

The water-tourism nexus in the island of Crete, Greece

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ABSTRACT: The island of Crete, Greece is located in eastern Mediterranean region which is characterized by limited water resources. It hosts more than 6 million of tourists every year who consume large quantities of water during their vacations. The study of the interdependence between water and tourism industry in Mediterranean islands with limited water resources is important for their prosperity. Their nexus in Crete has been investigated based on existing data regarding water consumption and the local tourism industry. The share of direct water use in tourism in the total water consumption in Crete has been estimated and compared with other tourism destinations. Tourism industry affects water resources in Crete while water is a basic resource in tourism industry. The share of direct water demand in tourism to total water consumption in the island, at 3.06%, is above the global average, at 0.6%. The high share of direct water demand in tourism industry to total water consumption in Crete, the expected future increase in tourists' arrivals and the future reduction of water resources due to climate change indicates that improved management of water resources is necessary to avoid water shortages and water-related conflicts. Our results could be useful to public authorities and private bodies related to tourism industry and water use in the island.

KEYWORDS: Crete, Climate change, Mediterranean, nexus, tourism, water resources

1. INTRODUCTION

The island of Crete, Greece is a popular global tourism destination hosting an increasing number of visitors every year. Tourism industry utilizes large amounts of water resources in various sectors [1], [2], [3], [4]. Crete is located in eastern Mediterranean region which is characterized by limited water resources. It has sufficient water resources, under normal climatic conditions, which are unevenly distributed along the island [5]. However, climate change results in lower precipitation in Crete threatening the sufficient water supply in various sectors including tourism. Existing research indicates that water demand in most tourism destinations in tourism industry in less than 1% of the total water consumption although there are some exceptions [2]. For instance, Cyprus and Malta consume significantly higher quantities of water resources in their tourism industry [2], [4]. Several researchers have emphasized the need for better management of the limited water resources in several tourism destinations avoiding the conflicts among locals, tourists and farmers [6], [7], [8].

The aim of the current work is to study the water-tourism nexus in the island of Crete, Greece examining their interrelation and interdependence. Additionally, to estimate the share of direct water demand in tourism industry compared to total water consumption in the island.

The text is structured as follows: After the literature review the water resources in Crete and the impacts of climate change on them are analyzed. After that the tourism industry in the island, its impacts on water resources and the impacts of water resources on tourism are examined. The text ends with discussion of the findings, the conclusions drawn and the citation of the references used. The current work covers the gap regarding the nexus between water resources and tourism industry in Crete as well as the estimation of the direct water demand in the local tourism industry. It is innovative since there are not many studies published so far in this topic related with the island of Crete. The results could be useful to public authorities, to policy makers and to stakeholders of the tourism industry and the water management organizations in the island.

2. LITERATURE SURVEY

The water-tourism nexus research in the Mediterranean region in the past two decades has been studied [1]. The authors stated that the existing literature remains rather water centric and pays little attention to behavioral change and stakeholders action. The supply and demand of water resources in tourism industry has been reviewed [2]. The authors stated that even though tourism increases global water consumption, direct tourism-related water use is considerably less than 1% of the global consumption and will not



become significant even if the tourism sector continues to grow. They also mentioned that the situation differs in areas with high tourism concentration and limited water resources. The use of fresh water in tourism industry in Mediterranean region has been examined [3]. The author stated that the Mediterranean is the main tourism destination in the world. Every tourist consumes between 300 and 850 liters of water daily. He mentioned that this rate could be reduced by 50% compensating the increase in tourist numbers in the coming decades. The tourism impacts on water consumption in Malta has been examined [4]. The author stated that the average tourist consumes more water than local residents. He suggested that tourism industry in small Mediterranean islands should try to economize water through appropriate water management strategies. The challenges and opportunities for sustainable management of water resources in Crete, Greece have been explored [5]. The authors stated that under average meteorological conditions the island is water self-sufficient. They also mentioned that agriculture is by far the greatest user of water with a share of 78% in total use, followed by domestic use with share at 21%. The governance of the water-energy nexus has been analyzed [6]. The authors emphasized the importance of involving stakeholders in effective governance of water resources in tourism destinations. They mentioned that within the water-tourism nexus governance tends to favor the water component over the tourism industry. The value of water use in dry tourism destinations has been studied [7]. The author stated that tourism industry overuses water resources by at least a factor of two over permanent residents. He also mentioned that there is a number of factors that need to be considered in order to develop an appropriate model for valuing water in tourism. The relation between tourism development and per capita water availability in 25 popular tourism destinations has been studied [8]. The authors stated that capital investments in tourism industry result in tourism development and in inequality regarding the per capita availability of water. The water-energy-tourism nexus in the island of Crete, Greece has been analyzed [9]. The author stated that the direct use of water in hotels is at 2.71 M³ per tourist arrival while the energy consumption in hotels is at 124.55 kWh per tourist arrival. The relationship among water, tourism and community equity in USA has been explored [10]. The authors stated that at destination level there is a complex relationship between tourism, the destination community and the water resources management. They mentioned that climate change influences the dynamic in the abovementioned relationship. The role of water resources in tourism development in rural communities has been studied [11]. The authors stated that rural communities perceive water resources through the lenses of agriculture, nutrition and human health but seldom as a tourism resource. They mentioned that the mythologies of rural communities towards water bodies do not favor the development of rural water tourism. The relationship among tourism, water and gender has been examined [12]. The authors stated that tourism development can affect water supply and increase the competition among tourism industry, agriculture and local residents. However, they mentioned, the role of women in opposing over-exploitation of water resources has not been analyzed adequately. The water-tourism-ecosystems nexus on the sustainable development of eco-cities has been investigated [13]. The author stated that desalinating ocean water with reverse osmosis technology has become crucial as it consumes large amounts of energy. The sustainable water management in tourism economy has been examined [14]. The authors stated that islands with mass tourism, like Santorini, Greece, rely on vast quantities of water for the development of tourism industry. Local populations in these islands were based on traditional cisterns in the past to store rainwater and use it in daily needs. They proposed the development of small decentralized storage reservoirs and their integration into the islands' centralized water systems. The water consumption and economic growth of tourism in arid areas with reference Xinjiang, China has been analyzed [15]. The authors stated that from 2003 to 2021 in Xinjiang, China the total water consumption was 3.5 times higher than of direct water consumption. The total water consumption was estimated at 7.1 M³ per person per day. They also mentioned that the water footprint related to tourist's accommodation has a small share, less than 5%, in the tourism-related total water footprint. The utilization of water resources in tourism destinations and their environmental assessment based on water footprint has been studied [16]. The author stated that the water footprint method should be used in water resources management to improve their utilization and to protect the environment. The water consumption in the Spanish tourism industry has been examined [17]. The author stated that in several Spanish regions tourists consume considerably larger quantities of water than local residents. He mentioned that local residents should have priority regarding water availability compared to tourism industry. A report titled "The inland water-related tourism in South Africa by 2030 in the light of global change" has been published [18]. It is stated that the negative impacts of water shortages or restrictions on tourism have been documented throughout the world while in South Africa water shortages during the water crisis in Cape town in 2018 raised fear to tourists staying away from this destination due to water restrictions. The water management in coastal tourism destinations in Spain and Malaysia has been compared [19]. The authors stated that water management in popular coastal tourism destinations with limited water resources like Costa Brava in Spain and Perhentian and Langkawi islands in Malaysia



is very important. They mentioned that an integrated and sustainable approach to water management involving collaboration among all stakeholders is necessary in these tourism destinations. The generation of sustainable water in the Greek island Skyros located in Mediterranean region has been studied [20]. The authors proposed the production of potable water from desalination units and the irrigation of crops with the effluent of the local wastewater treatment plant. They also proposed the installation of a power plant using local renewable energies covering the energy needs of water desalination while they estimated the cost of the produced water at 2.49 €/M³. A report related to water and tourism in the Mediterranean region has been published [21]. It is stated that in Mediterranean basin water consumption from tourism is relatively low compared to other sectors like agriculture. Direct water consumption in hotels in Cyprus and Malta accounts, at most, at 4.5% of total water demand, in Greece and Tunisia at around 2% while in Jordan at 0.4%. The climate change, the tourism industry and the water resources in Mediterranean region have been analyzed [22]. The authors estimated the tourism climate index indicating the appropriateness of climate conditions for outdoor activities in eight Mediterranean countries. They also mentioned that the expected reduction in water use in agricultural production in Greece and in other Mediterranean countries, due to climate change, is going to be higher than the expected increase of consumption by tourism industry resulting in net water savings. The direct and indirect water use in tourism in the eastern Mediterranean region has been estimated [23]. The authors stated that food production for tourists has by far the most significant impact on the overall tourism-related water footprint. They also used the water footprint methodology to distinguish between the global and local pressure of tourism industry on water resources. They estimated the total water footprint per tourist in Mykonos island, Greece at 65,500 lit per tourist and the total daily water footprint at 5,460 lit per tourist. The water consumption in hotels in the island of Mallorca, Spain has been evaluated [24]. The authors stated that while tourism promotes economic growth in several regions it has negative environmental impacts in regions with water shortages. They stated that direct water consumption in Mallorca's hotels varies in the range of 156.6 to 2,425.3 lit per night spent with a mean value at 541.6 lit per night spent. The global water footprint in travel and tourism sector has been examined [25]. It is stated that according to the findings of the 22nd World Tourism Summit held in Riyadh, Saudi Arabia in 2022 only 0.6% of global water consumption accounted for the sector's water footprint in 2021. It was also mentioned that water consumption in the tourism sector is mainly indirect while agriculture and food production are responsible for 2/3 of the total water footprint in the tourism sector. Additionally, it was stated that tourism industry in Europe and Africa has reduced its direct water consumption between 2010 and 2019. A detailed database for the world's 50 most important tourism countries has been provided [26]. The author stated that tourism generally accounts for less than 1% of the water consumption in the countries studied. The tourism-related water consumption in Greece in 2000 accounted at 0.55% of the total water consumption and at 3.34% of the domestic water consumption. However, he mentioned, there are some exceptions like Malta (7.3%), Cyprus (4.8%) and Barbados islands (2.6%). He also stated that the tourism-related direct water demand in Cyprus corresponds at around 16.9 % of the domestic water demand.

The findings of the published research indicate that: a) The direct water use in tourism industry is considerably less than 1% while globally it is estimated at around 0.6%, b) Tourists consume larger quantities of water than local residents, c) The direct water demand in Mediterranean islands with advanced tourism industry is in the range of 2% - 4.5% of the total water demand, d) The indirect water demand in tourism industry is considerably higher than the direct water demand, and e) Food production for tourists' catering has the highest impact in the tourism-related indirect water demand, and f) According to the existing studies the island of Crete, under normal meteorological conditions, is self-sufficient in water resources.

3. THE WATER RESOURCES IN CRETE

Crete, the largest island of Greece, possesses a distinctive environmental and climatic profile that shapes the availability and management of its water resources. Although the island benefits from mountainous landscapes, seasonal rivers, and significant winter rainfall, it also faces persistent water challenges due to its dry summers, growing population, and expanding agricultural and tourism demands. As a result, water resources in Crete represent both a natural asset and a topic of ongoing environmental concern. The island's hydrology is primarily influenced by its rugged topography. Mountain ranges such as the Lefka Ori, Idi, and Dikti capture substantial winter precipitation, including snow that slowly melts and feeds underground aquifers. These aquifers are vital for Crete, as they supply a large portion of the island's potable water through springs and wells. In many regions, groundwater recharge during the wet season is the backbone of the local water supply system. Karstic geological formations, common across the island, facilitate the rapid infiltration of water, forming extensive subterranean networks that store and transport groundwater.



Despite these natural advantages, Crete has few natural lakes. The island's rivers are mostly seasonal, flowing vigorously in winter and early spring but diminishing significantly during the summer. The absence of long, perennial rivers has historically pushed local communities to rely on groundwater extraction and rainwater harvesting. In recent decades, artificial reservoirs have also become crucial. The Aposelemis Dam, the largest water management project on the island, has played a significant role in improving the water supply for major population centers, including Heraklion, Hersonissos, and Agios Nikolaos.

Agriculture, one of Crete's most important economic sectors, places heavy pressure on the island's water resources. Olive groves, vineyards, and vegetable cultivation require substantial irrigation, especially during the prolonged dry season. This has led to over extraction of groundwater in some areas, resulting in declining water tables and, in coastal zones, the intrusion of seawater into aquifers. Such salinization reduces water quality and threatens long-term agricultural sustainability. Consequently, water-saving irrigation technologies—such as drip irrigation, which is widely used in Crete—have become essential tools for balancing agricultural productivity with resource conservation. Tourism, another major pillar of the Cretan economy, also intensifies water demand, particularly during the summer when supplies are most limited. Large hotels, swimming pools, and increased consumption by visitors create seasonal spikes in water use. This adds pressure to already stressed systems, prompting local authorities to adopt more sophisticated water management strategies, such as desalination plants and wastewater treatment for reuse in irrigation.

Therefore, while Crete possesses diverse and valuable water resources, careful management is essential to meet the island's ecological, agricultural, and tourism needs. By embracing sustainable strategies and modern technologies, Crete can safeguard its water supply for future generations while supporting its vibrant economy and unique natural landscape. Table 1 indicates the use of water resources in several sectors in Crete in 2016.

Table 1. Use of water resources in several sectors in Crete in 2016

Sector	Annual water consumption (%)	Annual water consumption (mil. M ³)	Annual water consumption per capita (M ³ per capita)
Agriculture	78.3	478.4	753.5
Domestic use	20.9	127.6	201.0
Others	0.8	4.9	7.7
Total	100	610.9	962.2

Source: Tzanakakis et al, 2020

4. THE IMPACT OF CLIMATE CHANGE ON WATER RESOURCES IN CRETE

Crete, the largest island of Greece, is particularly vulnerable to the effects of climate change, especially regarding its already stressed water resources. Located in the Eastern Mediterranean—a region recognized as a climate-change hotspot—Crete faces rising temperatures, declining rainfall, and more frequent extreme weather conditions. These environmental shifts pose significant challenges for the island's ecosystems, agriculture, tourism sector, and long-term water security. One of the most pronounced impacts of climate change in Crete is the alteration of precipitation patterns. Historically, the island receives the majority of its rainfall during the winter months, which replenishes groundwater aquifers and supports rivers and springs. However, in recent decades, rainfall has become increasingly irregular, with fewer but more intense storms. This shift leads to reduced groundwater recharge because heavy rainfall tends to run off quickly rather than infiltrate the soil. As aquifers are the main source of freshwater for much of the island, reduced recharge threatens both water quantity and long-term sustainability. Rising temperatures add further strain to water resources. Higher average temperatures increase evaporation rates from soil, reservoirs, and vegetation, intensifying water loss during the dry summer months. Crete's rivers, many of which are seasonal, are especially sensitive to prolonged heat. Reduced flow can lead to the disappearance of small streams and the drying of wetlands, which has negative consequences for local biodiversity. Endemic species, particularly those reliant on freshwater habitats, face heightened risk as their environments shrink or degrade.

Agriculture, a cornerstone of Crete's economy, is heavily impacted by these climatic changes. Olive groves, vineyards, and vegetable crops require reliable irrigation, yet rising temperatures and decreased water availability create an imbalance between water demand and supply. Farmers are often forced to rely more heavily on groundwater extraction, which can accelerate aquifer depletion. In coastal regions, over-pumping invites the intrusion of seawater into freshwater aquifers, leading to salinization. Once

an aquifer becomes saline, reversing the process is extremely difficult, making this one of the most critical long-term threats to Crete's water security. Climate change also indirectly affects water resources through its impact on tourism. As summers become hotter and heatwaves more common, water consumption by visitors increases. Large hotels, swimming pools, and intensified cooling needs strain local water systems precisely when resources are most limited. If water scarcity worsens, it may affect visitor experience, local infrastructure, and the tourism industry's sustainability. Extreme weather events, including both severe droughts and sudden floods, are projected to become more frequent under climate change. Droughts can lead to extended water shortages, reduced agricultural yields, and heightened fire risk, whereas flash floods can damage infrastructure and degrade water quality through contamination and erosion. These hazards underscore the need for resilient water management strategies. Therefore, climate change poses a significant and escalating threat to Crete's water resources. Addressing this challenge requires proactive, sustainable planning that balances environmental protection, economic needs, and the well-being of local communities. By adapting early and effectively, Crete can safeguard its water future in an increasingly uncertain climate.

5. THE TOURISM INDUSTRY IN CRETE

Crete, the largest and one of the most culturally rich islands of Greece, has long stood as a major hub for Mediterranean tourism. Its combination of natural beauty, mild climate, historical depth, and vibrant local traditions attracts millions of visitors each year, making tourism a central pillar of the island's economy. Over the decades, Crete has developed a diverse and dynamic tourism industry that continues to evolve in response to global trends, environmental concerns, and the needs of local communities. The island's appeal begins with its striking landscapes. From the rugged Lefka Ori mountains and dramatic Samaria Gorge to serene beaches like Elafonisi and Balos, Crete offers an abundance of natural attractions. These varied environments support numerous recreational activities, including hiking, swimming, diving, sailing, and ecotourism excursions. The mild Mediterranean climate enhances their accessibility, drawing visitors from early spring through late autumn. Nature-based tourism, in particular, has grown steadily, as travelers increasingly seek sustainable and authentic experiences. Equally significant is Crete's rich historical and cultural heritage. As the heartland of the ancient Minoan civilization, the island hosts iconic archaeological sites such as Knossos, Phaistos, and Malia. Museums in Heraklion, Chania, and Rethymno preserve important artifacts that highlight Crete's long and diverse history, from prehistoric times through the Roman, Venetian and Ottoman periods. This cultural depth attracts not only casual tourists but also scholars, school groups, and heritage enthusiasts. Traditional Cretan music, dance, and cuisine further contribute to the island's cultural tourism, offering visitors a chance to engage with local life in meaningful ways.

The tourism sector has also become a key driver of economic growth and employment. Hotels, restaurants, transportation services, tour companies, and local craft industries rely heavily on the steady flow of visitors. Many rural communities, once dependent on agriculture alone, now supplement their income through agritourism initiatives, guesthouses, and farm-to-table experiences. This diversification has helped revitalize smaller villages and encouraged the preservation of traditional practices that might otherwise have declined. However, the success of Crete's tourism industry brings challenges. Seasonal fluctuations create intense pressure on local infrastructure during the summer months. Water demand increases sharply, especially in hotel-dense coastal areas, contributing to environmental strain. Overdevelopment in certain coastal zones has raised concerns about habitat degradation, loss of natural landscapes, and reduced quality of life for residents. The influx of tourists also risks transforming cultural traditions into commercialized spectacles if not managed thoughtfully. To address these issues, both local authorities and private stakeholders are increasingly embracing more sustainable tourism models. Emphasis on responsible travel, protection of natural habitats, and energy-efficient accommodations is becoming more widespread. Initiatives promoting off-season tourism aim to distribute visitor numbers more evenly throughout the year, reducing pressure on peak months. At the same time, investments in infrastructure, such as improved public transport and updated waste-management systems, help support a more sustainable tourism future. Therefore, the tourism industry in Crete is a vital and multifaceted sector that shapes the island's identity and economic well-being. While it offers significant benefits—from employment opportunities to cultural preservation—it also requires careful, long-term planning to ensure that growth remains sustainable. With its unique blend of natural beauty, history, and hospitality, Crete is well-positioned to continue attracting global visitors, provided that its tourism development remains balanced and respectful of its environment and cultural heritage. Table 2 indicates the key figures of incoming tourism in Crete in 2023 and 2024 while table 3 the Tourism Climate Index for Greece. The climate tourism index is estimated taking into account precipitation, temperature, humidity, sunshine duration and wind speed (Roson et al, 2012).



Table 2. Key figures of incoming tourism in Crete in 2023 and 2024

Parameter	2023	2024
Hotel beds	196,586	196,877
Total number of tourists	5,521,700	5,959,000
Overnights spent	45,837,200	46,705,600
Average staying (days)	8.3	7.8

Source: Bank of Greece

Table 3. Tourism Climate Index for Greece (1991-2010)

January	58.23
February	61.85
March	67.16
April	73.62
May	86.35
June	94.38
July	91.22
August	94.91
September	91.22
October	76.08
November	64.03
December	58.20

Source: Roson et al, 2012

6. THE IMPACT OF TOURISM INDUSTRY ON WATER RESOURCES IN CRETE

The island of Crete is one of Greece’s most popular tourist destinations, renowned for its vibrant culture, sun-drenched beaches, and diverse natural landscapes. However, the rapid expansion of the tourism sector has also brought significant challenges, particularly regarding the management and sustainability of water resources. The impact of tourism on Crete’s water supply is increasingly critical, as seasonal demand, environmental pressures and infrastructural limitations converge. One of the most significant ways tourism affects water resources in Crete is through dramatic seasonal increases in consumption. During the high tourist season—typically from May to October—the island’s population swells as millions of visitors arrive. Hotels, resorts, and rental accommodations require significant amounts of water for daily operations, including cleaning, sanitation, swimming pools, and landscaped gardens. In popular destinations such as Heraklion, Chania, and Rethymno, water use can more than double in summer months, placing considerable stress on local supplies. This seasonal strain often leads to shortages in certain regions, requiring local authorities to implement water rationing or seek costly supplementary sources. Tourism also contributes to increased water demand indirectly through its influence on land use and development. The construction of new accommodation complexes, high quality villas, swimming pools, and water-intensive recreational facilities, such as spas and water parks, has grown steadily alongside rising visitor numbers. These developments often occur in coastal areas where freshwater availability is naturally limited. The expansion of infrastructure can disrupt natural hydrological systems, reduce groundwater recharge, and lead to over-extraction of aquifers. In some areas of Crete, groundwater levels have decreased sharply, resulting in the intrusion of seawater and deterioration of water quality. Agriculture, another major user of water resources in Crete, is affected by tourism-related pressures as well. As the tourism industry expands, agricultural land is increasingly converted into tourist resorts or urban development, altering traditional water allocation patterns. Moreover, the aggregate water demand from both sectors can exceed the island’s capacity during dry years. Competition for water between agriculture and tourism becomes more acute, causing tensions and highlighting the need for integrated resource management. Environmental impacts are also significant. Overuse of water resources can threaten the ecological health of rivers, wetlands, and springs. Natural attractions, such as the Samaria Gorge and Lake Kournas, depend on stable water systems to maintain their biodiversity and aesthetic value. Excessive water extraction and pollution from



tourism-related activities may contribute to ecosystem degradation, reducing the island’s environmental appeal and undermining the very foundation of its tourism offering. Therefore, tourism industry significantly impacts Crete’s water resources through increased consumption, infrastructure expansion, and ecosystem stress.

The direct water footprint is the water used directly by tourists and tourism enterprises while the indirect water footprint includes the water used to produce goods and services consumed by tourists. The main component of the indirect water footprint is often the water used for food production, mainly meat and meat products, consumed by tourists while the indirect water footprint is higher than the direct footprint in the tourism sector. The total tourism-related water footprint is the sum of the direct and the indirect water footprint. The use of water resources in tourism accommodations in Crete is presented in table 4 while the water consumption by tourists in Malta in table 5.

Table 4. Use of water resources in tourism accommodations in Crete

Number of nights spent from tourists in Crete in 2024	46,705,600
Average consumption of water per night spent by tourists in Crete	400 liters
Total consumption of water in tourism accommodations in Crete in 2024	18,682,240 M ³
Total consumption of water in tourism accommodations in 2024 in Crete as % of total water consumption for domestic use in the island in 2016	14.64%
Total consumption of water in tourism accommodations in 2024 in Crete as % of total water consumption in the island in 2016	3.06%

Source: own estimations

Table 5. Water consumption by tourists in Malta

Sector	Winter consumption (lt/day)	Summer consumption (lit/day)	Total consumption (lit/day)	Total consumption (%)
Water consumed by tourists in hotels	154	214	184	62
Water consumed in pools, spas, etc.	94	131	112	38
Total water consumption	248	345	296	100

Source: Mangion, 2013

The water consumption in tourism accommodation in Morocco is presented in table 6 while the share of water consumption in hotels to total water consumption in several countries in table 7.

Table 6. Water consumption in tourism accommodation in Morocco

Type of accommodation	Water consumption (lit per bed-night)
Luxury 5-star hotel	600
5-star hotel	500
4-star hotel	400
3-star hotel	300
Villa	300
Aparthotel	250
Apartment	180

Source: MEDSTAT II, 2009



Table 7. Share of water consumption in hotels to total water consumption in several countries

Country	Share of water consumption in hotels to total water consumption in several countries , %
Malta	4.5
Cyprus	4.5
Greece	0.55 - 2
Tunisia	2
Israel	0.5
Jordan	0.4
Globally	0.6

Source: MEDSTAT II, 2009, Gossling, 2006, Global water footprint examined in travel and tourism sector, 2023

7. THE IMPACT OF WATER RESOURCES ON TOURISM INDUSTRY IN CRETE

Central to the island's economic vitality is the effective management and availability of water resources. Water not only sustains daily life on the island but also acts as a critical pillar supporting its tourism industry. As tourism continues to grow, the relationship between water resources and tourism becomes increasingly important—and increasingly strained. One of the most direct ways water resources impact tourism in Crete is through their essential role in hospitality infrastructure. Hotels, resorts, restaurants, and recreational facilities require large quantities of water to operate. Swimming pools, landscaped gardens, and the rapidly expanding network of water parks further increase demand. During the peak tourist season, from May to October, Crete's population effectively doubles in some areas, leading to significant pressure on the island's freshwater supply. This seasonal imbalance places stress on water systems, often requiring local authorities to expand desalination efforts. Crete's agricultural sector, which coexists with tourism as a major economic activity, is also heavily dependent on water resources. Agriculture not only supports local livelihoods but also supplies the food products that fuel the island's renowned culinary tourism. Olive oil, wine, and fresh produce are integral to Crete's identity and visitor experience. However, agriculture's high water consumption competes directly with the demands of the tourism industry. During dry years, water scarcity can lead to reduced harvests and higher operational costs, indirectly affecting the tourism sector by raising prices and limiting availability of local goods. The island's natural water features themselves are significant attractions. Gorges, springs, lakes, and coastal ecosystems form part of Crete's outdoor tourism appeal. Visitors are drawn to freshwater attractions such as the Samaria Gorge, Lake Kournas, Lake Agia and various mountain springs. These natural sites depend on stable hydrological cycles to maintain their ecological health. Overuse of water resources and climate change—manifested in prolonged droughts and higher temperatures—threaten the long-term viability of these landscapes. Degradation of natural attractions could diminish Crete's competitive advantage in eco-tourism and nature-based travel. Environmental sustainability is therefore becoming a central concern for Crete's tourism planning. Many hotels and communities have adopted water-saving technologies, such as low-flow fixtures, wastewater recycling, and drought-resistant landscaping. Public awareness campaigns encourage both residents and tourists to conserve water, recognizing that individual behavior contributes to broader resource resilience. Investment in modernized infrastructure, including desalination plants and improved water distribution networks, can also help alleviate some pressure, though these solutions require substantial financial and energy resources. Water resources play a pivotal and multifaceted role in shaping the tourism industry in Crete. They support the hospitality sector, sustain agriculture, and preserve the natural environments that draw visitors from around the world. As tourism continues to expand and climate-related pressures intensify, sustainable water management will be essential for protecting the island's economic future and natural beauty. Ensuring reliable and responsible use of water resources is not merely an environmental consideration—it is a fundamental prerequisite for Crete's long-term success as a leading Mediterranean destination.

8. DISCUSSION

The current work indicates that water and tourism in Crete are strongly interconnected. The share of direct water use in tourism industry to total water consumption in the island, at 3.06 %, is significantly higher than the global average, at 0.6%, but lower than in other Mediterranean islands like Malta and Cyprus. According to the published research the indirect water demand in tourism industry is significantly higher than the direct water demand while the indirect water demand for food production used by tourists has the highest share in the total water demand. It should be noted that most of the foodstuff feeding tourists in Crete, including



meat products, are imported. Therefore, the tourism-related indirect water consumption in Crete, which is mainly attributed to local and imported foodstuff feeding tourists, is not related with local water resources. The high amount of direct water consumption in tourism industry in Crete indicates that optimization of the management of local water resources is required to avoid future water shortages and conflicts with local residents and farmers taken into account the future increase of visitors in Crete and the adverse impacts of climate change on the lower availability of local water resources in the future. The accuracy in the estimations regarding water consumption in the current study depend on the accuracy of the data used which have been taken from existing studies. It is recommended that future research should be focused on estimating the tourism-related indirect water demand in Crete and its share on tourism-related direct water demand.

9. CONCLUSIONS

The water-tourism nexus in the island of Crete, Greece examining their interrelation and interdependence has been studied. Additionally, the share of direct water demand in the local tourism industry compared to total water consumption in the island has been estimated. The main findings of our work can be summarized as follows:

- a) Tourism industry is expanding in Crete while the island has not unlimited water resources which are adversely impacted by climate change.
- b) Tourism industry and water resources are interlinked and interconnected in Crete.
- c) Direct water use in tourism industry in Crete has a share at 3.06% in the total water consumption and a share at 14.64 % in the total water consumption in the domestic sector.
- d) Taken into account the expected future growth of tourism industry in the island and the limited availability of water resources in the future optimization of water management is required to avoid undesired and harmful conflicts among tourism industry, farmers and local residents in the near future in Crete.

Our results could be useful to public authorities and policy makers in the island. The fact that the share of direct water consumption in tourism industry in Crete to total water consumption is significantly higher than the global average indicates that improvements in water management are required to avoid water shortages and conflicts among several local stakeholders in the future.

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