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Runoff Water as a Resource in the Campo de Cartagena (Region of Murcia): Current Possibilities for Use and Benefits

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Received: 23 February 2018; Accepted: 3 April 2018; Published: 10 April 2018

Abstract: The scarcity of water in the Campo de Cartagena has limited its exploitation, which is why, historically, runoff water has been used through sustainable traditional practices which have been dismissed by technological advances. In order to demonstrate the potential of this resource at present, an analysis by interpolation of rainfall distribution in the sub-basin of the *Rambla de Fuente Álamo-Albujón* was carried out (for the intense rainfall episodes of 2012 and 2016) as well as hydraulic modelling of the estimation of surface runoff. In addition, taking into account the future climate scenarios, a projection of the total runoff in the study area was made up to the year 2100. The bibliographic review and the press analysis showed that the traditional use of runoff water has remained in disuse, although there are infrastructures to collect water from floods but with an eminently sanitary purpose. The current model of agricultural and touristic exploitation is giving rise to serious socio-environmental conflicts which manifest in obsolescence. Therefore, the increase in the availability of water with the use of a specific endogenous resource may lead to a decrease in the pressures exerted on the study area.

Keywords: Campo de Cartagena; runoff water harvesting (RWH); reuse

1. Introduction

The Campo de Cartagena is located in the semiarid region of the southeast of the Iberian Peninsula, where the optimal conditions of temperature and insolation and the quality of its soils have contributed to the generation of intensive agricultural activity with high productivity. Also, the tourist activity has developed with extraordinary form in the last few years. These activities demand large amounts of water, and the natural supply (precipitation and river channels) is too scarce. The water deficit has generated, and continues to generate, important environmental, economic and social conflicts. This paper analyzes the benefits that can be achieved with the application of runoff water collection techniques, especially for the agricultural sector, originating more sustainable production that is respectful of the environment.

This research is novel, because there are hardly any other studies in this context that have proposed a catchment and generalized use of runoff water as a complementary resource to the additional contributions of groundwater, transfers (Tajo-Segura aqueduct) and desalinated and treated water. There is, therefore, a lack of specific bibliographic antecedents on this topic applied to the study area. We should mention, however, the study by Giráldez et al. [1] regarding the different water harvest strategies in the southeast of Spain. Nevertheless, on an international level, there have been numerous studies since the 1970s that have analyzed the importance of water harvesting (RHW) in arid and semi-arid regions.

On a global scale, we highlight the following publications regarding the importance of collecting rainwater as a resource for agriculture: Frasier and Myers [2], Boers et al. [3], Boers [4], Prinz [5], Oweis [6], Srivastava [7], Falkenmark et al. [8], Oweis and Hachum [9], Hamdan [10] and Helmreich and Horn [11], among others. With regard to Africa, some of the most representative research has been carried out by Bruins et al. [12], Woyessa et al. [13], De Winnaar et al. [14], Kahinda et al. [15], Ouessar et al. [16] and Biazin et al. [17]. In Asia, the Mediterranean countries have been the most studied, and the works of Preul [18], Oweis y Taimhe [19] Al-Adamat et al. [20], Zakaria et al. [21], Elewa et al. [22] and Wani et al. [23] are highlighted. Likewise, in this continent, India has been one of the territories where wide scientific production on this subject has been developed, with contributions by Machiwal et al. [24], Goel y Kumar [25], Sivanappan [26] and Singh et al. [27]. There have also been related studies in North America, and we highlight the work of Sekar and Randhir [28]. However, in South America, research on the use of runoff water is very sparse. More numerous are the analyses related to this topic in Europe, and among others, we are struck by the study about the collection of rainwater in a humid region (Sweden) by Villareal and Dixon [29].

The importance of this work lies in the fact that it is a study that can be extrapolated to other semiarid regions of the planet, where rainfall is also scarce and the balance between supply and demand of water is threatened.

Although there has been no study defending the importance of recovering the collection of rainwater as a resource in this territory of Southeast Spain, there has been a large number of studies that have analyzed the historical uses of rainwater over the past millennia. In this sense, the oldest archaeological remains which prove the use of complex techniques for the use of rainwater in the Campo de Cartagena, dating from the Punic era, when the city of *Qart Hadast* (founded by Asdrubal in 228–227 BC) had significant utilisation of rainwater through the building of numerous cisterns which were part of an extensive hydraulic infrastructure, in use until the Colonial Statute of *Carthago Nova* (45–42 BC), which led to the total Roman reconstruction of the city by order of Augustus [30]. However, while this catchment guaranteed the availability of water in the urban core, along with wells and aqueducts, this solution was also applied in rural areas, as attested by the remains of the Punic deposit of *La Fuente de la Pinilla* (*Fuente Álamo de Murcia*) [31,32]. Commanded by Scipio, the city was taken over by the Romans. It was under this empire (settled since the founding of *Carthago Nova* in 209 BC) that there was an exponential increase in the use of rainwater, which emphasizes the link between rural enclaves and sporadic water courses. In the city, the collection of rain was an established practice. Thus, it is noted that in some of the villaes in the region, these resources were used for the capture of runoff by means of sluices and dams, from which tanks and rafts were provided. In this sense, the country residences made efficient use of rain, and a large number of them were located in the vicinity of the seasonal streams which drain the basin, such as in the case of the settlements of *Los Morenos*, *El Villar*, *El Hondón*, *Casa de Valderas*, *Los Aguados*, *Los Granados and Los Covaticas/Casa Blanca* [33].

After the fall of the Roman Empire, the Visigoths destroyed *Cartagena* in the early seventh century and took power, resulting in a withdrawal of the population towards defensive or fortified sites, which led to stagnation and reduction of rural occupation and, consequently, to deterioration of the hydraulic works previously erected. In 711, the Visigothic king, Rodrigo, was defeated by Islamic troops, and in 713, the Pact of Tudmir or Treaty of Orihuela was signed, giving rise to the period of Muslim domination [34]. Little by little, the Campo de Cartagena (*Fahs Qartayanna* or *Fahs Arrabeh*) was populated by farmhouses, some built on ancient Roman *villaes*, although, after the destruction of the old capital of the Cora, *Ello*, and the establishment of a new creation, *Mursiya*, the *Huerta de Murcia* and its surroundingsbecame the main sites of occupation. However, the Muslim consolidation entailed improvement and expansion of the previous hydraulic systems, as well as the preparation of new infrastructures complementary to the capture of runoff. Either by the consolidation of the Arab population in the territory, or by its agriculture and livestock dedication, it was at this moment that there was a large increase in the number of cisterns, where the classic circular cistern, characteristic of the study area, appeared. Thus, the irrigation of sluices, the terracing and the use of cisterns were keynote among the different traditional methods of rainwater collection during the Muslim period, in addition to the widespread use of waterwheels of blood, infiltration galleries and underground dams, already used by the Romans [35].

In the waning of the Islamic period, the instability in the Campo de Cartagena caused an intense depopulation and the abandonment of the hydraulic infrastructures which had supplied the existing farmhouses. However, as of 1450, and thanks to the first divisions of the Murcian countryside, a relaunching of the agrarian activity began to take place (in spite of the danger of the attacks by the North African pirates) and increased after the culmination of the Reconquest in 1492. Over time, the number of inhabited areas increased, as did the size and intensity of the farming operations. The traditional systems of water collection inherited from Muslim culture were the basic element for survival in this "hostile" territory; cisterns, derivation sluices, spillways, waterwheels of blood and galleries consolidated subsistence in the region. Later, during the seventeenth century, the growth of agricultural areas remained stagnant in this territory, while from the end of this century and until the mid-eighteenth century, stability changed, and new irrigated areas began to appear, linked to drainage works and the utilization of underground surface and subterranean water, the latter favoured by the role of the windmill.

Since the middle of the 18th century, numerous agricultural areas have been exploited, after desiccation of wetlands and the construction of intricate systems of water galleries which captured the filtered water from the underground surface of the seasonal streams after rains and floods [36]. It was from then on, and in spite of the descent of the dynamism in the use of the rural environment in the Region of Murcia, that the big projects involving the transport of water from distant regions appeared as a supplement to the meagre flows provided by precipitation. However, most of these ideas, some already raised in the fourteenth century [37], failed to be implemented, and the population continued to be provided by traditional methods until the incorporation of combustion engines to artesian wells, achieving intensive exploitation of the groundwater of the study area. The richness and proximity of these resources meant that the entire territory was equipped with these modern water elevation systems which, as they evolved technologically, increased their durability and efficiency. Thus, as the 20th century progressed, the supply of runoff was relegated, as were the secular hydraulic works in an agricultural area that grew exponentially, demanding huge amounts of water on a regular basis (about 5500 m^3/ha/year for tree crops, essentially citrus, 8000 m^3/ha/year for greenhouse production, and 10,000 m^3/ha/year for outdoor horticultural crops), to the point that at the beginning of the 21st century, agriculture was depleting the water resources available, so that farmers were forced to irrigate with desalinated seawater, increase the demand for water from other descending basins and reduce the cultivated area.

Despite this, there have been few studies which have advocated the reuse of rainwater in this territory—none of them involving the impact that deep agricultural and tourist exploitation has on it—unlike in other regions of the country and abroad where recovery techniques from the roofs of houses and surface runoff have been proposed. Thus, the aim of the study lies in the manifestation of the loss of the traditional collection of this resource, along with its important associated heritage, despite being an effective and functional strategy which can offer numerous benefits to the detriment of the new techniques which are less popular and environmentally sustainable. Hence, the present work broaches the possibility of applying traditional knowledge in the preparation of future harvesting systems of considerable volumes of precipitated water, so that these can become a circumstantial endowment of an endogenous own resource. In addition, these resources allow for the reduction of socio-environmental conflicts arising from the intensive use of land, underground reserves and foreign flows, guaranteeing, in turn, the treatment of captured water and the reduction of pollutant discharges from agriculture, tourism and the remains of the mining industry.

This paper is structured as follows: After this introductory section, we present the study area and the materials and methods used. Next, we identify the current socio-environmental conflicts that affect the region due to the lack of sufficient water resources to cover the existing demand. Below are the main solutions projected or implemented to mitigate the impact of this water deficit situation. We show that the measures implemented are clearly insufficient. Subsequently, based on the analysis of case studies, we demonstrate, through modeling processes, the volume of water that could be captured in the ramblas (ephemeral watercourse) of the study area during episodes of intense precipitation. Finally, and taking into account all of the previous information, we indicate the main benefits that would be obtained if these practices of collection of runoff waters (of a long tradition in this territory) were taken up again.

2. Materials and Methods

The Campo de Cartagena is a natural region, about 1600 km^2, located in the southeast of the Region of Murcia (Figure 1), forming a coastal plain of gentle slope to the *Mar Menor*, whose drainage network is composed of seasonal streams with sporadic flow that are punctually torrential, characteristic of the semiarid climate of the area into which they are inserted and where barely more than 300 mm of annual average precipitation is exceeded. An annual structural water deficit of more than 400 mm is registered, motivated by the economic activities developed in the area of analysis. This region, despite the shortage of rainfall, is one of the main producers of agricultural products nationally and internationally. Agriculture is a fundamental economic activity. Undoubtedly, this region is one of the most important agricultural supply centers in Europe.

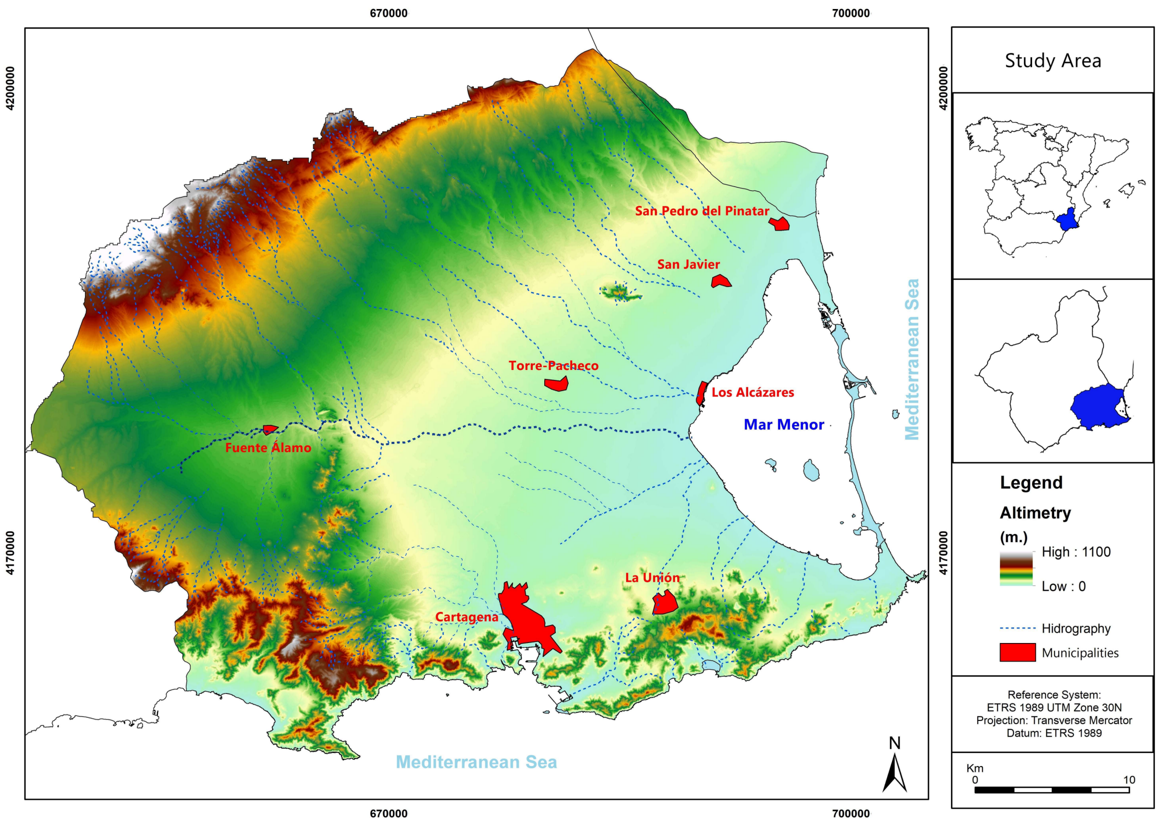

Figure 1. Campo de Cartagena (Region of Murcia), area of study. Source: own elaboration.

From a pluviometric point of view, the study area is characterized by a high interannual variability, so that long dry periods follow one another, with brief, but very heavy, rainfall episodes causing severe flooding. An example of this irregularity is that in the torrential rainfall episode of 15–19

December 2016, in the rainy station of Torre Pachecho-Torreblanca (Agricultural Information System of Murcia—SIAM), with a total of 299 L/m^2, the annual average was exceeded, which is 280 L/m^2. The average annual rainfall varies between 280 and 310 L/m^2 (according to the Spanish Meteorology Statal Agency information to the reference period 1981–2010). The equinoxes are the wettest seasons. In recent years, there has been a positive trend in autumn and a slightly negative trend in spring. The summer season presents a statistically significant decrease in precipitation (Mann–Kendall test, $p \leq 0.05$, 95% confidence level). In winter, there is a slightly positive trend. Finally, the annual rainfall trend has been fairly stable over the last 60 years.

The bibliographical consultation of publications has been the basis for the drafting of the sections referring to the traditional use of runoff water, as well as to identify the current disuse of this resource and the existing socio-environmental conflicts in the research area, to which the consultation of the regional and national press must be added. In the same way, this analysis has been fundamental for the development of the section devoted to the identification of the different environmental and socioeconomic benefits derived from the practice of reusing water from streams.

The elaboration of the cartography referring to the total precipitation of the episodes from 27–29 September 2012 and 17–19 December 2016 is based on the use of 42 meteorological observatories, 21 belonging to the '*Agencia Estatal de Meteorología*' (AEMET), 12 to the '*Confederación Hidrográfica del Segura*' (CHS) and 9 to the '*Instituto Murciano de Investigación y Desarrollo Agrario y Alimentario de la Región de Murcia*' (IMIDA). The interpolation used follows the ordinary spherical semivariogram kriging method, as it adapts better to the degradation of the spatial correlation between the points when they present a greater distance.

The hydraulic modelling carried out for the sub-basin of the *Rambla de Fuente Álamo-Albujón* (Table 1) during the aforementioned episodes is based on the application of the dimensionless model of the "SCS Curve Number Method" (Soil Conservation Service, SCS) for the estimation of precipitation loss, and the "SCS Unit Hydrograph" for its transformation into total runoff. Thus, four observation points are determined, one of them corresponding to the hydrological head zone (*La Murta*), two in the middle section (*Fuente Álamo* and *El Albujón*), and finally, one in the drainage of the sub-basin to the *Mar Menor* through its mouth in the south of the municipality of *Los Alcázares*.

Table 1. Main parameters (Basin Albujón) for the Soil Conservation Service (SCS) Unit Hydrographic.

Albujón Basin	Units	Values
Area basin	Km^2	669.9
Basin slope	(%)	7.9
River lenght	Km	42.0
River slope	(%)	1.6
NC (Number curve)	0–100	61.9
T_c (time of concentration)	h	10.5
Tr 10 (time of recession)	h	6.3
Tb (base time)	h	32.1
T_p (time to peak)	h	7.1
Q_{esp}	l/s/km^2	2122.1
Land use	Cocient C	0.45
Land use		Urban-rural mixed use.
Lithology		Alluvial fan, crust formations, edges and sands. Slits and clays. Marshes, muds and flat areas.
Topography		Coastal mountains and coastal plains

The adimensional SCS model expresses flows according to peak outflow (q_p), and times depending on the time to peak (T_p):

$$tr = 1.67\ T_p \quad (1)$$

where tr is the recession time (1.67) and T_p is the time to peak (h) (time between the start point of the hydrograph and the peak).

$$q_p = \frac{2.08A}{T_p} \quad (2)$$

where q_p is the peak outflow (m^3/s); 2.08 is the SCS Shape Factor; A is the basin area (km^2); and T_p is the time to peak (h), according to the expression:

$$T_p = \frac{D}{2} + t_p \quad (3)$$

where D is the effective rain duration (h) and t_p is the peak flow time (h) (time elapsed between the center of gravity of the effective rainfall and the center of gravity of the direct runoff hydrograph (Nanía and Gómez Valentín, 2006).

According to *Ministerio de Obras Públicas y Urbanismo*, MOPU [38] Spanish basins have a somewhat lower T_p/T_c ratio, around 0.3:

$$T_c = 0.3\left(L/J^{0.25}\right)^{0.76} \quad (4)$$

where T_c is the concentration time (h); L is the river length (km); and J is the slope (dimensionless).

The Muskingum method has been used, which includes the length of the propagation sections and the slope as main variables. The K factor used for the calculation has been estimated with an approximate value to the total storage (S_c) in accordance with Témez [39]:

$$S_c = KX(I - Q) \quad (5)$$

$$K = 0.18\left(L/J^{0.25}\right)^{0.76} \quad (6)$$

where K is a measure of the transport time of a wave from one point to another (h); I is the input flow; Q is the output flow; and X is a dimensionless variable (0 to 0.5) with a value of 0.18.

The future projection of the total runoff in the area of study is based on the calculations of the dynamic regionalization (CORDEX) in the Region of Murcia (Spain), in accordance with the data from the CMIP5 models (Coupled Model Intercomparison Project (CMIP).) from the IPCC (Intergovernmental Panel on Climate Change), choosing for these two emission scenarios, the RCP 4.5 (more moderate, whose total radiative force is stabilized before the year 2100, reducing therefore, greenhouse gas emissions), and the RCP 8.5 (more pessimistic, characterized by the increase of said emissions during the next few decades) [40], where a radiative force is established between 4.5 and 8.5 W/m^2 in 2100 respectively.

Finally, the study of statistical trends of total runoff is carried out through the non-parametric tests of Mann–Kendall and Spearman, using linear trends at a confidence levels of 95% and 97.5% respectively.

3. Results

3.1. Current Waste and Socio-Environmental Conflicts

The marked natural water deficit in this territory has been increased by the demands of the two economic activities—agriculture and tourism—which have developed, causing serious socio-environmental conflicts which affect the region (Figure 2). Firstly, The first one, it can be said that it is an intensive agriculture in terms of water consumption and occupied surface, while the second, in the same way, has inflicted considerable impacts because it also needs important water and soil inputs, in addition cause actions of tourist conditioning of the Mar Menor unfavorables for the lagoon and to generate anthropic waste that, sometimes, have been dumped without any treatment to its waters. In both cases, the capture of runoff from the seasonal streams after major rain could decrease part of the pressure exerted in the area of analysis; however, although historically this has been a resource used, both for agricultural and domestic and industrial work, today, is a surprisingly forgotten practice.

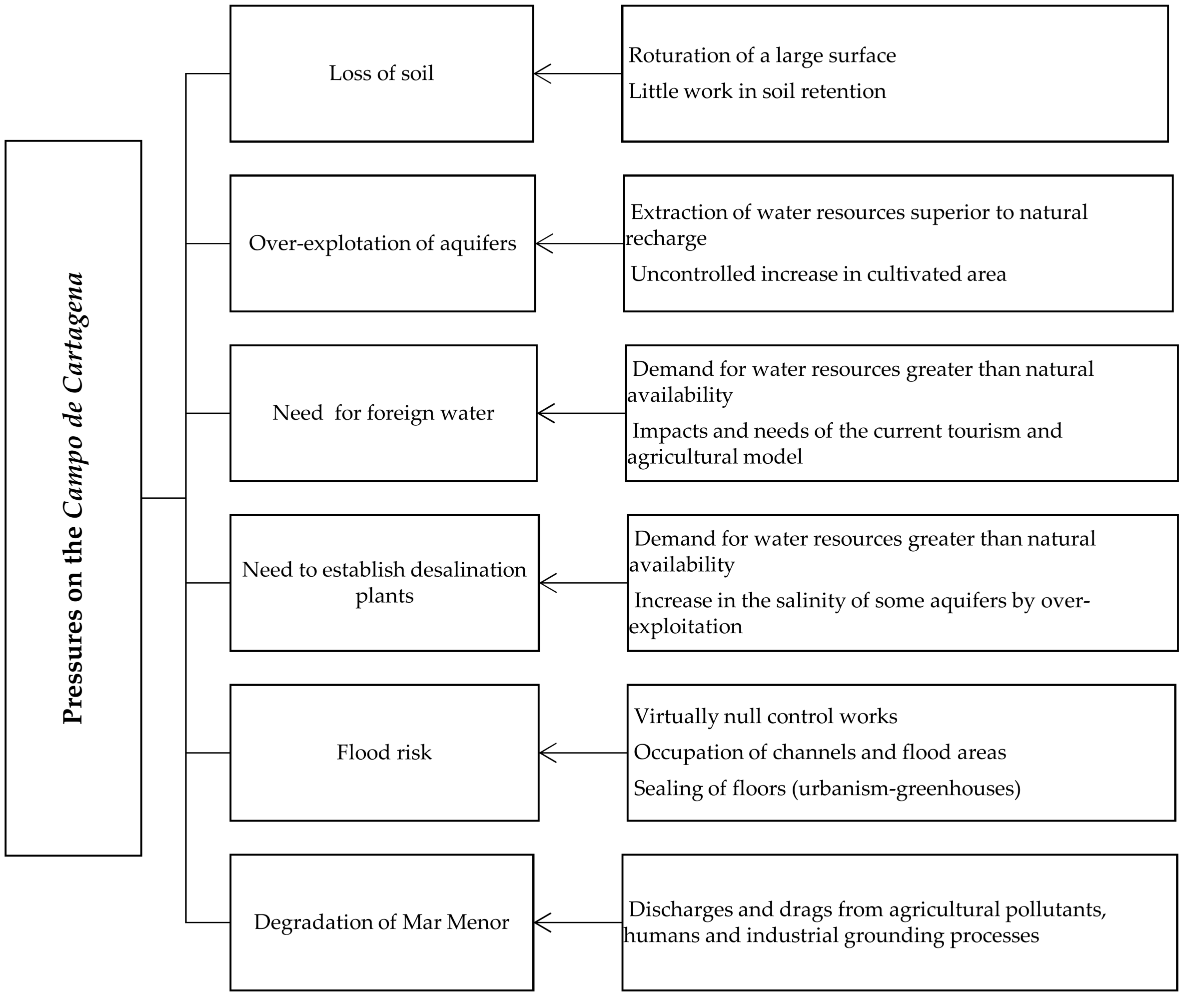

Figure 2. Socio-environmental conflicts derived from the exploitation model of Campo de Cartagena. Source: Own elaboration.

3.1.1. Loss of Soil and Siltation Processes

The ploughing of a large part of the study area has resulted in two major drawbacks—on the one hand, the loss of soil (physical, chemical and biological essential component) and, on the other, the origin of siltation processes in the Mar Menor which has led to a reduction in the existing water sheet. Both problems are intimately linked; the rains mobilize part of the soil, between 0.80 Tm/ha/year [41] and 0.78–1.20 Tm/ha/year [42], transporting it to the coastal lagoon in floods, adding an approximate total load of 23,000 m^3/year of solids [43]. Consequently, it is important to point out that in this area, there are three fundamental factors which aggravate this type of water erosion: the high erosive power of the rains (torrential on many occasions), high erosion of soils (mostly composed of deleterious neo-quaternary materials), and a substantial incidence of anthropic action (effects of intense agricultural exploitation). However, although agriculture plays a fundamental role, tourism is another key factor, since the creation of artificial beaches on the shore of the lagoon and the regeneration of existing natural beaches increase this soil contribution. Thus, while the loss of soil translates into the need to artificially add nutrients to the plantations which finally end up in the lagoon due to surface dragging and underground surface water streams or aquifers due to percolation processes, the filling of the Mar Menor generates bioclimatic changes in the ecosystem—variations which lead to an increase in salinity and water temperature.

3.1.2. Over-Exploitation of Aquifers

The method of agricultural production which is carried out in most parts of the Campo de Cartagena requires water contributions which are not available due to the lack of permanent water courses and the lack of rain, which has led farmers to worry about getting water through other means. Thus, at first and during a lax period of time, the capture of groundwater through wells (conventional, waterwheels of blood, windmills and motorized wells) was the solution, but as the number of cultivated hectares increased, a larger volume of water was needed and soon, the first symptoms of over-exploitation of aquifers were recorded; the repercussions of this were a marked decrease in piezometric levels (especially between 1940–1970 with the predominance of the use of electricity as extracting energy) and the verification of marine intrusion processes as technological advances allowed extractions at greater depths and in increasingly larger volumes. However, this situation, which had been especially aggravated since the end of the eighties and until the mid-nineties of the last century, improved thanks to the surplus of irrigated water supplied by the Trasvase Tajo-Segura, although its consequences did not affect the different aquifers existing in the area in the same way: only the Quaternary Aquifer (with an area of 1135 km^2) was affected by intrusion processes due to its hydraulic connection with the sea [44]. To all this, we must add the reduction of the infiltration capacity of the basin due to the increase in greenhouses and residential urbanism encouraged by the new tourism trends, actions which have caused the soil sealing of large surfaces, limiting the recharge of the underground masses.

3.1.3. Need for Foreign Water

Technical innovations have proved to be a fundamental element to alleviate the thirst for water, and this is reflected in the various inter-basin water transfer works which supply this territory, carried out in the last few decades. However, despite being projects of great strategic value, all of them have been questioned. The first of these is the Taibilla Chanel, an infrastructure created to supply water to the Navy Base of Cartagena (an objective which was reached in 1945, almost three decades after the first studies of 1913) and to different municipalities in the east of Spain (currently 58). This work, in its origins and until 2003, only transferred water from the Taibilla river (provincial of Albacete), although the increase in population, favoured by the development of new urban-tourist areas, has required complementary sources, such as those provided by the Trasvase Tajo-Segura since 1979 and the desalinated water, to the point that it currently supplies more than 2.5 million people. One of the keys to agricultural development in the area has been the increase in irrigated crops, an increase driven by the Trasvase Tajo-Segura [45]. This infrastructure supplies the great majority of the territory which is under the tutelage of the '*Comunidad de Regantes del Campo de Cartagena*' (CRCC) (Figure 3), responsible for managing 122 hm^3 from the River Tajo, 4.2 hm^3 from the Segura basin itself and 11.7 hm^3 of the different '*Estaciones de Depuración de Aguas Residuales*' (EDAR) or waterworks. It is worth mentioning that the consumption price of the transferred water for the irrigators within this organization—'*Zonas Regables Oriental y Occidental*' (Western and Eastern Irrigable Zones, irrigation with the Tajo-Segura Transfer)—is approximately 0.30 €/m^3, at present, although the cost varies depending on the available resources—a pretty high price.

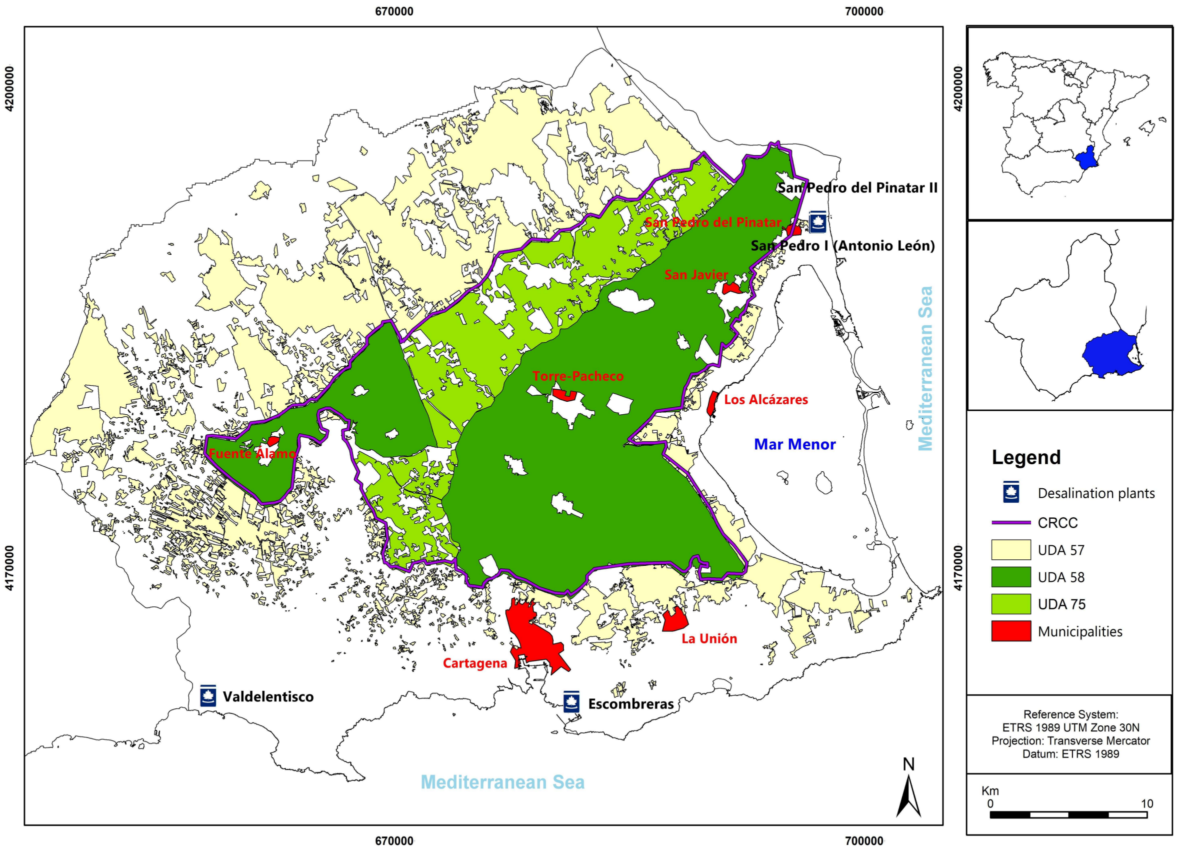

Figure 3. Desalination plants and irrigated land in the Campo de Cartagena: UDA 57 (*Unidad de Demanda Agraria* (UDA) or in English, Agrarian Demand Unit (ADU)) (mixed aquifers irrigation, treated and desalinated), UDA 58 (Western and Eastern Irrigable Zones, irrigation with the Tajo-Segura Transfer) and UDA 75 (Cota 120, hydrographic basin of the Segura). Source: own elaboration.

After this first "agricultural transfer", new supply projects emerged due to the exponential increase in water demand in the east of Spain. In this way, the 'Plan Hidrológico Nacional' of 2001 included the realization of the so-called 'Trasvase del Ebro' (Law 10/2001 of 5 July) in its objectives, a project which sought to eradicate the problems of water supply in the southeast with a contribution of 1050 hm^3/year. However, environmental, political and social pressures ended up paralyzing its execution, and it was repealed by the Real Decret-Law 2/2004 of 18 June (later converted into the Ley 11/2005), which led to the drafting of the AGUA Program (search for resources from desalination) [46]. Thus, water scarcity itself has caused the regional government to have recently proposed a Regional Water Pact whose main proposal is the increase of water transfer because the limits of the possible supply of water resources have already been reached, both their own and transferred ones, as well as the generation of environmental and economic controversies with the desalinated water.

3.1.4. Need to Establish Desalination Plants

The continuous expansion of crops, population growth and long periods of drought have led to foreign contributions being insufficient, which has added to the limitations of groundwater extraction imposed by the CHS to prevent over-exploitation of the aquifers; this has motivated the installation of desalination plants as a solution and alternative to the transfers [47]. However, there are serious problems due to the way the waste resulting from the desalination processes is handled and the cost of the treated water. Since 2004, with the start of the aforementioned AGUA Program (Ministry of Environment), four desalination plants have been built in the Campo de Cartagena (Figure 3): Valdelentisco, Escombreras y San Pedro del Pinatar (I y II), in addition to another project in Escombreras, which is the largest in the world destined for irrigation, with a generation capacity of almost 1 hm^3/day. The water coming from these facilities plays an essential role in the irrigation of the study area, although it is sometimes a difficult cost for farmers to afford (close to 0.50 €/m^3). However, it should be noted that these infrastructures were built due to the proliferation of residential complexes and golf courses [48], generating tensions between the users of these and the agricultural entrepreneurs. On the other hand, a large number of wells in the study area extract saline water which requires treatment in desalination plants to enable its use in irrigation, which is why there are more than 300 of these facilities registered [49], and a similar figure of clandestine plants is estimated, which, due to lack of control, pose a serious problem to pollutant drainage—e.g., brine poured on the surface of different channels which flow into the Mar Menor and agricultural waste derived from the possibility of expanding the irrigated area. This, added to the paralysis of the brine collection infrastructure linked to the Mar Menor sanitation plan, caused the CHS to order the closure of clandestine wells and desalination plants in 2016, while in the last months of this year, due to its inactivity, the old brine channel associated with the former works of the transfer is being dismantled.

3.1.5. Flood Risk

If rainfall scarcity is one of the most distinctive climatic characteristics of the study area, another one is the floods produced during episodes of torrential rain, a circumstance closely related to the Mediterranean climate which affects the zone and is characterized by a very irregular rainfall regime and the unusual occurrence of extreme hydrological events [50]. These precipitations of high hourly intensity are mainly registered in autumn, and secondarily, in spring. They are able to offer figures of around 50% of the total annual volume precipitated in a single episode [51]. This, together with the biogeographical and physiographic peculiarities of the region, means that only a small percentage of rainfall is useful, triggering important flows of concentrated runoff which, when merging into important channels, become torrents of water and material in suspension which lack any control. In this sense, over the last few decades, the drainage network has undergone a process of transformation and deterioration, which has given rise to seasonal streams of cultivated channels, or because of the modification or occupation of these due to the execution of residential projects, which, in addition to altering the morphology of the seasonal streams or channels and favouring soil sealing processes [52], have been established on floodplains on numerous occasions [53]. Thus, to this climate condition must be added the human factor of alteration of the landscape and the modification/occupation of the evacuation network, in addition to the scarcity of flood mitigation measures. Hence, in episodes of high rainfall intensity, the consequences on the population, urban areas, economic activity, traffic, communication networks and on the morphological dynamics of the channels themselves cause huge losses.

3.1.6. Degradation of the Mar Menor

Taking into account the previous sections, the Mar Menor is one of the areas which has suffered the greatest impact (Figure 4); however, although the most serious consequences have only recently become apparent, it is an ecosystem which has suffered numerous pressures over recent decades, both from the agricultural and tourist sectors, although its current state was deeply studied in the Informe integral sobre el estado ecológico del Mar Menor presented in February 2017 by the Comité de Asesoramiento Científico del Mar Menor [54]. The intensification of agricultural production has led to an increase in waste (e.g., mining waste) transported by rain to the coastal lagoon. Nitrates and phosphorus compounds are the most significant inputs with figures of between 1500–2000 Tm/year and 60–125 Tm/year [55,56], respectively, while the old mining sierras contribute heavy metals in a dissolved form (Zn and Cd) and as particulates (Pb and Cu). In comparison, approximately 50% of the dissolved inorganic nitrogen comes from agricultural sources, while 70% of the phosphate and 91% of the organic carbon come from particular urban sources [57]. Moreover, nitrates can also be added to the lagoon through percolation processes in the aquifers which cause concentrations of between 200–300 mg/L (when the limit is 50 mg/L) in reservoirs which, occasionally, are connected to the lagoon and have been estimated to contribute a total of 5 hm^3/year of contaminated water [58]. These seasonal streams, in turn, due to episodes of torrential rainfall and intense ploughing which the Campo de Cartagena has suffered, influence soil contribution due to the loss of soil, to which the tons of sand supplemented for the maintenance of the beaches must be added.

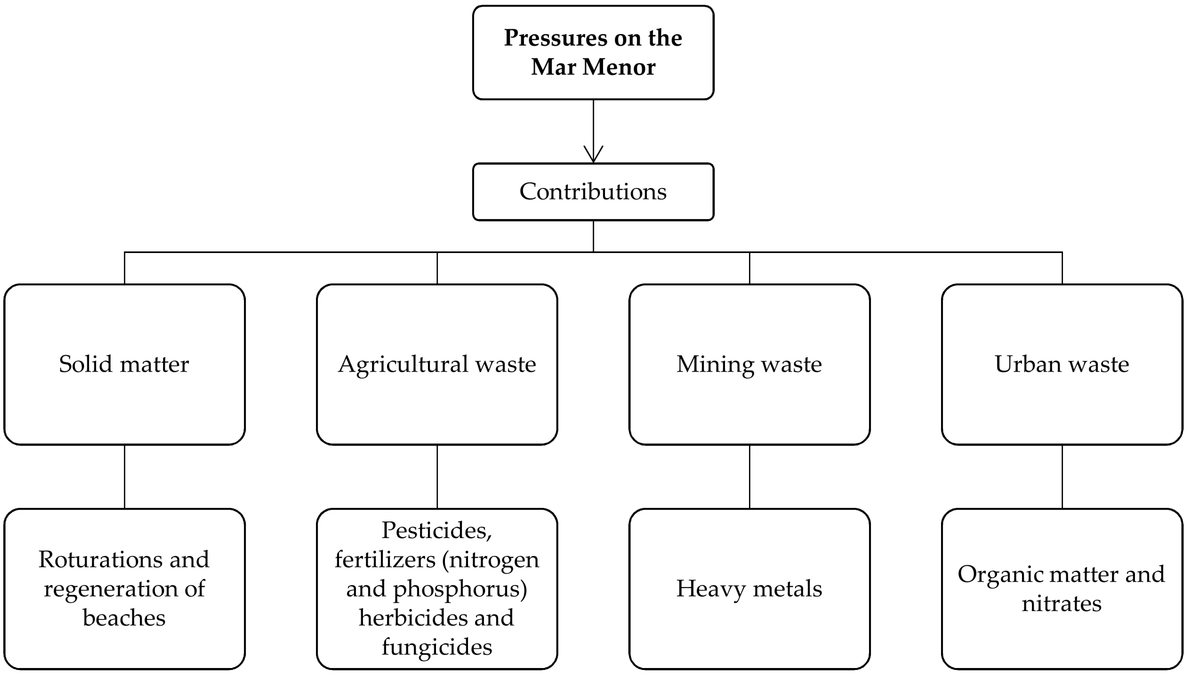

Figure 4. Pressures on the Mar Menor. Source: own elaboration.

Similarly, the installation of desalination plants generates waste (brine) in an uncontrolled or poorly treated way to the drainage network. Also, the intense urbanism in the area surrounding the lagoon, derived mainly from tourist activity with a figure of more than 300,000 visitors per year, has caused, at times, human waste to not be sanitised in an efficient manner. Thus, these pressures exerted on the natural space cause a decrease in the depth of the water and contribute pollutants which cause a change in bioclimatic conditions that seriously affects the marine ecosystem, causing, among other aspects, phenomena of eutrophication, proliferation of jellyfish, events of noxious flowering of algae and loss of aquatic biodiversity, and, therefore, negative impacts on the tourism image and fishing. Such has been the impact of the current waste on the Campo de Cartagena that it has been declared a Vulnerable Area to Nitrate Contamination, under the criteria established in Directiva 91/676/EEC, and the Mar Menor Environmentally Sensitive Area to Urban Waste Discharges, in accordance with Directiva 91/721/EEC. These disadvantages, as a whole, have led to the implementation of the Plan Vertido 0 and the Integrated Mar Menor Territorial Investment 2014–2020 (ITI) [59] which aims to implement Integrated Management of Coastal Zones in the Mar Menor and its surroundings of the Socioecological System [60] for the attainment of good environmental conditions in this zone and the surrounding area through public investment in R + D + I (Research, Development and Innovation, RDI) (especially European funds), with the purpose of optimizing the use of fertilizers in the agricultural sector, reducing waste and preserving and promoting natural spaces.

3.2. Projects and Future Perspectives: Capture as a Preventive System or as a Resource?

Technical innovations have practically put aside the traditional systems of runoff water collection, a fact that, in part, has been motivated by the feeling of false security of having inexhaustible foreign and subterranean endowments. However, it has been demonstrated that both of these methods have insurmountable limitations imposed both by nature, which provides the resources, and by the social, economic and environmental repercussions which their intensive exploitation generates. These same consequences are what have caused, in recent years, proposals to collect rainwater. However, these projects generally have, as a base, the collection and treatment of the streams to avoid floods and pollutant discharges into the Mar Menor, while they seldom consider the reuse of water as a resource for irrigation. In this way, the projects executed and those projected, are postulated, for the most part, as prevention systems and not as tools for the production of a useful and necessary resource. Currently, three actions are being carried out in the study area to treat the water flowing through the seasonal streams (Figure 5)—either runoff or from agricultural drainages.

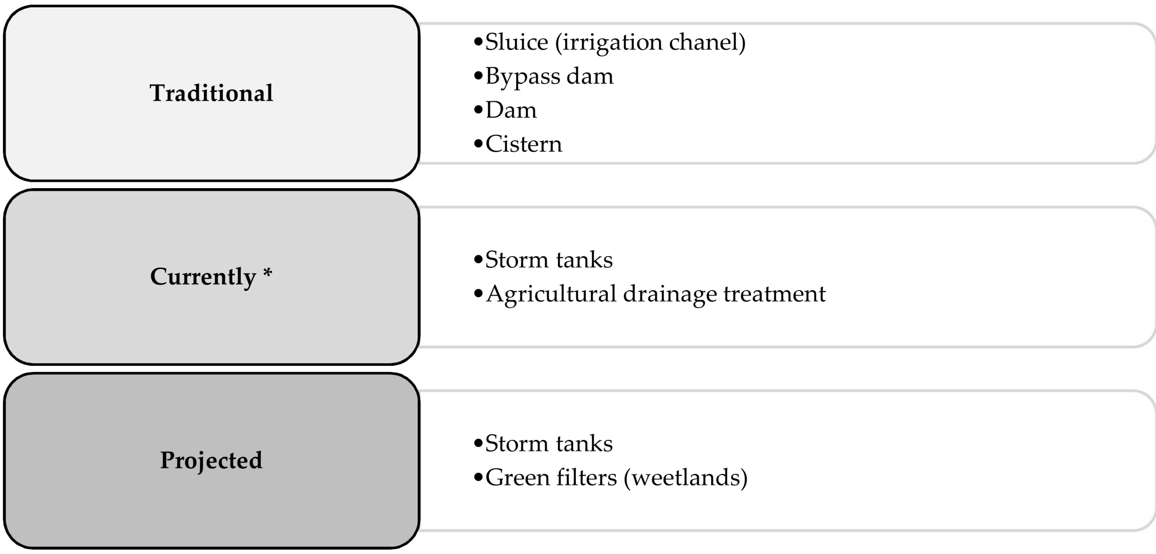

Figure 5. Measures to collect runoff in the Campo de Cartagena: traditional, currently executed or projected. * Without the function of collecting water for reuse. Source: own elaboration.

3.2.1. Storm Tanks

These hydraulic-sanitary infrastructures help, after episodes of precipitation, to manage water flows, mainly urban, with the aim of eradicating flood risk in populated areas and reducing the contribution of pollutants to the Mar Menor [61]. However, there are another set of projects which are part of the actions included in the Plan Vertido 0 promoted by the government of the Region of Murcia and whose development is motivated by the environmental degradation of the lagoon. The aforementioned strategy established the construction of 21 storm tanks in the study area, most of them located in the riparian villages of the lagoon, of which, to date, only six are functional, two are under construction and the rest are in an initial phase. In this way, a total of 21 tanks have been built throughout the Campo de Cartagena (Figure 6) which are currently operational (adding a capacity of 122,475 m^3): six belonging to the aforementioned Plan Vertido 0 and the remaining fifteen from another origin than this regional measure. In addition, there are many other facilities in anticipation of being executed. However, although these works collect the runoff water, its subsequent use is not their objective, since, according to the available data, only three have the possibility of pumping these recovered flows to waterworks to be reused in urban or agricultural irrigation.

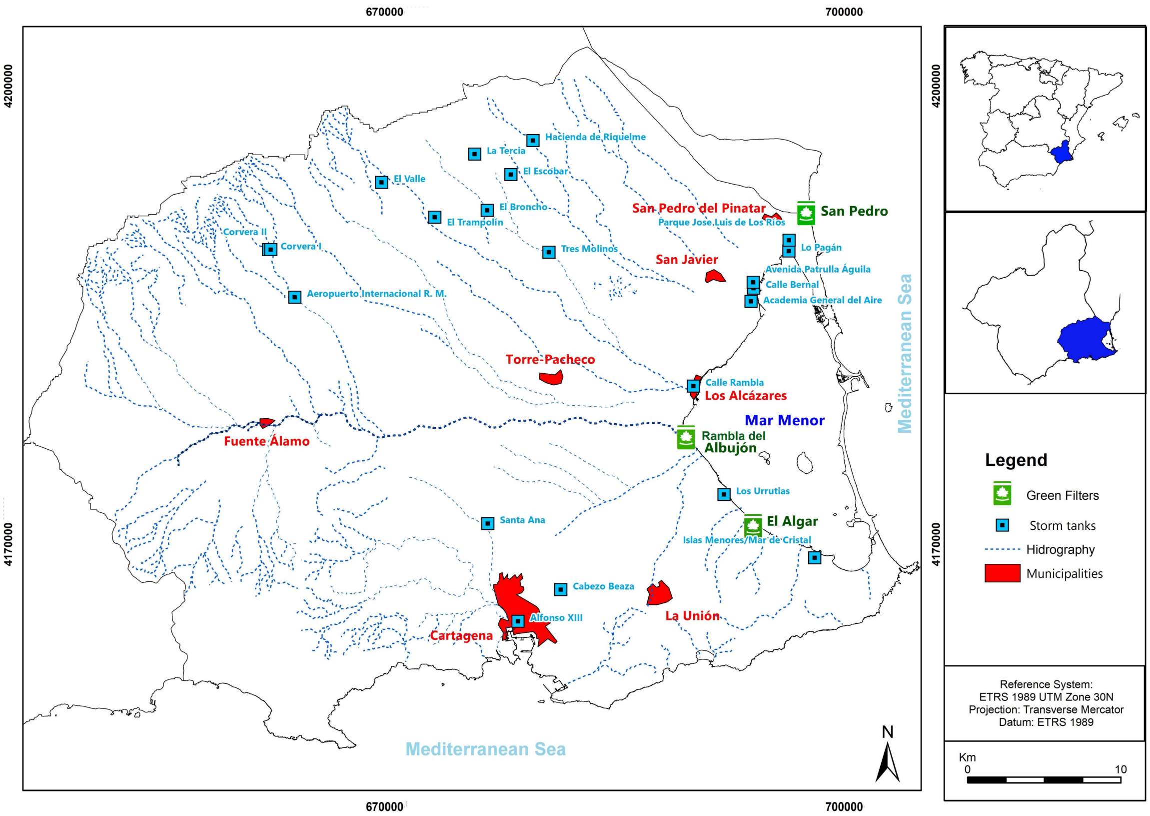

Figure 6. Points where green filters and storm tanks have been built or are under construction. Source: own elaboration based on press releases and García et al. (2016) [61].

3.2.2. Agricultural Drainage Treatment Plants

Another possible action which allows some recovery of precipitated water is the installation of treatment plants for agricultural drains in which, from the collection of surplus water from irrigation (artificial and/or natural) and after specific treatment, suitable flow rates are obtained for use again in irrigation. Accordingly, some authors have considered the environmental and economic benefits of this type of procedure applied to the specific case of the Rambla de Fuente Alamo-El Albujón, showing that it was an infrastructure of interest to care for and complete the irrigation endowments, in addition to reducing the contribution of polluting products to the Mar Menor by up to 10% for the entire Campo de Cartagena area, according to its dynamic models [62]. However, at present, the recovery of drainage water shows little development in the study area, despite being a contrasted measure and even having been executed through a project involving derivation of the drains of the Rambla del Albujón towards the desalination plant of Cabo de Palos, an infrastructure which never came into operation despite the investment made. Without a doubt, the management of the waste obtained after the processing of the water (brine) is the biggest impediment to the application of this technique.

3.2.3. Wetlands: Green Filters

Likewise, the recovery and creation of wetlands (green filters) in the areas surrounding the lagoon has been proposed (Figure 6), with the purpose of achieving the filtration and elimination of pollutants dissolved or dragged by the extensive drainage network through a natural solution which, in turn, allows the recovery of areas of high ecological-landscaping value and the regeneration of wastewater for agricultural use. Similarly, the construction of a green area which surrounds the Mar Menor has been considered. The green filter in the vicinity of the mouth of the Rambla del Albujón to the Mar Menor, promoted by the Consejería de Agua, Agricultura y Medio Ambiente, is the key outcome of this measure, although initiation of its construction is currently at a stand-still (despite the fact that on 19 April 2017 the construction and service contract was tendered) due to the allegation of drainage reduction due to the closure of the desalination plants and illegal wells. In a more difficult situation are the two remaining filters announced—San Pedro del Pinatar and El Algar (Cartagena)—whose construction has not been carried out yet, although environmentally, these actions seem to be highly advisable, due to their capacity to eliminate pollutants and provide ecosystem services [63].

3.3. Viability of the Use of Runoff: A Case Study on the Rambla of Fuente Álamo-Albujón (September 2012 and December 2016)

The episodes of torrential rain from 27–29 September 2012 and 17–19 December 2016 have been the two most significant rainfall events in the southeast of the Iberian Peninsula over the last two decades. Both episodes originated, in summary, from a cut-off low although the atmospheric synoptic situations which fostered this process have a different origin. The surface topographies of 300 and 500 hPa, from 27–28 September 2012 reflected on the Atlantic between 20–25° N and at lengths of 5–50° W—an omega block situation. In its descending branch, to the southwest of the peninsula, was located a perfectly detached cut-off low, characterized by three isohipsas—932, 928 and 924 dm—strangled and closed in the core of a deep retrograde thalweg. On the surface, the situation was a stationery high-pressure system (1016 hpa), corresponding to an anticyclonic col, favouring the flow of air from the Western Mediterranean to the Iberian southeast. On 28 September 2012, the concurrence of all these factors made focal points of very strong rainfall in the mountain ranges possible, in particular, in the Southwestern end of the Demarcación Hidrográfica del Segura [64].

During 17–18 December 2016, an atmospheric wave was created with a clear reflection in pressure, which moved and was placed over the Gulf of Cadiz and then later moved to the Western part of Morocco, configuring itself as a cut-off low. This low in pressure, isolated from the general atmospheric circulation, propelled winds in height from the southeast direction, with clear divergence on the coast of the Region of Murcia. The persistence and intensity of the Central European anticyclone (1036 hPa), together with the presence of lows relative to the south of the peninsula, formed a clear path of humid winds from the Mediterranean on the Iberian southeast, which generated a marked atmospheric instability on 17–18 December in this territory. In addition, at low levels, there was a clear moisture advection with a great sea trajectory, which, associated with the settlement of low pressure in the Mar de Alboran, provided abundant, effective precipitation. This configuration causedthe accumulation of rain in the area of analysis to be higher in this episode compared to 27–29 September 2012 (Figure 7), which also resulted in a greater flow and surface runoff (Figure 8).

Figure 7 shows a comparison of the total precipitation between the two episodes, observing that during the episode of 17–19 December 2016, rainfall was much higher, reaching almost 300 mm in some specific areas, which led to numerous economic losses, which amounted to 70.4 million euros throughout the southeast of the peninsula and in the Balearic Islands, according to the Consorcio de Compensación de Seguros. The most affected area was the Region of Murcia, and more specifically, the region of the Campo de Cartagena. At a state level, a total of 13,394 requests for compensation were made, of which 64% corresponded to the area of the Region of Murcia, with the municipality of Los Alcázares being the most affected with a total of 3419 applications.

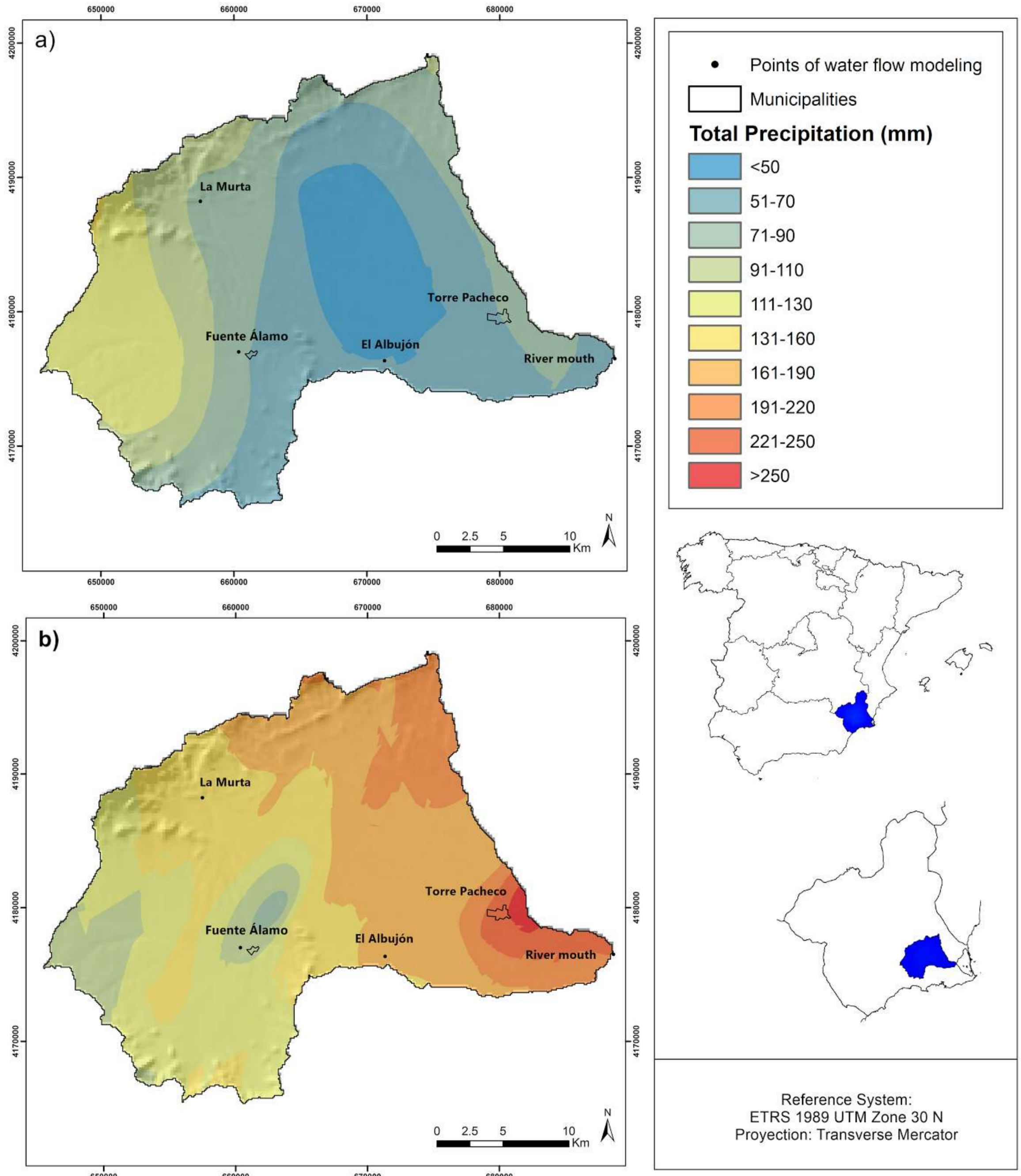

Figure 7. Total cumulative rainfall during (**a**) 27–29 September 2012 and (**b**) 17–19 December 2016 in the Basin of *Rambla de Fuente Álamo-Albujón*. Source: own elaboration.

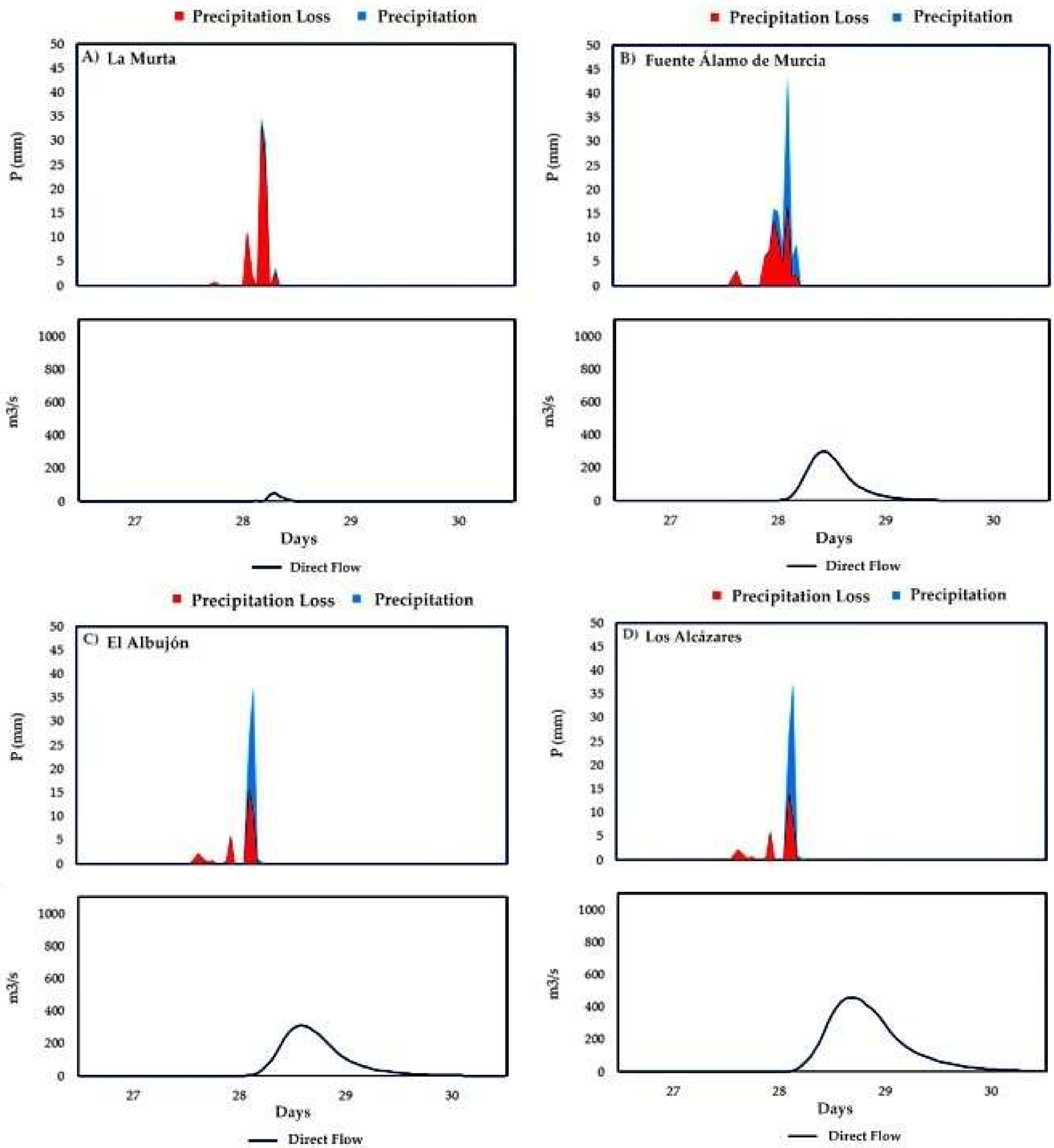

Figure 8. Hydrograms obtained in the period of 27–29 September 2012 for the channel of the *Rambla de Fuente Álamo-Albujón* at the indicated points. Source: own elaboration. (**A**) La Murta, (**B**) Fuente Álamo de Murcia, (**C**) El Albujón and (**D**) Los Alcázares.

During the rainy season of 27–29 September 2012, the highest accumulation was recorded in the Western end of the study area, in the area of Campillo de Abajo (Fuente Álamo de Murcia) where 117 mm was accumulated. The precipitation had a high spatial and hourly concentration, since in just4 h, about 80% of the total was registered. The La Murta point of water flow modelling (Figure 8A), located at the Northwestern end of the study area, was the only one which presented a greater flow and runoff during this episode. On the other hand, the rainy episode of 17–19 December 2016 was much longer-lasting (Figure 9), the moment of greatest intensity being in the afternoon of December 18. In this case, the most affected territory was located on the Eastern end. The maximum precipitation was recorded in the Torreblanca area (Torre Pacheco), with a total of 285.3 mm, accumulating a total of 191.7 mm in 12 h and 49.3 mm in just one hour. It should be noted that in only three days of precipitation, the annual average was exceeded (276.4 mm). This fact is a clear indicator of the pluviometric anomaly of this episode.

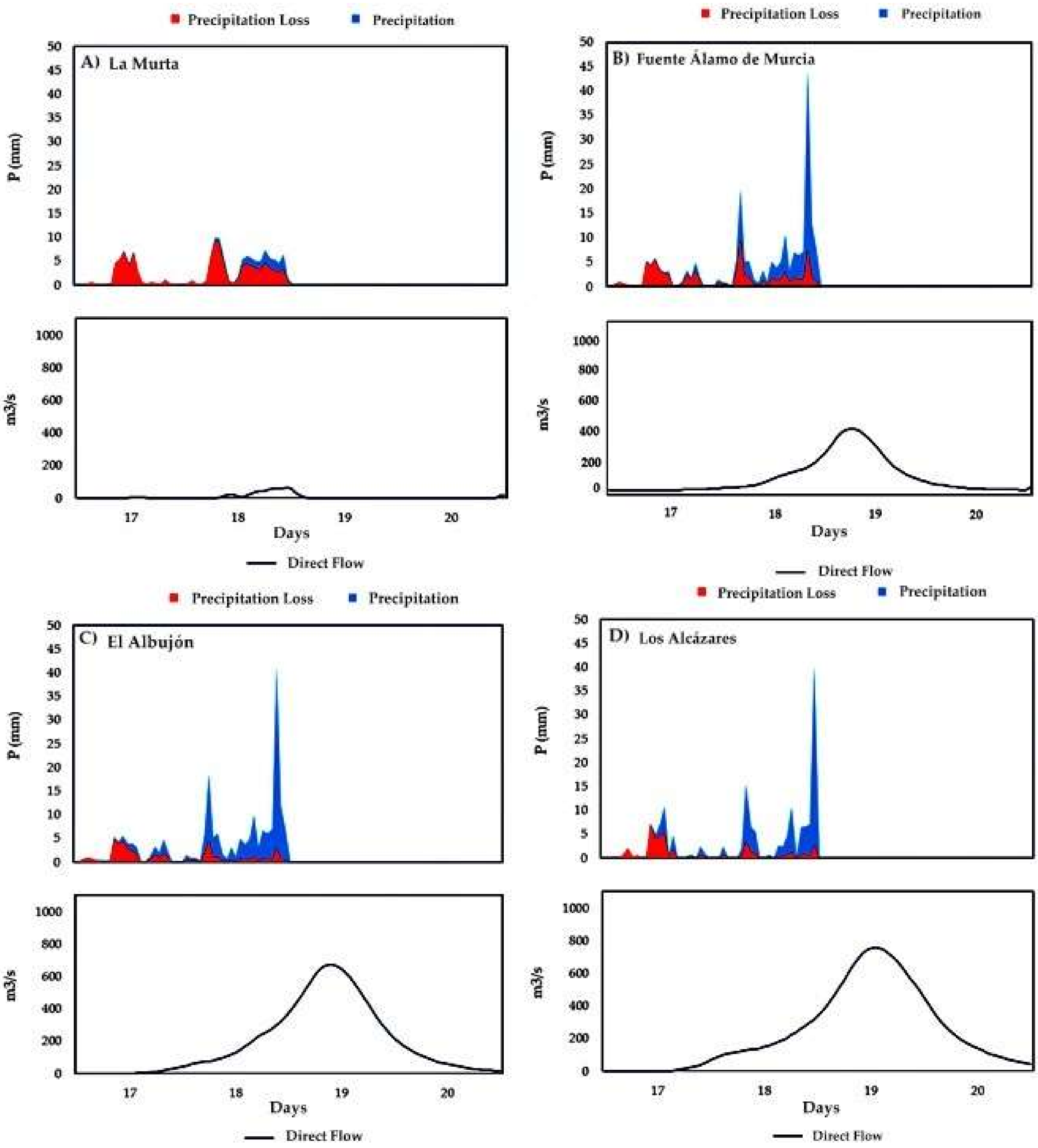

Figure 9. Hydrograms obtained in the period of 17–19 December 2016 for the channel of the *Rambla de Fuente Álamo-Albujón* at the indicated points. Source: own elaboration. (**A**) La Murta, (**B**) Fuente Álamo de Murcia, (**C**) El Albujón and (**D**) Los Alcázares.

During the aforementioned episodes of abundant and intense rainfall in the Campo de Cartagena (September 2012 and December 2016), innumerable socio-environmental problems were generated related to the torrential rainfall and the damage caused by the strong erosiveness of the floods due to the recent changes in land use in the last decades. The abandonment and disorganization of irrigation through sluices due to the recent and growing implementation of thousands of hectares of technified irrigation, as well as other uses of runoff, which have historically characterized the study area led to a worsening in the impact of floods on urban areas. Therefore, it is not possible to exert a work of lamination and reduction of the flood peaks at present, and, consequently, the effects of desertification in the semi-arid Iberian southeast have increased.

After the estimation of the effective precipitation during the two previous episodes, it has been concluded that the infiltration is significantly lower in the lower part of the Fuente Álamo-Albujón basin (47–26%), where land use is mainly destined for irrigation agriculture and therefore, surface runoff acquires larger volumes, while, in the initial part of the seasonal stream (La Murta), infiltration accounts for a percentage higher than 80% (Table 2). Likewise, in 2016, rainfall losses due to infiltration were lower than in 2012, which is directly related to an increase in soil sealing in the Campo de Cartagena, currently estimated at 126.6 km^2 (16.2% of the total), with an increase of 75.4% from 1981 to the present [65].

Table 2. Percentage of total rainfall loss, volume of total excess (mm), total volume of direct runoff (hm^3) and total volume of water through the channel (hm^3), recorded during the rainfall episodes of 27–29 September 2012 and 17–19 December 2016. Source: own elaboration.

Parameters	Total Loss (%)		Total Excess (mm)		Total Direct Runoff (hm^3)		Total Baseflow (hm^3)	
Episode Location	**12 Sep**	**16 Dec**	**12 Sep**	**16 Dec**	**12 Sep**	**16 Dec**	**12 Sep**	**16 Dec**
La Murta	92.3	81.5	24.2	6.4	6.4	2.4	6.3	2.4
Fuente Álamo de Murcia	58.7	41.8	48.2	50.4	12	29.2	8.8	7
El Albujón	39.3	26.2	35.1	122.2	17	64.6	9	10.4
Los Alcázares	46.6	27.6	52.6	222.6	30.9	82.5	10.3	6.9

It is necessary to consider the precipitation episode in December 2016 (178.4 mm of average rainfall) significantly more important than the one in September 2012 (56.9 mm), although, in the latter, rainfall intensity was more noticeable in the municipality of Fuente Álamo (Figure 8). Thus, the estimated peak flows for the Rambla de Fuente Álamo-Albujón near the mouth of the basin (Los Alcázares) reached 820 m^3/s [66]. The total volume of surface runoff mobilized during the December 2016 episode was greater than that in September 2012, with a total of 82.5 hm^3 (Figure 9). This huge amount of water exceeded even the 18.9 hm^3 collected by the dams of the Demarcación Hidrográfica del Segura during one of the most important rainfall events of the 21st century (28 September 2012). During the aforementioned day, there was a significant water wastage—the El Paretón diversion channel (municipality of Totana) evacuated a total of 29.1 hm^3 to the Mediterranean Sea through the Rambla de las Moreras, almost twice as much as the water collected at the regional level.

In short, the important figures of surface runoff during the episodes of heavy rainfall in the study area, raise the possibility of a profound restructuring of the use of flood water. The average flow of 40/50 hm^3 in the study area during the aforementioned events, represents approximately 30% of the reservoir flood limits of the Region of Murcia (149 hm^3), which represents, without a doubt, an extraordinary mobilization of water in an eminently semi-arid region whose average rainfall is 283.4 mm per year.

The regionalized future trends of climate change in relation to the total volume of runoff in the area of analysis do not show a very encouraging scenario. It is necessary to emphasize the strong influence of radiative forcing and gas emissions during the next decades in the final results. The role played by potential evapotranspiration, linked to current global warming, will be decisive in the evolution of water resources and the availability of water in the future, subject to population growth and a continuously growing demand for water. Indeed, scenario ARC 4.5 shows a slight increase in runoff (1.2%/decade) with a τ (tau) of Kendall and ϱ (rho) of Spearman (0.04 and 0.06) without any significant trend, showing values with no degree of relationship. In contrast, the most pessimistic scenario (ARC 8.5) does show a statistically significant trend (−3.5%/decade), considerably and significantly influencing the reduction of the average of the two aforementioned scenarios (−1.8%/decade, and values of τ and ϱ of −0.2 and −0.3 respectively). With great interdecadal variability, and subject to the change in duration of the dry spells (becoming increasingly frequent), but at the same time with a stable or slightly positive tendency for the intense rainfall events in the study area (with the same number of days a year) [67], the general trend is towards a marked decrease in runoff during the next decades, estimating, with great caution, a reduction of 15% in the year 2050, and 22% in the year 2100 for the area analyzed (Figure 10).

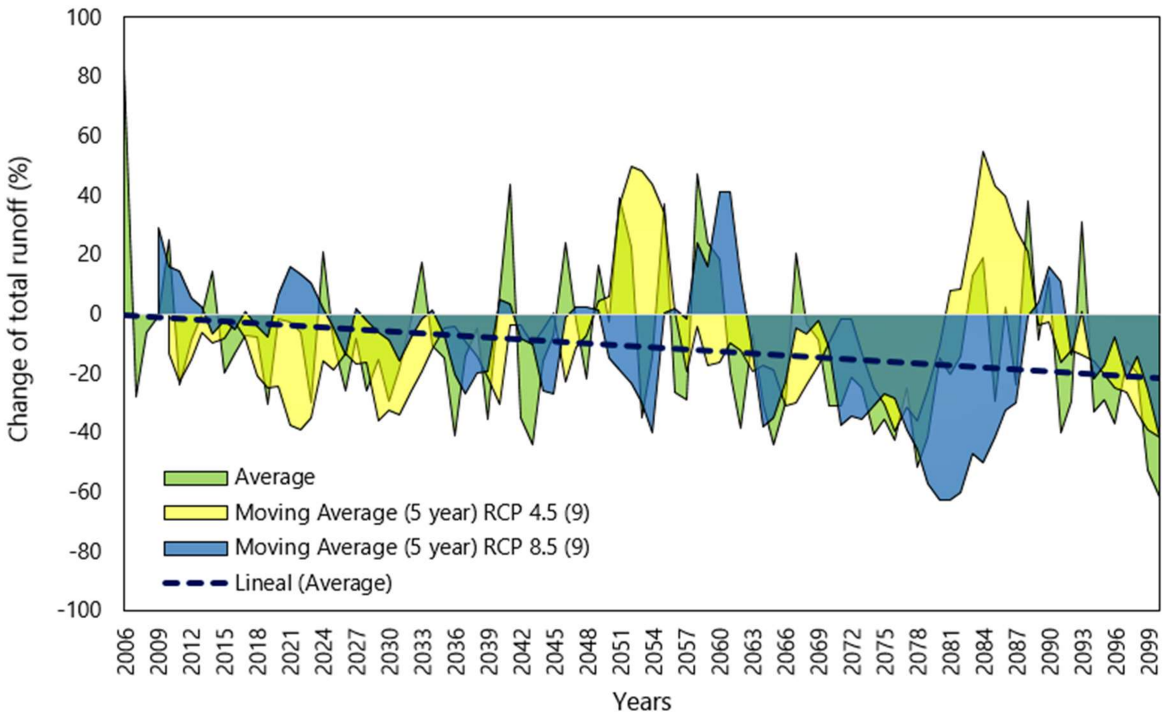

Figure 10. Variation in total runoff (%) according to the climate change projections for the 21st century (ARC5 IPCC). Source: own elaboration.

3.4. Environmental and Socioeconomic Benefits of the Use of Runoff

The reuse of runoff water offers a series of advantages due to its sustainable practice, which can be identified as environmental, social and economic benefits based—the collection of a scarce resource, the treatment of the discharges produced in the region and the establishment of infrastructures which allow flood mitigation (Figure 6).

3.4.1. Obtaining Resources

It is evident that the current agricultural and tourist model implemented in the Campo de Cartagena is a predator of water resources, and future projections predict a greater demand. In this sense, given the exhaustion or scarcity of the sources of supply which currently supply both intensive agriculture and tourism—transfers, wells and desalination—reintroducing traditional and efficient practices for the use of rain means the possibility of obtaining additional flow. Also, despite the treatment costs, it is water whose cost is affordable, and is even cheaper than that of other resources, both surface and underground; in addition, the social and environmental costs derived from conflicts over water ownership and over-exploitation must be added. A greater availability of this resource should reduce the demand for foreign water and consequently, the pressure and discrepancies between the ceding and receiving basins, even more so in periods of drought; this follows the controversies generated around the recent Greenpeace report, '*La Trama del Agua*', in which it is argued that the *Cuenca del Segura* could be self-sufficient only with its underground water reserves and desalinated water (a theory discredited by the CHS but of great importance among the most critical positions with the current water exploitation model) [68], thus reducing the widespread use of groundwater and, in this way, the pressure on the reservoirs confined to the subsoil of this territory.

3.4.2. Waste Treatment

The collection of runoff at specific points of emission of the effluents makes the treatment of the water in a more effective and economic way possible, which is a clear advantage, since part of the discharge from the Campo de Cartagena reaches the *Mar Menor* by means of diffused pollution [69]. In this way, the seasonal streams' own channels act as collectors of the surface flows which, through leaching processes, drag the agricultural, urban and mining pollutants, concentrating the bulk of the harmful elements in certain fluvial axes and facilitating the collection and subsequent treatment of them in specialized treatment plants. These infrastructures have the purpose of eliminating harmful substances, both in suspension and dissolved. The treatments are carried out through physical, biological and chemical processes. Through these actions, the environmental impact of intensive agriculture and tourism activities would be reduced, improving the quality of the water and the global ecosystem which forms the coastal lagoon. In the same way, the improvement of the chemical conditions of the water and the biotic characteristics of the lagoon will be a positive factor for the tourist image of the natural space, besides favouring the recovery of fishing activity.

3.4.3. Flood Mitigations

An extended use of the recovery and application of runoff collection techniques, at all levels, would generate a beneficial effect on flood mitigations on two scales. On a smaller scale, the collection of the flows mobilized at the headwaters of the seasonal streams will exert an effect of rolling floods due to the decrease in the flows which run into the main channels [70]; on a larger scale, direct collection in higher-level courses limits the amount of water transported by them and, in turn, reduces the risk of flooding in the flood plain when they transport extraordinary, sporadic and ephemeral flows, whose volume transported during episodes of torrential rainfall can be destructive, as has been previously demonstrated. Thus, the implementation of these measures of action would achieve on the one hand, a reduction in the risk of flooding and, on the other, the attainment of very considerable water resources, either through direct derivation, or through storage and subsequent use.

4. Conclusions

There is no doubt that the scarcity of rain which characterizes the Campo de Cartagena, as well as the lack of permanent water courses and the unusual existence of natural springs, limited mostly to the mountain ranges which surround the region, has caused, historically, settlers to collect the precipitated water by means of different traditional techniques (sluices, derivation dams, dams, cisterns, etc.) which are reflected in the territory and in popular culture.

The availability of water has been a constant struggle in the Campo de Cartagena. Rain has been a useful resource since prehistoric times through the use of traditional and sustainable techniques and inventions, created and modelled according to needs. However, this traditional water culture has been relegated by new water collection technologies: transfer of foreign flows, underground exploitation and desalination. This conscious amnesia has not only entailed a great cultural decline but has been linked to gradual elimination and/or abandonment of an extraordinary hydraulic heritage, both material and immaterial, which, to this day, has barely survived and has been partly destroyed due to a lack of real protection and an absence of conservation and dissemination strategies—that is, due to a general absence of sensitivity and heritage awareness.

The new infrastructures, whose aim is to increase the supply of water resources, have managed to expand agricultural production extraordinarily, but have fractured social and environmental stability because of the impact caused by the current exploitation model. We must also think about the unflattering future climate trends and the expected increase in the residential and tourist populations.

The intense agricultural and tourist use and exploitation of the region have resulted in a series of socio-environmental conflicts which are summarized by the following: a loss of soil and registration of siltation processes, over-exploitation of aquifers, need for foreign water transfer and establishment of desalination plants, risk of floods and degradation of the *Mar Menor*. These factors are signs of the lack of environmental friendliness and poor territorial management.

In light of these problems, different strategies have been developed to solve the negative effects of the exploitation model in the territory, among which the following stand out: the A.G.U.A Programme, the *Plan Vertido 0* and the *ITI Mar Menor 2014–2020*, whose aim is the implementation of the *Integrated Management of Coastal Zones in the Mar Menor and its surroundings* and the *Socioecological System of the Mar Menor and its surroundings*. In addition, considering the alarming situation, the citizen platform *'Pacto por el Mar Menor'* emerged at a grassroots level, while, in 2015, the *'Comisión Especial del Mar Menor'* was established at the Autonomic Parliament of the Region of Murcia, a committee created to study and improve the state of the lagoon.

A small percentage of rainfall is useful rain, due to its torrentiality, the rest is transformed into runoff collected by the drainage network, generating significant flow which ends up in the sea. In fact, during the episodes of intense and copious rainfall in September 2012 and December 2016, the accumulated rainfall, up to 300 mm (annual average rainfall), generated a total surface runoff volume between 31 and 82 hm^3 on the *Rambla de Fuente Alamo-Albujón*, which comprised one-third of the maximum total water stored in the Region of Murcia. Given climate change projections, which estimate a general reduction of total runoff by 22% during this century, it is therefore necessary to make better use of surface flow in flood events, given the slightly increasing future trend of events of intense precipitation in the Mediterranean area in the southeast peninsular.

The actions carried out in relation to the collection of rainwater, despite seeking, for the most part, the reduction of flood risk and waste discharge, require infrastructure capable of capturing runoff. However, although some methods return the water collected in the irrigation network, their expansion and development is very limited due to the lack of firm commitment to the use of these resources. Therefore, it is not surprising that they are projects designed to minimize the impacts of tourism and agricultural exploitation on the study area, despite the huge volumes of water which flow along the seasonal streams in episodes of flood and which, if used, could be an important and specific resource, as has been shown in this article.

In this sense, the use of this water, after its corresponding treatment, would be an advantageous strategy because three great benefits would be achieved: (1) obtaining complementary water resources in a territory where there is scarcity and in which future projections predict a reduction in rainfall, as a consequence of climate change and an increase of pressures exerted on the area, (2) processing of agricultural, mining and urban waste mobilized by illegal discharges or leachate processes of contaminated land, and (3) flood mitigation as a direct consequence of the collection of flow both in the headwaters and in the middle and lower courses of the seasonal streams.

Author Contributions: The coordinator of the paper has been G.C.-P., and he has also done Introduction and Current Waste and Socio-Environmental Conflicts sections. The Materials and Methods section has been carried out by G.C.-P., D.E.-S. and V.R.-Á. R.G.-M. has done the Projects and Future Perspectives section, a general review of the paper and revisions of style and language. D.E.-S. and V.R.-Á. have made the section: Viability of the Use of Runoff: A Case Study on the Rambla of Fuente Álamo-Albujón (September 2012 and December 2016); and D.M.-M. has done the section dedicated to the study of the Environmental and Socioeconomic Benefits of the Use of Runoff. Finally, the Conclusions section has been prepared by all the authors.

Conflicts of Interest: The authors declare no conflict of interest.

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