Interreg Euro-MED

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NaTour4CChange

# *Destination Zakros-koufonissi*

# Identification and assessment of the main coastal tourism-related issues concerning climate change mitigation and adaptation

The Consortium:

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|---|---|
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| Project Full Title | Governing sustainable tourism in territories with high environmental value: reconnecting tourism and nature for addressing the climate crisis with an ecosystem-based approach |
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| Project Mission | #4 Enhancing Sustainable Tourism |
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| 2 | 7.8.2025 | Nafsika Pitsou, Kyriaki Theodorou, Nikolaos Zervos |
| | | |

# Project Overview

The Mediterranean region is one of the most vulnerable hotspots in the current biodiversity and climate crises, warming 20% faster than the global average and being the second biodiversity hotspot in the world. The increase of severe climate events are also likely to influence the choice of destinations and time to travel for its over 510 million inhabitants. The effects of climate change will put additional pressure on already strained ecosystems and vulnerable economies and societies, with Tourism being one of the most affected economic sectors.

The recent Transition Pathway for Tourism and the Glasgow Declaration are building a global momentum for Climate Action in Tourism, but policymakers and destinations need support to better develop efficient climate mitigation and adaptation policies using ecosystem-based approaches and improved multi-level governance structures, including robust planning and ensure the long-term engagement of the private sector and citizens. Indeed, ecosystem-based management is considered a good practice to effectively deal with these threats as it considers the different stakeholders and factors affecting ecosystems and the mechanisms involved, in order to find solutions.

**NaTour4CChange** builds on and capitalises on successful experiences at the Mediterranean and global level to test solutions for increasing the resilience of coastal destinations in the Mediterranean. The project will aim to set common methods to allow participating regions to assess their tourism-related climate adaptation and mitigation priorities, and take climate action via plans and strategies, supported by cooperative governance.

In coastal destinations, cross-sector teams will deliver specific tourism climate Action Plans, focusing on climate adaptation, where Nature-based Solutions (NbS) will be tested to ensure their feasibility. At the same time, innovative destination marketing and communication approaches will engage private stakeholders, visitors, and residents in climate action.

The project will also ensure cross-fertilisation among participating regions and destinations, to achieve common methods and to compare the different tested plans and solutions, leading to lessons, best practices, and policy.

# Glossary

**Climate Change Adaptation (CCA)** means anticipating the adverse effects of climate change and taking appropriate measures to prevent or minimise the damage they may cause, or to take advantage of the opportunities that may arise.

**Climate Change Mitigation (CCM)** means making the impacts of climate change less severe by reducing the sources of emission of greenhouse gases (GHG) into the atmosphere or by improving the storage of these gases.

**Ecosystem Services (ES)** are the benefits that an ecosystem brings to society and that improve people's health, economy, and quality of life.

**Ecosystem-based Approaches (EbA)** focus on managing biodiversity and ecological systems in a holistic way to maintain and enhance ecosystem services benefits and functions.

**Nature-based Solutions (NbS)** encompasses all actions that rely on ecosystems and the services they provide to respond to various societal challenges such as climate change, food security, resource management, or disaster risk.

# 1. INTRODUCTION

## 1.1 DESCRIPTION OF THE PILOT DESTINATION

Zakros is located in southeastern Crete within the Sitia UNESCO Global Geopark, characterized by coastal ecosystems, archaeological sites (e.g., Minoan Palace of Zakros), mountainous terrain (Zakros Mountains), and tourism-dependent economy. Koufonissi epitomizes Mediterranean climate urgency: its archaeological treasures face inundation, its desert ecosystem hangs by a thread, and its avian refugees struggle amid warming. Yet, its uninhabited status offers a unique advantage—managed adaptation can prioritize ecology and heritage without displacing communities. Immediate action to stabilize coasts, digitize heritage, and monitor endemic species could transform this "African outpost in Europe" into a resilience laboratory for island systems worldwide.

### 1.1.1 OVERVIEW OF THE PHYSICAL AND BIOLOGICAL CHARACTERISTICS

In the table below we can see detailed information about important species the destination site:

**TABLE 1: DESTINATION SITE INFO**

| Destination Site | Area (ha) | Protection | Important species | Development Status |
|---|---|---|---|---|
| Zakros | 3878 | SPA-GR4320016, Archeological Subset Zones | | Developed |
| Koufinissi | 422 | SPA-GR4320017, SCI-GR4320008, Archeological site | Falco eleonorae, Bolinus brandaris (porphúra) | uninhabitable |
| Other Small islands | | | | |
| Strogilo (Koufonissi) | 16.4 | SPA-GR4320017, SCI-GR4320008, Archeological site | Falco eleonorae | Uninhabitable, unapproachable |
| Trachilos (Koufonissi) | 12.9 | SPA-GR4320017, SCI-GR4320008, Archeological site | Falco eleonorae | Uninhabitable, unapproachable |
| Makroulo (Koufonissi) | 6.9 | SPA-GR4320017, SCI-GR4320008, Archeological site | Falco eleonorae | Uninhabitable, unapproachable |
| Kavalos (Zakros) | 1.7 | SPA-GR4320017 | Falco eleonorae | Uninhabitable, unapproachable |
| Anavatis (Zakros) | 1.4 | SPA-GR4320017 | Falco eleonorae | Uninhabitable, unapproachable |

| Destination Site | Area (ha) | Protection | Important species | Development Status |
|---|---|---|---|---|
| Marmara (Koufonissi) | 0.9 | SPA-GR4320017, SCI-GR4320008, Archeological site | Falco eleonorae | Uninhabitable, unapproachable |
| Kefali (Zakros) | 0.5 | SPA-GR4320017 | Falco eleonorae | Uninhabitable, unapproachable |

The Eleonora's Falcon (Falco eleonorae*) is one of the most important bird species in Greece as the country and particularly the islands of the Aegean Sea host >85% of its global breeding population. In koufonissi was also produced *porphúra* ancient Minoan color that is produced from Bolinus brandaris

| Falco eleonorae | Bolinus brandaris |
|---|---|
|  |  |

*Falco eleonorae*[1] *is one of the most important migratory bird species hosted by Greece, since almost 85% of the world's population breeds in the Aegean Sea and Crete. In all the Mediterranean islands, its populations are declining. Only in the steep cliffs of the Aegean and Cretan drylands (Cape Sidero, Elasa, Dionysades) is there a slight increase in the population. In autumn, the black-headed starling leaves Crete to follow the migratory birds on their migration to East Africa and spends the winter in Madagascar. Until the end of July, it feeds mainly on large insects (butterflies, dragonflies, cicadas and beetles), while from August to October, its diet turns exclusively to migratory birds, when they use the black-legged flycatcher's nesting areas for passage southwards. Every year, millions of birds travel from wintering grounds to breeding grounds and vice versa. Typically, these birds breed in the temperate or Arctic zone of the Northern Hemisphere and spend the rest of the year in warmer areas of the Southern Hemisphere. A total of 136 species are typical migrants for the island. Some come in the spring as they return from tropical Africa to the*

[1] Short description form Sitia Geopark site

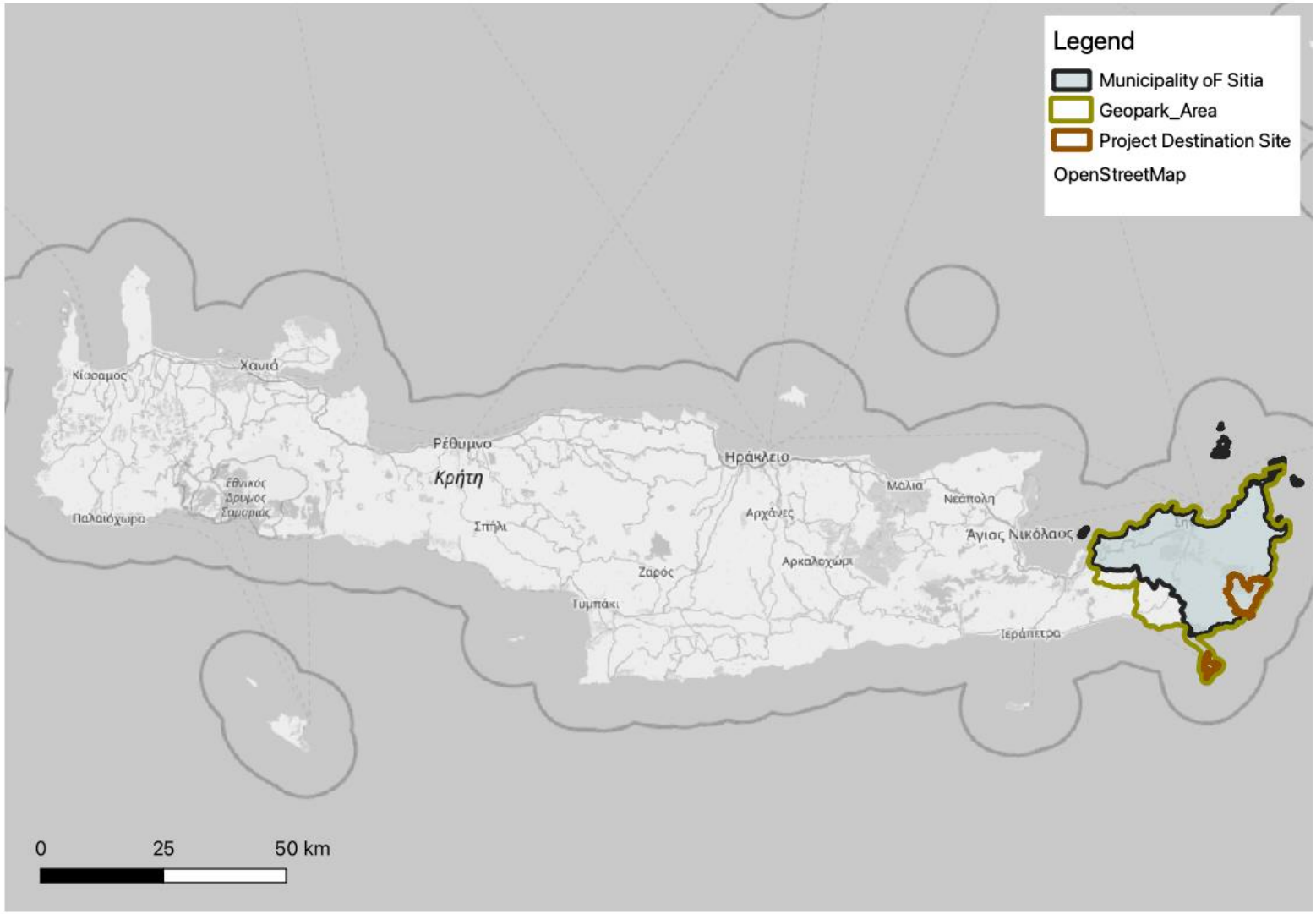
*northern countries, where they nest and breed. These flocks, which cross the Mediterranean on their journey to and from Africa, stop in Crete to rest. The small coastal wetlands, scattered all over the island, and more recently the artificial reservoirs, are their favourite stops. So much so, in fact, that many overwinter in them.*

*Regarding mammals, 14 species have been recorded in the Park area, four of which are cetaceans, such as the strictly protected bottlenose dolphin (Tursiops truncatus) and Mediterranean seal (Monachus monachus), as well as the bottlenose dolphin (Stenella coeruleoalba) and the common dolphin (Delphinus delphis).*

*The most characteristic terrestrial mammals are the hare (Lepus europaeus), the weasel (Mustela nivalis), the skunk (Martes foina bunites), the badger (Meles meles), and the shrew (Acomys minous), while the Pipistrellus savii, a strictly protected species, is found in the caves.*

*Many of the eight reptile species and two of the three amphibian species in the area are included in Directive 92/43/EEC and the Bern International Convention. All three amphibian species of Crete are found in the area: the green toad (Bufo viridis), the tree frog (Hyla arborea kretensis), a subspecies endemic to Crete, and the Cretan endemic frog (Pelophylax cretensis).*

FIGURE 1: DESTINATION SITE

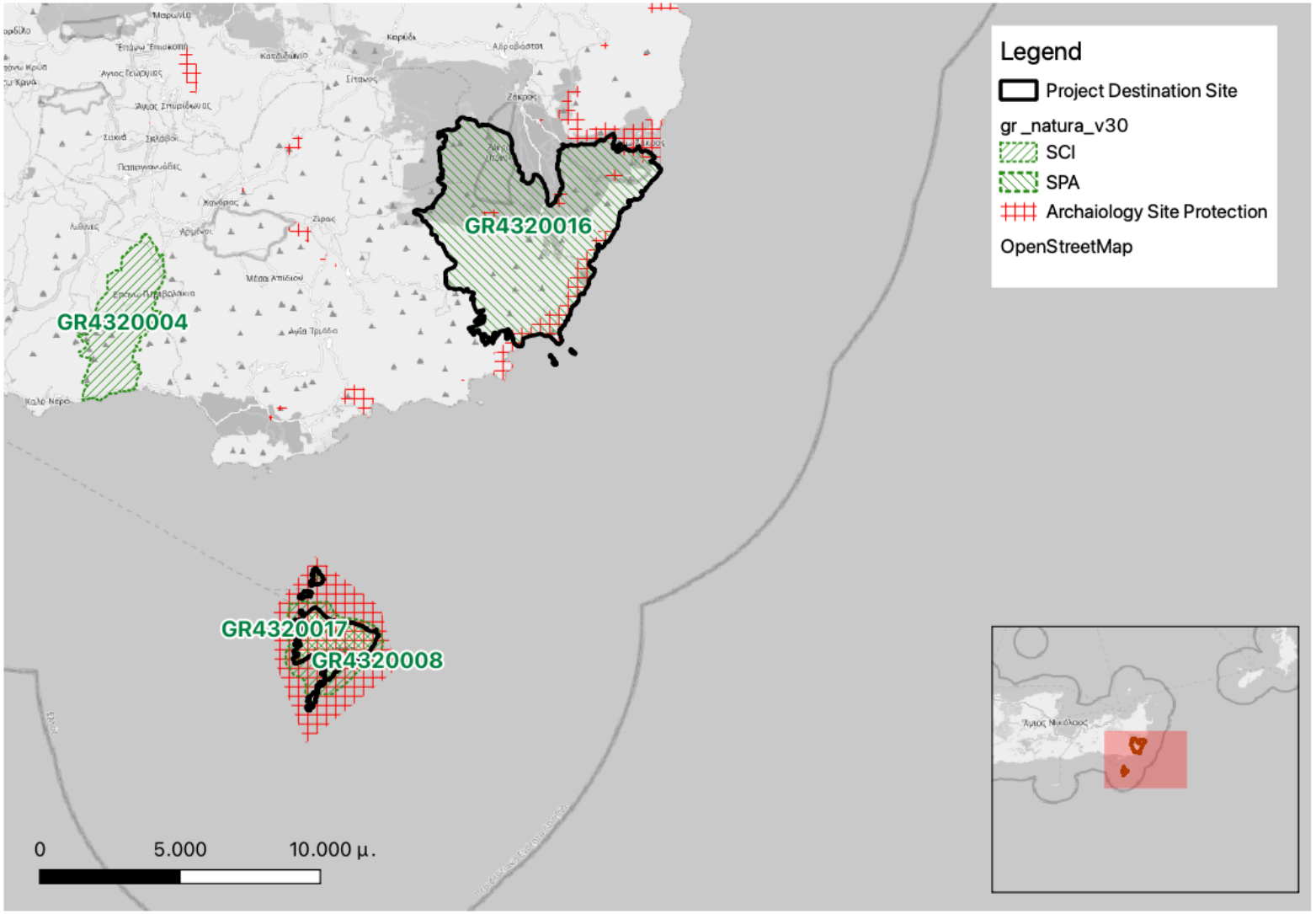


### 1.1.2 PROTECTION STATUS OF THE PILOT DESTINATION

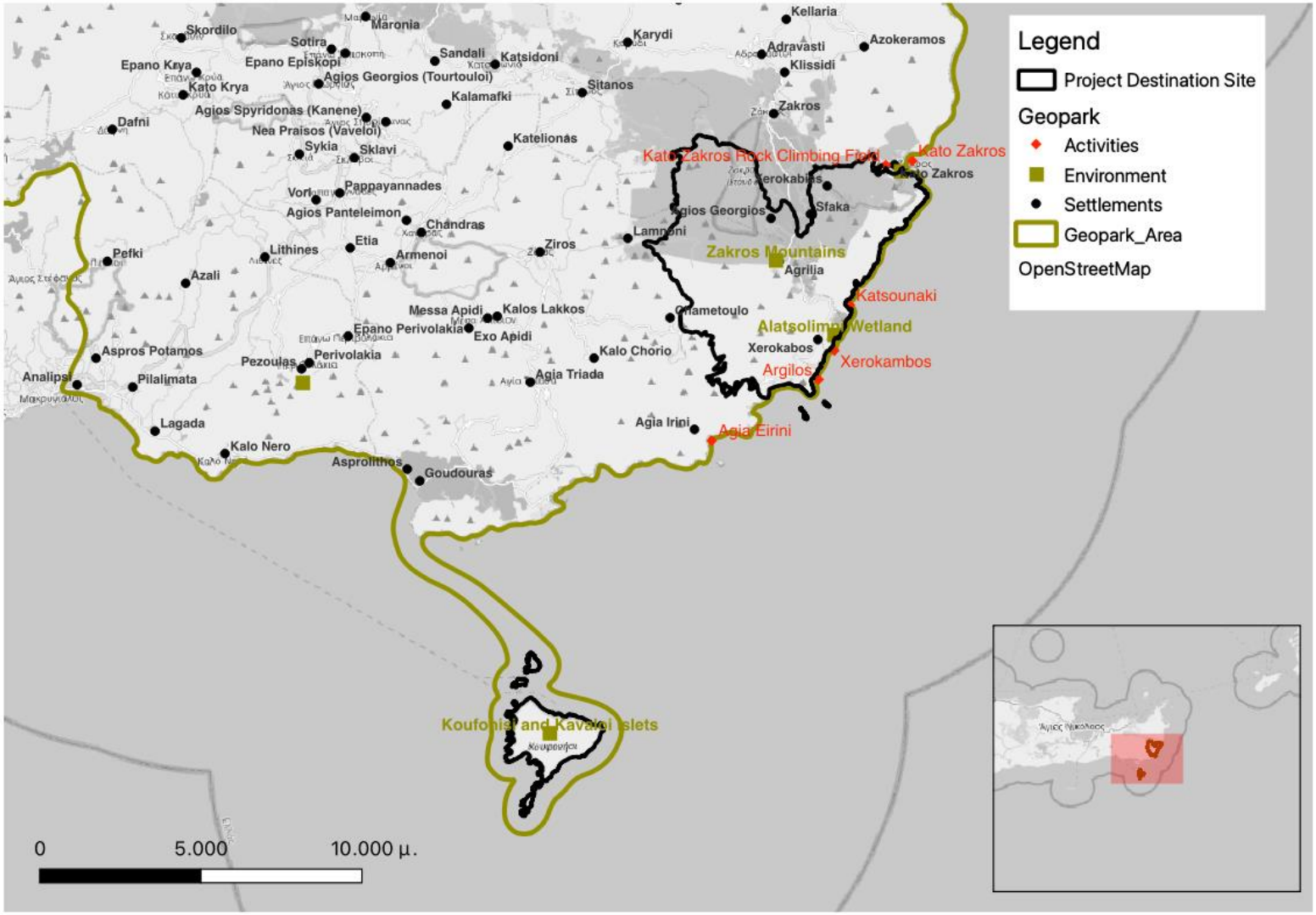
In the destination site is under development (approval) specific measures in order to protect Natura Special Protection Area (SPA) and Sites of Community Importance (SCI). Thus destination is subset of Unesco Sitia Geopark. UNESCO Global Geoparks strive to raise awareness of geodiversity and promote protection, education and tourism best practices. Together with World Heritage sites and Biosphere Reserves, UNESCO Global Geoparks form a complete range of sustainable development tools and make an invaluable contribution to the realisation of the 2030 Sustainable Development Goals by combining global and local perspectives.

The following map shows the areas of eastern Crete that are under Natura (SPA, SCI) protection status:

## FIGURE 2: DESTINATION PROTECTION STATUS



## FIGURE 3: SITIA GEOPARK ACTIVITIES



The specific environmental study, that is under approval process, is proposing the following measures :

- Restoration and/or creation of new artificial wetlands as biodiversity hotspots
- Creating environment paths
- Creation of birdwatching infrastructure
- Creation of infrastructure for the collection, treatment and reuse of rainwater and runoff
- Management of mountain springs and waterholes
- Special administrative arrangements for the licensing of Renewable Energy Sources installations
- Reintroduction/enhancement of existing populations of indigenous animals and local plant varieties
- Construction of ponds with natural clay substrate. Fencing and water supply/filling

These measures must be taken in consideration for any future touristic development in order to maintain nature integrity and

### 1.1.2 RELEVANT POLICY FRAMEWORKS

Crete's climate and tourism policies align with EU Green Deal objectives but require stricter local enforcement. Priorities include water conservation, renewable energy, and tourism carrying capacity. Bellow are summarized national, regional and sectorial planning regulations in the fields of climate change, tourism and biodiversity conservation

National level

In May 2022, the first climate law[2] was passed in Greece, establishing, among other things, the framework for the adaptation to climate change and the gradual mitigation of anthropogenic greenhouse gas emissions. In order to achieve the long-term objective of carbon neutrality by 2050, intermediate emission reduction targets are set for the years 2030 and 2040 (a reduction of 55% and 80%, respectively) relative to 1990 levels.

Regional level

The same year was approved[3] the Regional Plan of adaptation in climate change (PEPSKA Kritis) in order to mitigate the climate change effects in the region.

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[2] Law 4936/2022 (FEK 105/A)

[3] ΑΔΑ: ΨΔ507ΛΚ-ΞΕΣ

This plan is analyzing in short, middle and long term period (2021-2040, 2041-2060, 2081-2100) 2 Representative Concentration Pathway scenarios (RCP 4.5 and RCP 8.5) in the region of Crete in the following sectors :

1. Agricultural and livestock production
2. Forests and reforested areas
3. Biodiversity – Ecosystems
4. Fisheries and Aquaculture
5. Water resources (in terms of their availability)
6. Rivers (in terms of flooding phenomena)
7. Coastal uses
8. Tourism
9. Energy
10. Transport infrastructure (road network, port and airport infrastructure)
11. Health
12. Built environment
13. Cultural heritage

The Region of Crete approved Tourism Strategic Planning & Operational Plan 2024 – 2028 does not have specific targets for the destination area.

In regional level is also operational from 2017 the Regional Spatial Plan of Crete that delegates[4] regulations in spatial development in all sectors for the region of Crete.

Finally today from 2021 is under development the Sectorial National Spatial Plan for tourism development that categorizes municipalities in various level of touristic development with the respective policy goals and restrictions. In the following map are illustrated the level of touristic development from most developed (A) to less developed (E) and the respective policies and restrictions (mostly for the overdeveloped areas). The destination site is categorized in (D) category (Areas with development potential):

**TABLE 2: REGULATIONS SUMMARY**

| Regulation Level | National | Regional | Local (destination) |
|---|---|---|---|
| Non Spatial regulations/directives | Law 4936/2022 (FEK 105/A/2022)<br>(FEK 974/B/2001) 99605/3719 National Action Plan to against desertification | Tourism Strategic Planning & Operational Plan 2024 - 2028 | |

[4] To local spatial development plans

| Regulation Level | National | Regional | Local (destination) |
|---|---|---|---|
| Spatial regulations | Tourism National Spatial Plan | Regional Spatial Plan of Crete (2017)<br>Regional Plan of adaptation in climate change (2022) | Specific Environmental Study (ΕΜΠ09) – Environmental Management measures – Under approval |

### 1.1.3 TOURISM PRESSURES IN THE LOCAL ENVIRONMENT

The destination site has small amount of touristic volumes and is characterized from the purity of the untouched environment. This effect is caused primary due to protected environment and secondly due to abandonment. Thus major issues in the area is environmental erosion caused by the nature. Places like this It attracts visitors seeking history, hiking, and quiet escapes rather than mass tourism. Zakros offers intimate, nature-focused stays with cultural immersion, while Crete's broader hotel market caters to mass tourism with varied luxury and convenience. There are no luxury big hotels in the area so the tourism pressure is limited. As we can see  destination site has the 0.0002 % of the total volume of touristic beds.

| | |
|---|---|
| Number of beds Crete | 193928 |
| Number of beds Zakros area | 42 |

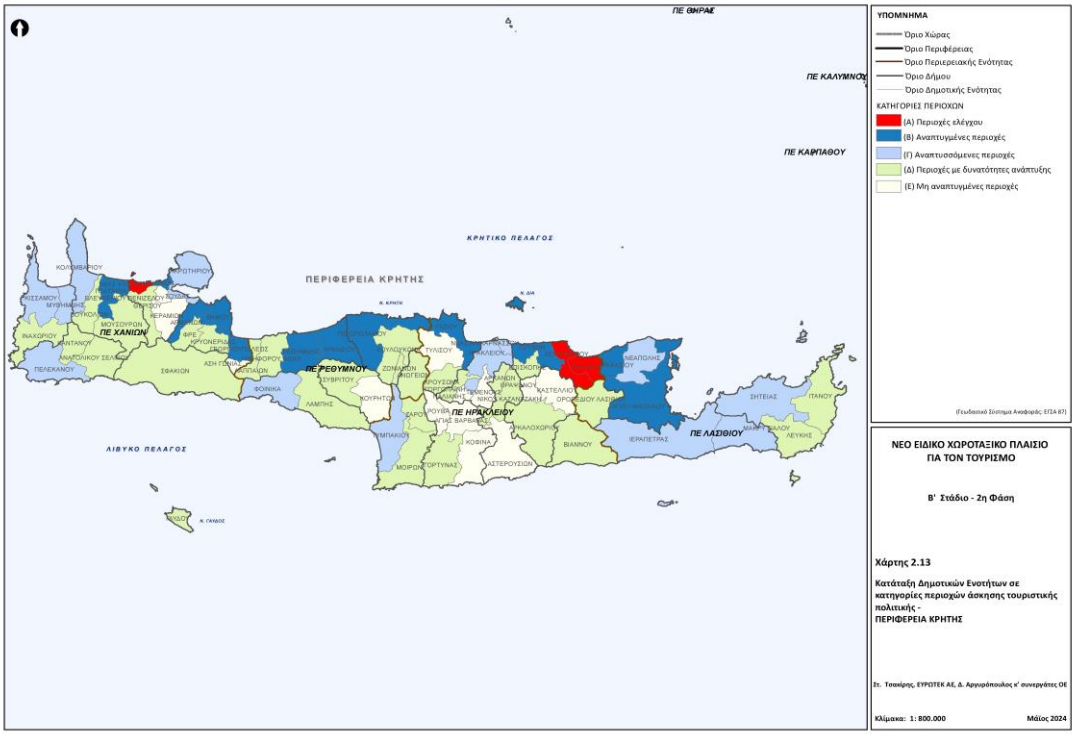


FIGURE 4: TOURISTIC DEVELOPMENT

The map[5] above shows touristic development in the region of Crete as follows:

- RED – Overdeveloped areas
- LIGHT BLUE – Developing areas
- DARK BLUE – Developed areas
- GREEN – Underdeveloped areas

Generally Tourism has brought significant economic benefits in regional level, but it has also led to visible environmental impacts, some of which threaten the island's natural ecosystems and long-term sustainability. Below are listed most relevant effects:

- Drought in eastern Crete especially in Sitia has significant environmental, agricultural, economic, and social impacts. Prolonged dryness leads to soil erosion and desertification. Municipalities impose water restrictions, affecting households and tourism-dependent businesses. Water shortages and landscape degradation may deter tourists, impacting hotels and restaurants.
- Water scarcity especially in high seasons, when the touristic volume is very high can affect other communities as consume large quantities of water, straining local supplies, especially during the dry summer months.

[5] National Spatial Plan for tourism 2004

- Coastal degradation. Construction of hotels, resorts, and beach facilities close to the shoreline disrupts natural sand movement and can accelerate erosion. Pollution generated by tourism affecting sea life and water quality
- Disturbance to Natural Parks and sensitive ecosystems. Massive tourism can affect negatively important habitats due to high traffic and noise levels

In summary impacts of tourism in local environment are minimal due to low touristic flows. In the area are located only 4 small hotels with limited ability to host massive touristic volumes.

One of the key sectors of economic development in the island is tourism. According to eurostat GDP (2021) datasets in Crete 80% belongs to tertiary sector, 10% to secondary and 10% to primary sector of economy. The following table illustrates a brief comparison of regional and local economic sectors:

TABLE 3: ECONOMIC SECTOR & RISK COMPARISON

| Sector | Region of Crete | Municipality of Sitia |
|---|---|---|
| **Agriculture** | Diverse, large-scale (olives, wine) | Limited, PDO olive oil & wine focus |
| **Tourism** | Major, well-developed | Growing, eco- & cultural focus |
| **Industry/Energy** | Small-scale, some renewables | Wind energy dominant (52% of Crete) |
| **Trade & Services** | Strong, well-connected | Smaller-scale, port-dependent |
| **Climate Risks** | Drought, erosion | Extreme drought, wildfires, erosion |

Tourism requires balanced policies to address seasonality, environmental costs, and equitable rural development. Diversification into sustainable and year-round tourism is critical for long-term resilience. Tourism dominates, especially in peak seasons, but can fluctuate also due to external factors[6]. Agriculture remains vital, with Crete being a top producer of olive oil and Mediterranean products. Trade/Retail and Construction are closely tied to tourism and EU funding (e.g., infrastructure projects). Shipping benefits from Crete's strategic location. Renewables are growing but still limited by grid connectivity issues.

Crete's economy is more diversified than Sitia, with strong tourism and agriculture. Sitia has a smaller, specialized economy (olive oil, wind energy) and faces greater climate risks. Both are investing in sustainable adaptation, but Sitia's challenges are more acute.

The touristic sector in Sitia is under development and the destination site undeveloped due to natural and archaeological protection rules.

[6] Seasonal heat waves, diseases, economic stability

# 2. METHODOLOGY

Datasets was collected from differed national and international sources according availability and scale. More specifically datasets are collected from:

- GIS Database of Greek Minister for the Environment (YPEN)
- GIS Database of Region of Crete
- Hellenic National Meteorological Service (EMY)
- CretaWeather, private meteorology service provider
- Natural Environment & Climate Change Agency – AdaptiveGreece[7] Hub
- European Environmental Agency GIS database (EEA)
- Copernicus EU

For the analysis are used public authorities data and local observations for the private sources that were available in the fields of interest.

The datasets cover the period from 1950-2023 from different sources. The majority datasets are in raster type with pixel size from 500 X 500 m to 6500 X 6500m Vector type datasets are used also for ground erosion

Different types of stakeholders are involved in the process. More specifically are involved public sector stakeholders like region of Crete and Sitia Geopark authority and private sector stakeholders like profesional in the sector of tourism from Ierapetra and Sitia.

Regional datasets are provided for without any issues, although local (destination) datasets are missing or are collected partially due to lack of detailed information about specific arguments. There are also some datasets[8] reliable only at national level. Finally dataset uniformity issues[9] are observed among different reference (spatial) levels

The methodology used to assess climate change vulnerabilities followed a qualitative (non quantitative) top down approach due to lack of specific information. The evaluation implemented: Vulnerability = Climate perturbations X Sensitivity – Adaptive capacity, with the nearest availability reasonable datasets, in order to achieve a consistent qualitative assesment.

More specifically a brief confrontation is made among destination site values and corespondent regional values in order to identify vulnerability sensitivity and adaptive capacity.

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7 https://ofypeka.dotsoft.gr/

8 Example: sea level rise

9 Measurement units

| | |
|---|---|
| Lower than the regional mean | Low |
| Near to regional mean | Moderate |
| Higher to regional mean | High |

For example the impact of the temperature rise is low because the number[10] of of days (+30C) is lower than the regional value and much lower to the national value.

| Number of Hot days (+30C) | |
|---|---|
| National level | 28 |
| Regional level | 22 |
| Destination site | 17 |

Thus vulnerability assessment was made in consideration of critical factors like temperature rise in confrontation of the regional temperature rise, precipitation values, ground moisture of destination site and regional mean values, etc.

Sensitivity is estimated based on ground erosion values in confrontation of the regional local values and considering very low flows of tourist in destination site.

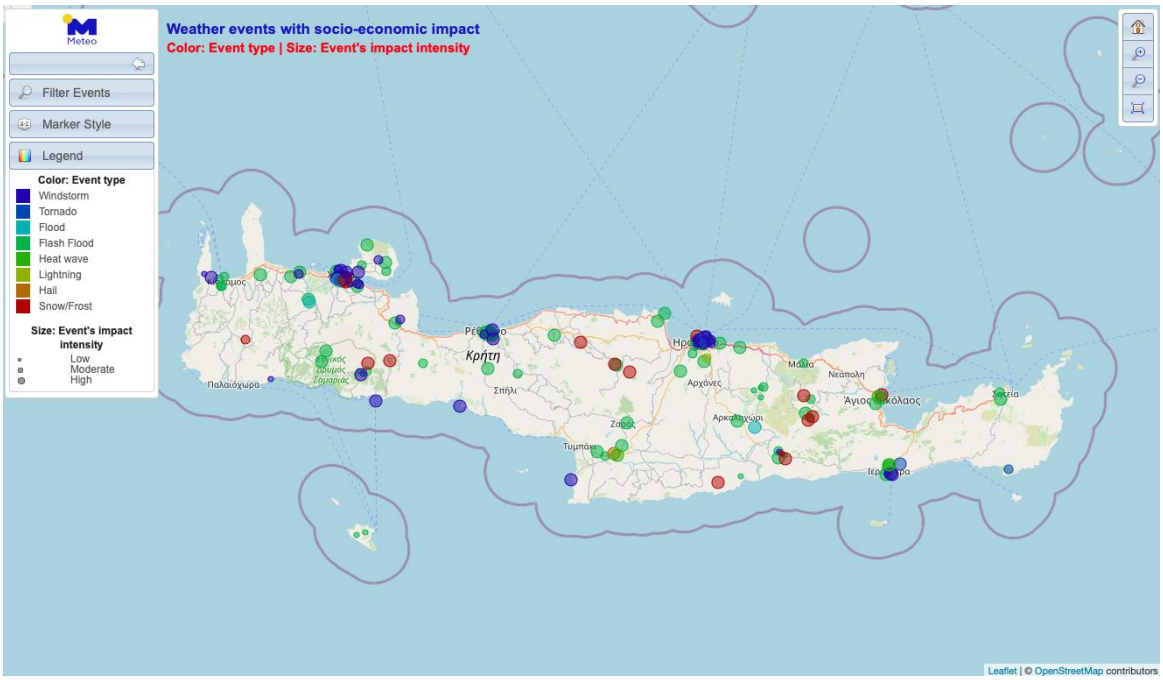
Finally adaptive capacity is estimated based on vegetation percentage on destination and region level considering very low touristic infrastructures

| | |
|---|---|
| vulnerability | Temperature, precipitation, moisture (drought ) , etc |
| Sensitivity | Soil erosion level |
| Adaptive capacity | Vegetation percentage |

[10] The mean value

# 3.ANALYSIS OF PAST EXTREME WEATHER EVENTS / OBSERVED CLIMATE CHANGE EFFECTS

According to National Observatory of Athens register of extreme weather events in the region of Crete for the period 2000-2023 there are NO extreme events registered in destination site.




### TABLE 4: EXTREME EVENTS CRETE

| | |
|---|---|
| Heat waves | 3 events |
| Wind storms | 33 events |
| Flash floods | 57 events |
| All extreme events | 109 events |

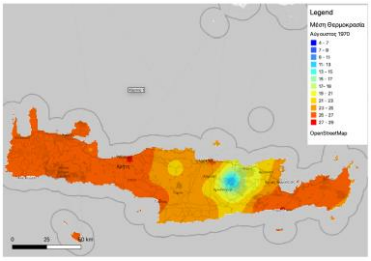
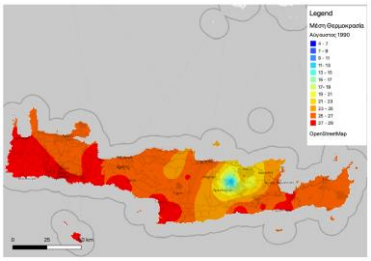
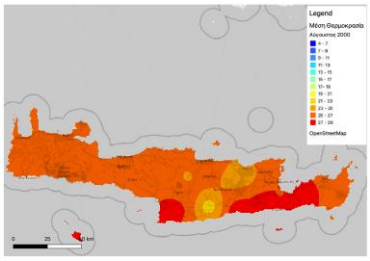
Although heat waves and wind storms extreme events have the major impacts in term of intensity. According to stakeholders major impacts in tourism represented by heat waves. Detailed informations about extreme events in Greece are available with interactive maps in : https://stratus.meteo.noa.gr/events

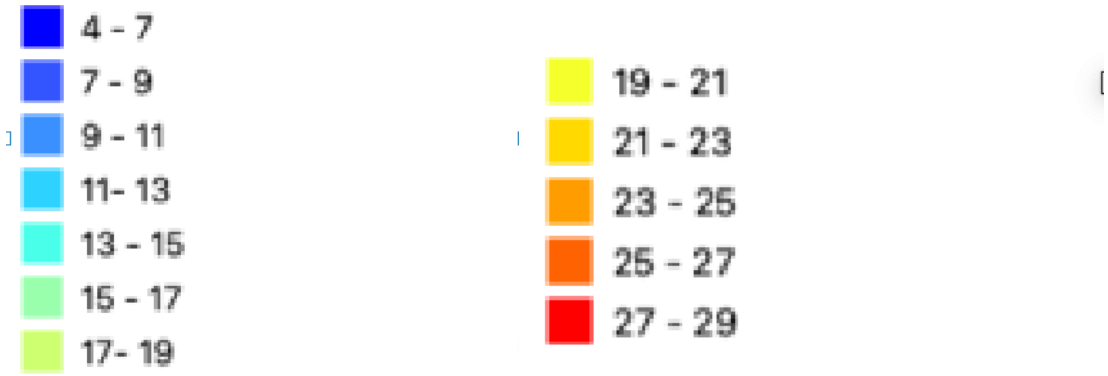
In the destination site **no extreme events** are registered according to available databases. According to unregistered local observations the most common extreme event is wind storms.

# 4. IDENTIFICATION OF MAIN COASTAL TOURISM-RELATED ISSUES WITHIN THE DESTINATION CONCERNING CLIMATE CHANGE ADAPTATION

For the Region of Crete we have increase of temperature ~1.5°C since pre-industrial times, and more intense droughts. Generally are Increased heatwaves and decreased rainfals.

As mention before major issues for the region of Crete are: increase of temperature, and more intense droughts. The mean annual temperature[11] is 16.7 considered as base.

| Mean temperature 1970 | Mean temperature 1990 | Mean temperature 2000 |
|---|---|---|
|  |  |  |




From local (Zakros) private Station measurements we have the following results:

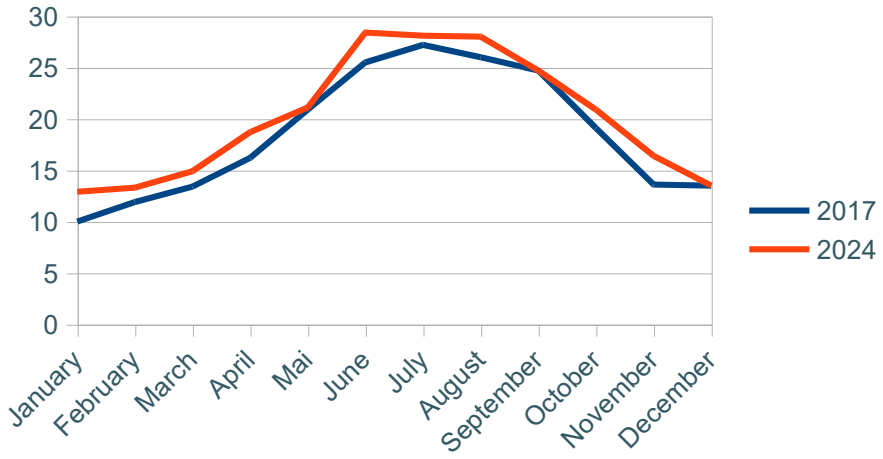
**TABLE 5: ZAKROS TEMPERATURE 2017-2024**

| Temperature Zakros (C) | 2017 average | 2024 average | 2017 max | 2024 max | 2017 min | 2024 min |
|---|---|---|---|---|---|---|
| January | 10 | 12,9 | 17 | 21,8 | 0,9 | 4,9 |

[11] Measurements from 1950-2023, although 1971-2000 is 15.3

| Temperature Zakros (C) | 2017 average | 2024 average | 2017 max | 2024 max | 2017 min | 2024 min |
|---|---|---|---|---|---|---|
| February | 11,9 | 13,3 | 19,8 | 21,2 | 6 | 6,9 |
| March | 13,4 | 14,9 | 22,8 | 27,2 | 8,3 | 9,6 |
| April | 16,2 | 18,7 | 27,5 | 29,4 | 8,6 | 13,3 |
| Mai | 20,9 | 21,1 | 37 | 36,9 | 14,6 | 12,7 |
| June | 25,5 | 28,4 | 39,1 | 40,3 | 18,1 | 18,8 |
| July | 27,2 | 28,1 | 38,8 | 36,3 | 20,8 | 21,8 |
| August | 26 | 28 | 33,1 | 37,9 | 20,6 | 21,2 |
| September | 24,7 | 24,7 | 36,8 | 33,2 | 18,1 | 19,3 |
| October | 19,1 | 20,9 | 27,8 | 33,2 | 13,3 | 15,1 |
| November | 13,6 | 16,4 | 25,6 | 26,2 | 9,9 | 9,6 |
| December | 13,5 | 13,5 | 20,8 | 21,5 | 6,4 | 5,5 |
| **average** | **18,5** | **20,1** | 28,8 | 30,4 | 12,1 | 13,2 |

FIGURE 6: AVERAGE TEMPERATURE INFOGRAPHIC

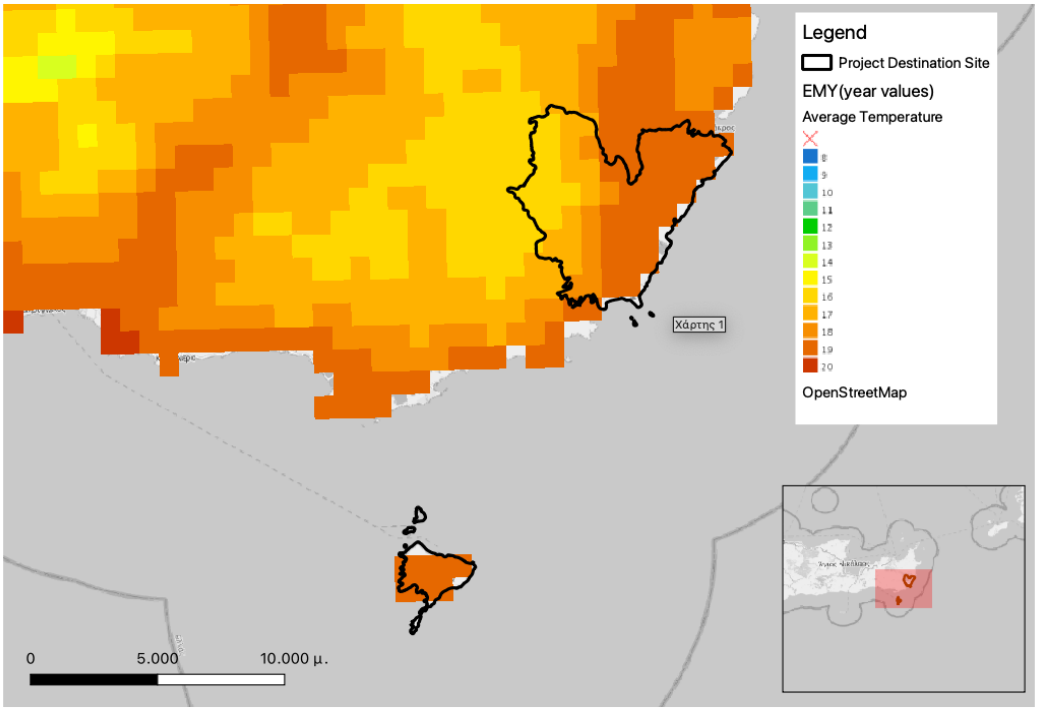



From the local (Zakros) temperature table we can figure that in Zakros the average temperature is high than the Regional 16.7 base ascending ~1.6°C

| | Average temerature | Increase (C) |
|---|---|---|
| Regional | 16.7 | ~1.5 |
| Zakros | 18.7 | ~1.6 |

In the following maps we can see national official measurements from climate atlas (1971-2000):

FIGURE 7: AVERAGE ANNUAL TEMPERATURE (EMY)




In these maps we see average and max temperatures in C

FIGURE 8: PRECIPITATION (EMY)

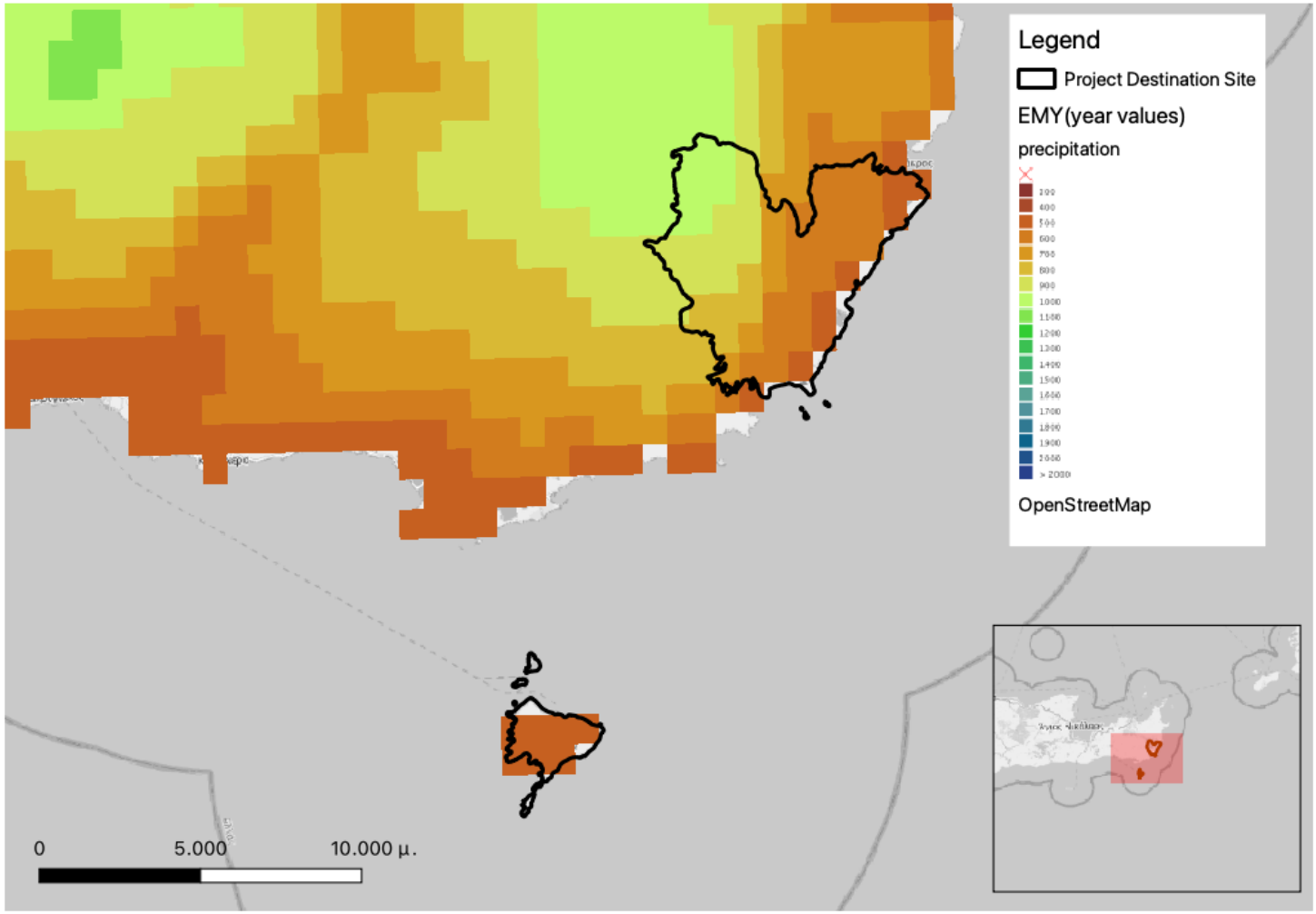
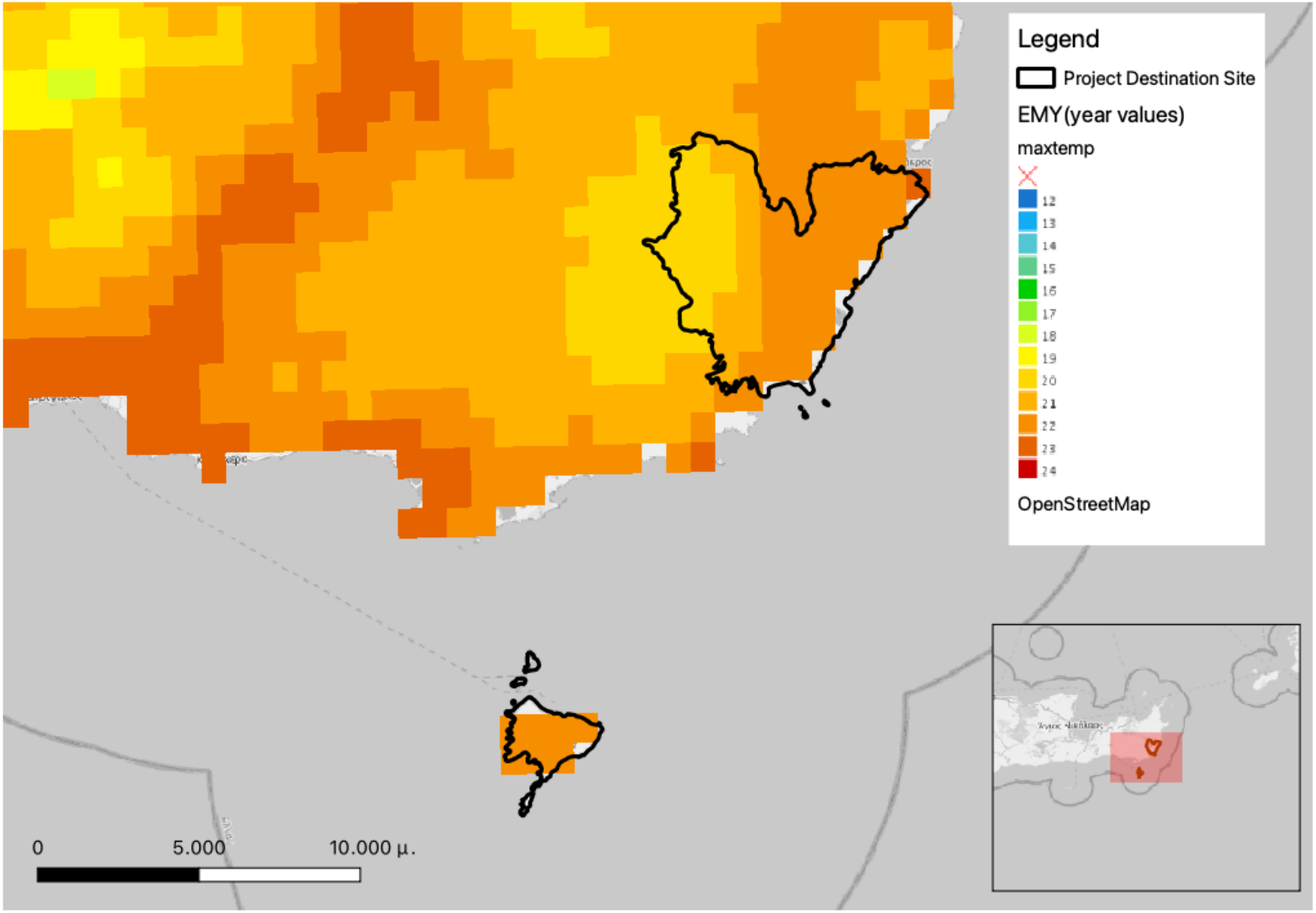
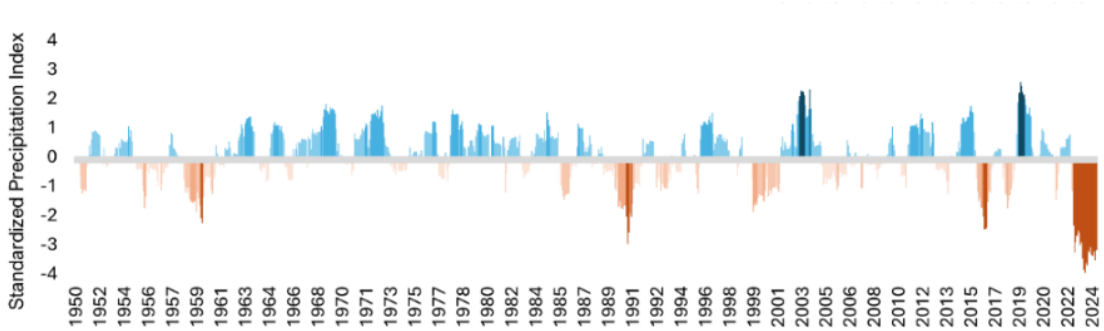


FIGURE 9: MAX ANNUAL TEMPERATURE (EMY)



Analyzing the precipitation trend[12] for the last 70 years we see rainfall deficit in 1959, 1991, 2017 and 2024. Generally precipitation differs in the years.




As mentioned before Crete from 2022 has adopted a Regional Plan of adaptation in climate change. *For the Region of Crete, based on the A1B scenario of the IPCC's 4th Assessment Report, an increase in the average annual temperature is predicted, ranging from 1.4°C for the period 2021-2050 to 3.1°C for the period 2071-2100.*

*According to the EMEKA Report (2011), a significant percentage reduction in the average annual rainfall is also predicted, which during the period 2021-2050 will approach 15%. The predicted increase in temperature and the decrease in rainfall are expected to lead to an increase in the duration of dry periods, especially in the northern Chania-Rethymno-Heraklion Region where 20 additional days of drought are expected during the period 2021-2050 and up to 40 additional days during the period 2071-2100. With the increase in temperature and the increase in dry periods, the number of fires during the summer period is expected to increase, as well as the total burned area, while on the contrary, a reduction in the interval between two consecutive fires is predicted. The forests of Crete, along with those of the southern mainland, are expected to be most affected by forest fires.* (source: Regional Plan of adaptation in climate change, 2022)

To address climate change effects in urban environments, elementary European measuring indicators are adopted to follow the mitigation process. More specifically with the Law 5037/2023 with article 177 a specific target was established in order to increase green cover in urban areas. More specifically the target is to increase trees (in urban environments) to 10% within 2050. The target is measured by Copernicus - Leaf Area Index (LAI) by ministry of environment. As mention before an action plan has been adopted at the level for the mitigation of climate change.

Until now there are not specific resilience measures in tourism sector except Tourism Spatial plan[13]. In destination site as a non developed touristic area development is not restricted. Thus large amount of photovoltaic systems are present in mainland area.

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[12] Climaax - Climate risk assessment report - Crete 2025

[13] Tourism Spatial Plan is a planning national tool in order to organize the touristic spatial development in Greece in order to mitigate overdeveloped tourism areas in the island

Absolute development restrictions area applied to Koufinissi as archaeological and environmental protection site

# 5 IDENTIFICATION OF MAIN COASTAL TOURISM-RELATED ISSUES WITH THE DESTINATION CONCERNING CLIMATE CHANGE ADAPTATION

## 5.1 EXPOSURE TO CLIMATE HAZARDS

As mentioned before zakros and koufinissi have very low volumes of touristic flows, but other threats are present especially in Zakros. More specifically, according to Specific Environmental Study Photovoltaic installations became a real threat in recent years.

Analyzing the basic climate indicators, maximum temperatures and precipitation values[14] (>1mm) from 1950 to 2000 we see an increase of hot days and decrease of raining.

| Destination | Temperature August 1950 | Temperature August 2000 | Temperature August 2017 | Temperature August 2024 | evolution |
|---|---|---|---|---|---|
| Zakros | 27.8 | 26.7 | 26 | 28 | increase |
| Koufonissi[15] | 27.9 | 26.8 | - | - | |

| Destination | Precipitation March (mm) 1950 | Precipitation March (mm) 2000 | evolution |
|---|---|---|---|
| Zakros | 83.08 | 25.12 | decrease |
| Koufonissi[16] | 81.06 | 25.69 | decrease |

The increasing temperatures with lower precipitation increasing vulnerability in the destination site. Furthermore koufonissi is more sensible due to higher soil erosion than Zakros.

## 5.2 ASSESSMENT OF CURRENT IMPACTS ON TOURISM

[14] Extreme precipitation days is near to zero

[15] Model estimation (no available station)

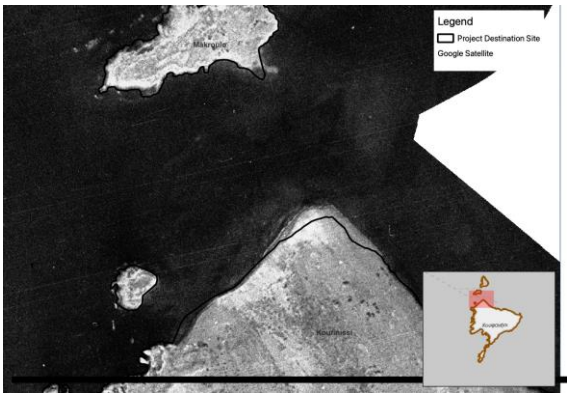
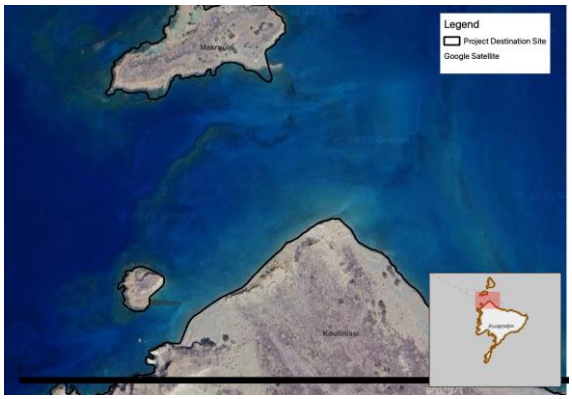
[16] Model estimation (no available station)

Zakros and Koufonissi have very low to zero touristic volumes in a region of very high touristic perturbations. In order to asses impacts on tourism we have seen weather conditions of the past 50-70 years. Obviously Zakros and Koufinissi are exposed to climate perturbations that are leading to extreme drought and followed by soil erosion. Soil erosion make up the sensitivity of the areas.

| | Climate perturbations | Touristic pressure | Sensitivity | Adaptive capacity | Vulnerability |
|---|---|---|---|---|---|
| Zakros | high | Low | moderate | Low | High |
| Koufonissi | high | Very Low | high | Very Low | Very High |
| Other islands | No data | None | No data | No Data | No Data |

Both Zakros and Koufonissi are not exposed to extreme climate effects or there are no registered data. As described previously Koufonissi is uninhabitable but is also archaeological and environmental protected site with increased erosion and desertification issues.

The following aerial fotos showing unarguably the increased coastal erosion (1940-2024):

| 1940 | 2024 |
|---|---|
|  |  |



**<u>Vegetation is a key indicator</u>** and enhancer of adaptive capacity, but its effectiveness depends on management, conservation, and integration with broader climate adaptation strategies.

1. Role in Ecosystem Resilience. Vegetation helps stabilize ecosystems by:

- Reducing soil erosion (roots hold soil together).
- Regulating water cycles (forests and wetlands absorb rainfall, reduce flooding, and recharge groundwater).

- Mitigating extreme temperatures (shade from trees lowers urban heat islands).

2. Climate Adaptation Benefits,

- Carbon sequestration (forests and plants absorb $CO_2$, reducing climate impacts).
- Buffering against disasters (mangroves protect coastlines from storms; vegetation reduces landslide risks).
- Supporting biodiversity, which enhances ecosystem stability.

3. Socioeconomic Adaptive Capacity

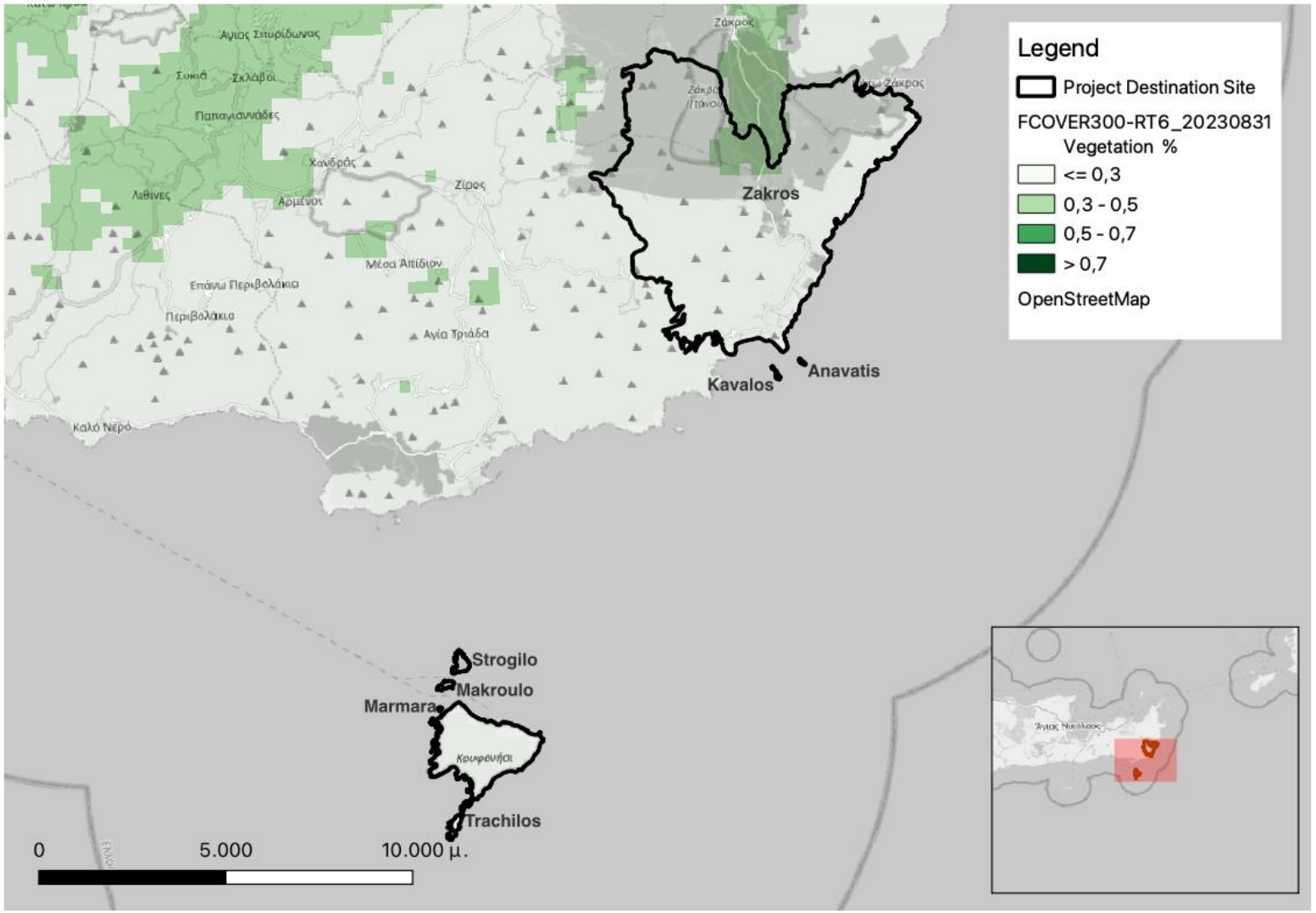
- Food security (crops, forests, and grasslands provide resources for communities).
- Livelihood support (agriculture, forestry, and ecotourism depend on healthy vegetation).
- Cultural and health benefits (green spaces improve mental health and community resilience).

Limitations:

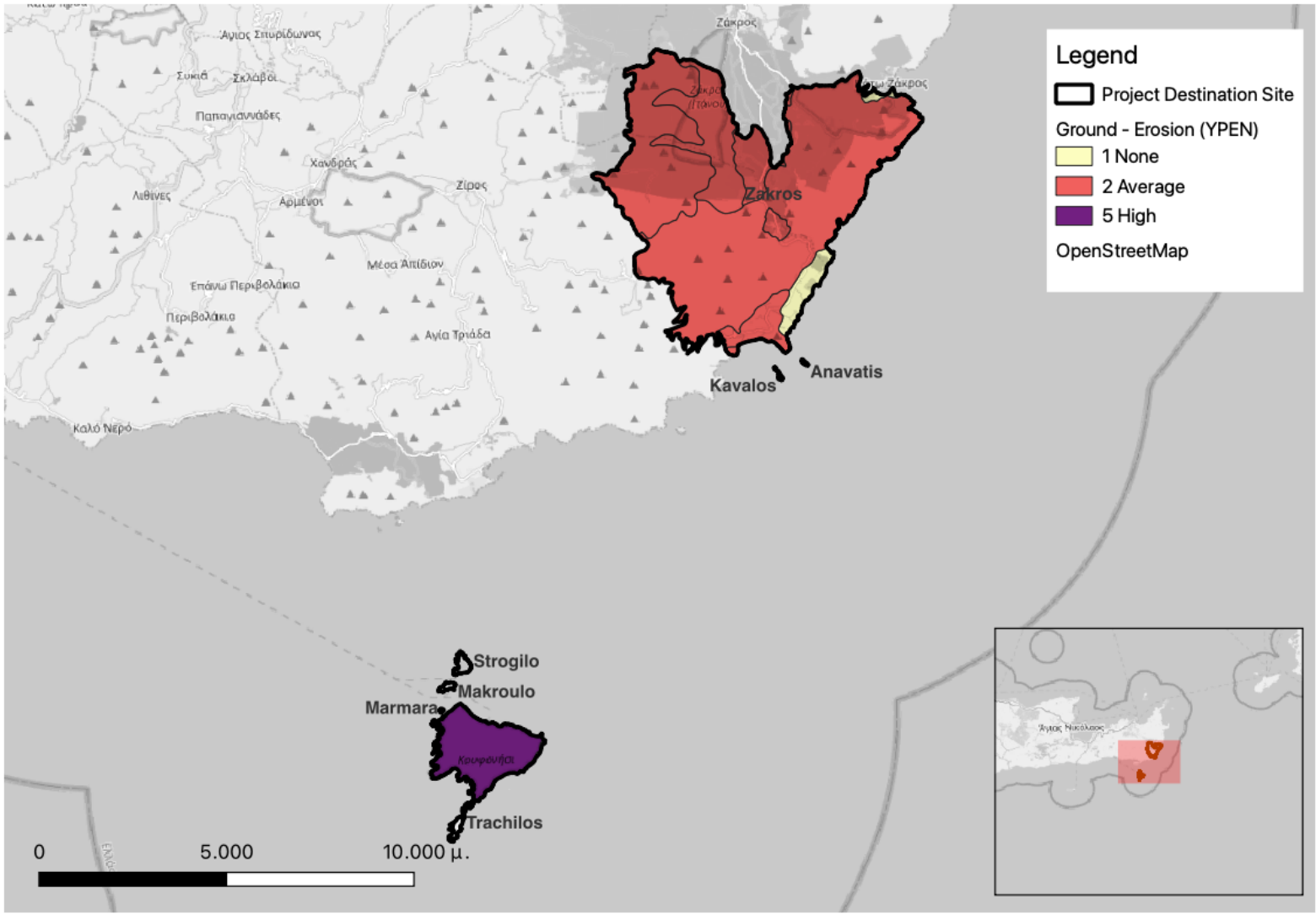
- Vegetation alone is not sufficient for adaptation—it must be combined with other measures (e.g., infrastructure, policies).
- Some areas may face challenges like droughts or deforestation that reduce vegetation's adaptive role.

Adopting vegetation as an effective **indicator of adaptive capacity** we see that only part o Zakros has 0.3-0.5 vegetation. Hence koufonissi has less adaptive capacity than Zakros

FIGURE 11: VEGETATION PERCENTAGE (ADAPTIVE CAPACITY)



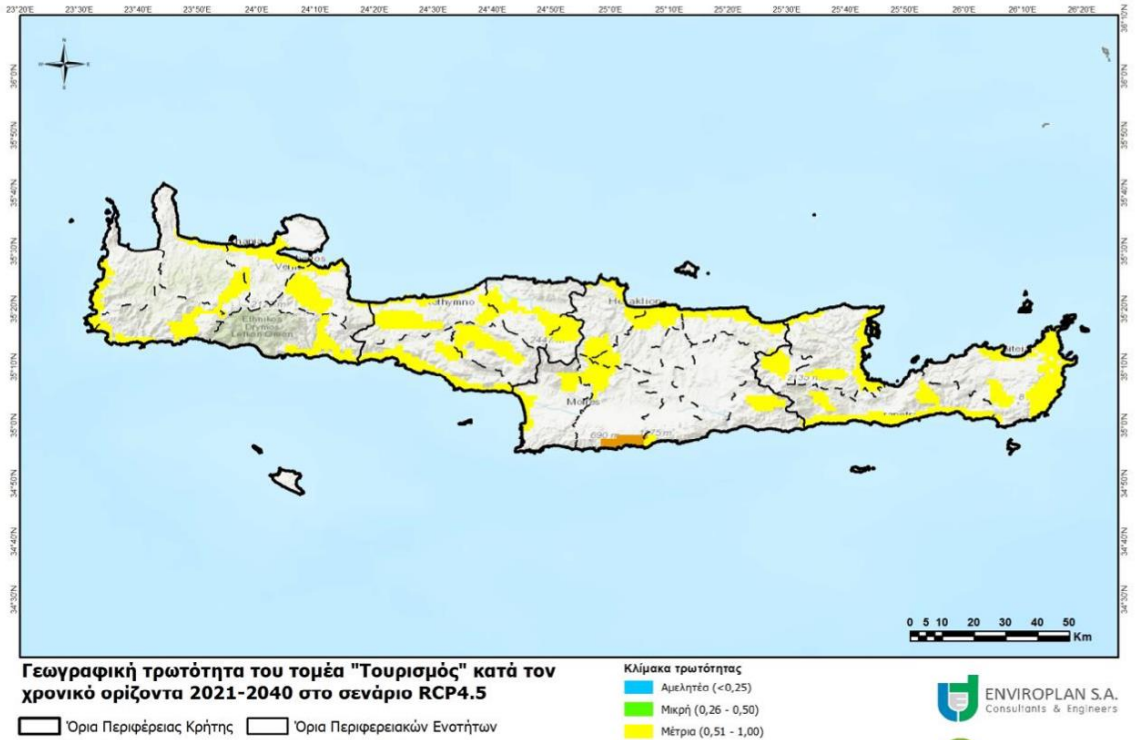
## FIGURE 12: EROSION LEVEL DESTINATION (SENSITIVITY)



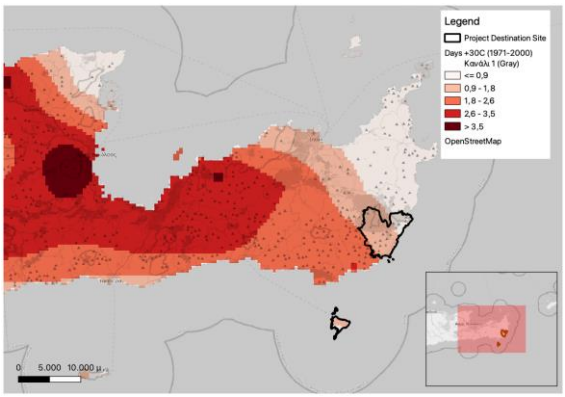
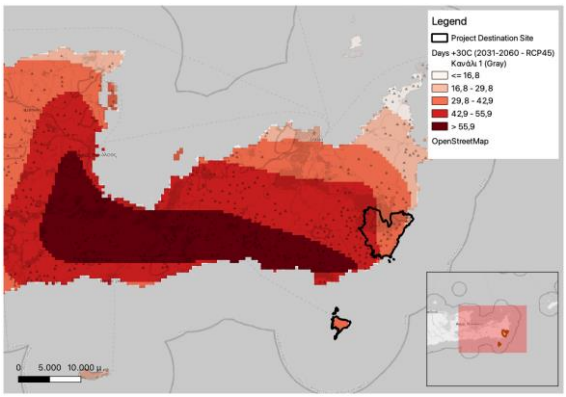
## 5.3 FUTURE PROJECTIONS AND ANTICIPATED RISKS

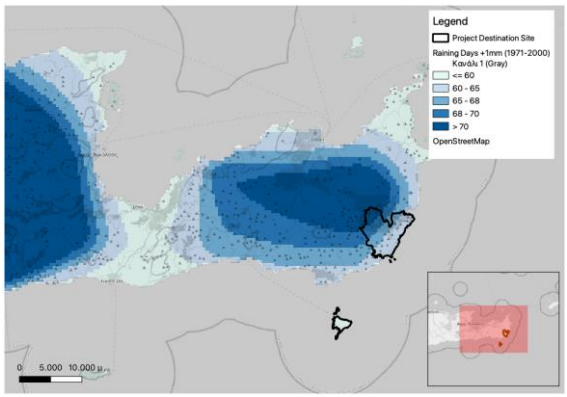
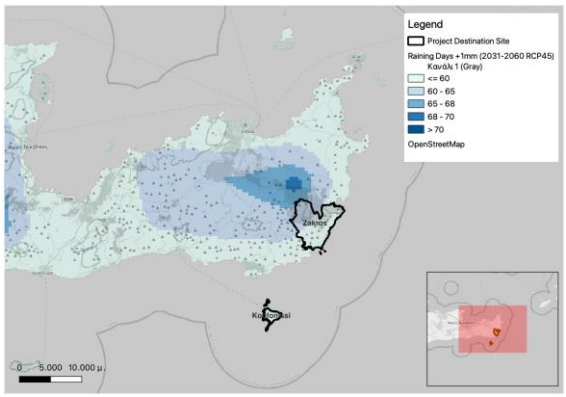
As mentioned before regional plan for the adaptation in climate change is adopted in order to mitigate climate change effects. In yellow we see high tourism vulnerability in short term.

**FIGURE 13: FUTURE VULNERABILITY SHORT TERM (2021-2040 RCP4.5)**



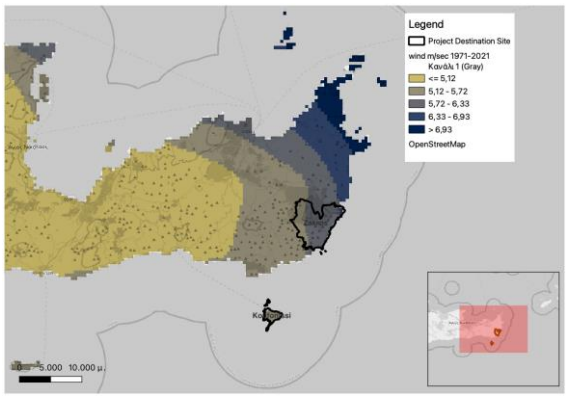
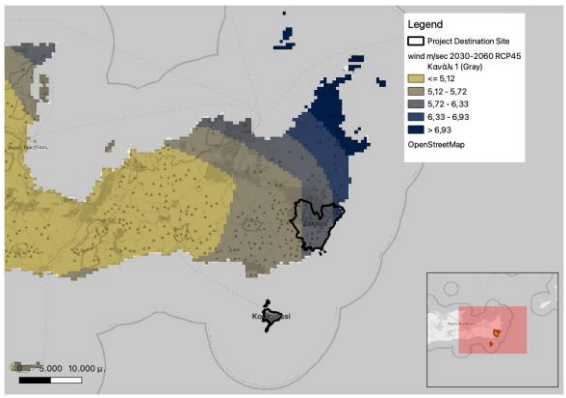

In the following maps are represented climate change components for the destination site:

| N. days with temp >30C (1971-2021) | N. days with temp >30C (2031-2060 RCP45) |
|---|---|
|  |  |

| N. Raining days (1971-2001) | N. Raining days (2031-2060 RCP45) |
|---|---|
|  |  |





| Wind m/sec (1971-2021) | Wind m/sec (2030-2060 RCP 45) |
|---|---|
|  |  |





## 6. GENERAL RECOMMENDATIONS FOR THE CLIMATE ACTION PLAN (ACT 3.4)

In this section we will try to propose adaptation and mitigation actions in order to tackle the short and long term effects of climate change effects according to the vulnerabilities indemnified previously.

## 6.1 SELECTION OF KEY CRITERIA AND INDICATORS

The following indicators are selected to monitor adaptation and mitigation actions for the region of Crete:

**Indicators:**

1. **Physical and Environmental Indicators**
   - Ind 1.1 Change in Annual Temperature
   - Ind 1.2 Number and Frequency of Hot Days
   - Ind 1.4 Extreme Precipitation Days
   - Ind 1.8 Water Availability per Inhabitant
2. **Economic Indicators**
   - Ind 2.1 Tourism Revenue Variability
3. **Sociocultural Indicators**
   - Ind 3.1 Tourist Satisfaction
   - Ind 3.2 Local Community Attitudes
4. **Governance and Policy Indicators**
   - Ind 4.3 Stakeholder Involvement
5. **Biodiversity and Ecosystem Health Indicators**
   - Ind 5.2 Habitat Loss and Degradation

The selection of these indicators is made by considering the following factors: reliability, availability and consistency.

## 6.2 ACTION PLAN RECOMMENDATION

As seen before major vulnerabilities for the destination site is drouth, land and habitat degradation. To mitigate these risks monitoring actions are necessary. Use of renewable energy policies will reduce climate effects. Community involvement will improve resilience. Adaptation measures are necessary to reduce soil erosion and improve infrastructures for extreme events. The following table summarize possible adaptation and mitigation actions:

**TABLE 6: ACTION PLAN**

| Criteria | Adaptation actions – Short term effects | Mitigation actions – Long term effects | indicator | Action specifications |
|---|---|---|---|---|
| Natural Evolution Monitoring | Observe extreme events | Create network of sensors and observation points | Ind 1.1 Change in Annual Temperature<br>Ind 1.2 Number and Frequency of Hot Days<br>Ind 1.4 Extreme Precipitation Days | Installation of meteorologic sensors in Koufinissi |
| Soft engineering solutions | Restore erosion with natural methods | | 5.2 Habitat Loss and Degradation | Plantation of native species on Zakros and Koufonissi |
| Sustainable Water Use | Implementing water conservation programs and incentives for reducing water use | | | Water wells |
| Stakeholder Collaboration | | Facilitating regular meetings and communication channels for stakeholders | Ind 4.3 Stakeholder Involvement<br>Ind 3.2 Local Community Attitudes | Train Cretan fishers to report erosion/illegal excavation |
| Removable and Flexible Infrastructures | Implementing infrastructure that can be easily adapted or relocated as needed | | | Water assortment infrastructures |

## 6.3 MONITORING AND EVALUATION USING KEY INDICATORS

For the monitoring and evaluation of the proposed indicators and from the analysis of the previews chapters :

**TABLE 7: AVAILABLE BASE INDICATORS**

| Indicator | Base (average value Zakros) |
|---|---|
| Annual Temperature | 18.7 C |
| Number of Hot Days | 0.7-1.3 |
| Precipitation Days | 50 (koyfinissi)<br>66 (Zakros) |
| Green Vegetation precentage | 0.05 % (Koufinissi)<br>0.11% (Zakros) |

The other indicators could be evaluated in qualitative scale “improved” or “deteriorated” due to lack of specific datasets.

Generally destination site presents slower climate change effects respect region of Crete. The major vulnerably was, is and will be drought that characterized eastern Crete environment for the last decade

The climate change effects in the destination site are minimal, respect to severe threats of photovoltaic invasion in sensible environments. According[17] to Perakis, Sitia Geopark coordinator :

*"Unfortunately, the Greek reality in the great chapter of the protection, promotion and management of the natural environment does not leave much room for optimism. For us, the biggest problem remains the uncontrolled placement of Photovoltaic Installations in our mountains, which not only alter the natural environment and degrade important geotopes such as the hundreds of caves, but also threaten any development prospects of this place whose greatest "dowry" is its natural environment. Of course, fortunately, a few*

[17] Source (todays local review): https://www.cretalive.gr/kriti/i-megalyteri-mas-proika-einai-fysiko-mas-periballon

*local factors are not exempt from this, who often stand against even these flimsy efforts made by the state and have reference to the management of protected areas."*

### TABLE 8: SUMMARY FOR DESTINATION

| Main Climate Change issues | Destination | Tourism assets (e.g. natural assets, infrastructures, visitor number, etc.) | Impact Low, Moderate, High; N/A | Expected change for 10-15 years Increase, Decrease, Unknown; N/A | Adaptation capacity The potential or ability to anticipate, mitigate or recover from the effects of climate change issues identified Low, Moderate, High; N/A | Vulnerability degree The degree to which a site is susceptible to harm from climate hazards, determined by its exposure, sensitivity, and adaptive capacity Low, Moderate, High; N/A |
|---|---|---|---|---|---|---|
| ***Average annual air temperature rise*** | *Zakros* | Low visitor number (4 hotels) | Low | Increase | Moderate | Moderate |
| | Koufonissi | *Important natural assets, very low visitor number* | Low | Increase | Low | High |
| ***Change in total precipitation*** | *Zakros* | Low visitor number | Low | Decrease | Moderate | High |
| | Koufonissi | *Important natural assets, very low visitor number* | Low | Decrease | Low | High |
| ***Mean sea-level rise*** | *Zakros* | Low visitor number | Low | Unknown | N/A | N/A |
| | Koufonissi | *Important natural assets, very low visitor number* | Low | Unknown | N/A | N/A |
| ***Flood hazard*** | *Zakros* | Low visitor number | N/A | N/A | N/A | N/A |

| Main Climate Change issues | Destination | Tourism assets (e.g. natural assets, infrastructures, visitor number, etc.) | Impact Low, Moderate, High; N/A | Expected change for 10-15 years Increase, Decrease, Unknown; N/A | Adaptation capacity The potential or ability to anticipate, mitigate or recover from the effects of climate change issues identified Low, Moderate, High; N/A | Vulnerability degree The degree to which a site is susceptible to harm from climate hazards, determined by its exposure, sensitivity, and adaptive capacity Low, Moderate, High; N/A |
|---|---|---|---|---|---|---|
| | Koufonissi | *Important natural assets, very low visitor number* | N/A | N/A | N/A | N/A |
| ***Coastal erosion*** | *Zakros* | Low visitor number | Low | Increase | Low | Moderate |
| | Koufonissi | *Important natural assets, very low visitor number* | High | Increase | Low | High |
| ***Fires dimension and frequency*** | *Zakros* | Low visitor number | Low | N/A | N/A | Low |
| | Koufonissi | *Important natural assets, very low visitor number* | N/A | N/A | N/A | N/A |

In conclusion destination pilot site has generally better climatic conditions as lower hot days, and lower extreme hot days, but also has lower rain. This factor make the destination site amore sensitive region. There are no impacts from tourism due to underdeveloped touristic sector. Climate change and is obviously affecting touristic development in the area. The fact that is an underdeveloped area probably caused by drought issues for the last 30 years. Future development must respect the sensitive ecosystem of the area