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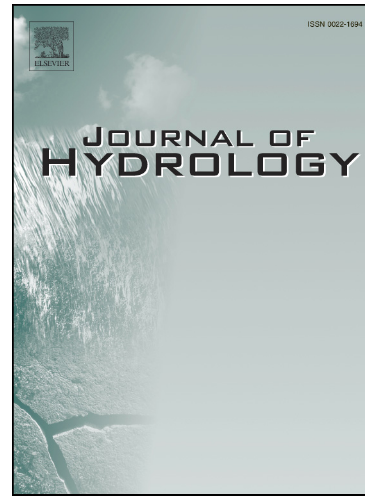

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THE END OF SCARCITY? WATER DESALINATION AS THE NEW CORNUCOPIA FOR MEDITERRANEAN SPAIN

Abstract

In this paper we explore the new orientation taken by Spanish water policy since the beginning of the 21st century and very specifically the shift towards desalination as an alternative to other water supply options such as river regulation or inter-basin water transfers. Desalination has been seen as the cure for everything that dams and inter-basin water transfers were unable to solve, including droughts, scarcities, social conflicts, environmental impacts, and political rivalries among the different Spanish regions. Desalination also means a new and powerful element in water planning and management that could provide water for the continuous expansion of the urban and tourist growth machine in Mediterranean Spain and thus relax possible water constraints on this growth. However, by 2012 most new desalination plants along the Mediterranean coast remained almost idle. Focusing on the case of the *Mancomunidad de Canales del Taibillla* in South-eastern Spain, our aim is to develop a critical, integrated and reflexive perspective on the use of desalination as a source of water for urban and regional growth.

Keywords: desalination, urban growth, drought, alternative water sources, AGUA Program, Mediterranean Spain.

1. Introduction

In this paper we explore the new orientation taken by Spanish water policy since the beginning of the 21st century and very specifically the shift towards desalination as an alternative (Jefatura del Estado, 2004, 2005 and Ambienta, 2006) to other conflict-ridden water supply options such as river regulation or inter-basin water transfers (Masjuan et al., 2008). Using Mediterranean Spain, and especially the areas served by the *Mancomunidad de los Canales del Taibilla* (provinces of Alicante and Murcia), as a case study, our aim in this paper is to develop a critical perspective on the use of desalination as a source of water for urban and regional growth. In the context of repeated droughts, likely to increase in the future because of climate change, and the economic, social and environmental costs of conventional, large-scale water supply options such as dams and inter-basin water transfers, desalination appears as a sort of "cornucopia" able in principle to solve future water needs of urban expansion in Spain (Swyngedouw, 2013). As President Kennedy envisaged more than fifty years ago, "no water resources program is of greater long-range importance than our efforts to convert water from the world's greatest and cheapest natural resources – our oceans – into water fit for our homes and industry. Such a break-through would end bitter struggles between neighbors, states and nations" (cited in Krishna, 2004, p. 1). Likewise, proponents of desalination in Spain argue that it is one of the technologies with a greatest capacity to solve water supply problems in coastal Mediterranean Spain and may become therefore a key resource for urban and regional growth in this area (Estevan, 2008a). Because it taps a seemingly endless source of water, desalination effectively removes the climatological and hydrological constraints associated with continental water resources (Feitelson and Rosenthal, 2012), and, more importantly perhaps in political terms, circumvents the social opposition and conflict increasingly associated with river regulation through dam building and long-distance inter-basin water transfers (Saurí, 2003). Desalination is not, of course, problem free. Energy availability and costs may be important, especially when compared with other water supply options (Domènech et al., 2013). In this sense, in Spain desalination costs have been compared with the cost of long-distance water transfers with conflicting evidence on which alternative is more cost-efficient (compare, for example Prats and Melgarejo, 2006 with Valero et al., 2001). Moreover, the impacts of brine on oceanic life could be very damaging (Dawoud and Al Mulla, 2012) and there is still considerable uncertainty on other impacts such as the loss of marine life during water intake operations or the release of chemicals used in the desalination process through the brine.

Our objective in this paper will be to examine the so-called AGUA Program (*Actuaciones para la gestión y el uso del agua,* Actions for Water Use and Management) developed by the Spanish Ministry of the Environment in 2004 as an alternative to long-distance water transfers. This plan, while including some water-saving and efficiency improvement initiatives, was mainly aimed at building an important number of desalination plants along the Spanish Mediterranean coast to provide water for agricultural, urban and tourist uses (Jefatura del Estado, 2004, 2005 and Ambienta, 2006). Our socio-political and socio-environmental assessment of this Program focuses particularly on the economic costs of desalination in a context of competition with other water supply sources, of declining demand in many municipalities and of the collapse of the real estate sector in Mediterranean Spain since 2008. Taking as an example the *Mancomunidad de los Canales del Taibilla* (MCT) our analysis demonstrates that despite that desalination increases security of supplies in times of drought and has a number of advantages regarding other options it hardly represents the ultimate water source able to put an end to scarcity for all users.

Our sources of information for this paper have been published literature on the subject, the critical reading of a number of official reports (especially the viability reports of a number of water desalination plants in Alicante and Murcia prepared by the public company *Acuamed*; see Ministerio de Agricultura, Alimentación y Medio Ambiente, 2013a and Acuamed 2013a, 2013b), and informal conversations with water planners and managers of the *Mancomunidad de los Canales del Taibilla* (Andrés Martínez, pers. comm., 2013) and Alicante's water company (Asunción Martínez, pers. comm., 2013). The paper is organized as follows. In section 2 we examine desalination in the context of water planning and management. In section 3 we trace a brief history of desalination in Spain with a special emphasis on the so-called AGUA Program of 2004, which was responsible for the current expansion of desalination in this country. In section 4 we focus on the specific case of the *Mancomunidad de los Canales del Taibilla* (MCT) for which we examine the recent evolution of water supply sources and, in particular, the situation of desalination plants *vis à vis* other water sources. In section 5 we situate desalination in the context of the current real estate crisis and diminishing water demand affecting the study area. Finally, we will critically assess the reality of desalination in the study area and the possible implications of the lessons learned in this case for other areas interested in developing desalination projects. This last section points out to the need, not only in Spain, but also in other parts of the world, of a better integration between water planning and urban and regional planning, as well as a more integrated consideration of water supply sources, with accurate assessments in terms of water use and cost.

2. Desalination in the context of water planning and management

The genesis and development of cities cannot be understood without tracing how water has been mobilized in order to facilitate urban growth. In this process, water supply and sanitation infrastructures are critical as they mediate flows of nature and power (Castán Broto and Bulkeley, 2013) and become historical products of human-nature interactions

(Gandy, 2002, Kaika, 2005 and March, 2013). From the use of local resources, such as groundwater, to the transportation of water through long-distance aqueducts and the development of desalination plants, the water cycle has been increasingly humanized since the Industrial Revolution, making possible the massive concentration of people in cities. Most recently and in a similar fashion, the development of massive water infrastructure has made possible the growth and consolidation of large tourist resorts in many parts of the world as well (see, for instance, Gössling et al., 2012).

The large amounts of capital involved and the urgent need to enlarge water availability throughout the 20th century led to the prevalence of centralized approaches to water supply. This is what could be called "the hydraulic paradigm" or, in other words, the control by the state of all matters regarding water planning and management with an emphasis on technological solutions (Saurí and del Moral, 2001). Water-supply systems developed along those principles have produced large benefits to the population by improving the reliability of provision, reducing water-related diseases associated with poor water quality, and containing the vagaries of climate and the impacts of extreme hydrologic events such as floods and droughts. On the other hand, conventional water supply systems (including dams and water transfers) have also produced large costs, including ecological and environmental degradation, social disruption associated with infrastructure, and economic and financial problems (World Commission on Dams, 2000 and Gleick, 2003).

As the most recent mutation of the "hydraulic paradigm", desalination has massively expanded in the recent years across the world. According to Swyngedouw (2013), desalination is being presented increasingly as a techno-social fix, against the pressures of urbanization, climate change and population on freshwater resources. As the World Health Organization (2011, p.1) recognizes: "desalination is increasingly being used to provide drinking-water under conditions of freshwater scarcity. […] This situation [water scarcity] is expected to worsen as competing needs for water intensify along with population growth, urbanization, climate change impacts and increases in household and industrial uses". The Intergovernmental Panel on Climate Change (IPCC) (Bates et al., 2008) presents desalination as a potential option, together with wastewater reuse, to adapt to the impacts of climate change, especially in arid and semi-arid regions. Desalination thus may contribute to enhance water security, and can "yield a reliable long-term water supply with the flexibility to be decommissioned if not needed" (Baldwin and Uhlman, 2010, p.195).

Nonetheless, desalination presents a series of contradictions and problems. First and as said before, desalination may have deleterious effects on marine ecosystems (Sadhwani et al., 2005 and Bernat et al., 2010). Second, and more relevant for the purposes of this paper, desalination implies high-energy consumption and CO_2 emissions (Meerganz von Medeazza, 2004, Sadhwani et al., 2005, Bates et al., 2008 and Bernat et al., 2010). In this sense, the water-energy nexus (Gober, 2010 and Siddiqi and Diaz Anadon, 2011) becomes especially evident with desalination due to the high amounts of energy needed to desalt water. While the average cost of a unit of water used in Spain is 0.45 kWh/m^3 (this figure includes water-related electricity consumption before the final use of the water) (Hardy et al., 2012) desalination requires between 3.5 KWh/m^3 (under ideal conditions) to 5 kWh/m^3 (the modern plants with reverse osmosis) or more in the older plants (Instituto para la Diversificación y Ahorro de la Energía (IDAE), 2010; see also Bernat et al., 2010).

In any case, the economic cost of desalted water may vary depending on plant capacities, the type of water (brackish or seawater), the type of energy used (conventional, photovoltaic, etc.), water salinity, location (costs of labor and energy subsidies), capacity of the desalination plant, and desalination technology used (Multi-Stage Flash distillation or Reverse Osmosis) (see Karagiannis and Soldatos, 2008). For instance large desalination plants in Spain (with a capacity over 100,000 m^3/day), according to Bernat et al. (2010) using Reverse Osmosis may obtain freshwater from seawater at a cost between 0.36-0.53 euros/m^3 (as we will discuss later, other authors have calculated higher costs). However, as mentioned, these costs are highly dependent of location. Thus, Rygaard et al. (2011) point out to production costs ranging from 0.9-2.2 dollars/m^3 in countries such as Australia or Singapore. These figures may be higher for final consumers due to distribution costs from the plant to the point of consumption (especially if the consumers are located far away from the plant and/or in higher altitudes) and other operation and maintenance costs. Furthermore, costs may be subject to the fluctuations of electricity prices (see below for the Spanish case). At any rate, the high price of desalted water compared to traditional sources may imply the likely underutilization of desalination plants (see Rico Amorós, 2010 for the Spanish case). Along these lines, as Meerganz von Medeazza (2004) argues, desalination (an apparently endless source) might solve physical water scarcity in arid environments, but on the other hand it may create relative scarcity as it might propel an increase in water demand due to the growing expectations of large (and wealthy) consumers, while other users with lower ability to pay could not afford to buy desalted water.

Because of these and other impacts, some authors, such as Barnett and O'Neill (2010) or McEvoy and Wilder (2010 and 2012), consider desalination as a maladaptation to climate change because it may stress the water-energy nexus, at the same time that may contribute to greenhouse emissions and other environmental impacts. Furthermore desalination may increase water prices, induce uncontained urban growth, shift geopolitical relations of water security and increase dependence on technical expertise as well (see McEvoy and Wilder, 2012). All in all, desalination creates a path dependency and may reduce the incentives to adapt to water stress with other means while reducing flexibility of change for future generations (Barnett and O'Neill, 2010). Desalination, finally, and as happens with other large-scale water projects, such as water transfers, may fall prey to misleading projections of water demand based on scenarios of intense agricultural, urban and tourist growth.

3. Desalination in the Spanish Mediterranean Coast: The AGUA Program of 2004

Spain is a perfect example of how the command-and-control approach in water resources planning and management (López-Gunn, 2009) has been articulated through large engineering systems and centralized forms of governance (Saurí and del Moral, 2001 and Bakker, 2002) leaving a very discernible print on the landscape (Swyngedouw, 1999 and 2007). Put more bluntly, water supply in Spain throughout the 20th century has been based on building and enlarging water infrastructure rather than focusing on demand management. Despite being challenged, this approach mutates with the use of new technologies, such as desalination plants. The endless faith in technology to tame and produce new water flows is arguably the most widely shared ideology in water planning and management in Spain (March Corbella, 2010) and also in general all over the world at least until very recently. After dams and inter-basin water transfers, desalination has become the new alternative (Jefatura del Estado, 2004 and 2005) for solving the differences in supply between the "dry" and "wet" parts of the Iberian Peninsula. In recent years, desalination has substituted water transfers as a sort of new "cornucopia", a symbol of water abundance, able in principle to solve future water needs of urban expansion (Swyngedouw, 2013).

In Spain, the desire to turn seawater into freshwater is anything but new. In 1965, the first desalination plant in Lanzarote (Canary Islands) was built. In the same year the newspaper *La Vanguardia* (12 October 1965) reported the attendance of Barcelona Water Company (SGAB) technicians and managers to the First Symposium on Water Desalination held in Washington. Interestingly, it was emphasized that the physical and social conditions of Spain would justify the study and implementation of such technologies at a large scale. Forty years later, the social and territorial upheaval produced by the *Plan Hidrológico Nacional* of 2001 (National Water Plan), including a large water transfer from the Ebro River to Eastern and South-eastern Spain, paved the way to the massive construction of desalination plants along the Mediterranean coast (Masjuan et al., 2008). We contend that desalination was seen as the cure for everything that dams and inter-basin water transfers were unable to solve, including droughts, scarcities, social conflicts, environmental impacts, and political rivalries among the different Spanish regions. Along those lines, one of the main mottos of the AGUA Program was "More water forever; the sea, an endless source of life" (translated from the Spanish, March Corbella, 2010, p.345). Desalination also meant a new and powerful element in water planning and management that could provide water for the continuous expansion of the urban and tourist growth machine in Mediterranean Spain and thus relax possible constraints on this growth. This new hydraulic structuralism did not challenge the foundation of Spanish water politics oriented towards agricultural and urban growth and helped to overcome the new challenges posed by suburbanization along the Spanish coast in terms of rapidly expanding water uses (gardens and swimming pools) (EEA, 2006, Larrabeiti Rodríguez, 2013 and Parés et al., 2013).

Probably the main cause of the growth in desalination capacity in Spain during the last decades lies in the increasingly insurmountable difficulties faced by conventional water supply projects and the concurrence of severe drought episodes. In the Spanish mainland desalination was not considered as an alternative until the very severe drought of 1991-95. During the extremely dry summer of 1995, the Spanish government announced the construction of a number of desalination plants in the coastal areas of Southern and South-eastern Spain. Due to the wet period after 1995, only the Cartagena plant was built. In 1996, desalted water use in Spain attained some 500,000 cubic meters per day, 60 per cent of which concentrated in the Balearic and Canary islands (Rico et al., 1998). Besides the islands, the other Spanish areas where desalination became important in the 1990s and early 2000s were the coast of Málaga (where according to some estimates, desalted water may cover up to 40 per cent of the water needs of the Costa del Sol) and the area served by the *Mancomunidad de los Canales del Taibilla* in the provinces of Murcia and Alicante. All in all, 95 per cent of desalted water served urban and tourist purposes and only 5 per cent went to irrigation (Olcina Cantos and Moltó Mantero, 2010).

The national elections of 2000 gave the Popular Party a majority in the Spanish Parliament and therefore the political capacity to pursue a specific agenda for water planning and management. After several amendments to the Spanish Water Law of 1985 (among them the possibility of creating controlled water markets) and the approval of basin plans for the major Spanish rivers, the Spanish government launched the so-called *Plan Hidrológico Nacional* (National Water Plan) (Jefatura del Estado, 2001) which, as the most prominent feature, included the transfer of some 1,000 million cubic meters (henceforth MCM) of water from the Ebro river (the most important of Spain) to the Barcelona area (North) and to Valencia, Murcia and Almería (South). The Northern diversion, of about 200 kilometers, would help to alleviate the chronic water problems of Barcelona and its metropolitan region while the Southern diversion (up to 900 kilometers long) would provide for the needs of intensive agriculture and tourism in Eastern and South-eastern Spain.

As expected, the planned Ebro diversion caused enthusiasm in Valencia and Murcia (political strongholds of the Popular Party), although not as much in Barcelona, and raised strong opposition in the Ebro basin, especially in Aragon, and above all, in the lower Ebro valley and delta. In this area, a social movement, the Ebro Platform, with the participation of almost all local political and civic associations was created and immediately began a campaign to stop the project. While the Spanish Ministry of the Environment (see Gil-Olcina and Rico, 2008) defended that the Ebro had sufficient water for these diversions without endangering in-stream flows, and above all, the future of the Ebro delta, this was highly questioned by the opponents to the plan (Masjuan et al., 2008). The Ebro Platform, and increasingly also the scientific community, argued that the Ebro diversion would result in the collapse of the delta, already threatened by coastal erosion, jeopardizing the future of the lower Ebro valley and delta and their ecological and economic functions (Masjuan et al., 2008). Furthermore, voices from the scientific community also argued that the calculations by the Spanish Ministry of the Environment missed likely declines in Ebro flows during the next decades because of climate change (reductions in precipitation in the headwaters of the Ebro catchment) and also because of an increase in evapotranspiration in the same catchments caused by an expanding forest cover on former agricultural and pasture land.

The campaign against the plan included massive popular protests such as the large demonstrations in 2001 and 2002 in Barcelona, Zaragoza and Madrid as well as a "March to Brussels" followed by some 10,000 people. On their part, irrigation and tourist interests in Valencia and Murcia argued for the diversion under the slogan "*Agua* *para todos*" (Water for all) and were able to mobilize large numbers of "*Trasvase*" (water transfer) defenders.

The European Commission, which was asked to provide a substantial part (up to the 80 per cent) of the 6,000 million euro project, also showed considerable concern about the impacts on the delta and hence was reluctant to participate (El País, 2002). At any rate, the Spanish government decided to pursue the diversion with or without European funding (El Periódico de Aragón, 2003).

In March 2004, when national elections took place, some parts of the gigantic new water scheme were already under construction. However, the Popular Party lost these elections and the winning Socialist Party, who had opposed the Ebro project, formed the new Spanish government. One of the first actions taken by the Socialist government was to cancel the Ebro project and, as an alternative, implement the so-called "*Programa AGUA*" (AGUA Program) (Jefatura del Estado 2004, 2005 and Acuamed 2013b), which, among other actions, envisaged the construction of a number of desalination plants along the Spanish Mediterranean coast in order to compensate for the lost flows of the Ebro River (see Table 1 for a list of desalination plants included in the AGUA Program). These plants would join the desalination plants already in operation, under construction or planned along the Mediterranean coast. As expected, the reaction of the regional governments of Valencia and Murcia (both in the hands of the Popular Party) was very hostile to this change, partly because of the need to pay for the desalted water at cost per cubic meter beyond the capacity of farmers who, on the other hand, expected water from the Ebro at subsidized, smaller costs. A war on the relative costs and benefits of desalted versus water diverted from the Ebro ensued in the following months with unclear results. On the other hand, the European Commission, through Cohesion Funds, assumed without much debate, an important share of the costs of the Spanish desalination program (see Acuamed 2013a and 2013b) (up to 75 per cent of the total in some cases (such as the case of the desalination plant in Barcelona; see ATLL, 2014)) while it had been highly reluctant, as said before, to assume the costs of the Ebro project. Thus, out of the 3,600 million euro in the AGUA Program (not all of them for desalination plants as we will see) over 1,000 million euro came from European funds (Acuamed, 2013b).

-table 1-

The public company *Sociedad Estatal de Aguas de las Cuencas Mediterráneas* (*Acuamed*) led the development of an important part of the desalination plants included in the AGUA Program, with investments over 1,500 million euro (Acuamed, 2013b). To do so this state-owned society used their own funds, loans from financial organisms, among them the European Investment Bank, public funds from the European Union and contributions from the users. The construction of the plants, however, was handed out to private companies, most of them large contractors that had to adapt to the new paradigm once the Ebro transfer was cancelled. In table 1 (see also table 2 for the specific case of the *Mancomunidad de los Canales del Taibilla*) we can observe that while ownership of the desalination plants of the AGUA Program is held by the public sector (in many cases by *Acuamed*), plants were constructed by temporary consortiums (UTE in Spanish) of private companies, with an important presence of large Spanish contractors (Sacyr, FCC or Ferrovial) and international water utilities such as Veolia, Acciona and Suez Environnement. In most cases those companies have also assumed the operation and maintenance of the plants under a concession from 3 to 6 years (in the small plants) and from 15 to 25 years (in the big plants) (see tables 1 and 2).

-table 2-

From 2004 onwards, the expansion of desalination in Spain proceeded at a fast pace beginning with the plants located in the more arid parts of Valencia, Murcia, and Almería (see table 1). However, a number of factors soon proved that the demand for desalted water was grossly overestimated. First of all, a succession of relatively wet years in Mediterranean Spain filled up reservoirs and aquifers whose water could be obtained at much lower costs. More importantly, the expectations of urban growth made some city councils sign agreements for co-financing desalination plants in order to avoid land use laws restricting development in areas with insufficient water resources. After the burst in the real estate market in 2008, thousands of projected new homes were cancelled making redundant the need of water and leaving some municipalities unable to comply with the agreements signed to use desalted water (see for instance El País, 2012a). All in all, according to the Spanish Minister of Agriculture, Food and the Environment, in 2012 only 16 per cent of the total capacity of desalination plants in Spain was actually used (Cortes Generales, 2012, p.15). The disclosure of such data prompted the reaction of the European Commission who is now pressing Spain to justify the more than 1,000 million euro of European money spent in desalination in Spain during the last decade (El País, 2012b).

To show a more detailed case study of the reality of desalination in the Mediterranean coast of Spain, next we turn to the case of the *Mancomunidad de los Canales del Taibilla*.

4. Desalination and the reconfiguration of water supply sources in the *Mancomunidad de los Canales del Taibilla*

The *Mancomunidad de los Canales del Taibilla* (henceforth MCT), an autonomous public company ascribed to the Spanish Ministry of Agriculture, Food and the

Environment, is the third largest regional water supply company of Spain (after those of Madrid and Barcelona). It serves 78 municipalities in the provinces of Alicante and Murcia with a total population of some 2.4 million people (plus an additional one million in summer) and covers an area of some 12,000 square kilometers (see Figure 1). Moreover, during drought periods the MCT may also provide water to other coastal areas in the north such as the giant tourist resort of Benidorm.

-figure 1-

The initial source of water was local, from the Taibilla River. In 1979, water from the aqueduct Tajo-Segura was also incorporated in the supply system to be followed by desalted water since 2003, and by water rights purchased to several farming communities along the Tajo River during the drought years of the late 2000s (see Figure 2). This enhancement and diversification strategy followed the rationale of water supply augmentation through new resources, both conventional and non-conventional, especially after times of drought such as in the years 1981-1984, 1989-1990, 1991-1995, and 2005-2009. Currently, the MCT operates two desalination plants in Alicante (Alicante I and II) and two in Murcia (San Pedro del Pinatar I and II) with a total capacity of 96 MCM per year (see table 2). Moreover, the MCT signed an agreement with *Acuamed*, the state-owned company in charge of implementing the AGUA Program, to use 40 MCM per year from the Torrevieja plant (still not operative in 2013), 20 MCM per year from the Valdelentisco plant, and 10 MCM per year from the Águilas plant (see Figure 1).

-figure 2-

However, as we can see in figure 3, the MCT only used 44 MCM of desalted water in 2012, mostly from Alicante I and San Pedro del Pinatar I plants, while virtually no water was used from the aforementioned *Acuamed* plants. These figures show that desalination plants remain underused or even idle because desalination has not been able to capture the interests of water users in the area. Farmers, especially, are reluctant to sign up agreements with *Acuamed* because of the cost of desalted water. In part, this has been exacerbated by the strong increases of electricity bills since 2008 when, under direction from the European Union, Spain underwent the reform of the electricity market eliminating "protected tariffs". In 2008, the toll fee for energy production oscillated between 0.012 and 0.014 €/kWh, while in 2012 it had risen to 0.024-0.044 €/kWh[1]. This motivated a sharp increase in average electricity prices that, for industrial uses, grew from 0.08 €/kWh in 2007 to 0.14 €/kWh in 2012 (UNESA, 2013). Therefore, the increase in energy costs was the main driver behind the increase in production costs of desalted water from 0.32-0.36 €/m^3, in 2008, to 0.56-0.63 €/m^3 in 2012[2]. Taking into account that the electricity bill might represent around 55 per cent of the operation and maintenance costs of a desalination plant[3], it could be estimated that given current energy costs the real cost of producing desalted water would be situated between 0.9 and 1 €/m^3 if we take into account all ancillary charges. These real costs coincide with those calculated by the analysis of the real cost of water produced by the desalination plants of the AGUA Program by Del Villar García (in press). For instance, for the Mutxamel plant Del Villar García (in press) calculates a cost of 1.11 €/m^3 and for the plant in Torrevieja a cost of 1.03 €/m^3. Those figures, thus, are considerably higher than

[1] The interval indicates the fluctuation between diurnal and nocturnal electricity rates.

[2] Assuming that that average electricity consumption in a state-of-the-art desalination plant with energy recovery mechanisms oscillates between 4 and 4.5 kWh/m^3

[3] This figure varies from one plant to another. But for instance, in the case of the desalination plant of Barcelona energy costs are estimated to represent 64 per cent of operation costs (Campos, 2009), while from the data by Acuamed (2007) and Acuasegura (2007) for the Mutxamel and Valdelentisco plants it can be calculated a percentage around 55.7 and 55.3, respectively. However, from the data presented by Estevan (2008b) we can observe that this percentage might vary across years, location characteristics of the plant, and capacity and operation routines of the plant.

the figure estimated in 2007 by *Acuamed* whose design projects for plants in the MCT area envisaged costs between 0.58 €/m^3 in the Valdelentisco plant (70 MCM/year) and 0.68 €/m^3 in the Mutxamel plant (18 MCM/year) (Acuamed, 2007, Acuasegura, 2007 and Ministerio de Agricultura, Alimentación y Medio Ambiente, 2013a). At these cost levels, farmers, who pay around 0.10 €/m^3 for subsidized surface water (Ministerio de Agricultura, Alimentación y Medio Ambiente, 2013b) plus the costs of the irrigation communities (with a final price of water normally between 0.20 and 0.30 €/m^3), are unable to afford desalted water unless a subsidy (above 0.60 €/m^3) is provided (Rico-Amorós, 2010).

-figure 3-

The evolution of urban and tourist water consumption in the 1990s and early 2000s, on the other hand, appeared to justify the recourse to desalination. Until the early 1990s, water consumption grew especially in the coastal towns but from then onwards urban expansion also engulfed municipalities located inland. One stunning example is Torrevieja, the water consumption of which increased from 0.8 MCM in 1975 to more than 4 MCM in 1994, as a result of the creation of more than 1,400 hectares of new urban land and the presence of some 400,000 people in summer (Rico Amorós, 2007).

During the second part of the 1980s, water served by the MCT increased from 131.2 MCM per year in 1984 to 191.3 MCM in 1991. This was to a large extent related to a vigorous demand by tourist areas. However, in 1991 a drought cycle began affecting much of Spain to the point that, in the MCT case, water served had fallen to 167 MCM in 1996. From this year onwards, consumption recovered and expanded again to reach 225 MCM in 2007 (Figure 2) (Andrés Martínez, pers. comm., 2013). This trend, however, presented a rather marked unevenness and thus in large cities such as Alicante, Elche or Murcia, stabilization or even decrease could already be noted in the

1990s. Most of the growth in water consumption, therefore, took place in medium and small urban and tourist settlements.

5. Desalination, decreasing consumption and the collapse of urban growth in Mediterranean Spain

The first half of the 2000s coincided with the real estate boom in the MCT area and in the Mediterranean coast in general upon which, and as argued before, the construction of desalination plants under the AGUA Program was justified. Nevertheless, since 2007, or even before as we have shown for some municipalities, many cities and tourist centers of the Spanish Mediterranean coast began to observe a decrease in water consumption (AEAS and AGA, 2012). There are a number of factors that may explain this trend. At the household level reductions in consumption are, in part, responses to water conservation and awareness campaigns (March et al., 2013) or socio-demographic changes (March et al., 2012). Perhaps more important are technical improvements in water delivery systems reducing leaks and other losses. Better delivery systems have implied that the efficiency of the water network serving urban households in the larger cities of Valencia and Murcia has increased and, consequently, the final consumption has decreased (Asunción Martínez, pers. comm., 2013). Alicante, for instance, went from 30.7 MCM in 2004 to 29.4 MCM in 2006 with an overall efficiency in distribution of 85 per cent. Perhaps the most striking aspect in this respect is the city of Murcia. In 1987 when the resident population was 309,000, water delivered to the municipal network attained 35.8 MCM but water finally metered in households was only 18.9 MCM. In other words, the efficiency of the network barely reached 57 per cent. In 2006, with a population of 427,000, water consumption had fallen to 34 MCM (of water delivered to the city) thanks to a large extent, to improvements in the network that made efficiency rise to 85 per cent of the water delivered (Gil Olcina and Rico Amorós, 2008). Figures are even better in tourist areas with concentrated, vertical urbanism (i.e. high density multi-storey buildings) such as Benidorm, where efficiencies attain 90 per cent or more (Rico et al., 2009 and Rico et al., 2013).

At the same time, projected upward trends in water demand due to the continuous expansion of urbanization failed to materialize with the collapse of the real estate sector beginning in 2008. For example, in Valencia, in 2005 some 227,000 housing permits were granted by local planning commissions. In 2011, this figure had been reduced to 23,000; that is only 10 per cent of those given six years before (Hernández et al., submitted).

Both factors have contributed to the downward trend in water consumption in the MCT area observed since 2007. In 2010 the total quantity of water delivered to the system, 201 MCM, contrasts with the 234 MCM delivered in 2008 (see Figure 2). Regarding sources, both the amount received from the Tajo-Segura aqueduct and of desalination plants decreased whereas the amount provided by the Taibilla River had increased thanks to a series of relatively wet years in the area. Reductions in water delivered, as said, are largely attributable to reductions in demand in municipalities which may have fallen between 5 and 10 per cent between 2004 and 2010, or even more in the larger municipalities such as Alicante or Elche where the reduction attains 15 per cent in the first case and 17 per cent in the second (Asunción Martínez, pers. comm., 2013).

According to studies in the mid-2000s (Confederación Hidrográfica del Segura, 2007) water demand in 2025 in the MCT area would be situated in the vicinity of 340 MCM a year. In 2012, the water supply potential of the MCT amounted to 361 MCM per year provided by the Tajo-Segura Aqueduct (131 MCM), the Taibilla River (70 MCM), and desalination plants (160 MCM). Moreover, agreements with irrigation communities along the Tajo River could add an extra 36 MCM. Hence, the total capacity of the system could approach 400 MCM/year. This contrasts with a demand that in 2012 had declined to 194 MCM. After these trends, the *Confederación Hidrográfica del Segura* (2013) lowered substantially the water demand figure expected for 2015 and 2027 to 220 and 257 MCM, respectively. All in all, therefore, the capacity of the MCT system exceeds by more than 200 MCM the current demand. While this margin appears wide enough to offset scarcities caused by future droughts (thanks to the extra capacity of desalination plants) it is also true that the cost of "secure" (i.e. desalted) water would only be affordable by urban and tourist interests and not by farmers who currently use only a very small fraction of the total desalted water produced. As Rico-Amorós (2010) points out, very few farmers can assume costs of water beyond 0.20-0.30 €/m^3 no matter how secure and reliable the source may be as it is with desalination. Farmers therefore turn to other options such as treated wastewater, water purchased from other irrigation communities, or even desalted water mixed with other water sources to decrease costs.

6. Conclusions: Desalination, cornucopia for whom?

In this paper we have focused on the expansion of desalination in Spain since the mid-2000s, which we have defined as the newest mutation of a water planning and management approach strongly based in the enhancement of water supply sources rather than in the management of water demand. We have situated the emergence and expansion of desalination in this country within the debates and conflicts surrounding the National Water Plan of 2001 and the cancellation of the Ebro transfer to Mediterranean regions in 2004. Under the name of AGUA Program, desalination at a grand scale was offered to the Spanish Mediterranean Coast as a conflict-free alternative to provide water for presumably booming agriculture and, especially, urban –tourist demands.

The rationale of desalination was built on two premises. First, costs at least equal or inferior to other large-scale alternatives, and second, expanding demand after the boom in the urban and tourist sector of the mid-2000s. Both premises failed to materialize because costs (and more so after the important price hikes in electricity in Spain since 2008) made desalted water unaffordable for some users, such as farmers, and uncompetitive for urban and tourist users who could access cheaper water sources. Likewise the expected increase in water demand linked to the massive urbanization of the Mediterranean coast also failed to materialize after the burst of the real estate bubble in 2008. But there are other causes also partially responsible for the failure of desalination; among them a relatively benign climatology with abundant precipitation in the last 4-5 years and also important structural changes in water demand such as the increase in the efficiency of the delivery networks.

In 2013, many desalination plants operate at a very low capacity, the construction of others suffers considerable delays, and still others may not be built as envisaged, at least in the short and medium term (see Table 1). The overcapacity in water production contrasts with the economic, social and territorial landscape left by the real estate crisis and the many unfinished residential developments that supposedly were to be "watered" by desalination. In one sense, desalination is no different than other large-scale and costly infrastructure planned and built during the years of the Spanish economic "miracle" be these power plants, high speed train lines or convention centers; and in that sense desalination plants are a continuation of the business-model of the hydraulic Spanish paradigm with big contractors being awarded lucrative concessions. We have observed that despite publicly-led, the construction and operation of desalination was handed out to building companies and water utilities, which quickly adapted to the new water supply framework, in which desalination had a major role. It is not a coincidence, therefore, that 6 out of the top 20 world desalination water providers were Spanish companies: Befesa Agua, ACS, Acciona Agua, Sadyt, Cadagua and Aqualia (Fundación Cajamar, 2009).

Desalination also exemplifies the continuation of the subordination of water planning to urban and regional planning based on growth scenarios. Rather paradoxically but perhaps not surprisingly, the failure of harmonizing both planning processes has not resulted in insufficient water quantities to cover demand but rather in overcapacity in the water supply system. We argue that the massively idle capacity of desalination plants in Spain is the result of a mismatch between forecasted scenarios of intensive urbanization and ensuing increase in water demand and the harsh reality brought about by the economic crisis since 2008. To a much lesser extent this overcapacity could be attributed to the conscious decision to have a strategic water reserve.

While this overcapacity diminishes the risks of future droughts, the fact that to a large extent it is based on desalination introduces the issue of relative scarcities. In other words, water scarcity for the urban and tourist sectors of the Spanish Mediterranean coast could be overcome with desalination but water scarcity for agricultural users would not vanish but probably become more common as traditional supplies dwindle and the area moves into the next dry cycle.

In a context of more promising alternatives, some of them already considered by the AGUA Program, desalination (as water transfers) appears to be increasingly problematic (Olcina- Cantos et al., 2010). Those alternatives might include local-based sources such as treated wastewater use, greywater reuse or rainwater harvesting (despite issues on acceptability or energy use in some of them) (Baldwin and Uhlman, 2010, Domènech et al., 2013 and Domènech et al. 2014). It may also include the proliferation of water trading mechanisms, if they do not compromise environmental flows and socio-economic life of the population in the donor basins, between the farming sector and urban and tourist centers for exchange of water of different qualities (already active in places such as Benidorm, see Rico et al., 2013). But above all, it should include water demand management measures.

In this sense and as the newest expression of the hydraulic paradigm, with large investments locked in (sometimes redundant) infrastructure, desalination will occupy an important role in Spanish water planning and management in the coming years but probably not the leading role as the AGUA Program envisaged. The Spanish case may serve as an example, altogether with other examples such as Australia (Baldwin and Ulhman, 2010), of the need to be cautious when preparing water plans strongly based in just one source of supply ignoring more integrative views (including other water alternatives), accurate forecasts and projections of water demand, and integration between water and urban/regional planning scenarios.

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CAM e Instituto Universitario de Geografía, Universidad de Alicante, Alicante, pp. 179-200

Figure 1. Supply area of the *Mancomunidad de los Canales del Taibilla* (MCT). Source: own elaboration. Note: desalination plants directly operated by MCT are San Pedro del Pinatar (I and II) and Alicante (I and II). 1 Hm^3 is equivalent 1 million m^3 (MCM).

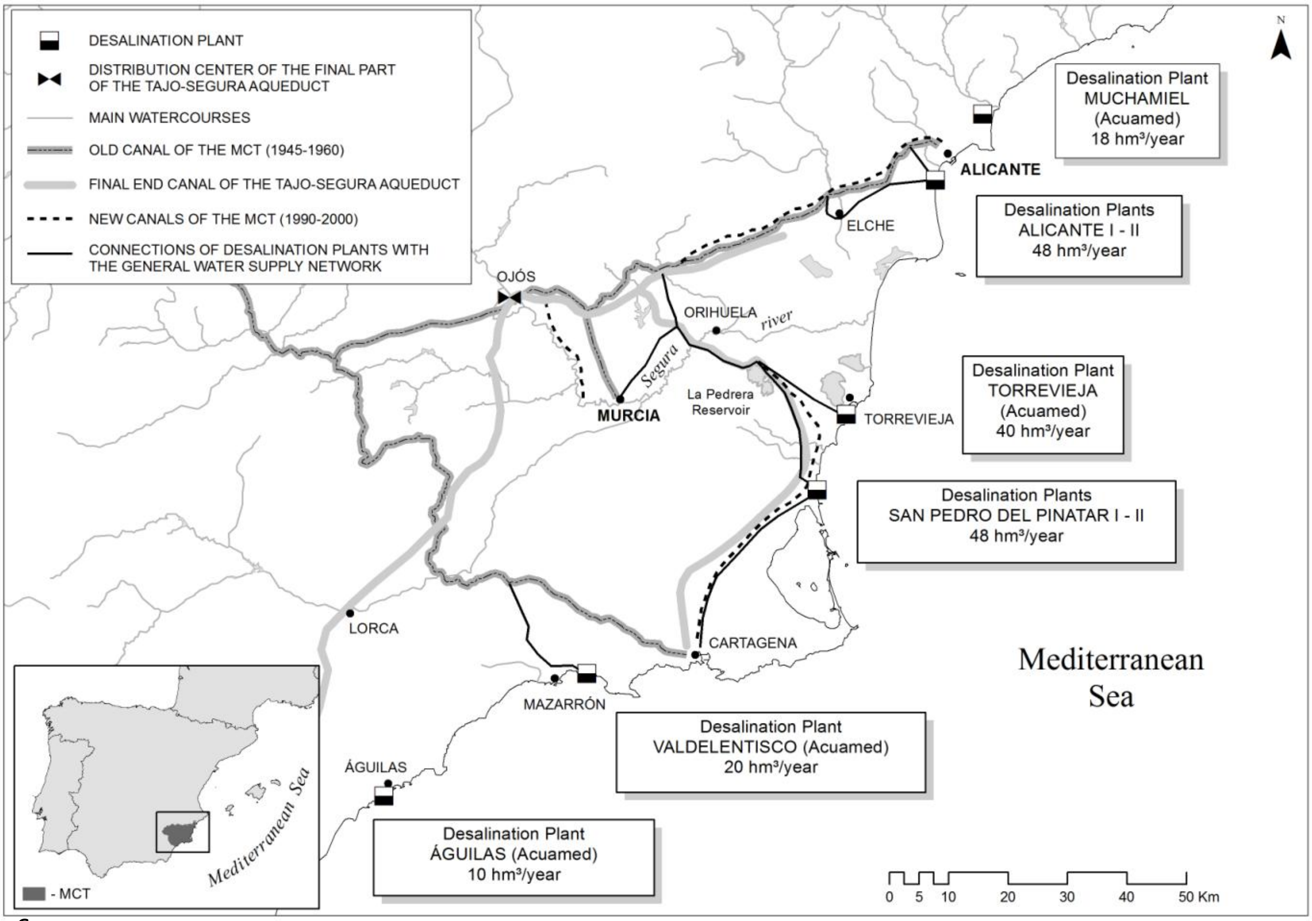

Figure 2. Water sources of the *Mancomunidad de los Canales del Taibilla*, 1989-2012 (in thousands of cubic meters). Source: own elaboration from data provided by the *Mancomunidad de Canales del Taibilla* (Andrés Martínez, pers. Comm., 2013)

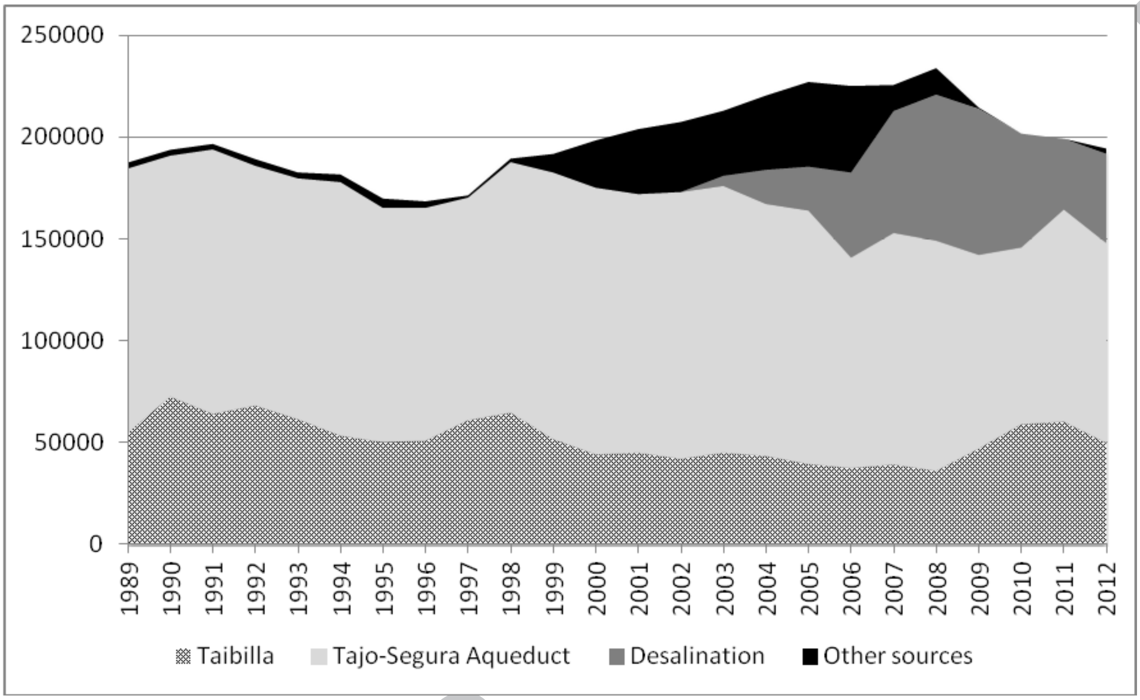

Figure 3. Desalted water used (in MCM) by the MCT in 2011 and 2012. Source: own elaboration from data provided by the *Mancomunidad de los Canales del Taibilla*

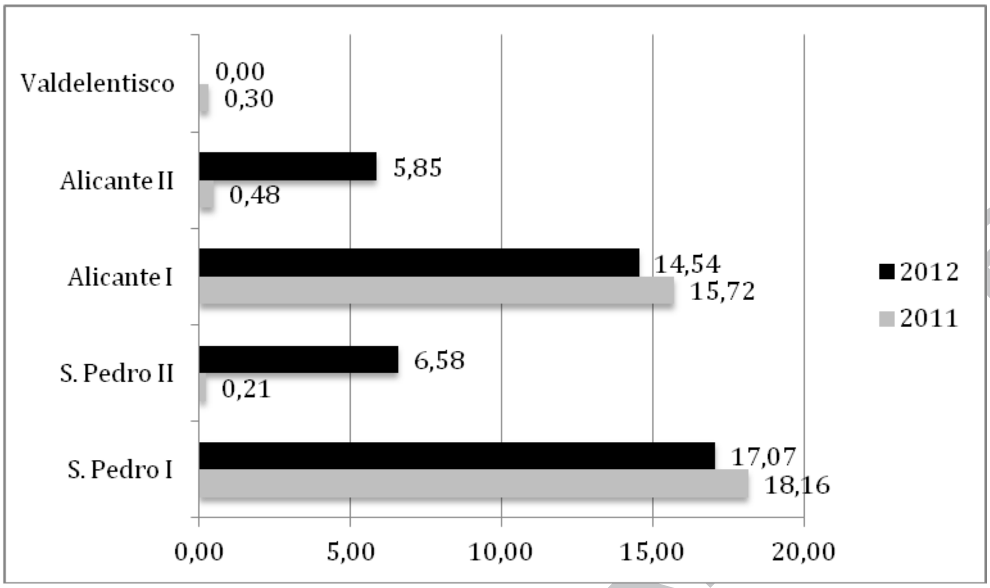

Table 1. Current status of the most important desalination plants included in the AGUA Program. We have included concessions duration when available. Compiled from the following sources: Ministerio de Agricultura, Alimentación y Medio Ambiente (2013), Acuamed (2013a, 2013b), ATLL (2014), Copisa (2009), Cadagua (2014), Degrémont (2014), Gobierno de Canarias (2009), Infobalear (2009), Periodista Digital (2005), Sacyr (2013). The investments might slightly vary according to the source of Acuamed (Acuamed 2013a or 2013b).

Note: MAGRAMA: Ministerio de Agricultura, Alimentación y Medio Ambiente; UTE: *Unión Temporal de Empresas*, Temporary Consortium of Contractors; ACA: Agència Catalana de l'Aigua; ABAQUA (Agència Balear de l'Aigua i la Qualitat Ambiental)

LOCATION	**Pop. served**	**Irrig. area (Ha)**	**Cap. water prod. (MCM)**	**Ownership**	**Construction, operation and maintenance**	**Invest. M €**	**Current state**
Telde II (Canarias)	94,000	0	5.6	MAGRAMA and Canary Islands Government	UTE Acciona Infraestructuras and Acciona Agua Exploitation and management Was handed out in 2013 to the mixed capital company Aguas de Telde.	16	Finished in 2011. Remains unused.
El Prat de Llobregat	Over 4.5 Million	0	60	Catalan Government (ACA)	UTE Degrémont Suez, Drace, Agbar Concession until 2012 to Agbar. Now operated by ATLL.	230	Finished and operational since 2009.
Bahía de Alcudia (Mallorca)	49,000	0	4.9	MAGRAMA and Balearic Islands Government (ABAQUA)	UTE Sadyt-Sacyr Concession: 15 years	24	Finished in 2010. Operates at 15 % of capacity, especially during summer.
Andratx (Mallorca)	525,000	0	4.9	MAGRAMA and Balearic Islands Government (ABAQUA)	UTE Degrémont Iberia (Suez Environnement) and Copisa Constructora Pirenaica Concession: 15 years	51.9	Finished in 2010. Remains unused
Torrevieja (Alicante)	440,000	8,000	80	Acuamed	UTE Acciona Infrastructuras and Acciona Agua, Infilco Española, Pridesa Proyectos y Servicios and Romymar Concession: 15 years	300	Pre-operational (testing phase) but no agricultural users.
Bajo Almanzora (Almería)	140,000	24,000	15	Acuamed	UTE FCC Construcción, Befesa Construcción y Tecnología Ambiental, Servicios y Procesos Ambientales (SPA) and Aqualia Concession: 15 years	88	Operational until 2012. In September 2012 the plant was flooded by heavy rains. By September 2013 the plant was not operational
Valdelentisco (Murcia)	400,000	7,577	48	AcuaSegura, integrated into Acuamed in	UTE Ferrovial-Agroman S.A and Cadagua Concession to Cadagua: 4-6 years, for 15 M Euros.	224	Operational. In 2012 was unoperational. No tourist uses. Concession in 2012 to Cadagua for 4 to 6 years for 15 Million

				2010			euros.
Campo de Dalías (Almería)	300,000	8,000	30	Acuamed	UTE Veolia Water Solutions, Construcciones Sando, Inypsa and Crescencio Pérez Concession: 15 years	130.3	Under construction
Oropesa del Mar (Castellón)	150,000	0	18 (extenisble to 43)	Acuamed	UTE Técnica Reunidas S.A., Ionics Ibérica S.A.U., Torrescámara y Compañía de Obras S.A. and Constructora Hispánica S.A. Concession duration not available	55.4	Under construction. No tourist uses
Moncofa (Castellón)	120,000	0	11 (extensible to 21)	Acuamed	UTE GS Inima, Isolux Ingeniería S.A., Renos S.L., Sociedad de Fomento Agrícola Castellonense S.A. and Corsan Corvian Construcción S.A. Concession: 2 years (2012 and 2013) to Inima	49.1	Under construction. No tourist uses
Sagunto (Valencia)	62,500	0	8	Acuamed	UTE Pavasal Empresa Constructora S.A. and Luís Batalla S.A.U. (LUBASA) Concession; 3 years	37.3	Pre-operational (testing phase) but no industrial or tourist uses
Mojón (Murcia) (expansion of a brackish water plant)	0	36,200	6	Acuamed	UTE Telecontrol, Tecnología Canaria del Agua, Depuración de Aguas del Mediterráneo and Villegas Construcciones Concession: 15 years for 31.1 M euro	30	Operational
Águilas (Murcia) (expansion)	130,000	9,600	70	Acuamed	UTE Sadyt (Sacyr), Ferrovial, Agroman and Cadagua Concession: 15 years	238.3	Pre-operational. No urban-tourist demand. Project to irrigate agricultural areas inland some 300 meters high
Denia (Alicante)	65,000	0	5.8	Acuamed	UTE Cobra Instalaciones y Servicios S.A., Técnicas de Desalación de Aguas S.A. (TEDAGUA), Compañía Levantina de Edificación y Obras Públicas S.A. (CLEOPS), Construcciones Luján S.A. and Saneamientos Marítimos S.A. Concession: 3 years	27.1	The Denia city council cancelled the Project in 2011
Mutxamel (Alicante)	200,000	0	18	Acuamed	UTE Degrémont Iberia (Suez Environnement), Drago Sub, Rover Alcisa and Acsa Obras e Infraestructuras Concession: 3 years	90	Pre-operational No urban-tourist demand
Costa del Sol (Mijas, Málaga)	750,000	0	21	Acuamed and Agencia Andaluza del Agua	UTE Sacyr-Sadyt and Construcciones Vera Concession: 3 years	62	The Mijas city council blocked the construction in 2011

Table 2. Construction, operation and maintenance of desalination plants owned by the *Mancomunidad de los Canales del Taibilla* (MAAMA). Source: MCT (2014), BOE (2012) and Ministerio de Hacienda y Administraciones Públicas (2009)

Plant	Construction, Operation and Maintenance	Concession
San Pedro I	UTE Proyectos e Instalaciones Industriales, S.A. and Abengoa, S.A. (currently BEFESA Construcción y Tecnología Industrial, S.A.)	15 years
San Pedro II	UTE Acciona Agua and Degrémont S.A.	Renewable every 1 year
Alicante I	UTE Ferrovial-Agroman S.A., Necso Entrecanales Cubiertas S.A., Infilco S.A. and Cadagua S.A.	15 years
Alicante II	UTE OHL Medio Ambiente Inima and Construcciones Alpi	Renewable every 1 year

Highlights

> We develop a critical and reflexive perspective on the use of desalination in Spain

> Desalination plants were massively implemented by means of the AGUA Program

>We focus on the *Mancomunidad de los Canales del Taibillla* in South-eastern Spain

> High price and the crisis of the building sector explains the low use of desalted water

> Other alternative water sources and demand-side management should be promoted