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An Analysis of the Cost of Water Supply Linked to the Tourism Industry. An Application to the Case of the Island of Ibiza in Spain

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Abstract: Tourist activity has a number of impacts on the destinations in which it takes place, among which are the environmental ones. A particular problem is the increase in water demand and wastewater production, which can compromise the balance of ecosystems. As many authors point out, there is a research gap in the comparative analysis between available water resources and the demand associated with tourism. In this respect, the main objective of this work is, on the one hand, to assess the water needs linked to the tourism industry and the capacity of natural resources to meet such a demand and, on the other hand, to estimate the economic cost of the water supply associated with the growing tourist demand in a territory, such as the island of Ibiza in Spain. It has been determined that the resources available are not sufficient to meet the water demand of the resident population at this destination, which is why it is necessary to resort to producing desalinated water. Therefore, the additional requirements associated with tourism must be met fully with desalinated water, which results in an increased cost of water management for the region. This paper also points at water losses in distribution networks and tourism seasonality as two phenomena that aggravate this issue.

Keywords: sustainable tourism; cost of desalination; environmental impacts; water management

1. Introduction

Tourism industry generates diverse impacts on the destinations where it develops [1]. These impacts can be classified as economic, socio-cultural, and environmental [2]. Environmental impacts derive from the intensive use of natural resources of certain enclaves. The character and intensity of these impacts are conditioned by the tourism model developed and, frequently, the result depends greatly upon the number of tourist arrivals [3]. It can be said that the impact that tourist activity has on water resources is one of the most important. The pressure exerted by certain human activities, like tourism, are factors that have notably reshaped the balance and correct functioning of aquatic ecosystems, and with it, the future uses of their resources [4]. In this line, the EU Water Framework Directive (WFD) considers necessary the further inclusion of conservation and sustainable water management in areas such as energy, transport, agriculture, fishing, regional policy, and tourism [5].

Academic literature has highlighted the damage that tourist activity can cause to water resources [6]. The problem is aggravated by the fact that certain types of mass tourism, such as sun-and-beach tourism, are located precisely in environments where there is not much water available [7]. Therefore, when it comes to the sustainability of water resources and their responsible use, tourism poses a great challenge that needs to be studied carefully.

The academic literature highlights several gaps in the analysis of water consumption linked to tourism. We present below some of the research gaps to which this paper contributes. There is little development in the comparative analysis between water resources and tourism-related demand, even though research indicates the high dependence of this sector upon a sufficient quality water supply [8]. Water scarcity is recognized as a key factor in the development of the tourism industry [9], so more research is necessary on the efficient and sustainable use of water [10–12]. In fact, water consumption in the tourism industry has received increasing attention from organizations such as the World Tourism Organization (WTO) [13], United Nations Environment Programme (UNEP) [14], and Organisation for Economic Co-operation and Development (OECD) [15]. These institutions have voiced the need to reduce water consumption and reduce the pressure on water resources. The tourism industry is well known for its heavy water consumption, which has generated numerous conflicts with local communities [10,16–20]. One of these conflicts deals with the extra cost that must potentially be assumed to meet the water demand linked to the tourism industry, this being a major research gap in the literature, as pointed out by Gössling et al. [21] and Tortella and Tirado [22].

In relation to the research gaps noted above, this study proposes analyzing the increasing pressure on water resources, in a context of growing tourism demand and at a time when certain European areas are noticing the impacts of years of pro-growth strategies driven by the consolidation of low-cost mass tourism [23–25]. Specifically, this paper focuses on the island of Ibiza in the Balearic Archipelago (Spain), a destination that has experienced a high increase in tourism demand over the last two decades and which also suffers from the highest tourism seasonality in Spain [26,27]. Furthermore, since we are talking of an island, available natural resources are clearly limited, unlike other coastal tourist destinations. In order to ensure the future availability of water resources, and thus, guarantee the sustainability of tourism activity at medium and long term, it is necessary to analyze the availability of existing resources, the rate of their exploitation and the influence of the tourism industry on the consumption of such resources. In this sense, in addition to understanding the environmental impacts, it is necessary to evaluate the economic costs associated with uncontrolled growth in tourist activity.

Therefore, this study provides the academic literature with a clear methodology for analyzing the effect of tourism on a delimited territory, such as an island. The island is considered a closed system because the water available, which is obtained from rainfall, is used in its entirety locally. What is more, there are no water inflows to the island other than rainfall and seawater desalination. Specifically, in response to a gap identified in the academic literature, this study proposes a comparative analysis of water resources and water demand associated with tourism. It also makes use of a methodology that can be replicated in other destinations. The academic literature has also pointed out the importance of analyzing the additional cost that must be incurred to cover the demand for water associated with tourism, something that this work aims to calculate. Therefore, this paper does not start from a research question, but seeks to provide empirical information on aspects that various authors have pointed out as requiring further research and evidence. Thus, the significance of this work lies in the need to provide new data and evidence on the relationship between the tourism sector and water consumption. This will make it possible to more accurately diagnose the problem arising from high water consumption in contexts of scarcity, so that it is possible to define strategies for action. This information will be useful for those responsible for public planning, whether related to water management or tourism. Likewise, the data presented here should help to raise awareness about the need to reduce water consumption in environments where it is particularly scarce. The aim is to contribute to the debate related to the efficiency of water consumption, but also to reflect on the phenomenon of over-tourism and the carrying capacity of destinations [28]. In this debate, the position of the authors is clear. It is necessary to estimate what is the optimal volume of tourists, so as to maximize tourism's economic benefits without overusing resources.

The paper is organized as follows: The introduction is followed by a brief analysis of the academic literature on water consumption associated with tourism. Next, a section contextualizes the tourist activity developed in the island of Ibiza and in the whole archipelago where it is located. Then, a brief review of different methods of water treatment capable of making this resource available for human use is proposed. After this section, we present the methodology that has inspired this study and the data sources consulted. The paper continues with the presentation of the results and the discussion of the main conclusions drawn from this analysis.

2. Analysis of the Existing Scholarly Literature on Tourism-Related Water Consumption

This section is concerned with a brief review of studies focusing on tourism-related water demand. Some important concepts for this study are also clarified. Firstly, it is important to define what is meant by sustainable tourism, as this is a concept that encompasses sustainable water management. The World Commission on Environment and Development (WCED), defines sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987, p. 43) [29]. In particular, the World Tourism Organization connects sustainable tourism with seven dimensions: tourism seasonality, leakages, employment, tourism as a contributor to nature conservation, community and destination economic benefits, tourism and poverty alleviation, and competitiveness of tourism businesses [30]. The concept of sustainable tourism implies the sustainable development of this activity from an economic, social, and environmental perspective. One of the problems that can hinder sustainable development in the tourism industry is exceeding the carrying capacity of the destinations, as the volume of visitors may be the factor that determines the degree of sustainability [31]. The phenomenon of seasonality associated with beach tourism may aggravate the problem [32] since during peak periods resources may not be able to regenerate in time, this being something that should be studied in depth.

The development of tourist activity results in diverse and complex interactions with the settings in which it unfolds [33]. Such interactions, both positive and negative, are known as tourism impacts [34]. Accordingly, environmental impacts refer to interactions between tourist activity and the environment [35], whose positive or negative effect, along with its intensity, depend upon factors such as the volume of tourists, the regulation of the sector, the vulnerability of the environment and the activities carried out, among other factors [36]. A part of the tourism impacts is associated with the effect on water resources, since tourism activity will increase the demand for water as well as the production of wastewater. Tourism-related water consumption may exceed the local population's demand [37] and some studies have found that water consumption per tourist and day is two to three times higher than the volume of water consumed per inhabitant and day [14,21,38].

The academic literature makes frequent references to the environmental implications which tourism poses for water consumption, highlighting the intensive use of this resource and the changes in availability-consumption patterns [6]. Scholarly studies on tourism and water consumption are classified into three main lines [39]. One of them concerns the analysis of direct or indirect use measured in liters or cubic meters [21,40,41]. Second, studies focused on sustainability implications of water use, including water scarcity, competition for scarce resources between tourism and other economic sectors or local populations, as well as the transfer of water use between countries and continents as a result of global tourism flows [7,16,21,42–45]. Finally, the line devoted to water management, including all actions that can help to reduce water demand [14,15,21]. Studies dealing with tourism-related water consumption have mainly been conducted in coastal destinations, as several factors converge in such areas that can lead to serious problems: high population density, water scarcity, high tourism pressure, high level of economic development, highly seasonal consumption and vulnerability of certain natural areas [46,47]. A high concentration of water demand for tourism might exceed the renewal rates of these resources and, therefore, compromise the socio-economic and environmental sustainability of this economic activity. This scenario, as regards intensive use of water resources was noted by Cazarro et al. [7], who stated that sun-and-beach destinations are clustered in areas with scarce water resources, some of which already require intervention if soil salinization is to be avoided. In this context, the use of non-conventional resources has become a necessary solution [11], such as desalination and wastewater reuse [48].

In addition to the above, there are numerous studies on tourism-related water demand, which focus on the importance of defining management systems capable of respecting the needs of the different stakeholders involved [49]. Gössling et al. [50] point out the importance of improving regulation on water use in sun-and-beach tourist spots, so that each stakeholder is assigned responsibilities in this regard. The diversity of sometimes conflicting interests makes it difficult to design useful policies. Regulation is a key aspect in improving water management in tourist areas, as it has been demonstrated that self-awareness and water-saving devices are not sufficient to compensate for the growing water needs associated with tourism [51]. As mentioned above, water management requires the engagement of the stakeholders, but it is also important to have adequate information and efficiency control systems [52]. The present study focuses precisely on the importance of improving knowledge about the impact of tourism-related water demand on water resources in an environmentally sensitive area.

3. The Tourist Background on the Island of Ibiza and the Balearic Islands

Tourist activity in the Balearic Islands causes a great deal of controversy among residents. Even though it represents the main source of income in the region, it is also the source of many negative impacts. The growth in the number of tourist arrivals to the islands is a success but, at the same time, a challenge as regards the management of the derived environmental impacts [28]. In 2018, the Balearic Islands received a total of 18.3 million visitors, 40% more than in 2008 [53]. These islands have one of the highest ratios of tourists per capita in the world, 16:1 compared to the local population. In addition to the problems derived from the increase in arrivals, this tourist destination must also manage the challenges arising from recording the highest level of tourism seasonality of all Spanish regions [26,54]. This archipelago has oriented its tourist product largely towards sun-and-beach tourism, and unlike other areas with more stable weather conditions throughout the year, the Balearic Islands are highly dependent on the summer months. Using data from 2018, it is possible to see how 50% of tourist arrivals were concentrated in the months of June, July, and August, attracting more than 9 million visitors [53]. Employees of the tourism industry are to be added to this floating population, as the former come to the islands every summer from different parts of Spain to fill vacant positions. The average number of people employed at hotels and aparthotels reaches 176,727 in the summer months, while the lowest figure is 73,198 in the low season [53]. The increasing demand and the high concentration of visitors create a complex situation with regard to managing the potential impacts that tourist activity generates on the natural environment.

Water resources are subject to high pressure due to tourist activity, even more so in resource-limited systems such as an island. Heavy concentrations of people can lead to severe consequences in environmentally sensitive areas, such as coastal zones and, particularly, islands [55,56]. In the case of the Balearic Islands, the success of its tourism model has led to the saturation of its beaches in the summer season, with less than six square meters of beach per person, generating a peak in water consumption that coincides with the period of least availability of water resources. This situation implies an over-extraction and a decrease in the levels of the aquifers [57]. The consequence of this overexploitation, which entails more water being extracted than supplied, means that underground water reserves cannot be replenished, which leads to seawater infiltrations in areas of contact and; thus, to deteriorating the quality of the water. Seawater infiltrations generate an increase in the concentration of dissolved salts in the water, which has negative consequences for both urban and agricultural consumption of water resources [58].

The above information is of interest to contextualize the archipelago in which the island of Ibiza is located. The following provides some data specifically related to this island, although there is little individualized information. Scarcity of information is partly explained as a result of the fact that the registries referring to tourist accommodation are incomplete, given that a large part of the offer is associated with the informal economy. Moreover, much of the data concerning this island are issued together with those of Formentera (both form the so-called Pitiusas Islands), instead of being individualized.

Diverse estimates place the number of travelers arriving to the island of Ibiza at a little less than two million per year [59,60], which represents the average of the last few years. Annual overnight stays associated with this tourist flow were expected to reach 7.8 million by 2018 [59,60]. Almost three quarters of the travelers who come to the island stay in informal tourist accommodations. The information available on the offer of regulated accommodation (hotels and tourist apartments) is more complete. For this modality, the average length of stay was between 3.4 and 3.96 nights, as shown in Table 1. The number of bed places in hotels on the island reached 9236 in August, whereas that of tourist apartments reached 4361, as data from 2018 show [59,60]. It is interesting to mention that there are only statistical records on the supply of places between the months of April and October, which suggests that during the rest of the year the supply is marginal, as a result of the high level of seasonality. Ibiza is the second destination in the world with the highest tourist pressure [61]. The local population of Ibiza reaches 157,704 inhabitants [60]. These data reveal a vigorous tourist sector that is heavily concentrated in the summer months. As a result, it exerts a great pressure on the environment in addition to being based on non-regulated supply.

Table 1. Key data of the tourism industry in Ibiza, 2018.

	Visitors	Overnight Stays	Average Length of Stay	Bed Places
Hotels	404,825.00	1,374,419.00	3.40	9236.00
Tourist apartments	122,559.00	485,859.00	3.96	4361.00
Peer-to-peer tourist accommodations	1,438,148.75	5,893,749.00		
Total	1,965,532.75	7,862,131.00		

Source: National Statistics Institute and Institute of Statistics of the Balearic Islands [59,60].

The main objective of this work is, on the one hand, to assess the water needs linked to the tourism industry and the capacity of natural resources to meet such a demand and, on the other hand, to estimate the economic cost of the water supply associated with the growing tourist demand in a territory, such as the island of Ibiza.

4. Seawater Desalination and Other Water Treatment Processes

There are currently various methods of water treatment capable of making this resource available for human consumption or for the various activities that require it. The economic cost associated with each of the different treatment options is largely determined by the amount of energy used in the process. Desalination is the process whereby freshwater is obtained from salt or brackish water, whether from the sea, the ground or inland surface water. This process produces water with a low salt concentration, which is suitable for human consumption, agricultural irrigation, and other uses. Spain is the fourth-largest producer of desalinated water in the world in terms of installed capacity, only behind Saudi Arabia, the United States and the United Arab Emirates [62]. There exist a number of desalination methods depending on the process upon which they are based. Among the desalination processes, reverse osmosis (RO) stands out for its energy efficiency and wide implementation.

This process best balances the quality of the water produced with the costs of implementation and operation [63]. In line with Pearce's (2008) [64] estimate for medium salinity waters (Total Dissolved Solids TDS around ppm) such as those of the Mediterranean, for which the author estimated desalination energy requirements between 2.3 and 4 kWh/m^3 by means of RO [65]. Another reason for the widespread implementation of this system is its greater versatility in terms of production flow rates, i.e., it is easier to expand its capacity if necessary, a requirement in coastal tourist areas such as the Balearic Islands where existing seawater plants are based on the RO process [62].

The treatment process required to make wastewater available for reuse is called reclamation, which produces reclaimed water. It consists in restoring water, partially or totally, to the quality level before being used by humans. The term reuse refers to the process by which water is used a second time [4]. The reuse of wastewater is part of the water cycle. Historically, wastewater has been discharged into various water bodies such as rivers, lakes, aquifers, etc. In these places, wastewater mixes with natural water, with the consequent dilution of the former, to be then re-used at another point in time [66]. A distinction should be made between two types of water reuse, the indirect reuse described above, and direct reuse. In indirect reuse, regenerated or unregenerated wastewater is discharged into environmental water reservoirs to be later collected and treated for new uses. Whereas direct reuse implies that the water is reused without it being first discharged into natural reservoirs [66,67].

In Spain, mainly in the Mediterranean coastal stretch and its two archipelagos, high population densities coincide with limited water resources. Additionally, the distribution of rainfall is highly seasonal, characteristic of the Mediterranean climate: the summer, which entails that the period of higher temperatures coincides with that of lower rainfall [68]. This phenomenon leads to various imbalances in the use of water resources since the increase in demand and the needs of human communities and other living beings coincide with the period in which the availability of water and the carrying capacity of ecosystems is lower. It is here that reusing wastewater becomes relevant, as it allows increasing the available water resources while decreasing the impact caused by the pollutant load present in wastewater [69]. It should be noted that for safe reuse, water treatment schemes must meet high quality standards including removal of persistent micropollutants [70,71] some of which have been shown to persist after some wastewater treatments [72–76].

A further advantage of this unconventional resource is the energy cost of producing reclaimed water. An analysis of Table 2 shows that the energy required to desalinate a cubic meter of water is eight to ten times greater than that required to produce drinking water from other natural sources such as rivers, reservoirs or freshwater aquifers. Producing drinking water from natural sources involves an energy cost of between 0.2–0.4 kWh/m^3, making it the most appealing option but also the most limited given the availability and regenerative capacity of the resources. As shown in Table 2, the energy required to obtain one cubic meter of reclaimed water is equivalent to between one fifth and one quarter of that required for the desalination of seawater by means of RO. With regard to the production of drinking water from natural sources (rivers, reservoirs or aquifers), the energy required for wastewater reclamation is 2.5 times higher. The lower energy cost and, therefore, the lower economic cost of reusing wastewater means that, for certain uses, it must be considered as an economic alternative to desalination.

Table 2. Energy requirements for the production of water supply from different sources.

Type of Water Supply	Energy Consumption (kWh/m^3)
Conventional surface water treatment	0.2–0.4
Wastewater reclamation	0.5–1.0
Indirect water reuse	1.5–2.0
Desalination of brackish water	1.0–1.5
Desalination of seawater by RO	2.5–4.0

Source: Voutchkov (2018) [77].

5. Materials and Methods

The methodology applied in this study consists in the following calculation blocks: calculation of the demand of water in the island, calculation of the water resources, calculation of the tourism-related water demand, and calculation of the cost of water desalination. For the calculation of the total amount of water supplied to the population, we have added data concerning the urban supply, the consumption of isolated dwellings, agricultural consumption, and that associated with industrial activities [78]. In addition to the official data available on the urban water supply, there is an unrecorded demand for water associated with isolated houses, which are not considered to be part of urban areas.

This self-supply takes place by means of groundwater extractions external to the general supply system. To determine the consumption of groundwater associated with isolated houses, we proceed according to the assumptions established by the Hydrological Plan of the Balearic Islands HPBI [79]. The HPBI estimates water consumption according to the size and characteristics of the plot, excluding buildings with less than 100 m^2 of surface area. The number of plots larger than 100 m^2 has been obtained by consulting the General Directorate of the Cadaster of Spain. The total water demand on the island has been estimated by adding up the demand associated with isolated houses (dispersed consumption), the demand associated with urban areas, water losses in distribution networks, the data on industrial consumption, and the data on water consumption for irrigation. The above information has been taken from official sources.

In order to calculate the water resources of the island, we have added the available water resources of the aquifers and the volume of wastewater that is reused. To determine the quantitative and qualitative condition of the aquifers, we have consulted the Early Review of the Hydrological Plan of the Balearic Islands 2015–2021 [78] and the Special Drought Action Plan [80]. By comparing the total water demand and the available water resources, it is possible to ascertain the water balance of the territory and determine the existence or absence of additional water supply requirements.

To determine the consumption of water associated with tourism, it is necessary to determine the average water consumption per tourist. To this end, we have consulted various sources which provide estimates. From the estimates reported in the academic literature, we have chosen that which offered an average consumption in accordance with the characteristics of the area of study [9,21,22,39]. The total amount of water required by the tourist industry is obtained by multiplying the water consumption per tourist per day by the total number of overnight stays in Ibiza. The number of overnight stays has been obtained from the Spanish National Institute of Statistics. Once the tourism-related water consumption has been calculated, the water consumption associated with the local population can be calculated. This is done by subtracting the tourism-related demand from the total demand.

The consumption of water for accommodation purposes and tourism-related activities represents the direct water consumption, also called direct water footprint (direct WF). Conversely, there is an indirect water consumption related to tourism, called indirect water footprint (indirect WF). The water consumption associated with the production of food destined for tourists and the consumption of fuel resulting from tourism is included in the indirect WF [39,81]. The present study aims to determine the cost of drinking water supply in the tourist destination, which corresponds to the direct WF. For this reason, it has been deemed unnecessary to calculate the indirect WF. Nevertheless, in the absence of detailed data, there is a fraction of direct WF that is difficult to determine: the water consumption that takes place in restaurants and food establishments as well as shopping centers and other establishments related to tourist services. However, if sufficient data were available, it would be interesting to carry out a future study on the total water footprint (direct and indirect) associated with the tourist activity developed on the island.

There are different estimates on the average water consumption per tourist. This may vary depending on the region and type of accommodation selected. It has been found that water consumption is directly related to the type of establishment; water consumption per tourist is higher in high-end accommodations [21,81]. According to Hadjikakou et al. [81], water consumption amounts to 180 L/tourist/day for tourists staying in apartments, while consumption in five-star hotels grows to 500 L/tourist/day in the same region.

At a global and regional level, several authors have reported water consumption levels directly associated with tourism that exceed 300 L/tourist/day [9,21,22,39]. In Spain, it is estimated that average consumption is 400 L/tourist/day, based on the high percentage of luxury resorts and hotels [21]. In the Balearic Archipelago, Tortella and Tirado [22] reported an average water consumption of 541 L/tourist/day. In the same study, 86.7% of the establishments studied were three-star establishments or higher. However, as can be seen in Table 1, overnight stays in hotel establishments represent less than 20% of the total in Ibiza and; thus, a lower average consumption is to be expected.

Due to the lack of official data on the water consumption of non-regulated tourist accommodations, we can only estimate the average water consumption per tourist and day. According to the information available in the published research, the characteristics of the region, and the nature of the existing tourist establishments on the island, we consider that 350 L/tourist/day for accommodation purposes and 20 L/tourist/day for activities are reasonable estimates.

The total production of desalinated water in Seawater Reverse Osmosis (SWRO) plants of the island is determined by using yearly data provided by the General Directorate of Water Resources of the Government of the Balearic Islands (GBI). To estimate the costs of desalination in Ibiza, we have used information provided by the updated version of the HPBI [78], which establishes the cost for Ibiza and Sant Antoni's SWRO plants based on the following formula:

$$E = 0.850x^{-0.0577} \tag{1}$$

where x is the SWRO production capacity measured in m^3/day and E is the total operating and maintenance cost expressed in euros/m^3 of desalinated water. The energy cost is included in this calculation. Considering this estimate, and bearing in mind the volume of desalinated water produced annually in each SWRO, it is possible to calculate the annual operating and maintenance costs of the SWROs. Once the annual cost of operation and maintenance has been determined, we add the equivalent annual cost (*EAC*), which is estimated from the following formula. Where r is the discount rate; n, their lifespan, and I the initial investment in constant prices. This cost represents the annual distribution of the investment initially made.

$$EAC = \frac{r \times (1+r)^n}{(1+r)^n - 1} \times I \tag{2}$$

Finally, if we know the water consumption associated with tourism, it is possible to determine the proportion of desalinated water that will be used to cover the needs of this activity. This will make it possible to calculate the proportional cost of desalinization derived from tourism.

6. Results

6.1. Water Consumption in Ibiza

On the island of Ibiza, 100% of the water used for agricultural purposes and the irrigation of golf courses comes from groundwater, amounting to 3.05 cubic hectometers per year (hm^3/year) [82,83]. The land used for agriculture on the island is about 500 hectares (Ha), and the area used for golf courses is 43 Ha. The existing industrial activities in Ibiza receive water from the municipal water systems. Water consumption linked to the industrial sector and urban population in Ibiza is 12.91 hm^3/year [82,83]. As regards the consumption of isolated dwellings in urban areas, on the one hand, it is estimated that an average of 500 m^3/year is allocated for watering gardens and farms, whereas 200 m^3/year are set for the consumption of the household itself and a swimming pool in properties larger than 100 m^2 (the most important fraction of consumption). Based on these figures and the number of plots of land with buildings larger than 100 m^2 (8109 plots), water consumption is estimated at 5.68 hm^3/year with regard to the island's isolated dwellings. As a result of the above, the annual water demand on the island is 21.64 hm^3/year, to which the estimated losses in the system must be added, 6.35 hm^3/year (Table 3).

The elevated water losses are noteworthy, reaching 33% of the volume of drinking water produced on the island (19.26 hm^3/year). This figure is above the average registered in Spain and Europe. According to data from the National Institute of Statistics [83], water losses in distribution networks in Spain represented 25.3% of the volume of drinking water produced in 2015. During the same period, water losses represented 24.9% of the drinking water produced in the Balearic Islands [84]. The European Federation of National Associations of Water Services (EurEau) reported a similar situation: the mean values for water losses are 23% in EurEau member countries [85]. Water losses in the distribution system are due both to leaks (real loss) in pipes and storage reservoirs, and to measurement errors, fraud and unmeasured authorized consumption (apparent loss) [83]. In the Balearic Islands, real losses represent 18.2% of the water supplied [84]. These so-called real losses derive from the old age of a large part of the distribution network, whose renovation would entail a large investment [83,86].

Table 3. Total consumption in Ibiza (hm^3/year) 2015.

Agricultural + Golf Consumption	Geographically Dispersed Consumption	Urban Consumption (Population and Industrial)	Total Consumption	Losses	Total Supply Required
3.05	5.68	12.91	21.64	6.35	27.99

Source: The authors.

6.2. Water Resources Available in Ibiza

Being an isolated system, the island has a clearly established resource limitation. The water resources available in Ibiza consist of natural water resources, those obtained from the desalination of seawater and the volume of wastewater that is reused.

Rainfall, land permeability and the small size of the basins mean that there are no permanent surface courses. The surface drainage network is made up of torrents with very short courses and small basins with hardly any extension [80]. As a result, groundwater resources are the main natural resource on the island. Analyzing time series data on rainfall rates is the main source of data for characterizing water resources and their future availability since they are the natural replenishment mechanism of groundwater bodies. There are two weather stations of the Spanish Meteorological Agency (AEMET) on the island, one at the airport and the other at Can Palerm (Santa Eulària). For the period between 1952 and 2015, the average annual rainfall on the island stands at 466.8 mm. As for the temporal distribution of rainfall, the maximum values in the rainfall series occur from September to November, while the minimum values occur in July (see Figure 1). The rainfall pattern on Ibiza reveals a clear Mediterranean climate model, in which rainfall is concentrated in a short period of the year. The climate can be considered as sub-dry Mediterranean [68].

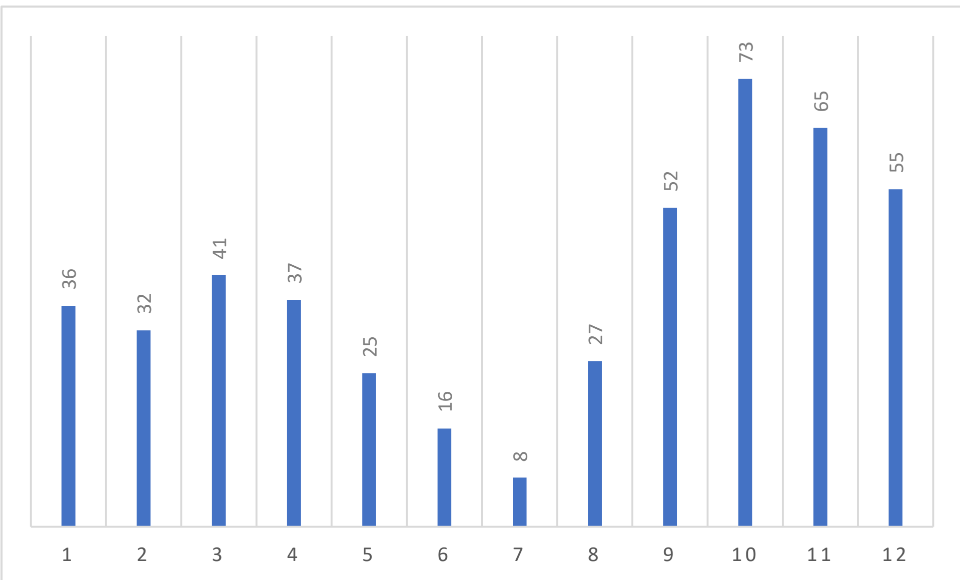

Figure 1. Monthly rainfall data (mm) averaged over the 1952–2015 period. Source: Institute of Statistics of the Balearic Islands [60].

Based on the extraction level of 2015 [78], currently, 9 of the 16 aquifers are in a poor quantitative resource status due to the fact that exploitation exceeds water availability. The availability of water is conditioned upon the aquifer's regeneration capacity, which, in turn, depends on the annual rainfall. On the other hand, studies of physico-chemical characteristics of the water, which are able to determine its quality, show that 8 of the 16 water bodies are in poor condition. All such cases are due to the presence of chlorines from sea intrusion, but no pollution of agricultural or livestock origin can be observed [78]. In 2015, the available water resources of the island's aquifers amounted to 20.01 hm^3/year. To these resources, we must add the volume of wastewater that is reused, which on this island reaches 0.58 hm^3. Due to the absence of permanent surface water resources, it is not possible to establish additional sources of supply associated with natural resources, and therefore, based on the supply needs indicated above (27.99 hm^3/year) and taking the volume of water available as a reference (20.59 hm^3/year), it can be concluded that the additional water needs amount to 7.4 hm^3/year (Table 4).

Table 4. Additional supply requirements (hm^3/year) 2015.

Aquifers Water Supply Capacity (Available Resources) A	Annual Reused Water Supply (Water Reuse) B	Total Supply Requirements (Total Demand) C	Additional Requirements D = C − A − B
20.01	0.58	27.99	7.4

Source: The authors.

After confirming the limited groundwater resources available on the island and the additional water needs, it is advisable to carry out an analysis of the production of desalinated water in the territory. The data on monthly water production at the San Antoni, Ibiza, and Santa Eulària desalination plants are shown in Table 5. It can be seen that the production of desalinated water during the peak period of tourist arrivals (May–September) almost doubles the production during the valley period (January–March). The highest volume of desalinated water production coincides with the months with the most tourist arrivals and overnight stays (July and August). The total annual production of desalinated water on the island of Ibiza is 7.62 hm^3. A difference of 0.22 hm^3 is observed with respect to the additional requirements, established at 7.4 hm^3. This difference can be attributed to the consumption of desalinated water in the SWRO plants themselves in response to their own operation and maintenance needs.

Table 5. Production of desalinated water on the island of Ibiza 2015.

2015	Sant Antoni's SWRO Plant (hm^3)	Ibiza's SWRO Plant (hm^3)
January	0.228	0.234
February	0.196	0.217
March	0.227	0.263
April	0.314	0.222
May	0.394	0.262
June	0.358	0.383
July	0.503	0.406
August	0.509	0.402
September	0.426	0.383
October	0.325	0.314
November	0.325	0.211
December	0.327	0.194
Total	4.134	3.489

Source: Data provided by the General Directorate of Water Resources of the GBI [87].

6.3. Water Consumption Linked to the Tourism Industry

Based on various studies, it can be stated that the average global water consumption is approximately 350 L/tourist/day for accommodation purposes and 20 L/tourist/day in the case of activities associated with the tourists' stay [39]. If we take this average consumption as a reference, and the data on overnight stays on the island, 7,862,131 [59,60] it is possible to calculate the water consumption directly associated with tourism (Table 6). Total consumption is estimated at 2.91 hm^3/year. If we consider that the water losses in distribution networks represent 32.97% of drinking water produced in the territory, we can calculate that 1.43 hm^3 will be lost and, therefore, it will be necessary to produce 4.34 hm^3 to meet the demand estimated at 2.91 hm^3.

Table 6. Estimation of the volume of water used in connection with tourism, 2015.

Overnight Stays	Water Per Tourist and Day (L/Tourist/Day)	Water Needs (hm^3/Year)
7,862,131	370	2.91

Source: The authors.

As stated above, the total water needs registered on this island reach 27.99 hm^3/year. If we deduct the necessary amount of water directly linked to tourism (4.34 hm^3/year) the result is that the consumption not directly linked to tourism is approximately 23.65 hm^3/year (Table 7).

Table 7. Estimation of local consumption (hm^3/year), 2015.

Total Water Needs A	Tourism-Related Water Needs B	Local Population's Water Consumption C = A − B
27.99	4.34	23.65

Source: The authors.

The local population's water demand reaches 23.65 hm^3/year, while the volume of natural resources available is 20.01 hm^3/year. If we consider the tourism-related water needs (2.91 hm^3), water consumption for irrigation (3.05 hm^3) and water losses in distribution networks (6.35 hm^3), we learn that the local population´s water supply requirements are 15.68 hm^3/year. The local population of Ibiza was 132,637 inhabitants in 2016 [60] which means that consumption per capita represents more than 300 L/day. This figure is above the average registered in Spain (136 L/day) and the Balearic Islands (134 L/day). Such a difference cannot be explained only by high-water losses and there must be other reasons behind these figures. This volume of water consumption, which cannot be justified by existing official data, may imply that there is unregulated tourist activity being developed at the island, for which there are no data. Various authors have tried to examine unregulated tourism in the Balearic Islands [3] but there are no differentiated data for the island of Ibiza. Martín et al. (2018) [3] reported that, in the archipelago, unregulated tourism represented 33% of the total overnight stays with an upward trend. In addition to the above, there are no available data when talking about bed places offered outside of hotels; nevertheless, this seems very important since it may intensify the seasonal pattern [3]. If the difference between the water consumed and the statistics is truly so, many of the problems detected in water management could be heightened. Thus, it is necessary to further elaborate on this analysis, given that if the volume of tourism developed on the island is higher than that registered in official data, public administrations should consider these when developing policies for the efficient use of water resources. This negative balance implies that the demand for water is 3.64 hm^3 greater than the maximum capacity of the territory and if this demand is supplied with groundwater, the aquifers will be overexploited. An over-exploitation of these water resources would compromise their future availability, which, in turn, could affect their quality and availability [88]. Moreover, the effects of this over-exploitation are already having an impact on certain coastal areas in the territory studied. The excessive extraction of groundwater has led to a drop in the piezometric level of the aquifers and seawater intrusion. Studies of the physico-chemical characteristics of the water show that 8 of the 16 groundwater bodies have high concentrations of chlorine [78,80]. The presence of chlorine is an indicator of seawater intrusion that implies a loss of groundwater quality, which compromises diverse water uses [58]. It is also one of the main problems affecting coastal aquifers globally, and especially in semi-arid regions such as the Mediterranean [89,90].

Therefore, it is possible to assert that the extra demand, generated by the arrival of tourists, should be covered with desalinated water. The previous idea does not imply that the water supplied to tourists comes specifically from desalination plants, but rather that this demand volume represents additional consumption that cannot be met by natural sources. In addition, in this context, public authorities should make an effort to improve efficient water use and reduce per capita demand, both in the case of the local population and tourists, as well as trying to reduce the amount of water losses.

6.4. Economic Cost of Producing Desalinated Water

Applying the formula that determines the operating cost of SWROs plants (Formula 1) results in an operating and maintenance cost of 0.49 euros/m^3 in the case of the Ibiza and Sant Antoni plants. On the basis of this figure, and considering the annual production of desalinated water of each plant, it is possible to calculate the annual operating and maintenance costs (Table 8). Therefore, the operating and maintenance costs associated with desalination amount to €2,126,513 which is considerably higher than the costs of producing drinking water using alternative technologies, as described above.

Table 8. Desalination cost, 2015.

Tourism-Related Water Needs + Water Losses (hm^3)	Tourism-Related Water Needs + Water Losses (m^3)	Cost Per Cubic Meter (€/m^3)	Total Cost Associated with Tourism/Desalination (Expressed in €)
4.34	4,339,823	0.49	2,126,513

Source: The authors.

To the above estimated amount, we must add the amortization associated with the investment made in the construction of the plant, which is conditioned by the estimated exploitation period. The exploitation period extends for 20 years and the investment amounted to €10,416,267 in the case of Sant Antoni's SWRO. Whereas in the case of Ibiza's SWRO, the investment reached €14,818,966 [78]. The equivalent annual cost (EAC) is estimated from the following formula.

$$EAC = \frac{r \times (1+r)^n}{(1+r)^n - 1} \times I \tag{3}$$

where r is the discount rate; n, their lifespan, and I the initial investment in constant prices. The EAC of Ibiza's SWRO is €637,000 and Sant Antoni's SWRO is €906,279. To determine the EAC associated with tourism demand, we have considered the water production associated with this particular type of demand: 4.34 hm^3. This consumption represents 56.96% of the volume of water desalinated annually (7.62 hm^3) at SWROs. Due to the fact that the production of desalinated water for tourism represents more than half of the desalinated water on the island, it is necessary to consider an additional cost of €879,051 the equivalent to the EAC of the desalination plants. Therefore, the total cost associated with the production of water required to cover the needs of the tourism sector ascends to €3,005,564.

To this is added that a third plant, that of Santa Eulària, began its construction in 2018, which would not have been necessary were it not for the fact that tourism seasonality generates peaks in water consumption during the summer months (Table 5). In the remainder of the year, this plant would not have been necessary, since the aforementioned ones would meet the population's demand.

7. Discussion and Conclusions

Tourist activity generates both positive and negatives impacts on the areas in which it takes place. From the environmental point of view, such impacts are associated with the overexploitation of natural resources and negative effects on the environment [33,91]. Regarding water resources, the impact is clear, as it has been shown that tourism-related water consumption per capita is clearly higher than that of the resident population. Additionally, in certain coastal areas a series of factors coincide that aggravate these impacts, for example, the number of tourist arrivals and the scarcity of drinking water, among others. In an isolated territory such as an island, the problem is aggravated if consumption grows beyond the limits of the supply of natural resources.

On this occasion, the analysis has concluded that the supply capacity based on natural resources is not enough to cover the needs of the population of the island of Ibiza. Therefore, to cover the additional demand linked to the tourism industry, water desalination must be used. From a conservative point of view, the annual cost of water production associated with the additional demand generated by tourism has been estimated at €3,005,564. This amount should be used to pressure the tourism industry to adopt a more appropriate policy of water use efficiency. Failure to do so could result in a request for an economic compensation to pay for this expense. This, however, entails a cost overrun, as the aforementioned system is comparatively more expensive than the one based on groundwater extraction. These considerations must be taken into account by public planners, as the continued growth of tourism leads to environmental impacts that are usually not accounted for. This means an increase in supply costs due to the consequent increase in demand, which, in turn, would lead to further desalination of seawater, and an increase in the volume of wastewater to be treated. This problem could be partly solved if water leaks were reduced, a problem that affects the entire distribution system of the island. These water losses represent 32.97% of drinking water produced. Therefore, reducing this amount would also reduce the need to produce desalinated water. In order to guarantee the future and sustainability of the tourism industry, a greater effort should be made to reduce water consumption per tourist and per local inhabitant, or at least that linked to tourist accommodations themselves. Improving efficiency in garden irrigation, water use for swimming pools, water use in hotels, etc. should appear as a priority on the political agenda.

Another problem detected by this study would be that associated with tourism seasonality. In Ibiza, a new SWRO (Sta Eulària), which came into operation in 2018, is only necessary to cover the peaks of demand that take place in summer. It can be seen in the tables of desalinated water production that the Ibiza and Sant Antoni SWRO plants operate at almost full capacity during the summer months, while in the months with little tourist influx they reduce their water production. Therefore, if tourism were less seasonal in Ibiza, the production capacity of the Ibiza and Sant Antoni plants could meet the tourism-related water needs, and the construction and start-up of the new SWRO plant in Santa Eulària would not have been necessary nor would the economic cost associated with a project of this magnitude. Therefore, a third strategy to reduce the amount of desalinated water needed would be improving tourism seasonality, so that the same number of annual arrivals are more evenly distributed throughout the year. Revenue associated with tourism would be the same, but the use of water resources would be more efficient. The results of this study have revealed some interesting managerial implications that should be highlighted. In an isolated system such as this island, public managers should make a greater effort to reduce water leaks from the system and address the phenomenon of seasonality. It would also be necessary to obtain more information on the aquifers of the island, so that it is possible to analyze their evolution on a monthly basis and compare it with the tourist activity. Lastly, the public sector should encourage the implementation of water-saving policies in the different accommodation establishments. The current amount of water consumed per tourist is too high. This work has shown the imbalance between the demand for water and the supply associated with natural resources, so any improvement in this imbalance would be desirable.

Analyses such as this one are necessary in order to adequately structure the tourism sector, adapting it as much as possible to the resources of the environment. In view of the cost of producing desalinated water and the comparatively lower price of regenerating wastewater for its subsequent reuse, this study proposes increasing the production of reclaimed water on the island so as to meet the demand associated with certain purposes, as stipulated in Spanish and European legislation. Moreover, it is necessary to determine the specific costs and the infrastructures required to undertake this transformation, as well as the total savings in water management resulting from the potential substitution of desalinated water by reclaimed water. This study belongs to the academic literature on over-tourism. The rationale behind this concept does not imply the elimination of tourism. Instead, it seeks to determine the optimal number of visitors so as to achieve the highest possible level of income in a way that is compatible with environmental sustainability. This estimate will be conditioned by the way in which tourist flows are distributed throughout the year. But this consideration seems pending on the island of Ibiza.

The results of this study are consistent with previous studies, which indicate that mass tourism takes place in locations where water is scarce or natural resources are not sufficient to meet the demand [4,6,7,26], and, therefore, it is necessary to resort to desalination. This study has calculated the additional cost associated with such a water demand. This confirms what previous studies have pointed out, i.e., that this cost would be higher than the cost associated with the exploitation of natural resources. Finally, this study has also shown that part of the desalination infrastructure is necessary only as a consequence of the seasonality of demand, something that had been postulated in previous studies.

The main limitation that has conditioned this study has to do with the availability of data. The study would be more accurate if there were monthly data on the main variables that we have worked with. In this respect, it should be noted that monthly data are available on the production of desalinated water, but we do not have monthly data on the evolution of the aquifers. Without this information, it is not possible to determine the needs for desalinated water at any given time based on the capacity of the aquifers to supply water. It is true that desalination is necessary even in a scenario without tourism, but it is not possible to establish a monthly balance based on the aquifers' regeneration capacity. It would also be interesting to include the employees who come to the island every summer as part of the water consumption associated with tourism. Since it is not possible to objectively quantify the number of workers and the length of their stay on the island, their water demand is included as part of urban consumption. Nor would it be possible to estimate the indirect water consumption associated with tourism, for example, that related to tourists' meals. Since part of the food comes from outside the island, the amount of local water used in the tourists' diet cannot be determined. In this case, we have considered expenditure on agricultural irrigation as part of the local demand for water. Nor would it be possible to estimate the indirect water consumption associated with tourism, for example, that related to tourists' meals. Since part of the food comes from outside the island, the amount of local water used in the tourists' diet cannot be determined. In this case, we have considered expenditure on agricultural irrigation as part of the local demand for water. At the same time, there is a fraction of direct water consumption related to tourism that is impossible to determine, given the lack of pertinent data. Such consumption is the water consumption that takes place in restaurants and food establishments, as well as shopping centers and other establishments related to tourist services. A restaurant's water use for food production depends on the type of restaurant, number of seats, equipment design and behavioral patterns [92]. Water consumption in kitchens may also depend on the type of cuisine [93]. All these would make determining the water consumption that takes place in restaurants and other establishments somewhat weak.

Tourism seasonality is one of the main problems conditioning the tourism sector of the island, since it causes problems both in the peak and in the valley season. Therefore, we consider that this research should be expanded from a monthly perspective, if it is possible to overcome the limitations of information. To this end, the public administration should provide the necessary data to complete this analysis. This research would help to improve water treatment planning as well as tourism planning. This new research would have to take careful account of the data limitations outlined above. Likewise, given the clear methodology proposed in this study, it would be interesting to replicate it in other islands with tourist activity. This would allow for a comparison of the results and for new approaches to support or refute what is concluded in this paper. We would also like to point out that if sufficient data were available, it would be interesting to carry out a future study on the total water footprint (direct and indirect) associated with tourist activity on the island.

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