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The use of rainwater in Alicante (southeast Spain). A new urban approach to urban water management

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Highlights

- Rainwater can mitigate water scarcity in urban environments.
- Rainwater harvesting improves the sustainability of drainage systems: storm water runoff is reduced.
- Rainwater harvesting collects the pollutant load from urban areas and so reduces pollution in disposal areas.
- Rainwater can replace drinking water in various uses.

Abstract

The Mediterranean Spanish coastal has witnessed since the 1960s a spectacular increase in residential construction and beach tourism. This process has led to an increase in water consumption and greater risk of flooding. This is related, on the one hand, to the increase in population and housing and, on the other, to the occupation of risk areas. The aim of this research is to show and examine the importance and potential that rainwater has in the hydro-social cycle in the city of Alicante for increasing water supply for certain uses (watering gardens, street cleaning, etc.) and mitigating flooding. Databases from the local water company (*Aguas Municipalizadas de Alicante Empresa Mixta SA* - AMAEM) have been analysed as part of this research. Interviews have also been carried out with the technical staff of the water company to collect data and qualitative information. The analysis highlights the interest in the city of Alicante for the adoption of green infrastructure to, on the one hand, reduce the risk of flooding and, on the other, increase the available water resources. Using rainwater would enable a reduction in the use of drinking water for certain municipal water uses, and reduce pollution and flood risk during storms.

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1. Introduction

Since the late 1990s, and particularly since the start of the current century, a large number of studies have highlighted the consequences of low-density urban development in Europe (EEA, 2006). This type of development is common along much of the Spanish Mediterranean coastline, including the Balearic Islands (Artigues & Rullán, 2007), Costa del Sol (Raya & Benítez, 2002), Murcia (Monreal, 2001), Catalonia (Padullés, Vila & Barriocanal, 2014) and Valencia (Morote & Hernández, 2016). Such developments are also common along other European Mediterranean coastlines such as the French Cote D'Azur or Italy (Salvati & Sabbi, 2011), as well as in Florida (Fernández & Barrado, 2011) and Australia (Troy & Holloway, 2004). The European Environment Agency published a report in 2009 forecasting that between 1995 and 2025 urbanised land areas would increase by 55% to 73%. Water and urban development share deeply interwoven historical links (Swyngedouw, 2015). Cities depend on reliable water sources for their expansion while urbanization has enormously modified local, regional, and even national water cycles (Vallès-Casas et al., 2016). Over the last decade, there has been growing interest in innovative water management practices, thus breaking away from conventional 'end of pipe' approaches. In the European Union, the emphasis is on 'sustainable' and 'integrated' water resource management and this is reflected in the Water Framework Directive (Directive 2000/60/EC). The demand management approach must be assessed within the scope of a broad and integrated water resource management (IWRM) in which supply and demand combine to produce efficient mixtures that decrease the urban need for freshwater (Stephenson, 1999). According to the IWRM philosophy, previously ignored water resources within the urban cycle are being rediscovered under the concept of fit for purpose (Brown et al., 2009), i.e. the assumption that water has many qualities and not all water uses (urban, industrial, agricultural, environmental and recreational) require the same quality. The IWRM approach and non-conventional water resources (rainwater, treated wastewater, and greywater) also herald new forms of governance and control of the urban water cycle (Sedlak, 2014).

Non-conventional water resources occupy a key role in strategies for the integrated management of water resources, often together with measures of demand management. Rainwater harvesting (RWH) is recognised as an effective tool for improving the sustainability of urban drainage systems by increasing water security (limiting demand for drinking water) (Mercoiret & Howsam, 2007; Domènech, March & Saurí, 2013) and reducing negative impacts on the environment (for example, by mitigating the generation of storm water runoff) (Williams, 2007; Campisano et al., 2013). Changes in land use in recent decades in urban and tourist centres of the Mediterranean coastline have caused a disorganisation and alteration of the natural rainwater collectors that, together with an increase in soil sealing, have produced an increase in the frequency and severity of flooding. Hence the failure in many cases of the evacuation strategies for these flows and the adoption of a series of stormwater management initiatives ranging from the construction of large holding tanks for storm flows to the creation of sustainable drainage systems and water-sensitive urban design (Perales-Momparler et al., 2016). Water-sensitive urban design is a planning and design philosophy for minimising the hydrological impacts of urban development on the environment (Morison & Brown, 2011). It is an integrated water management system that encompasses low-impact design, water conservation and recycling, water quality management, and urban ecology (Donofrio et al., 2009). According to Saunders and Peirson (2013), water-sensitive urban design provides an effective method for improving discharge water quality, providing water storage capacity, and achieving peak flow attenuation. Studies on floods and sustainable urban drainage systems have been carried out since the 1980s (Krejci & Gujer, 1985). Australia, USA, UK, and Germany have been the centres of research on this subject (Rahman et al., 2017).

Many urban areas suffer from water scarcity although, paradoxically, a local source of water – such as rainwater – is mostly treated as a risk rather than a valuable resource. Rainwater and its use could play a central role in increasing water security and reducing negative impacts on the environment According to Domènech & Saurí (2011) rainwater harvesting may turn hazards (floods and polluted water) into local resources. Harvested rainwater can be used to water gardens, flush toilets, and wash clothes (Mercoiret & Howsam, 2007). These sources are seen as the basis of a change in water management and a possible alleviation for shrinking water resources (Gires & De Gouvello, 2009).

The importance of these resources and the management of storm water runoff take on special importance in the light of climate change (IPCC, 2018) and how to adapt societies to global changes. According to Notaro, Fontanazza, Freni & Puleo (2013) an increase in heavy rains and severe droughts in the Mediterranean accentuates the need to adapt water management to new and challenging environmental and socio-economic conditions. The storage and use of rainwater could improve the resilience of territories to climate change (Morote & Hernández, 2017). In terms of sustainable urban drainage systems, rainwater harvesting also reduces surface run-off and minimises the risk of flooding.

The use of rainwater for urban uses is a technique practiced in many developed countries to mitigate water scarcity (Fisher-Jeffes et al., 2017), and it has also been adopted in developing countries (Jing et al., 2017). Recently, it has become a particularly important option in arid and semi-arid areas – mostly because of its numerous benefits and affordable costs (Ursino, 2016).

2. Study area, Objectives and Methodology

The study area (city of Alicante, Southern Spain) has witnessed a marked increase in urban land as a consequence of the spread of residential developments and beach tourism since the 1960s – favoured by warm weather and the arrival of sun-seeking European retirees (Morote et al., 2016). Urban land use has grown from 16.2 million m^2 in 1978 to 45.8 million m^2 in 2015 (an increase of 182%). It is important to note that constructions are mostly low density (detached houses) (15.8 million m^2; 34.4%) (Morote, 2015). The intense urbanising process between 1997 and 2007 increased soil waterproofing and the use of floodplains (Pérez-Morales et al., 2015). In addition, several ravines have been urbanised and this has accentuated the risk of flooding. According to the latest census (INE, 2018), the city of Alicante has 329,988 inhabitants and 186,516 households (18% and 14.03% of the total in the province, respectively). The city has a semi-arid climate with an average rainfall of 311 mm/year and recurrent cycles of drought with heavy rains concentrated mostly in the autumn months (Gil & Rico, 2007). For example, on 30 September 1997 some 270 millimetres of rain per square metre fell in just five hours. In contrast, just 224 mm of rain fell in 2014. The hydrogeological balance (water in the soil) for average values of precipitation and potential evapotranspiration reveal a deficit estimated at 438 mm/year (Murillo et al., 2009). It is forecasted that rainfall will become more intense in this area as a consequence of climate change (IPCC, 2018).

The dryness of the climate combined with the increase in consumption as a result of increased population, the number of dwellings, and changes in the urban model are reflected in the configuration of complex hydrosocial cycles. These are visible in: 1) the creation of complex distribution systems; 2) the diversity of users; and 3) the use of resources of diverse origin (transfers from the Tagus to Segura rivers -TSA-, aquifers in the northwest of the province, desalination, and reuse). The water is supplied to the city by the *Comunidad de los Canales del Taibilla* (MCT) (a public company) and delivered by *Aguas municipalizadas de Alicante, Empresa Mixta S.A.* (AMAEM), a mixed public and private company. The percentages from different sources of supply vary from year to year. This is conditioned by several factors, including the amount of water that is received from river transfers and the amount extracted from the Alto and Medio Vinalopó aquifers. Variability in the first two (associated with periods of drought) can result in an increase in the use of desalinated water. For example, for the year 2017, water from the MCT totalled 17.67 hm^3 and 5.56 hm^3 was pumped from the aquifers. Desalinated water accounted for approximately 60% of the water supplied by MCT. This is the highest ever value and a result of the intense drought affecting Spain that reduced flows from river transfers (18.7%) (Morote et al., 2019).

Since the middle of the first decade of 2000, the decline in drinking water consumption has become widespread throughout Spain and in other conurbations in developed countries (Gil et al., 2015; March & Saurí, 2016). In the case of the city of Alicante, the consumption of invoiced household water reached its peak in 2004 with a total of 16.93 hm^3, decreasing in 2017 to 14.43 hm^3, a decrease of 20.47% (Morote et al., 2016). This tendency has been caused by various structural and conjunctural causes. In relation to the structural causes, we should highlight: an improvement in efficiency; an increase in the price of water; the success of environmental awareness campaigns

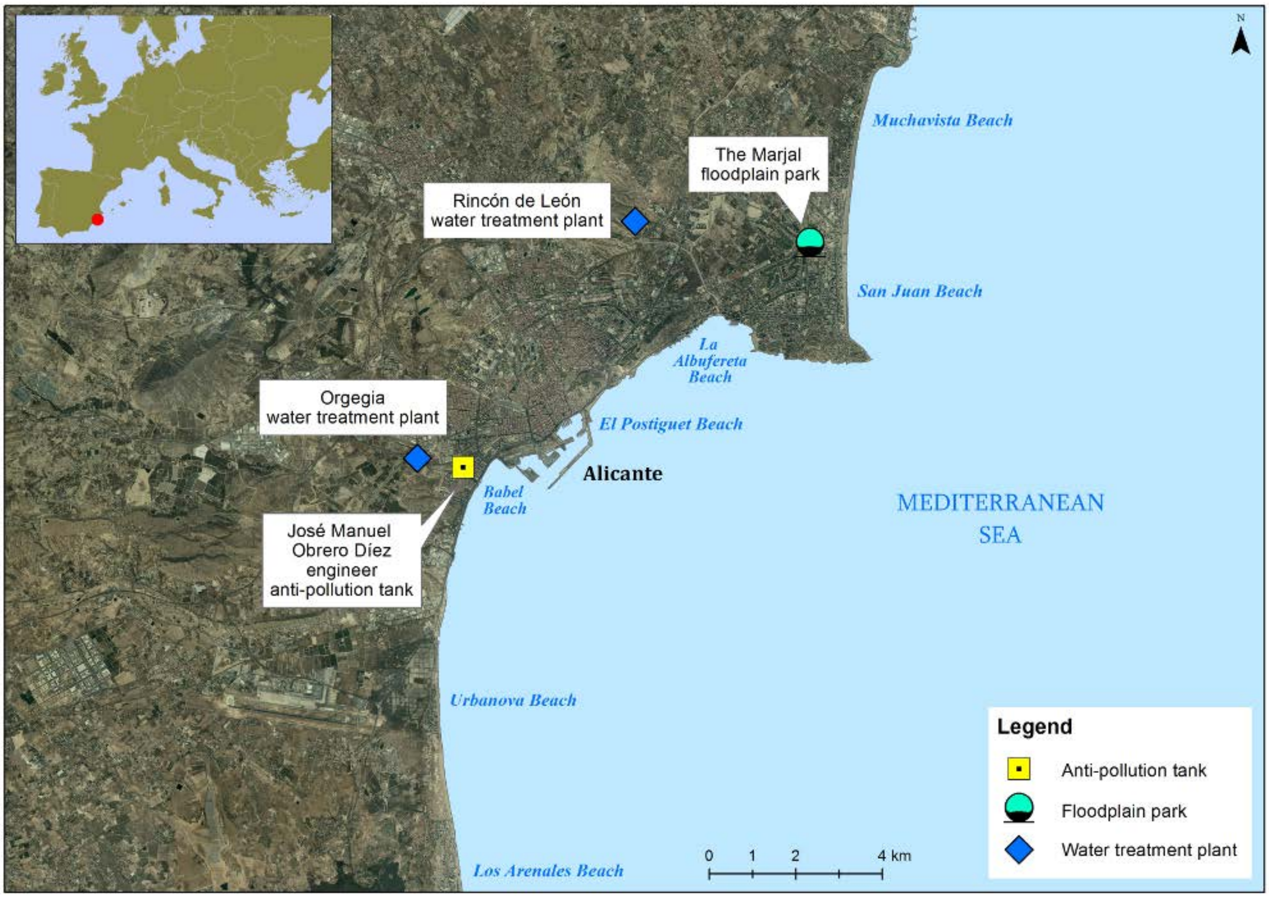

Figure 1: Location of storage and collection of rainwater facilities in Alicante. *Source: Plan Nacional de Ortofotografia aérea (PNOA) and Authors' elaboration.*

aimed at reducing water use; and the use of treated reclaimed water and, to a lesser extent, rainwater. Both of these non-conventional water sources, after treatment, have replaced a large percentage of drinking water for several urban uses – such as the irrigation of public and private gardens or street cleaning. The use of reclaimed water has increased remarkably in the last decade. Since the implementation of a reuse plan in the city of Alicante in 2002, the volume has increased from 39,358 m^3 in 2002 (only for municipal uses) to 1,141,456 m^3 in 2017, of which 57.80% was supplied to the city council and the rest to individuals (Morote & Hernández, 2017). The use of purified reclaimed water has been facilitated with the creation of a double distribution network since 2004. The progressive increase in the areas accessing these waters has resulted in an increase in irrigated areas. Treated water represented 4.79% of the total drinking water supplied in 2017 in Alicante. This has enabled some 80% of the green areas of the city to be maintained with treated water (446 ha). This process, as well as creating economic, energy, and environmental savings, has made it possible to triple the size of parks and other environmental areas over the last ten years (Morote et al., 2019).

The objectives of this research are to: 1) analyse the current use of rainwater in the city of Alicante; 2) show and examine the importance and potential of rainwater in the hydro-social cycle; and 3) pinpoint the strengths of this resource. The interest of this study is that rainwater can become a strategic resource and therefore improve the environmental sustainability of the city of Alicante. The evolution and the importance of rainwater over the last few years will be analysed. Rainwater is considered to be an alternative water resource in Alicante, which, apart from increasing the city's water supply, may help resolve pollution and mitigate the risk of flooding in several neighbourhoods. The hypothesis of this research is that rainwater is becoming increasingly important in the planning and management of water resources in urban-tourist areas of the Spanish Mediterranean coastline. However, at the same time, there is still limited knowledge about the characteristics of these flows of water, their history, degree of implementation, and in particular, their role in local hydro-social cycles.

To achieve the aims proposed, quantitative and qualitative methods and data were combined. Quantitative technical data on the use and storage of rainwater was obtained from the AMAEM water company. AMAEM manages two infrastructures: the '*José Manuel Obrero Díez* Engineer anti-pollution tank', located in the *San Gabriel* neighbourhood (south of the city) and the '*Marjal* Floodplain Park' (northeast of the city) (Figure 1).

A questionnaire was prepared under the title 'Study on the use of rain and storm water in the city of Alicante. From risk to alternative water resources', and the objective was to collect information on:

1. technical data;
2. objective of the infrastructure;
3. monthly and annual volume of stored rainwater (m^3) since operation;
4. end-use and final destination of these waters;
5. weaknesses and strengths of this infrastructure.

This survey was complemented by data on the total water supply and the use of reclaimed water for 2000-2017. This data enabled including the use of rainwater in the hydrosocial cycle of the city. For qualitative data, several semi-structured interviews were carried out in April 2018 with managers and technicians from the company that manages the two green infrastructures. Collecting qualitative information about the current status, advantages, disadvantages, and future projects regarding the potential use of this resource was possible. These were completed with a visit to the two green infrastructures.

3. Green infrastructures and a new approach to rainwater in Alicante

As water demand increased, the spread of developments with outdoor uses and repeated flooding in some sectors of the city gave rise to a change in the approach to urban water management. These changes were aimed at achieving greater sustainability. Since the beginning of the 21st century, non-conventional water resources have begun to be used (reuse of treated wastewater). In recent

Figure 2: The inside of the anti-pollution tank is shown. *Source: the Authors.*

years, AMAEM has been integrating rainwater into the hydrosocial cycle (after being treated in sewage treatment plants) with the aim of:

1. increasing water supply for watering public and private gardens and street cleaning (after treatment);
2. harvesting rainfall runoff to minimise the risk of flooding in low lying and urbanised sectors of the city (ravines, marshy areas, etc.);
3. reducing pollution caused by urban surface drainage given the high percentage of lead contained;
4. mitigating the disruption generated by these discharges on the beaches and the resulting loss of water quality.

The last two factors are important issues in the city given the importance of beach tourism.

AMAEM has carried out two initiatives in rainwater harvesting: the *José Manuel Obrero Díez* Engineer anti-pollution tank and the *Marjal* Floodplain Park.

The origin of the first of these infrastructures goes back to 2006. As part of a special investment plan, AMAEM approved the construction of a 14-meter deep tank (Figure 2) costing €15.7 million. It is located in the basement of the Juan Antonio Samaranch Sports Centre and has a maximum storage volume of 60,000 m^3. It is intended to:

1. harvest the initial runoff generated by approximately 50% of the urban spaces in Alicante. This water contains high levels of pollution. In this way, the number and volume of pollutant discharges through spillways at the mouth of a ravine (*Barranco de las Ovejas* in Spanish) into the sea are reduced;
2. significantly improve problems related with overflowing drains and waterlogging in the central and southern areas of Alicante on extreme rainfall days and avoid the collapse of sewage networks.

Once the water is harvested, it is pumped to the *Rincon de León* water treatment plant (one kilometre away). The rainwater is then treated and

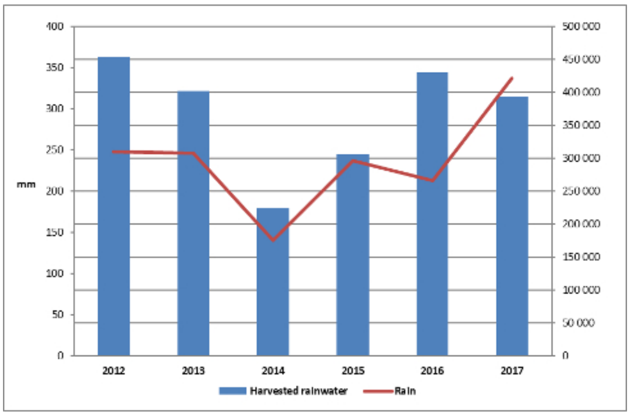

Figure 3: Volume of harvested water in the anti-pollution tank and rainfall (2012-2017). Water collected in 2011 is not included in this chart since the tank started operating in May 2011 so as not to disturb the analysis period (annual). *Source: the Authors.*

Table 1: Evolution of stored rainwater (2011-2017) (m^3).

	2011	2012	2013	2014	2015	2016	2017
January	0	32,428	20,586	0	0	19,051	95,681
February	0	10,418	20,718	0	0	0	11,440
March	0	59,944	14,611	0	24,891	21,989	64,446
April	0	25,905	148,068	1,162	36,577	26,513	6,679
May	0	0	17,247	2,863	0	17,875	1,200
June	0	6,433	0	0	10,060	0	0
July	0	0	0	0	0	5,040	32,310
August	0	0	76,768	9,620	0	0	66,857
September	0	65,395	0	52,818	98,496	0	60,000
October	20,400	108,209	0	29,084	76,726	83,390	39,579
November	62.214	145,651	16,793	76,500	60,000	86,263	15,000
December	24.380	0	87,170	52,115	0	170,432	0
Total	106.994	454,383	401,961	224,162	306,750	430,553	393,192

Source: AMAEM. Authors' elaboration.

inserted into the city's water cycle as reclaimed water.

This tank has become operational several times since its inauguration in May 2011 (Figure 3). A brief analysis of the harvested volumes shows that 2012 was the year with the greatest volume of stored water (454,383 m^3) and with most rainfall in the autumn and spring months (Table 1). The torrential rainfall pattern is reflected by prominent peaks in certain months and years, such as November 2012 (145,651 m^3 or 31% of the total year), April 2013 (148,060 m^3, the36% of the total year), and December 2016 (170,432 m^3, the 39% of the total year). Because of its capacity, with a rainfall of 30 mm/hour, it nearly fills in just 30 minutes. On 26 April 2015 the tank prevented the discharge into the sea of a flow of 18,500 m^3 that would have caused significant damage to the beaches of *Postiguet, San Gabriel, Urbanova and Arenales del Sol.*

The second infrastructure is the *Marjal* Floodplain Park (a recreational area with landscape and features that replicate a marsh) which opened in 2015 (Figure 4). Budgeted at €3.6 million, the park serves as infrastructure to mitigate flood risk – and as a public space with gardens and play areas.

It is located in an endorheic basin (known as a '*marjal*' in Spanish or marsh in English) and has a capacity of 45,000 m^3 and flood level of 5.60 meters for temporarily storing flows concentrated in this urban sector (an area that was built in the 1960s and includes buildings with basements). The neighbourhood is partially enclosed by a ring of dunes that hinders rainwater drainage to the sea and it is one of the areas of the city with the highest risk of flooding. During heavy rainfalls, the park fills slowly to minimise any potential risk in the play spaces and reduce the local effects of water accumulation. In addition, if the capacity of the park's stored volume is exceeded, there is an overflow that evacuates the surplus by surface run-off to the sea. Once the water has been stored, it is then emptied through the existing sewage network to San Juan beach through motorised valves controlled remotely by AMAEM. If the quality of stored water is sufficient, it can be sent to the *Monte Orgegia* treatment plant (approximately 4 km away) for later reuse.

Due to its recent construction and a period of drought since 2014, this infrastructure has only been used on a few occasions. In April 2015 it stored a total of 26,100 m^3 and on 14 March 2017 it accumulated 15,500 m^3 in just a couple of hours (Table 2).

Figure 4: The *Marjal* Floodplain Park. *Source: Authors' elaboration.*

Table 1: Evolution of stored rainwater (2011-2017) (m^3).

	2015	2016	2017
January	0	0	600
February	0	0	0
March	0	0	15500
April	0	0	0
May	0	0	0
June	0	0	0
July	0	0	0
August	0	0	2000
September	0	0	0
October	2.000	3.000	0
November	1.500	0	0
December	0	1.500	0
Total	3500	4500	18100

Source: AMAEM. Authors' elaborations.

4. Conclusion

The use of rainwater harvesting in urban areas is quickly expanding (Belmeziti et al., 2013). In recent years, a number of individual and collective projects have been completed in houses and buildings, and, more recently, in various urban projects. In some residential areas, particularly those facing water scarcity, rainwater harvesting is being encouraged through regulations and financial incentives (Sazakli et al., 2007). France gave regulatory recognition to rainwater harvesting devices with the adoption in 2007 of a tax credit for installations in private houses (De Gouvello & Deutsch, 2009).

Innovative strategies (referred to as sustainable urban drainage systems, low impact developments, or green infrastructures) that enable the management of runoff as close to its origin as possible, have become popular among practitioners and public authorities (Sage, Berthier & Gromaire, 2015). The adoption of sustainable urban drainage initiatives also aims to increase the resilience of territories to climate change and encourage the circular economy. Significant in this regard is the Natural Water Retention Measures programme sponsored by the European Commission (2014). Among the actions implemented are the creation of rainwater tanks, rainwater collectors, natural flooding areas in Rotterdam, Copenhagen or Berlin (Mazza et al., 2011; Pérez de las Heras, 2015), and floodplains such as the *Zanjón de la Aguada* (Santiago de Chile) (Ministry of Public Works, 2001), or the so-called sponge city (Shun Chan et al., 2018). Growing interest in this type of infrastructure is reflected in numerous initiatives aimed at encouraging green infrastructure. Two projects in different phases of execution are worth mentioning in the province of Alicante, namely, the floodplains in San Juan, Elche and Benidorm. These are intended to retain the initial circulating flows coinciding with heavy rainfalls, reduce flooding processes, avoid polluting discharges into the sea, and create new green areas. The Benidorm project has been selected within the Urban Innovative Actions initiative of the European Union.

The use of rainwater is an alternative of great interest to alleviate the natural shortage of water resources and increase the resilience of territories to climate change in the Mediterranean area (IPCC, 2018). Other advantages include: 1) its nature as a renewable resource; 2) local sourcing (which helps eliminate competitive tensions for water resources between territories); 3) access (at least a priori, free) and relatively easy affordability if adopted on a domestic scale and linked to sustainable water harvesting and urban drainage strategies (Vargas-Parra et al., 2014). This last point demonstrates the importance of including a social and political dimension, especially with regard to the conditions regulating rainwater. The so-called urban political ecology approach has emerged as a theoretical reference of great interest for examining socio-ecological processes that occur within urban and tourist areas and, particularly, the frameworks of power under which resources such as water are organised (Hernández et al., 2016). Thus, urban water flows that were previously unknown, ignored, or treated as dangerous, can acquire new functions as assets that attract the interest of water suppliers (as has happened in Alicante) or large users such as local corporations or individuals (Troy, 2008).

In the city of Alicante, the long established use of rainwater had been neglected since the 1960s after the arrival of new water resources (aquifers and river transfers). In recent years, innovative initiatives have been started. This explains why they have been classified as new, although these techniques have been implemented elsewhere since the mid-1980s (Krejci & Gujer, 1985). The many benefits of using rainwater include:

Urban streets are properly drained and floods can

be avoided in some urban areas;
Harvesting rainwater helps collect the pollutant load from urban areas and so stops contamination in disposal areas (either urban or in the sea) (Farreny et al., 2011);

1. the different methods used to harvest water have led to the establishment of public parks that makes cities more sustainable. The creation and maintenance of parks and gardens has been favoured by a greater availability of water and lower prices (€0.32/m^3 for reclaimed water compared to €1.2/m^3 for drinking water). Currently, 80% of the city's gardens are watered with reclaimed water (446 ha) (Morote et al., 2019);
2. increased drinking water supply since the pressure on drinking water is reduced by substituting some water uses that formerly used drinking water for outdoor activities (watering gardens, cleaning, etc.) and indoor activities (flushing toilets, for example, something not yet implemented in Alicante). The use of reclaimed water (where rainwater is integrated) for watering gardens, together with other measures, has enabled reducing drinking water consumption in detached houses by 54% in the city of Alicante (Morote et al., 2016). Although rainwater is characterised by a high randomness due to climatic factors (see Figure 3), its use is encouraged by the water supply companies and the administration, as evidenced by the proposals for new green infrastructures in San Juan and Benidorm. The main argument is the benefit from the point of view of flood management (sustainable drainage) and more sustainable integrated management systems. Sustainable urban drainage and rain water harvesting approaches have been adopted and show potential. For example, in 2012, the volume of rainwater accumulated in the anti-pollution tank amounted to 454,383 m^3 (248 mm in 2012). This data represented 48.12% of the treated water that was supplied in Alicante that year (944,155 m^3). Moreover, if we compare the rainwater stored with the total water supply in Alicante (drinking water; 23.87 hm^3 in 2012), this non-conventional water resource represents 1.9 % of the total water supply;
3. the use of local sources such as rainwater could help reduce dependence on large infrastructures such as dams, water transfers, and desalination plants, thus improving the quality of freshwater ecosystems and reducing the conflicts concerning water resources (Morote & Hernández, 2017);
4. it could also be an important step towards a more democratic society in which environmental resources are controlled by the citizenry and used in a rational and recyclable manner (Domènech et al., 2013). In other words, it promotes self-sufficiency;
5. the creation of areas (the *Marjal* Floodplain Park is an example) for awareness and dissemination of information about flood risks (environmental education) through school outings.

Among the weaknesses it is worth mentioning, the lack of implementation at the household level. The initiatives adopted have been developed by the water supply company. It is necessary to encourage harvesting water in detached houses, as is done in San Cugat (Barcelona, Spain) (Vallès-Casas et al., 2016). The limited length of the reclaimed water network (where rainwater is integrated) is another weakness. This network, which totals 72.77 km^2, is concentrated in the northern sector of the city and contrasts with the drinking water network that totals 1,112.37 km^2 (Morote et al., 2018). Given its acceptance in the areas where it is established, its extension to other municipal sectors is forecasted.
The feasibility of rainwater harvesting depends greatly on the volume and intensity of rainfall. In regions with little rain, the use of rainwater alone is not enough to meet the water demands of the rural and urban population (Liuzzo et al., 2016). However, this resource may be an effective supplementary water source because of its many benefits and affordable costs (Imteaz et al., 2011). Nevertheless, it is important to take into account that rainwater also has drawbacks (Morote & Hernández, 2017). Despite acquiring more experience, planners frequently disregard rainwater harvesting for domestic consumption for two main reasons. Firstly, not enough is known about its benefits for users.
Most studies have focused on theoretically estimating (Eroksuz & Rahman, 2010), but very few base arguments on the current performance and use of existing rainwater harvesting systems. Only a few researchers have explored user practices and perceptions (Baguma et al., 2010). Secondly, the cost of rainwater harvesting systems is normally perceived as high, but economic analysis usually fails to consider life cycle costs and various positive externalities (Batchelor et al., 2011).

Domènech et al., (2013) argue that governments may be reluctant to promote this technology because of uncertainty about the ability of users to manage the system appropriately and the associated health risks. However, rainwater and green infrastructure will be playing an important role in the near future due to climate change. This resource should be a strategic option for adapting to more intense droughts and fewer water resources (IPCC, 2018). According to Sitzenfrei et al. (2013) to meet upcoming challenges such as climate change, rapid growth, shrinking cities, and water scarcity, water infrastructure needs to be more flexible, adaptable, and sustainable (e.g., sustainable urban drainage systems and water sensitive urban design). In other words, minimising the hydrological impacts of urban development on the environment (Okhravi et al., 2015; Rahman et al., 2017). The more that is known about the features of these resources, how they can be used, the corresponding management systems and their potential, then the greater progress can be made for a more sustainable and resilient planning model to combat possible effects of climate change in Spain.

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