



Journal of Business and Social Science Review
Issue: Vol. 4; No.3; March 2023 (pp.1-13)
ISSN 2690-0866(Print) 2690-0874 (Online)
Website: www.jbssrnet.com
E-mail: editor@jbssrnet.com
Doi: 10.48150/jbssr.v4no3.2023.a1

Climate Change Adaptation of Tourism Industry in The Island of Crete, Greece

John Vourdoubas
Consultant Engineer
107B El. Venizelou str., 73132, Chania, Crete, Greece
E-mail: ivourdoubas@gmail.com

Abstract

Climate change consists of the most important problem affecting the global tourism industry in the 21st century. Adaptation to climate change is necessary in order to minimize the uncertain but undesired impacts and the risks that the alteration of climate conditions could create in various vulnerable tourism destinations. Island of Crete, Greece is a popular tourism destination worldwide while the current prosperity of the island is based on the hospitality sector. The impacts of climate change on tourism industry in the island of Crete, Greece have been examined and several adaptation policies and measures have been proposed. Adaptation of tourism industry to climate change is a complex process requiring holistic approach and the acceptance of the problem and its undesired and harmful impacts by all stakeholders who should collaborate and be involved in the adaptation process. Various existing barriers make difficult the creation and implementation of adaptation policies and activities so far in Crete. Our results indicate that Crete is a vulnerable tourism destination to climate change while the local tourism industry should try to adapt to it. They could be used by local authorities, policy makers, public and private entities as well as to other stakeholders who should be mobilized to avoid the harmful impacts of climate change on the prosperous local tourism industry.

Keywords: adaptation, climate change, Crete-Greece, impacts, tourism industry, vulnerability

1. Introduction

Climate change consists of the most important global environmental problem threatening the prosperity in the developed countries and creating many disasters and devastation in developing and poor countries. Tourism industry is growing rapidly worldwide with more people willing to travel for holidays and entertainment in various destinations all over the world. The attractiveness of tourism destinations depends heavily on the local environmental conditions and climate change affects positively or negatively them (*UNWTO, 2007*). Tourism industry also contributes to climate change emitting greenhouse gases mainly due to energy use. Many studies so far have highlighted the importance of climate change mitigation of tourism industry and the necessity to adapt to it (*Scott, 2008, Nicholls et al, 2008, Jopp et al, 2010, Kajan et al, 2013, Aall et al, 2004*). Any delay in climate change adaptation of tourism destinations jeopardize their future prosperity (*Becken, 2008, Moreno et al, 2009*). Island of Crete is a well-known and popular tourism destination worldwide with more than five million visitors every year. Existing studies related with climate change impacts on Crete and on island's tourism industry are limited. However, the prosperous tourism industry in the island of Crete, which is vulnerable to environmental changes, needs to adapt urgently. Adaptation to climate change is a long and costly process requiring holistic approach and the cooperation and involvement of all stakeholders (*Saarinen, 2006, Wong et al, 2013*). It requires the acceptance of climate change, the study of its impacts to local tourism, the investigation of its vulnerability, the design of adaptation policies and appropriate measures while the cooperation and the involvement of all stakeholders is necessary but not always easy. Our research aims to fill the gap related with the effects of climate change on the vulnerable local tourism industry and the necessary adaptation measures which could mitigate the undesired consequences.

It is going to contribute in the existing knowledge regarding climate change adaptation in tourism-dominated islands. It could be useful to local and regional authorities as well as to all stakeholders of tourism industry in the island of Crete.

The text is structured as follows: After the literature review the concept of climate change is presented followed by the description of the local tourism industry. In the next section the impacts of climate change on tourism in Crete are stated and the reasons for the adaptation to environmental changes are analyzed. After that several tourism adaptation policies and measures are mentioned while the text ends with discussion of the findings, the conclusions drawn and the citation of the references used.

The aims of the current study are:

- a) *The identification of climate change impacts on tourism industry in Crete,*
- b) *The presentation of the necessity of the hospitality sector in Crete to adapt to climate change, and*
- c) *The outline of various adaptation policies in the tourism industry in the island.*

2. Literature survey

Elsasser et al, 2002 have studied the impact of climate change to tourism in Alps. The authors stated that winter tourism in Alps depends on snow-reliability. They mentioned that if the assumptions of climate change impacts are true the snow cover in Swiss Alps will diminish resulting in the jeopardization of the local tourism industry. *Becken, 2005* has investigated the climate change adaptation and mitigation in tourism resorts in Fiji-islands. The author stated various barriers which make difficult the mitigation and the adaptation to climate change while she also proposed several measures to cope with it. *Saarinen et al, 2006* have studied the adaptation strategies of tourism industry in Finland. The authors interviewed several nature-based tourism entrepreneurs in northern Finland. They stated that half of the interviewees did not believe that climate change exists and that it will influence the local tourism industry in the future while there were almost no adaptation strategies in the region. *Scott, 2008* has examined the relation between climate change and tourism globally. The author stated that Eastern Mediterranean-sea is a vulnerable tourism area where climate change is going to cause warmer summers, water scarcity, land and marine biodiversity loss and increase in disease outbreaks. He also mentioned that all tourism businesses and destinations will need to adapt to climate change in order to minimize the industry's risks. *Nicholls et al, 2008* have investigated the impacts and adaptation policies to climate change in northern Europe. The authors stated that climate change could considerably enhance northwestern Europe's competitive advantage compared to Mediterranean-sea in the summer season. These changes are going to have substantial impacts on the European tourism industry. *The Samoa island's sustainable tourism adaptation program* has been developed. It is stated that the success of local tourism industry depends on other sectors such as water, sanitation, health and electricity. It is also mentioned that there are no strategies developed so far for tourism adaptation to the adverse impacts of climate change. *Moreno et al, 2009* have developed a methodology to assess the vulnerability of coastal tourism to climate change. The authors stated that coastal and marine environments are among the most popular areas for outdoor recreation and tourism, while they are also vulnerable to climate change.

They also proposed a five-step vulnerability assessment methodology for tourism in coastal areas. *Jopp et al, 2010* have developed a framework for adaptation of tourism destinations to climate change. The authors stated that the proposed model offers a holistic approach to adaptation that aims to increase resilience and resistance to climate change by implementing appropriate adaptation strategies which reduce vulnerability, while increasing readiness to capitalize on opportunities presented by climate change. *Buzind et al, 2010* have studied the adaptation to climate change of a tourism destination in Playacar, Mexico. The authors stated that despite the biophysical environmental changes tourism industry promotes an ideal picture of the destination. The authors proposed the re-branding of the entire destination taking into account the scenario of climate change which may include, for example, increase in sea level that threatens the local attractive beaches. *Scott et al, 2011* have studied the promotion of sustainable tourism and the adaptation to climate change. The authors stated that due to the interrelation between tourism and environment, climate change is going to have severe impacts on tourism industry and tourism destinations. They mentioned that accurate weather and climate information and data can facilitate the adaptation of tourism industry to climate change. *Munk Klint et al, 2012* have examined the adaptation of tourism to climate change in the Pacific island of Vanuatu. The authors stated that tourism has a great potential in the island while it is vulnerable to climate change.

They investigated the implicit and explicit adaptation processes as well as the types of adaptation approaches including technical, business management, behavior, policy, research and development measures. *Wong et al, 2012* have studied the potential of public-private partnerships during adaptation in south Pacific islands' tourism. The authors stated that the adaptation is costly affecting the financial resources of the government while the private sector, with public-private partnerships, can contribute in financing the necessary adaptation activities. *Wong et al, 2013* have evaluated the policies for climate change adaptation of tourism in south Pacific islands. The authors analyzed three aspects of the policy environment including: a) stakeholders' commitment, b) resource availability and capacity and c) the presence of enabling mechanisms or processes. *Kajan et al, 2013* have studied the interrelation among tourism, climate change and adaptation. The authors stated that during the previous 15 years the issue of tourism adaptation to climate change has been emphasized. They also mentioned that adaptation studies in tourism have not focused so far on community perceptions. *A report on adaptation policies of the tourism industry in Greece has been published, 2014*. The report has examined how climate change can affect the country's tourism product. It also stated the sector's strategy and action plan for addressing the impacts of climate change especially in the islands. *Kajan et al, 2014* have studied the cost of adaptation of tourism industry focusing in northern Finland. The authors stated that stakeholders had difficulties in understanding the concept of adaptation.

They also mentioned that small businesses were more affected in terms of financial costs while some of the adaptation expenses could be decreased with effective mitigation policies and the occurring benefits can be equally important as the costs. *Njoroge, 2014* has studied the framework for regional tourism adaptation to climate change. The author stated that the urgent need for tourism adaptation to climate change has triggered tourism stakeholders to develop generic adaptation frameworks for tourism destinations. He focused on sustainable adaptation frameworks reducing the vulnerability and increasing the resilience in a sustainable way. *Maguigard et al, 2015* have proposed a political ecology approach to island tourism planning and climate change adaptation focusing in Philippines. The authors stated that climate change adaptation planning processes for island tourism is inherently political. They used two theories in their analysis including: a) the tourism area life cycle to assess the level of tourism development, and b) the cultural theory to determine stakeholders group dynamics. *Njoroge, 2015* has reviewed the literature regarding climate change and tourism adaptation. The author has identified five thematic areas including business adaptation, consumer adaptation, destination adaptation, adaptation policy and frameworks for adaptation. He mentioned that after 2010 a new area of research has emerged focusing on sustainable adaptation. *Kaenzig et al, 2016* have studied the climate change adaptation of tourism in Bolivian Andes. The authors stated that the Chacaltaya glacier at high altitude had disappeared since 2009 and skiing was not possible anymore. They mentioned that since 2005 the place has become a new attraction for tourists offering new experiences different to traditional skiing. *Da Huynh et al, 2019* have evaluated the climate change adaptation for tourism in the Mekong Delta of Vietnam. The authors have analyzed the short- and long-term adaptation strategies that arose out from empirical research. They evaluated the adaptation approach to climate change for government authorities, business and tourists mentioning that there were small differences among them in the adaptation approaches. *Arabadzhyan et al, 2021* have reviewed the literature among climate change, coastal tourism and impact chains. The authors stated that climate change affects tourism since both the supply and demand of tourism services depend on the quality and the management of a set of environmental attributes. They also mentioned that the majority of recent studies mainly deal with only a few of the most important impacts on tourism. *Filho, 2021* has explored the links between tourism and climate change. The author stated that the tourism sector was already severely affected by the COVID-19 pandemic and it is now on a slow path to recover. However, climate change is adding an additional pressure to it. *Lopes et al, 2022* have studied the collaborative practices for climate change adaptation of tourism sector in Porto, Portugal. The authors using empirical data stated that tourism adaptation in urban areas requires more detailed information, better cooperation among stakeholders and more human and financial resources. *A policy report for tourism adaptation to Belize islands, Caribbean-sea has been published*. The report stated that around 45-70% of the tourism sector is vulnerable to the effects of climate change. It is also mentioned that adaptation of tourism sector is necessary to cope with the effects of climate change while it requires the involvement of the government, the private sector, the academia and the local communities. *Aall et al, 2004* have studied the adaptation of tourism to climate change in Norway. The authors stated that there are few examples of tourism adaptation to climate change in the country.

They also mentioned four indicators that could be used for the assessment of the capability of local tourist destinations to adapt to climate change comprising: a) climate change, b) nature vulnerability, c) socio-economic vulnerability, and d) institutional vulnerability. *The international cooperation for sustainable development in Mexico has proposed a plan for climate change adaptation in the tourism sector, 2021*. The plan stated that if the tourism sector wants to protect its business it has to adapt to climate change. Adaptation presupposes smooth cooperation between the public and private sector. It is necessary that all stakeholders in the tourism sector and the society should participate in the development of solutions and joint measures. *The intergovernmental panel on climate change has provided a synthesis report regarding climate change, 2007*. The report is targeted to policy makers and it intent to assist governments and other decision-makers in the public and the private sector in formulating and implementing appropriate responses to the threat of human-induced climate change. *Brooks et al, 2005* have studied the assessment and the enhancement of the adaptive capacity of a system to climate change. The authors stated that in a given system it is necessary to understand the components of the change in terms of: a) Who needs to adapt?, b) To which climate risks?, c) What are the barriers to adaptation?, and d) What are the capacity constraints of the adaptation process?. *A report on climate change and tourism has been published by the World Tourism Organization of United Nations, 2007*. The report stated that tourism is a highly climate-sensitive economic sector similar to agriculture, insurance, energy and transportation. It is also mentioned that climate change is not a remote future event for tourism and all stakeholders need to adapt to it. *Giannakopoulos et al, 2009* have studied the climate change impacts in Greece in the near future. The author stated that conditions for tourism are expected to improve in northern and western Europe leading to a gradual shift to tourism destinations further north. They also mentioned that climate change is going to affect Greek tourism with various ways. *The Greek national plan for energy and climate, 2019* promotes sustainable tourism development as well as the climate change adaptation in tourism destinations. It also promotes the use of renewable energy sources (RES) and the increase of energy efficiency in tourism complexes. *Scott et al, 2010* have examined the adaptation of tourism industry to climate change. The authors stated that the willingness and the ability of tourism industry and of tourists to significantly reduce global carbon emissions is limited and below expectations. *Vourdoubas, 2020* has studied the over-tourism in Crete. The author stated that Crete is categorized as an overcrowded tourism destination among EU regions. He also mentioned that coastal ecosystems in the island are fragile and vulnerable to over-tourism and they should be protected. *Vourdoubas, 2019* has estimated the carbon emissions due to tourism industry in Crete. The author stated that CO₂ emissions from the tourism industry in the island are at 428.77 kgCO₂ per tourist and trip. He also mentioned that the international and domestic air-flights have the highest share in the total tourism-related carbon emissions. *Vourdoubas, 2018* has studied the feasibility of net zero carbon emission hotels in Mediterranean region. The author stated that the combined use of solar energy, solid biomass and high efficiency geothermal heat pumps in hotels could zero their net carbon emissions due to energy use. He also stated that these technologies are mature, reliable and cost-efficient while they are already used in several hotels worldwide.

3. Climate Change

‘Climate Change’, the most uttered environmental term of present time has been used to refer to the change in modern climate brought predominantly by human being. It is perhaps the most serious environmental problem that developed and developing societies are facing though the issue is not new. Climate change has emerged in the early nineteenth century while up to late twentieth century the issue was a topic discussed exclusively within the scientific society. It is now more certain than ever, based on many lines of evidence, that humans are changing Earth’s climate. The atmosphere and oceans have warmed, which has been accompanied by sea level rise, a strong decline in Arctic-sea ice, and other climate-related changes. The impacts of climate change on people and nature are increasingly apparent. Unprecedented flooding, heat waves, and wildfires have cost billions in damages. Habitats are undergoing rapid shifts in response to changing temperatures and precipitation patterns. Greenhouse gases such as carbon dioxide (CO₂) absorb heat emitted from Earth’s surface. Increases in the atmospheric concentrations of these gases cause Earth to warm by trapping more of this heat. Human activities—especially the burning of fossil fuels since the start of the Industrial Revolution—have increased atmospheric CO₂ concentrations by more than 40%, with over half the increase occurring since 1970. Since 1900, the global average surface temperature has increased by about 1 °C (*Climate Change, Evidence and Causes, 2020*). In the mid to-late 1980s climate change first emerged on public discussions and policies. Since then, in one hand, it has been manifested by the believers that the impacts of human activities on world climate are going to harm the physical and socio-economic structures of societies.

Many extreme weather events causing natural disasters have highlighted the necessity to develop new policies targeting to climate change mitigation and adaptation. On the other hand, the sceptics have presented fairly enough evidence to disqualify the anthropogenic trait of Climate Change. Thus, with increasing public involvement in the Climate Change discussion the potential risks and uncertainties attached to the issue have been debated and analyzed from diverse standpoints. During the last decades it has been declared that climate change “must be considered the greatest challenge to the sustainability of tourism in the twenty-first century”. Climate change is a problem in which the stakes are high and political decisions may well be necessary, but in which facts are still very uncertain and values very much in dispute, so much so that “traditional science is not always able to legitimize” – and governments unable or unwilling to take – the drastic steps that may in fact be needed to deal with the climate change ‘problem’. Tourism is responsible for roughly 8% of the world’s carbon emissions. The majority of this footprint is emitted by visitors from high-income countries. As the number of people who can afford to travel grows, so will tourism’s environmental footprint. According to United Nations World Tourism Organization (UNWTO) tourism industry should:

- a) Strengthen the measurement and disclosure of CO₂ emissions in tourism,
- b) Accelerate the de-carbonization of tourism operations, and
- c) Engage the tourism sector in carbon removal.

4. The tourism industry in Crete

Tourism is the most dynamically developing sector in the island and its demand triggered important investments in many types of hotels. Tourism in Crete is currently facing structural problems, consisting mainly in its seasonal nature and the limited expansion of the tourist movement to the inland settlements, as tourist infrastructures are mainly gathered in the northern coast and small centers in the south, while its sustainability is largely influenced by outward, uncontrollable conditions like the pandemic Covid-19, contributing to fluctuations in its performance. An important competitive advantage of the tourist branch is the high percentage of high standard hotel infrastructures. Crete has 30.31% of the total of 5 star’s beds in Greece and 24.57% of 4 star’s beds respectively. The visitors of Crete are from all ages, look for adventure, activities, relax and spa therapies. The last years the tourists prefer, except from sea and sun, alternative tourism such as natural and botanical routes, climbing, trekking, new undiscovered places such as small traditional villages. The main elements that attract and satisfy tourists include:

- Weather and Climate
- Famous gastronomy (the well-known Cretan Nutrition)
- Tradition and Cretan way of life
- Cultural heritage and history
- Natural environment
- Beaches and Coasts

Moreover, there are specific groups of tourists who are satisfied with various activities including:

- Religious and pilgrimage sites
- Botanical and natural routes
- Alternative tourism of well-being and relaxation
- Off-road activities
- Organization of scientific and professional conferences

Several characteristics of the tourism industry in Crete are presented in table 1.

Table 1. Several characteristics of the tourism industry in Crete

Parameter	Value
Number of inhabitants (2011)	634,930
Area of the island	8,332 Km ²
Number of tourists (2016)	4,902,194
Share of tourism to regional domestic product	47%
Number of tourists’ bed-nights in Crete (2017)	24,516,000
Tourism density	4,463 bed-nights per Km ²
Tourism intensity	69.8 bed-nights per inhabitant

Number of Airbnb accommodation facilities	0.034 per inhabitant
Carbon emissions per tourist	488.77 kgCO ₂ per trip

Sources: *Vourdoubas, 2019, Vourdoubas, 2020*

Apart from climate change pressures in the local tourism industry are imposed by other causes including: a) the current over-tourism in the island (*Vourdoubas, 2020*), and b) the pandemic Covid-19. The tourist arrivals in Crete during 2020 and 2021 were less than the arrivals in 2019 due to the global pandemic. However, the arrivals in 2022 were almost the same like in 2019 which indicates that the tourism industry in Crete has recovered from the pandemic shock.

5. The impacts of climate change on tourism industry in Crete

According to various studies climate change will decrease the attractiveness of Mediterranean countries to tourists (*Scott,2008, Nicholls et al, 2008*). Although there is high uncertainty regarding the impacts of climate change in the island, they will affect all aspects of the local tourism industry. Due to alteration in the local climate thermally comfortable conditions are going to occur earlier in April instead of May and later in October instead of September. It is quite probable that summers in Crete will be similar like to day in red sea, India and Persian Gulf. The traditional “sea and sun” tourism product of the island is going to be less attractive than today. Increase in thermal discomfort during summer will result in higher energy requirements and higher operating costs in hotels and other tourist accommodations. Changes in precipitation patterns and more frequent droughts will result in water shortages requiring new water resources. Higher temperatures, forest fires and more frequent droughts will result in land desertification and in the extinction of various species which cannot survive under the new climate conditions. Agriculture is also going to be affected by higher air temperatures. The local agricultural production in Crete will probably decrease making necessary the import of food stuff for tourists’ catering. Higher sea water temperatures are going to favor various invading species which are going to migrate from southern regions to eastern Mediterranean-sea competing with the indigenous species. It is foreseen that climate change will enhance the competitive advantage of central and northern European countries compared to Mediterranean countries for summer holidays (*Nicholls et al, 2008*). Therefore, a number of tourists who currently visit Greece during the summer will prefer to stay in their countries or to visit other more attractive destinations due to the uncomfortable environmental conditions in Crete. Additionally, climate change will affect island’s infrastructure. It will be necessary to improve the resilience of the existing infrastructure to cope with extreme weather events. These events like flooding will be more frequent threatening and causing disasters in the local infrastructure like roads, bridges, electric grid et cetera which are necessary for tourists as well as for the locals. Sea level rise will damage the attractive but vulnerable beaches of the island having high economic impacts to various hotels and tourism resorts which are currently developed near the beach front. This, will require the construction of coastal protection systems including beach stabilization and creation of sea walls. The impacts of climate change to tourism industry in Crete are presented in table 2.

Table 2. Impacts of climate change on Crete

Average annual temperature rise
More frequent droughts
More frequent flooding
More frequent heat waves
More hot days and nights every year
Erosion of the sea front and the beaches
Extinction of several species
Soil erosion and increase of land desertification
Increasing risk of forest fires
Change in precipitation patterns
Invasion of several species from other climate zones competing with indigenous species
Less water availability

Source: *own estimations*

6. The need for adaptation in Cretan tourism industry

The island of Crete and the tourism industry must adapt to climate change in order to minimize the risks and capitalize on new emerging opportunities in a sustainable way. The acceptance of climate change and their impacts on tourism industry in Crete is not obvious to all stakeholders in the island. However, the ability of tourism industry to adapt successfully in the new climate conditions depends on the recognition of climate change and its consequences by all stakeholders and their collaboration in the implementation of adaptation activities. The time horizon to adaptation is usually unknown as well as the time that it should start. Adaptation to climate change is often complementary to mitigation while they have both synergies and trade-offs. Hotels and other tourist accommodation facilities which replace the use of fossil fuels with RES reduce their carbon emissions contributing to climate change mitigation while they also promote their adaptation increasing their resilience to extreme weather events. The uncertainty regarding the impacts of climate change on Crete does not facilitate the creation of concrete and efficient adaptation policies. Therefore, policies should be flexible. Additionally, it has been indicated that adaptation to climate change is costly. Probably it will require the cooperation of the public and private sector in the implementation of joint projects. A range of barriers limits the design, implementation and effectiveness of adaptation measures. The capacity to adapt is dynamic and is influenced by the productive base of the society, including natural and man-made capital assets, social networks and entitlements, human capital and institutions, governance, national income, health and technology. Even societies with high adaptive capacity remain vulnerable to climate change variability and extreme weather events. Stakeholders' involvement in the identification and prioritization of adaptation options in Crete is absolutely vital since, to be successful, adaptation measures must be acceptable to those who are going to implement them. Stakeholder representatives should come from all sections of society likely to be affected by climate change or by the implementation of adaptive measures. Stakeholder groups with little or no historical power to influence decision-making should be represented and the fact that adaptation may create "winners and losers" must be recognized. A wide variety of stakeholders should participate in adaptation policy formulation. People are far more likely to support adaptation strategies if they feel their views have been taken into account. In an era of global climate change, it will no longer be sufficient to rely on past experience. The information requirements for effective, anticipatory climate change adaptation will be substantial. The main types of adaptation in the tourism industry in Crete includes technical adaptation, business management adaptation and behavioral adaptation. It also includes the creation of new policies, information, education and collaboration among the local actors. The main stakeholders in the tourism industry of Crete are presented in table 3.

Table 3. Several stakeholders of the tourism industry in Crete and their vulnerability to climate change

Type of stakeholder	Stakeholder	Vulnerability to climate change
Public authorities	Region of Crete Municipalities in Crete Airport and seaport authorities Public Power Company, Grid operator Water and wastewater treatment utilities Several other public authorities, museums, et cetera Greek tourism organization Higher Educational Institutes and Research Centers	Authorities having immobilized assets in Crete are more vulnerable to climate change
Private entities based on Crete	Local tour operators and tourism companies Hotel owners Owners of various types of accommodation Several enterprises offering services to tourists including restaurants, bars, various giftshops, merchants, organizers of local excursions, rent a car companies, et cetera Farmers producing local agricultural foodstuff	Entities having immobilized assets in Crete, like hotel owners are more vulnerable to climate change
Private entities based abroad	International air-transportation and cruise ship companies International tour operators International hotel chain companies	They are less vulnerable to climate change
Consumers	Tourists	They are less vulnerable to climate change

Source: own estimations

Several barriers are hindering the adaptation of tourism industry in Crete to climate change which should be removed. These barriers can be categorized as technological, scientific, financial and institutional and are presented in table 4.

Table 4. Several barriers which are hindering the adaptation of tourism industry in Crete to climate change

Barrier	Categorization
Lack of knowledge regarding the precise climate change impacts to tourism industry and the appropriate time to start adaptation	Scientific
Lack of governmental incentives	Institutional
Lack of financial resources required in the implementation of various activities	Financial
Lack of skilled staff which is required in the design and implementation of various activities and projects	Scientific, technological
Lack of reliable technological solutions	Technological
Lack of cooperation among tourism industry's stakeholders which is required for the implementation of joint activities	Institutional
Lack of acceptance of climate change from stakeholders and its undesired and harmful impacts on tourism	Scientific, institutional
Lack of appropriate legislation and policies	Institutional
Lack of good and successful practices in other regions which could be transferred to Crete	Technological
Different interests among stakeholders since some of them will suffer more than others	Institutional
Lack of time	Scientific, technological

Source: Becken, 2005, own estimations

7. Adaptation policies and measures in Crete

Adaptation of tourism industry requires the involvement of all stakeholders, listed in table 3, who are affected by climate change. Adaptation in the island of Crete is categorized as technical adaptation, adaptation of business management, behavioral adaptation and development of new policies.

7.1 Technical adaptation

- a) Improvement of the necessary infrastructure providing adequate water to tourists including the use of better water irrigation technologies, water conservation, construction of water desalination plants, recycle and reuse of waste water as well as construction of artificial reservoirs collecting rainfall water,
- b) Improvements in the infra-structure of tourism destinations so that they may be adjusted to take into account high temperatures on the one hand, and other extreme weather events such as floods or droughts on the other,
- c) Avoiding erosion of beaches, in coastal areas, with beach stabilization, construction of seawalls, and construction of coastal protection systems,
- d) Improvement of the thermal behavior of hotels in order to be provide thermally comfortable conditions to visitors. Increase in air-condition systems,
- e) Coping with land desertification planting trees and bushes in threatened lands,
- f) Protection of species which are under extinction and better management of invaded species from other climatic zones,
- g) Setting new building structures away from the beachfront,
- h) Improving the resilience of forests to cope with extreme heat waves and creating a better forests' fires monitoring system, and
- i) Use of natural building materials.

7.2 Adaptation of business management

- a) Spatial and temporal diversification of the tourism product. New forms of tourism should be developed in the island redefining the current model of "sea and sun" tourism, and
- b) Promoting weather-proofing indoor activities.

It has been indicated that climate change will increase the operating cost in hotels by around 5-7% annually (Zerefos *et al*, 2014).

7.3 Behavioral adaptation

a) Adjusting the type of clothing worn, changing the activities engaged in, adjusting the timing of the visit, changing the destination altogether.

7.4 Development of new policies

- a) Improvement of the education and the communication among tourism stakeholders,
- b) Creation of supporting and collaborative networks,
- c) Increasing the interest of local researchers in tourism climatology,
- d) Promoting the use of indigenous sustainable energy sources and efficient energy technologies in order to increase the resilience of tourist's accommodation and other critical infrastructures like hospitals,
- e) Adjustments in plans to deal with crises such as forest fires, to facilitate the evacuation of tourists and the local inhabitants, whenever needed, and
- f) Providing the necessary financial resources required for the implementation of adaptation measures.

The main types of adaptation in the local tourism industry are presented in table 5.

Table 5. Types of adaptation in Cretan tourism industry

Adaptation type	What does it involve?	What does it require?	Examples?
Technical adaptation	This involves utilizing technology and being innovative in order to determine methods of coping with climate change and vulnerability.	This often requires specialized equipment and/or the use of new technologies and innovations. Also, due to the cost and complexities of many technical adaptation options, this type of adaptation often requires financial support from the government.	Construction of water reservoirs and desalination plants, creation of coastal protection systems, improvement of the thermal behavior of hotels in order to provide thermally comfortable conditions to visitors.
Adaptation of business management	Involves techniques used by tourism operators, regional governments, and tourism industry associations to reduce vulnerability to climate change.	This may require destination managers to change their marketing approach to try and increase or decrease travel during certain times, and/ or redirect tourists to different locations, or encourage them to engage in different activities.	Marketing techniques such as new pricing strategies, product/market diversification and positioning can all be utilized.
Behavioral adaptation	This form of adaptation is normally associated with the tourist, as they have the ability to decide on the tourism activities they engage in and where and when they do so.	Although behavioral adaptation is generally undertaken by the tourist, there are some strategies that destination	Adjusting the type of clothing worn, changing the activities engaged in, adjusting the timing of the visit,

	This ability for spatial, temporal, and activity substitution subsequently provide tourists with substantial adaptive capacity.	managers can use to affect behavior.	changing the destination altogether.
Development of new policies	New regulations regarding the construction of new buildings near the beachfront, energy and water savings, protection of endangered species et cetera	Active participation of the local tourism industry's stakeholders in the consultation process	New national and regional regulations in several sectors.

Source: Jopp et al, 2010, own estimations

8. Discussion

Crete has a flourishing tourism industry which is an important pillar of the regional economy contributing in island's prosperity. Climate change has undesired consequences on Cretan tourism industry changing the local mild climate and altering various environmental conditions which attract millions of tourists every year in the island. Due to inherent difficulties and to different priorities the local public authorities as well as the other stakeholders of the local tourism industry have not developed up to now a holistic and concrete adaptation plan in Crete. Climate change also threatens the fragile ecosystems in Crete while extreme weather events destroy the valuable infrastructure to visitors and locals. Apart from climate change the over-tourism in the island threatens also the viability of tourism and the valuable and unique ecosystems. Although tourist arrivals during 2020 and 2021 were low, due to Covid-19 pandemic, 2022 was a successful year with arrivals almost similar to 2019 while the expectations for 2023 are high. In order to cope with the uncertain and undesired effects of climate change the tourism industry has to mitigate and adapt to climate change. Unfortunately, there is limited experience and good practices in other insular tourism destinations regarding successful adaptation policies and plans. Adaptation of the tourism industry in Crete is a complex process requiring holistic approach and cooperation among all stakeholders. Appropriate policies and measures are limited while the precise consequences of climate change to Cretan tourism industry are unclear and vague so far. Limited efforts have been made regarding the information of stakeholders regarding this issue, the necessity to cope with it and the need for their collaboration in future adaptation activities. The local stakeholders who should be involved and mobilized in the adaptation process have been identified. Various adaptation policies and measures have been proposed although the uncertainty of climate change impacts complicates their quantification as well as their cost estimation. Similar adaptation policies and measures have been proposed in other coastal tourism destinations by several authors (*Becken, 2005, Scott, 2008, Moreno et al, 2009, Arabadzhyan et al, 2021*). Future research should be focused on more detail studies related with adaptation of the local tourism industry to climate change and their undesired consequences. Our findings indicate that local stakeholders and public authorities should be urgently mobilized in order to cope with climate change which threatens the prosperity of tourism in Crete.

9. Conclusions

Climate change has severe impacts on tourism industry and tourism destinations. In order to reduce the risks and avoid disasters due to alteration of environmental conditions and to extreme weather events the tourism industry in Crete has to adapt in the new climate conditions. Island of Crete, Greece consists of an attractive and popular tourism destination, accepting more than five mil. visitors annually, which is severely affected by climate change. The impacts of climate change on Crete comprise higher mean annual temperatures combined with heat waves and droughts, changing precipitation patterns combined with flooding and water scarcity, extinction of several species, land desertification, erosion of beaches and increasing risk of forest fires. Island of Crete has to adapt to climate change in a sustainable way in order to minimize the climate change-risks and capitalize on new emerging opportunities. All stakeholders of the local tourism industry should recognize and accept climate change and its threats in order to cooperate and develop jointly sustainable adaptation policies and activities. Various technological, scientific, financial and institutional barriers are currently hindering the adaptation of the local tourism industry. Adaptation can be categorized as technical adaptation, adaptation of business management, behavioral adaptation and development of new policies.

The current work could be helpful to policy makers, public authorities, private entities, municipalities and to other stakeholders of the local tourism industry who should design and promote a concrete adaptation plan to climate change which threatens the prosperous tourism industry in the island.

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