirs, about 1200, which are distributed throughout Spain [12], with a storage capacity of about 56,000 $hm^3$ [13]. Among other functions, these structures have helped regulate and supply water to the cities. However, in some regions the creation of reservoirs has not been enough, because their rivers do not have the necessary flows to cover the demand of the area. Channels between ceding basins and deficit basins have been built, for example, the Tajo-Segura transfer. This channel connects the Tajo basin, located in the centre of the peninsula, with the Segura basin, in the southeast of Spain [14]. Due to this transfer, the regions that make up the Segura basin, an area characterized by its structural water shortage and reduced rainfall, have been able to supply water for urban demand and agricultural demand (which require around 80% of the total demand of the basin). These water regulation and transport systems have been the basis of the Spanish model for decades. However, in some regions, such as those located on the Mediterranean coast, in the late 1990s the combination and mixing of surface water (own and external) and groundwater was not enough to satisfy the continuous increase in demand. It then became necessary to search for new supply sources to complement conventional resources [15]. This action is included in the so-called hydraulic paradigm, where demand is satisfied by increasing the supply [16]. The solution for increasing water volumes has been the incorporation of non-conventional resources, desalination and the reuse of reclaimed water. Highest quality water (desalted water) can be set aside for human consumption, and lower quality water (reclaimed water) can be used for other activities that are less demanding, such as agriculture [17]. Given the progress made in water treatment, water can now be created depending on quality needs, with water management policies that are based on the concept of “fit for purpose” [18].

A good example of this is the province of Alicante, located in the southeast of the Iberian Peninsula, which is characterized by less than 300 mm of rainfall a year, despite having high agricultural and urban-tourism water demands [17]. These factors have generated a water deficit that, by the year 2016, was around 200 $hm^3$ [19]. This water shortage is expected to increase in the future, considering the anticipated scenarios caused by climate change. According to the experts [20,21], it is estimated that in regions located in the western Mediterranean, there will be a rise in temperature and an increase in the frequency of extreme events, as well as a decrease in precipitation. These predictions highlight the need for a change in the water policy to promote the incorporation of new sources, such as non-conventional sources and the implementation of sustainable solutions.

Periods of rapid and disorderly urban growth that have greatly altered the water flows of the area have been recorded in the majority of these regions of the Spanish Mediterranean. This growth is due to periods of economic prosperity and a flexible urban policy [22]. Not only has there been an increase in the population of the area, but there has also been a significant changes in the land uses of populated areas. Large tracts of land have become urbanized [23]. These important land transformations have been recorded in Spain since the 1990s and have affected the urban environment in particular, and as aforementioned, this has intensified on the Mediterranean coast [3]. According to Greenpeace [24], in the Valencian region the artificial surface area practically doubled between 1987 and 2005, from 15,000 to almost 30,000 hectares, with an increase in the number of houses built between 1996 and 2006 going from 30,000 to 92,000 [25]. A clear example of this can be observed in the province of Alicante, which, between 1997 and 2008, was the third Spanish province in terms of the number of houses built [26]. Throughout the last few decades, various processes of concentration, dispersion and the creation of new urban nuclei can be distinguished. These transformations are different to the traditional compact settlement model of the mid-twentieth century [27]. The impervious surface of the land makes it impossible for water to infiltrate it and this means that the runoff water cannot be absorbed, thus increasing the associated environmental problems (floods and pollution).

Thus, urban areas have had to adapt their hydraulic infrastructure to urban and population growth. Considering the great hydraulic tradition of Spain, several plans of action have been developed that are associated with the collection and transportation of water, which to a great extent have satisfied demand. This includes the construction of dams and reservoirs [28], transfers between basins and running underground aquifers. However, these measures are now insufficient to meet urban and agricultural demands. This situation is aggravated by the effects of climate change. That is why it has been necessary to seek new supply sources, including unconventional resources (desalination and the reuse of reclaimed water) [29] and to promote sustainable urban measures to increase resilience and create smart and sustainable cities.

The incorporation of new water supply sources in urban environments with fast-growing tourism has been a constant practice during the last decade on the Mediterranean coast of Spain [30]. The reuse of treated flows for agricultural irrigation has been popular for decades. Despite being a more recent practice in Spain, desalination has gained tremendous value in terms of ensuring human supply. These changes have altered the hydrosocial cycle of those areas, increasing their complexity. The combination of the effects of natural and social components has been modified, as will be seen later, with the aim of reaching, as far as possible, a water balance.

The purpose of this paper is to highlight the various hydraulic measures that have been carried out in cities located on the Mediterranean coast in order to adjust to different scenarios over the years. These adaptive strategies are examined through the analysis of flow patterns that characterize the hydrosocial cycles of three cities (Alicante, Benidorm and Torrevieja). The three cities are located in the province of Alicante, in southeastern Spain (Figure 1), a region characterized by serious water shortages that have led to an intensification of these adaptive measures. These cities have been chosen due to their different urban models and water circumstances, and they evince the importance of non-conventional water resources in detriment of conventional resources.

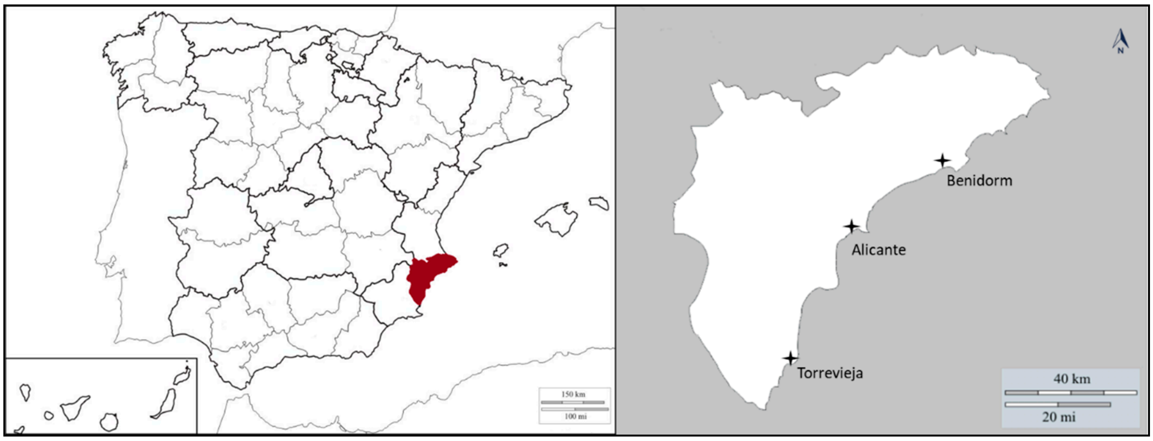


**Figure 1.** Location of the cases studied.

In order to achieve this purpose, three objectives are proposed: (a) highlight the relationship between resources and demands that leads to water imbalance; (b) analyse the temporal evolution of this relationship; and (c) demonstrate the importance of the incorporation of unconventional resources as a measure to reduce the water imbalance, by analyzing three cities in the study area as examples.

## 2. Materials and Methods

### 2.1. Data Collection

In order to carry out the evolutionary analysis of the flow diagrams in cities located in the Mediterranean area and translate it in the three case studies, diverse and varied information was collected. Literature on the evolution of these areas and how they are linked with the water resources throughout history were consulted. Urban development in recent years was explored, as well as the evolution of the supply sources of the different entities involved. Furthermore, several entities were contacted in order to obtain information on the water resources (disaggregated by source), demands (disaggregated by uses) and the governance systems of the three case studies. Diagrams were created using data for 2013 because, by then, we considered that the models were already well consolidated and the largest amount of data could be collected.

At a regional level, for both Alicante and Torrevieja, water management is run by the Mancomunidad de los Canales del Taibilla (MCT, Murcia, Spain), a public entity considered to be one of the largest national hydraulic complexes [31]. In the case of Benidorm, the Consorcio de Aguas de la Marina Baja (CAMB) is in charge of water management. Data has been collected from these two entities, both qualitatively and quantitatively, including the volumes of each source (groundwater, surface water, Tajo-Segura transfer and desalted water) and its catchment, production, regulation, distribution infrastructure and its adaptation to the quality required by regulations.

On the local level, in each of the cities the water cycle is managed by a company, or rather a different business model. In Alicante, Aguas Municipalizada de Alicante, a mixed company (City Council and Hidraqua) is in charge of the water cycle and it provided information on the domestic supply and consumption for this study, along with data on the management of regenerated water in the urban environment. The private company that is in charge of water management in the city of Benidorm is Hidraqua, which provided information about urban consumption. Finally, the water management company in Torrevieja is Aguas del Arco Mediterráneo (AGAMED), a mixed company (city council and Hidraqua), which also provided data on management and supply at the urban level.

The management of waste water in the Valencian region, to which the province of Alicante belongs, is carried out by the Public Entity of Wastewater Sanitation of the Valencian Region (EPSAR). In addition to information on the types of treatment of the different plants involved, they provided the magnitude of the flows treated and reused by each of the residual plants of the cities.

### 2.2. Creating Hydrosocial Cycles

Using the data provided by the different actors involved in this process, a hydrosocial cycle model was created (Figure 2) [30], which has various components of this hybrid system where society and nature closely interact [32,33]. Those systems have been analysed by several authors during the last decades, providing a great model for cities such as Guayaquil [34] and Mendoza (Argentina) [35,36]. The structure of the model has been created through a detailed analysis of the evolution of the systems but acquires greater relevance when it incorporates the quantitative and governance components of the cities studied. In this way the order of magnitude of the different sources and states in which water is in its flow through the cycle and its performance in different scenarios can be seen. Likewise, knowing the different entities involved in each of the processes helps to understand the complex governability of these systems.

In order to create those models for the studied cases, the input in the system must be taken into consideration first. The complexity of these cycles in Spain is mainly associated with the capacity to provide the resources needed to meet the demands by diversifying sources. Initially, conventional sources (surface water and groundwater) were used, but as these contributions have decreased and not been able to cover the increasing demands it has also been necessary to incorporate non-conventional sources, such as water from wastewater treatment and desalination plants. The amount supplied to the system by each of these sources, which depends on the current availability, helps creating a dynamic and adaptive subsystem that can cope with different adverse scenarios.

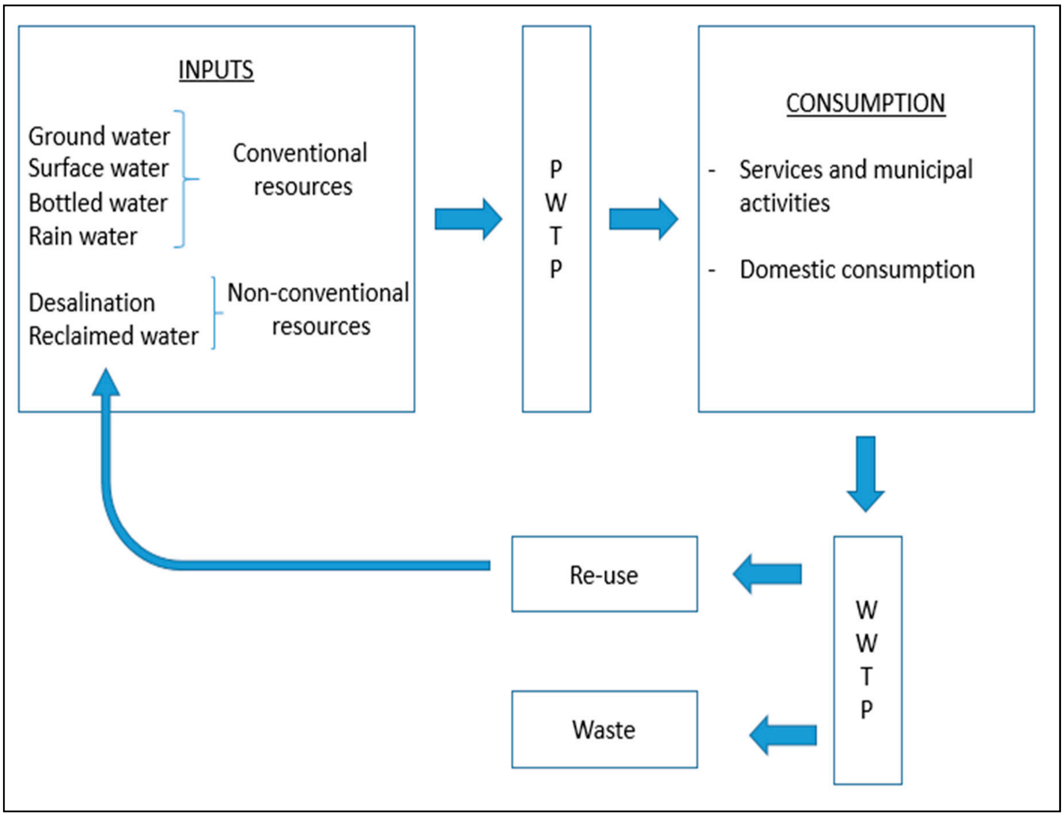


**Figure 2.** Model to create urban flow diagrams. Compiled by the author.

Water from different sources is treated for domestic use in potable water treatment plants (PWTP). Then drinkable water is distributed to be used in municipal services and activities, hotels (where appropriate) and domestic consumption, which is the most important. This water mixes with rainwater and is brought to the waste water treatment plant (WWTP). Once there, it is treated to fulfil the legally established physical, chemical and biological parameters, so that it can be reused. Although some of this treated water is still dumped into rivers or the sea, a certain percentage is reused, mainly for irrigation and for recreational purposes (golf courses). In some cases, this regenerated water is also used for other activities that require low quality water for urban demands, such as the irrigation of landscapes or to clean the streets, therefore it goes back into the cycle again. Furthermore, the different actions that has been taken during the last few years to optimize the management of all the water resource-related phenomena must be taken into account. For instance, the implementation of sustainable drainage systems, the incorporation of grey water and rainwater collection, and treatment and reuse systems in buildings.

This model can be used and adapted for all cities and at different levels, by incorporating the special features that characterize and differentiate certain urban spaces from others. The hydrosocial cycle of a city, which combines the flow of water within a city with the social, economic or political aspects that influence it, highlights the complexity of these systems, especially in areas where water is scarce, such as those in the Mediterranean part of Spain.

## 3. Results

After a theoretical analysis of the components that make up the hydrosocial cycle, this data is extrapolated and applied to three cities in the province of Alicante. Each one is for a different urban model, which indicates that these flow diagrams are flexible and can be adapted to the situations that characterize each city. These flow diagrams not only provide for the processes that water undergoes in the city, but also the management of these waters. The entities involved in each of the processes are identified by a colour system that is detailed in the legend. The volumetric quantification of the resource from each of the sources or types of treatment, as well as the contributions of rainwater and its interaction with the urban environment have also been incorporated, wherever possible. In this way the diagram acquires a quantitative component that helps show the magnitude of each of its components. The difference in volume between the water treated in the PWTP and the water consumed in the urban environment that is observed in the diagrams, is due to the losses that occur in the distribution networks (leaks). Those facilities are in many cases, old, and need to be replaced by new ones in order to reduce these significant losses. The key components of these adaptive measures have been highlighted with a red circle on the diagrams to demonstrate their importance and significance in the evolution of the hydrostatic cycles of these cities.

### *3.1. The Case of Alicante*

Alicante is a city of services, although the coastal areas are also a place of tourist-residence. After analyzing the flow diagram created using the data obtained for 2013 (Figure 3), the diversification of sources is clear: surface water (from the Taibilla river and through the Tajo-Segura transfer), the underground aquifer water located in the inland area of the province and desalinated water from the two plants located in this city.

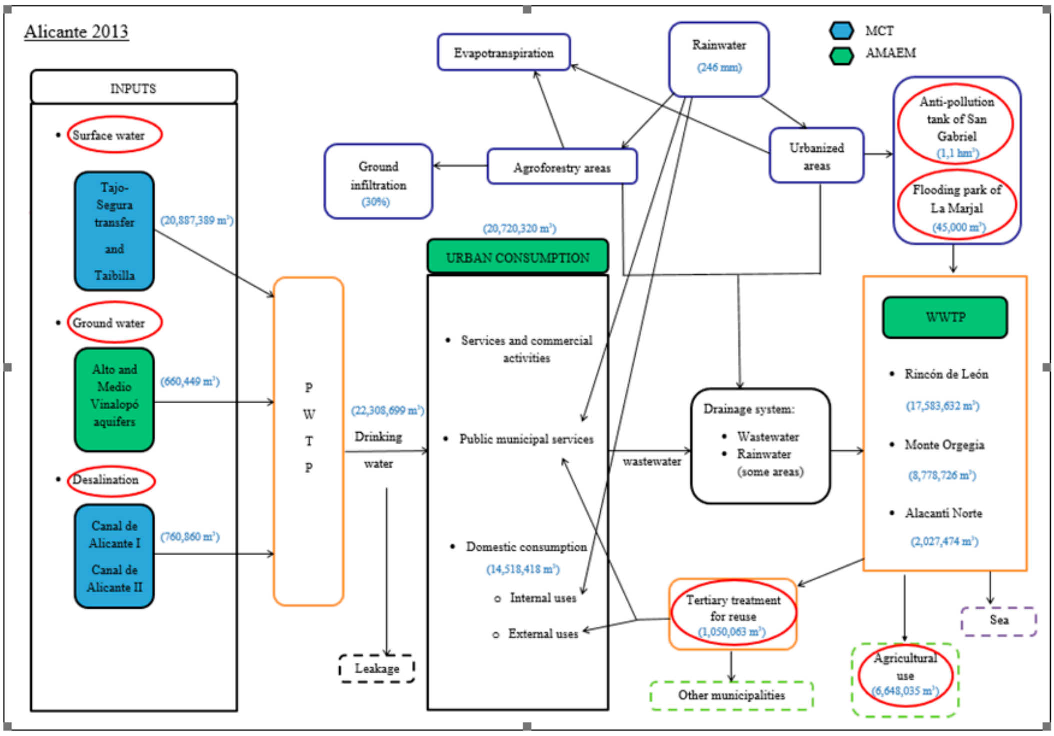


**Figure 3.** Flow diagram of the city of Alicante in 2013. Compiled by the author.

This city has also encouraged the use of regenerated water thanks to the Reuse Master Plan (2002–2003). Through this plan a double distribution network has been created through which regenerated water can reach all parts of the city to cover different urban demands [37]. Currently, more than 70% of the green areas in this city are irrigated with reclaimed water. Likewise, intakes have been created that can be accessed by private users, as is the case of many single-family dwellings, whose gardens are already irrigated with regenerated water [18]. Water intakes have also been set up in different parts of the city for trucks that clean the streets. Moreover, initiatives have been promoted to mitigate the floods generated by heavy rainfall events. One example is the "San Gabriel" anti-pollution tank, which can store up to 1.1 $hm^3$. A further example is the "La Marjal" natural marsh flooding park, with a storage capacity of up to 45,000 $m^3$. Although the latter was not built until 2015, it has been included in the diagram because this type of initiative can have a significant effect on the flow of urban water. These two structures are not only considered to be mitigation measures in the event of heavy rainfall events (a situation that is expected to get worse as a result of climate change), but they also provide an opportunity to reuse (after passing through the treatment plant) effluents that were previously wasted.

### *3.2. The Case of Benidorm*

Benidorm is a clear example of a tourist city predominated by hotels [38]. This tourist resort [39] has one of the most efficient drinking water management systems in Spain, both in times of high and low supply. This is the result of a complex configuration where the conventional source diversification strategy is consolidated by the reuse of wastewater and it is linked to the city's compact and vertical urban nature [40]. The key to the success of this exemplary and unique model and its overall use of water resources, lies in the exchange of wastewater treated by white water. The irrigators, who hold the concessions for most of the water, reached an agreement with the CAMB through which groundwater was exchanged for reclaimed water, when necessary, which means that the former can be used for urban supply and the latter mainly for agricultural irrigation [41,42]. There is an increase in the water consumed in the city and the water treated in the WWTP. This is due to a water park that connects directly to the WWTP, increasing the volume of water to be treated. Due to the high salinity of the effluent produced by the secondary treatment, a desalination plant has had to be incorporated to adapt the conductivity according to the parameters required for its subsequent use in agricultural irrigation. As shown in the diagram (Figure 4) the system receives both surface water and groundwater. In the event of an emergency, water can be supplied through the Rabasa-Fenollar-Amadorio connection [2]. Initially water from the MCT could be used, and since 2015 water from the desalination plant of Muchamiel, located next to Alicante.

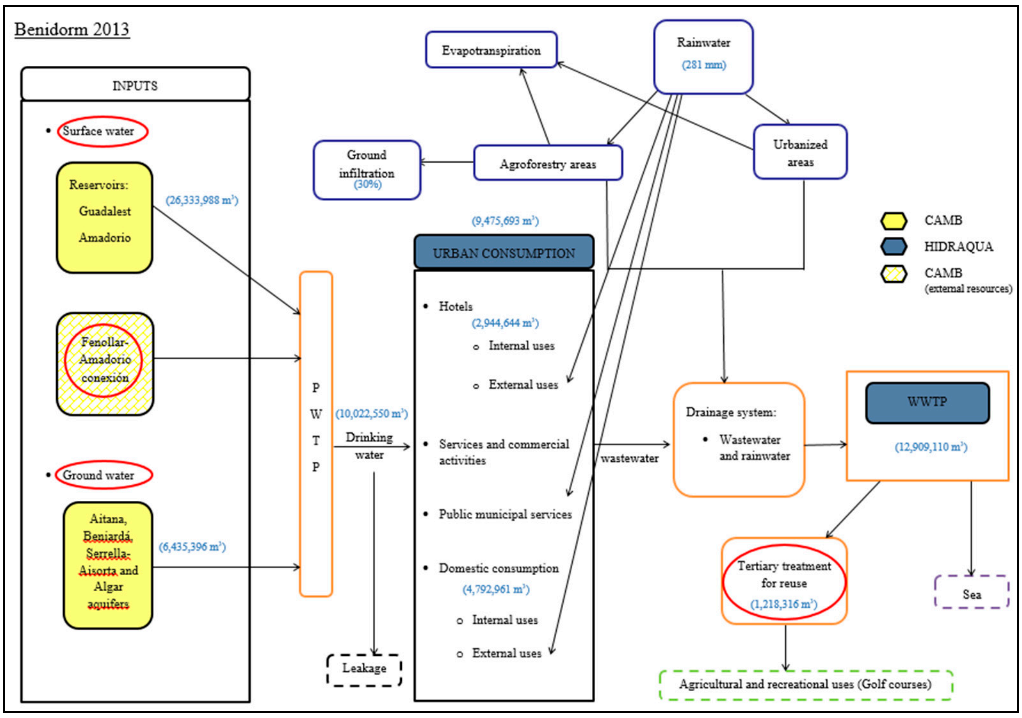


**Figure 4.** Flow diagram of the city of Benidorm in 2013. Compiled by the author.

### *3.3. The Case of Torrevieja*

Torrevieja is a city where so-called residential tourism predominates, as demonstrated by the high percentage of second homes in its housing sector; according to data from the National Statistics

Institute in 2011, second homes comprise 67% of the housing stock in the city. Notably, more than half of the population on the census are foreign residents, which highlights the importance of tourism here. This is a major challenge in terms of water management since second homes are mainly occupied during the summer season, therefore the population of this tourist resort at that time of the year can triple. The treatment plants have adapted to the distribution system over the years to cope with these peaks in supply. Another factor that makes management difficult is the fact that the greatest increase in demand is generated when the contributions are lower.

Torrevieja, like Alicante, receives water from the MCT (desalinated plants located in San Pedro del Pinatar, located in Murcia, and from superficial sources). One of the peculiarities to be highlighted in the flow diagram for this city (Figure 5) is the fact that 100% of regenerated water is reused for agriculture [18]. In order to do this, the effluent from the secondary treatment undergoes a tertiary treatment (ultraviolet filtration), which ensures that the regenerated water is suitable for its new use. There is also a private desalination plant located in the vicinity of this city and in the event of an emergency it can provide water to the MCT, which is what is happening in 2017.

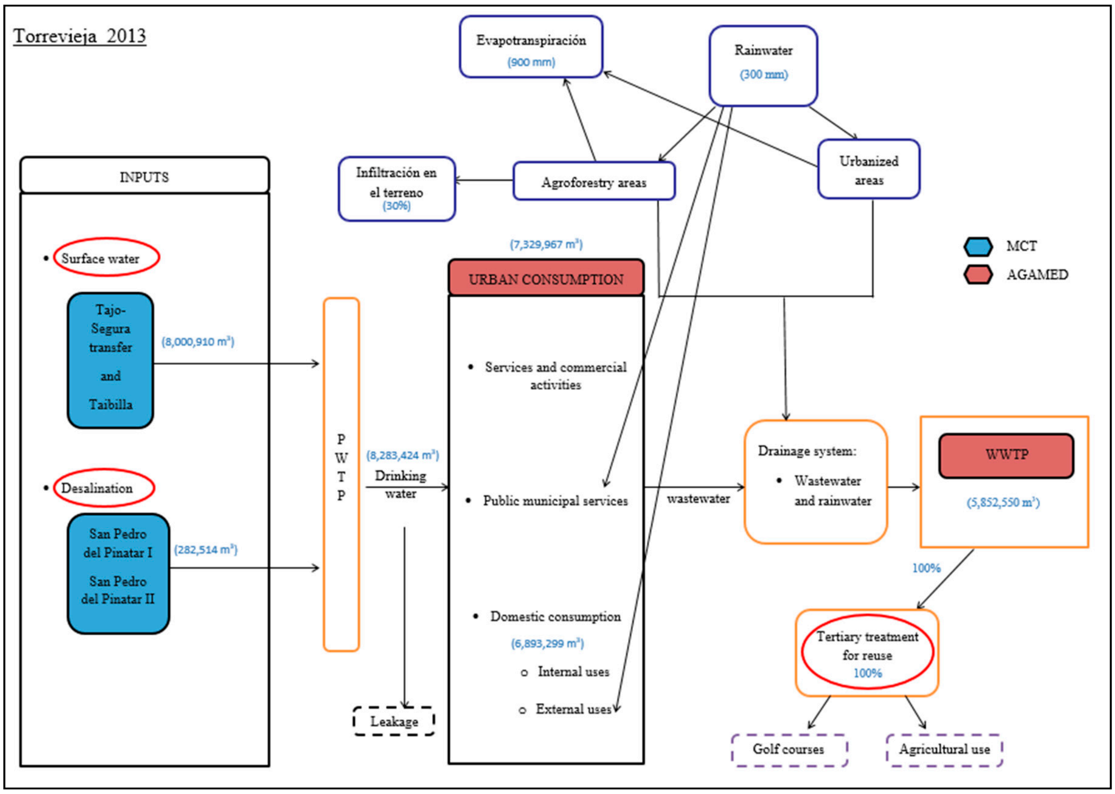


**Figure 5.** Flow diagram of the city of Torrevieja in 2013. Compiled by the author.

## 4. Discussion

Due to the reuse of reclaimed water, a practice that entails several economic and environmental advantages [43], higher quality water volumes can be released for priority uses, with this non-conventional resource being used in compliance with the R.D. 1620/2007, mainly for the agricultural irrigation of certain crops, and to a lesser extent, for certain urban, recreational and industrial uses. The restrictive requirements of this regulation, the high salinity of some effluents, as well as the social reluctance to face possible sanitary problems [44,45] limit the expansion of this practice for some uses [18].

The reuse of reclaimed water has been developed more widely in regions with severe water shortages, such as in the Mediterranean arc and the Balearic Islands. These regions have pioneered the use and development of this practice. In spite of this, all the water in question is not reused [2].

Moreover, recycling other water, such as rainwater or grey water, also provides additional and significant input on a local level [45]. However, this practice is also carried out in countries with other water problems through the use of rainwater harvesting or sustainable urban drainage systems (SuDS), increasing the resilience of the system and mitigating floods, as occurs in the United Kingdom [46].

Although the reuse of wastewater is considered to be measure with the greatest potential, recycling other waters such as grey water and rainwater is also worthwhile, because on a smaller scale this can promote the overall use of available water resources and the sustainable management of the resource. These practices are still embryonic in Spain, but in other European countries their practice is widespread because government agencies subsidize them. Studies carried out on this matter [47,48] show that reusing this water can save up to 40% of the household water consumed (Figure 6); it replaces better quality water that was previously used for flushing the toilet or watering gardens. However, to achieve this objective, a legal framework is required to regulate the use and the implementation of grey water and storm water reuse systems, both on a European level and on a national or regional level, which does not exist at present.

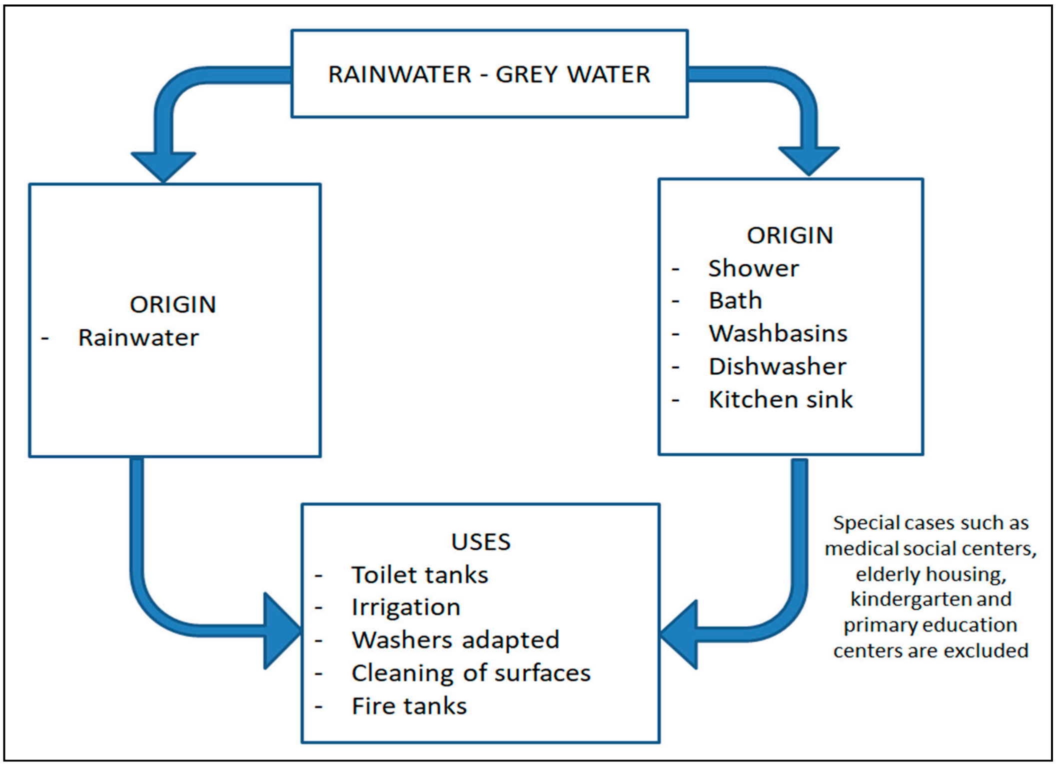


**Figure 6.** Origin and uses of rainwater and grey water [47,49].

The advantage of desalination is that its source, the sea, can be considered to be inexhaustible, which considerably increases its contribution to the system. However, the high energy and economic costs (especially during RO, the most widespread technique in Spain) make this resource too expensive for some sectors, such as agriculture [50]. In Spain, desalination was presented as being the solution to the country's water problems, promoting the construction of a large number of plants along the Mediterranean arc under the protection of the A.G.U.A Program [51]. The demand estimates for the watersheds on which this program was based have never been met and most of the time the majority of plants do not work at full capacity [52], although their activity increases in periods of drought, for example, in 2017 and 2018 due to the closure of the Tajo-Segura transfer. Several measures are being taken to reduce energy consumption, such as the incorporation of energy recovery devices or latest generation membrane systems [53]. Therefore, the resource could be economically accessible to a larger number of users, but while this is not possible, desalination ensures human supply in the event of drought or an emergency, and it is considered to be a strategic resource [29].

The MCT, created in 1927, is a perfect example of the diversification of resources, as it distributes water from the Taibilla River, the Tajo-Segura transfer, the desalination plants it has in the Segura basin, and if there is an emergency, other waters such as those coming from the so-called "dry wells" of the Calasparra syncline. This fact is made clear in Figure 7, which illustrates the variability of each of the sources according to the circumstances and the needs for each year.

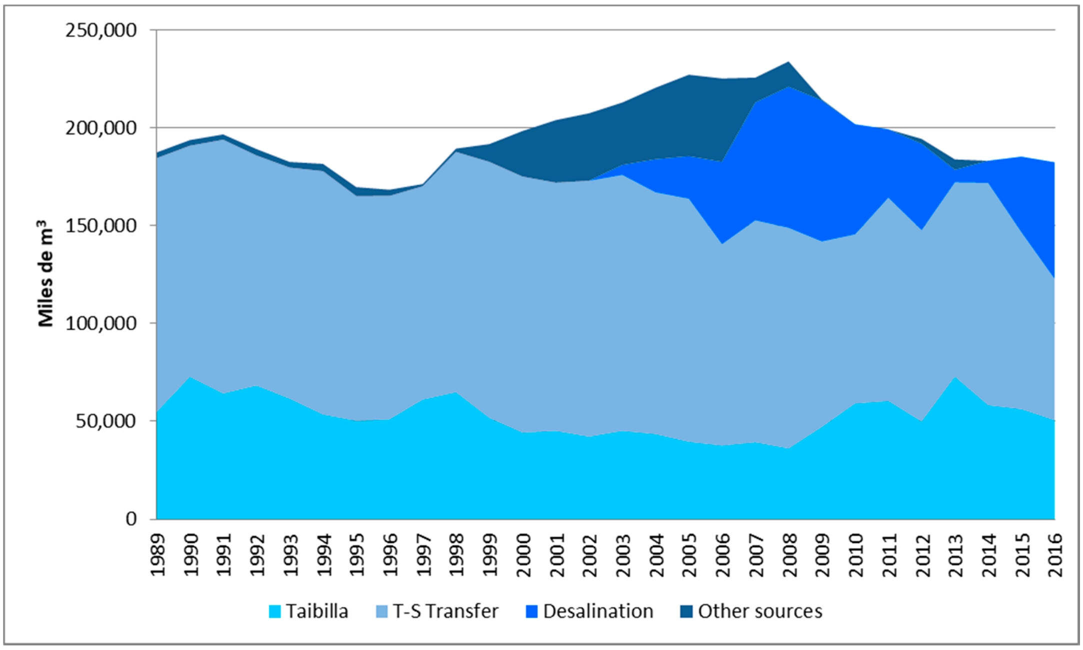


**Figure 7.** Origin of the different sources of the MCT.

Furthermore, various measures have been taken to optimize the management of water resources in the cities studied. An example of this is the sustainable urban drainage systems, which in addition to mitigating the effect of flooding, help reduce the pollution they produce and make it possible to reuse the rainwater that is collected [54]. Locally, another example would be building new catchment and treatment systems, both grey water and rainwater, to use later as part of urbanization, as discussed above. The incorporation of this type of resource (rainwater and grey water) would help increase the resilience of these areas in the event of future scenarios involving climate change and would also reduce the pressure on water resources.

The gradual incorporation of the different sources of supply has been the key to the hydrosocial cycles of the cities studied being able to adapt (Table 1). Each of the three examples, with different urban models, has been able to adjust to increasing demand by diversifying sources and incorporating unconventional resources, such as desalination and reuse.

Alicante, with its urban-residential model, includes desalinated water in its urban supply by means of the flow received from the MCT. In 2015, it reused almost 35% of the volume treated. These waters were used for agricultural irrigation and for urban activities (irrigation of public and private green areas and washing the streets) due to the double network of regenerated waters, which is being developed in the city. One special feature of Benidorm, a tourist model that is predominated by the hotel industry, is that the white water is exchanged for regenerated water and between agricultural and urban uses during drought situations. Although Benidorm does not incorporate constant desalinated flows, it is connected to the desalination plant of Mutxamel through which it can receive this resource in the event of a drought or an emergency. Torrevieja, a tourist model, where second homes predominate, receives desalinated flows through the volumes supplied by the MCT, as well as Alicante. However, one point that must be highlighted here is that this city reuses 100% of the flows treated for agricultural use and to water golf courses.

**Table 1.** Chronological incorporation of supply sources.

| | Ground and Surface Water | MCT | CAMB | Tajo-Segura Transfer | Desalination | Reuse |
|---|---|---|---|---|---|---|
| *Alicante* | X | 1958 | - | 1979 | 2003 | 2002 |
| *Benidorm* | X | - | 1977 | 1997 (Emergency) | 2016 (Emergency) | 90s |
| *Torrevieja* | X | 1972 | - | 1979 | 2003 | 1980 |

The complex situation observed in the province of Alicante, where the resources come from different intraregional and interregional sources and the water governance also varies according to the city is shown schematically in Figure 8.

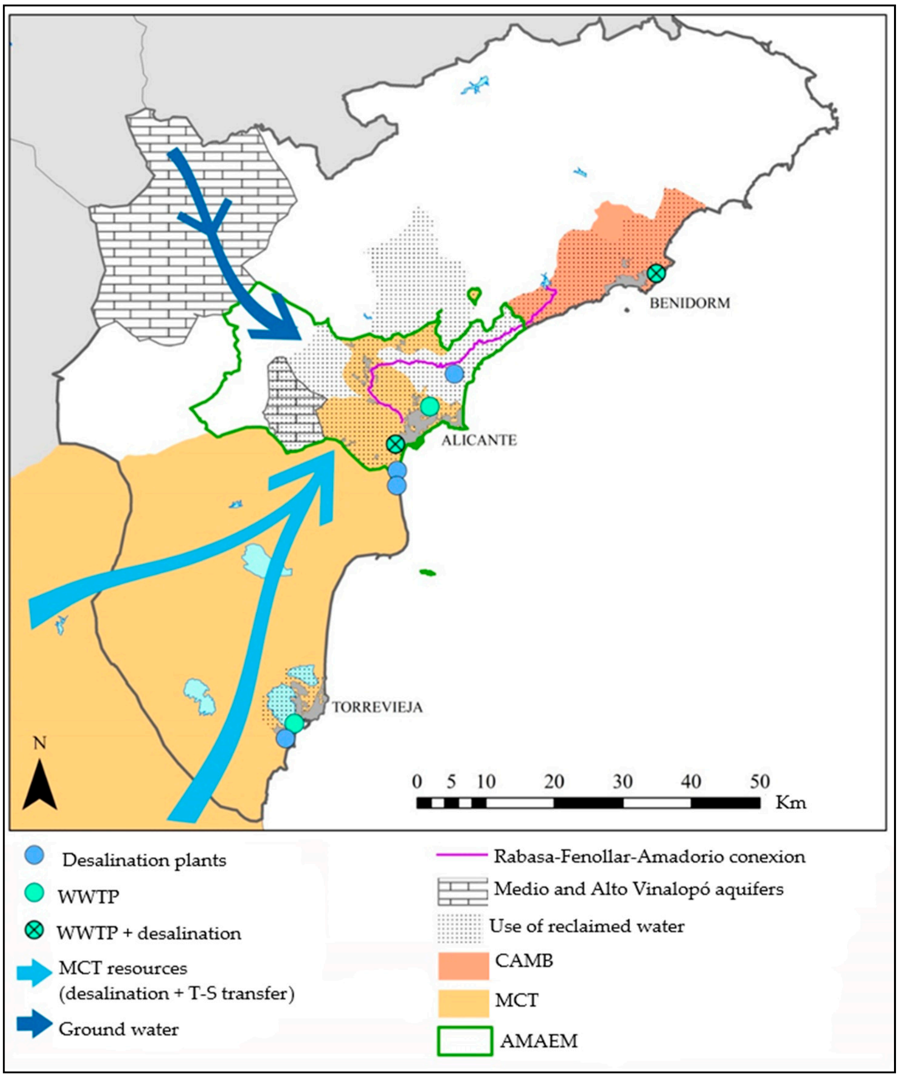


**Figure 8.** Diagram of the distribution, management and use systems linked to case studies in 2017. Compiled by the author.

## 5. Conclusions

The increase in population has generated a rise in demand for water, which is difficult to meet in those regions marked by water scarcity. This situation is expected to worsen with future growth and due to the effects of climate change. Therefore, a large number of countries, like Israel, Spain or the west coast of the USA, have resorted to diversification of water sources, combining traditional underground and superficial waters with non-conventional water resources such as reclaimed water, desalinated water or rainwater.

These additions result in a need to increase, over the years, the water capacity of the hydrosocial cycle of these cities in order to adapt and meet the new demands. This fact, which in itself is a challenge, becomes more complex in regions and municipalities that are characterized by the water shortages mentioned, such as on the Spanish Mediterranean coast. The flow diagrams of cities with water shortages, which are likely to worsen in the future as a result of the effects of climate change, highlight the importance of diversifying sources in these regions. An important point has been the incorporation of non-conventional resources, desalination and water reuse. Desalination has made it possible to ensure supply in some regions, despite its high price, while reuse has meant that higher quality water can be set aside for priority uses, such as human supply, by using lower quality water, such as reclaimed water for agricultural or recreational activities. Furthermore, an emerging trend associated with the introduction of sustainable measures is observed in the management of urban water associated with the use of rainwater.

In this paper urban flows models are applied in three cities in the province of Alicante during 2013, highlighting the sources incorporated during recent years. Thus, it corroborates their adaptability to the circumstances and different urban models. Each one of the case studies has a peculiarity that makes them pioneers at an international level. Alicante stands out thanks to the balance between the different sources of supply and the incorporation of infrastructure that supports its implementation, including the distribution network of reclaimed water, the storm tank and the flooding park. Torrevieja is distinctive for reusing 100% of the treated water and Benidorm has a unique agreement between irrigation communities and the supply company.

The urban flow models for the three cities show the adaptive measures that the system has taken to meet the demand for water and to ensure they are able to cope with future scenarios. Moreover, the diversification of sources and the incorporation of non-conventional water resources are highlighted as key elements.

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## Abbreviations

The following abbreviations are used in this manuscript:

| | |
|---|---|
| AGAMED | Aguas del Arco Mediterráneo |
| AMAEM | Aguas Municipalizadas de Alicante Empresa Mixta |
| CAMB | Consorcio de Aguas de la Marina Baja |
| EPSAR | Entidad Pública de Saneamiento de Aguas Residuales de la Comunidad Valenciana |
| MCT | Mancomunidad de los Canales del Taibilla |
| PWTP | Potable Water Treatment Plant |
| RO | Reverse Osmosis |
| WWTP | Waste Water Treatment Plant |

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