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CULTURAL HERITAGE IN MARATHON: THREATS AND DISASTERS

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Abstract

The municipality of Marathon presents a rich reserve of cultural heritage and natural landscapes with significant ecological, sociocultural, and historical values. Unfortunately, this legacy is not widely known. Moreover, it remains under constant pressure from environmental and anthropogenic risks, which result in ecological degradation, material deterioration, and, in many cases, partial or complete destruction. The research questions aim to examine the impact on Marathon's national and cultural heritage and the challenges that occur both from human activities and a changing Mediterranean climate. Various methods, including literature review, recorded data analysis, and site surveys of selected study areas, were used at different research stages. The results indicate a sequence of risks that may act individually or combined. The degree of impact in the study areas can differ significantly, mainly due to local characteristics such as topography, vegetation, hydrology, and materiality. This variation results in different levels of vulnerability between the selected examples. The paper concludes that significantly more efforts and major restructuring of both the management and coordination and response between all the representatives of the local society, both institutional and citizen initiatives, are needed towards the preservation of such important cultural and environmental assets.

Keywords: *Cultural Heritage; Cultural Landscapes; Climate Change; Environmental Management; Coastal Front; Mediterranean Ecosystem; Municipality of Marathon*

Introduction

Cultural heritage is a precious and irreplaceable part of our collective memory. It includes tangible and intangible aspects of any society and its culture that are considered worthy of preservation [1]. Furthermore, cultural landscapes and natural ecosystems are inseparable components of cultural heritage because they support societal development, shape individual and social identities, and contribute to the well-being of local communities. They also provide evidence of past events, form strong bonds between cultural and natural aspects, and enhance cultural variability.

The cultural reserve is threatened by incidents of environmental or anthropogenic causes, where the boundaries between them are often unclear. Human activities either pose a direct risk to natural ecosystems, cultural landscapes, and cultural reserves or contribute to the manifestation of environmental risks. In addition, climate change has become a substantial environmental threat that evolves with tense characteristics, leading to extreme weather conditions and changes to the environmental dynamics [2, 3]. The emerging research questions focus at a large scale on the degree of interaction between risks and their succession process but also investigate, at a smaller

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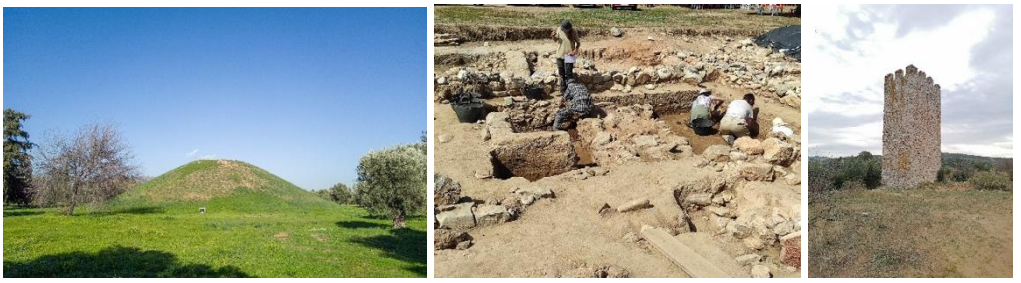
scale, the effect of local characteristics on the way that risks affect cultural assets and manifest their vulnerability.

Focusing on the Greek context, these questions are addressed in the historic area of Marathon, on the eastern coast of Attica, Greece. The region presents a rare combination of rich history and traditions with tangible cultural legacy and diverse natural features with significant ecological value. In many cases, especially in Greece, cultural heritage sites are inextricably connected to their sites and the natural environment, together forming the distinct landscape, the genius loci of the place. Therefore, these cultural assets are largely determined by the qualities of their surrounding landscapes. Specifically, a variety of tangible cultural heritage dating back to prehistoric times spreads throughout the Municipality of Marathon and becomes part of the rich and diverse natural landscape. Examples of natural heritage sites can be witnessed in Schinias and Brexiza with the marshy ecosystem and the rare forest of stone pine (Pinus pinea) along the Schinias coast. The tumulus of Marathon is another cultural landscape dating back to the battle of Marathon. Samples of an ancient agricultural landscape can be witnessed across Marathon, with old olive trees around Oinoi testifying to human presence and growth. Examples of cultural heritage sites are the Mycenaean vaulted tomb (15^{th}-14^{th} century BC) in Arnos, a burial site of a prominent man containing within its chamber two pit tombs and a 25m long road. Also, in the area of Chepi, a cemetery of the Early Helladic period (3000-2300 BC) and numerous rectangular and circular tombs in rows have been excavated. Findings in the cemetery also include marble figurines and pottery, which reveal close links with the Cyclades. At the site of Vranas, a cemetery of the Middle Helladic period (2000-1300 BC) is located, consisting of seven burial mounds. The Roman sanctuary of the Egyptian gods in Brexiza with the adjacent bathing facilities is one example of the several sites created by Herod the Atticus in Marathon. Archaeological research in Plasi reveals the human presence in the area with a settlement and burial grounds dating back to 3000 BC (Fig. 1).

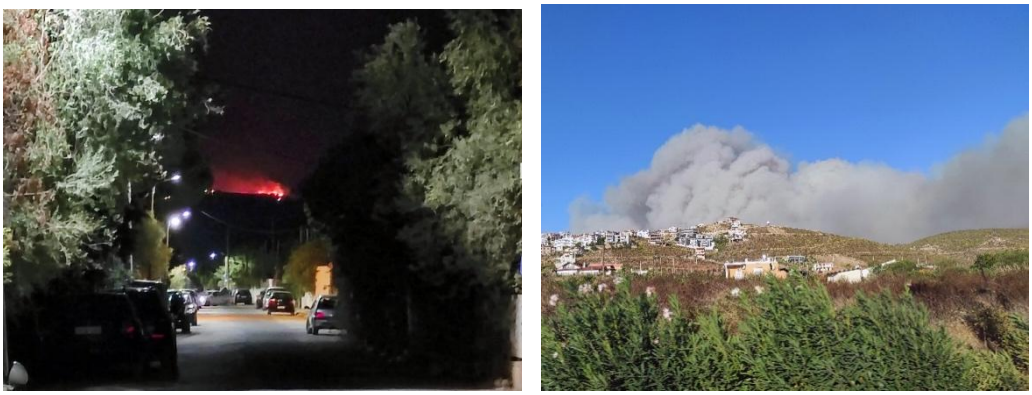


(a) (b) (c)

Fig. 1. (a) View of the historic Tumulus of the Athenians at Marathon, a burial ground of the Athenians and Plataeans who fell during the battle of Marathon. It forms a natural landscape with strong cultural character, as it is also the starting point of the modern Marathon run (January 19, 2024) [5].
(b) View of the archaeological excavation in Plasi Marathon in progress. (May 2024) [6].
(c) The medieval tower of Oinoi built in 1250 A.D. to protect the surrounding area. (November 2023) [7].

The material structural properties and construction methods of these monuments may vary, affecting their vulnerability to anthropogenic dangers and environmental risks. In many cases, several monuments and sites of natural beauty are largely unknown, remain neglected, and lack protection. Many of the causes of invisibility and exclusion from the life of the region can be traced to the dysfunctions of state and local administrations, the intensive residential development in the absence of planning policies since the late 1970s, the absence of disaster risk management frameworks for the area of Marathon [4], and other chronic management issues of the municipality. These practices alter the cultural and natural character of the area, disgracing its cultural qualities. At the same time, environmental risks associated with climate change affect the broader region of eastern Attica, manifested mainly by extreme weather events, wildfires, heatwaves, desertification, heavy rainfalls, and floods, as well as land and coastal corrosion.

The most recent and one of the most disastrous fire outbreaks in all of Eastern Attica and the Municipality of Marathon started on 11 August 2024 in Varnavas, Attica, during the final writing stages of this paper. The fire spread rapidly, affecting much of eastern Attica, including the areas of Marathon, Marathon Lake, Grammatiko, Varnavas, Oinoi, and Nea Makri (Fig. 2). It continued southwest, reaching suburban areas of Athens, such as Dionysos, Penteli, and Halandri. The fire caused irreparable damage to buildings, residences, and agricultural establishments but also severe ecological destruction to the precious suburban natural environment of Attica. The fire spread widely as strong winds (6-8 Beaufort) and very high temperatures prevailed in the area. It is worth noting that Greece has just experienced its hottest June and July on record, with long heat waves and temperatures reaching 42 degrees Celsius. These hot and dry conditions combined with the high August winds were favorable for the outbreak of fires. Furthermore, the lack of any serious precautionary measures and of a clear fire management plan from the city council of Marathonas, combined with chronic administration issues, has contributed to the lack of effective prevention policies for environmental disasters. Climate change on cultural and natural heritage can have a serious impact on large areas. However, the results depend to an extent on local characteristics such as the microclimate, local topography, vegetation species, and the hydrology, combined with the anthropogenic threats that apply on-site and the physical and structural characteristics of cultural heritage.



(a) (b)

Fig. 2. (a) View of the August 11th, 2024, fire approaching the outskirts of the city of Nea Makri the same night [6] (b) View of the August 11th, 2024, fire threatening a residential area in the city of Nea Makri the next morning [6]

This study aims to investigate the interactions and succession process of the environmental and anthropogenic risks that threaten the Municipality of Marathon's cultural and natural reserve. It also highlights the necessity of special urban plans that tackle the dangers and threats of cultural sites [4]. Plans that incorporate fully analyzed and evaluated cultural heritage sites can be used as tools to achieve more sustainable planning, design, and management approaches. Understanding the current challenges is essential for pursuing viable solutions so that the cultural reserve can be preserved and passed on to future generations.

Materials and Methods

A comparative analysis was performed from a selection of literature-reviewed sources, databases, and site surveys. The evaluation of the information was implemented based on (a) the reliability of the source, focusing mostly on academic and peer-reviewed publications; (b) the relativity with the area of Marathon or its specific Mediterranean characteristics; (c) the date of selected material, choosing a time period that included the last 50 years; and (d) the comparability of the material. The study of the vulnerability of cultural heritage sites within the researched area

demanded, at an early stage, the categorization of the threats and dangers to cultural and natural heritage as anthropogenic and environmental. Although the boundaries between them are not strict, existing correlations were recognized and considered.

The literature review included the selection and review of the following sources:

- Academic research studies of universities, scientific papers, and institutions with related publications that refer to sites in the Municipality of Marathon and the wider area of Attica, Greece.
- Published books that develop subjects related to this study's research interests or refer to the study areas.
- Publications in newspapers, periodicals, and the electronic press about historical flood events, wildfires, and other natural or anthropogenic disasters that were cross-referenced. The relevant information included qualitative data and was primarily used during the comparative analysis.

Statistical analysis was conducted to process primary recording data, aiming to understand and identify the extent of natural and anthropogenic hazards and to conclude results cross-referenced with the literature review through a comparative analysis. Primary recording data were collected from open electronic databases of public bodies that documented wildfire and flood incidents and were categorized as follows:

- Electronic records of flood incidents from the municipality's fire department, with data collected over a twelve-year period (2000 to 2011). The records included the event date, the city, the specific location, a description of the affected area (e.g., industrial, residential, agricultural), and the possible cause of the flood (e.g., rainwater, stream overflow, burned areas). This information is highly geographically discrete and used only for cross-referencing with data from other relevant sources.
- Electronic records of the most critical fire incidents in eastern Attica from 1983 to 2021, with data collected from the Institute of Mediterranean Forest Ecosystems and the Hellenic Fire Department.
- Electronic records of the wildfires that hit archaeological sites in Greece from 2000 to 2021, with data from the Hellenic Fire Department.

Finally, a field survey was carried out for selected areas within the Municipality of Marathon. The sites where the field study was performed were the archaeological area of Brexiza in the city of Nea Makri, the national park of Schinias, the archaeological site of Ramnoundas in Grammatiko, and the archaeological site of Oinoi, west of the city of Marathon. The selection of the specific areas complied with criteria such as the importance of the natural and tangible cultural heritage and their different local characteristics regarding topography, altitude, vegetation types, ecosystems, proximity to the urban environment, hydrology, and materiality. The collected data helped to estimate the role of the microclimate and local topographic characteristics in the degree of vulnerability of the cultural reserve to different risks. Furthermore, it remained a valuable source of information to compare with the previously conducted analysis.

Results

Below, a taxonomy of threats is attempted.

Environmental Threats

The impact of the environment on tangible cultural heritage is not a recent finding. Nevertheless, nowadays, it returns in a compelling way with different attributes. It frequently occurs as a set of natural events that arise from environmental processes instigated by climate change and intensive, invasive, and essentially harmful human activities [8].

Fire Events

Bushfires are considered a major threat to the Mediterranean ecosystems [9] and remain a natural hazard for sites with tangible cultural heritage and natural value [10]. Bushfires have always been a part of life in the Mediterranean and especially in Greece. They may be ignited and controlled by humans to create pastures or, in the past decades, as a result of negligence, arson, accident, or spontaneous combustion due to high temperatures. In all cases the result is the same. During the dry season, which starts in May and ends in October, with increasingly higher temperatures, heat waves, and dryness, especially in July and August, combined with strong prevailing winds, once they occur, they may very easily get out of control. The area of Attica has suffered severe wildfires in the past [11, 12]. Primary recording data of fire incidents between 1983 and 2021 were collected and analyzed for understanding the dynamics of wildfires in Greece and their impact on cultural heritage. From the preceding statistical analysis, the following results emerge. The majority of fire incidents occur mostly during the summer, with more numerous and more severe incidents recorded in July and August. These results apply to areas of Central Greece [11], but they are also observed throughout the Greek territory [12]. The increased recording of incidents during the summer months is related to several factors that enhance the possibility of fire incidents in the summer and deal with climatic characteristics and vegetation types. The most important features are the prevailing dry-thermal climatic conditions, the reduction of air humidity, the steepness of the topography, the strong summer winds, the dry native Mediterranean vegetation, and the presence of flammable vegetation (species of the genus Pinus) [9, 11]. Furthermore, the most vulnerable vegetation type that enhances the initiation and spread of wildfires is the forest. Woodland is recorded to be the most damaged ecosystem by wildfires compared to other vegetation types between 1983 and 2021 in Greece.

During the period 2000-2021, there was a significant increase in the number of burnt areas on archaeological sites across the country. The highest number was recorded between 2016 and 2020 (1255.12 acres burnt), constituting 70.3% of the total burnt area within the 20-year study period. An increase in fire incidents was also observed during that time. The forest ecosystem is recorded as the most vulnerable vegetation type [11, 12] for the occurrence and spread of fires in archaeological sites, with 73% of the burnt areas being classified as woodland, followed by grassland at 13%. A large part of the vegetation cover of archaeological sites in Greece consists of grasslands with annual-perennial grasses and leathery broad-leaved evergreen shrubby vegetation of maccia. These vegetation species adapt to water scarcity conditions in the summer, with a large portion of aboveground vegetation drying out [9]. Dry vegetation cover is typical of the Mediterranean ecosystem during the summer and becomes an ideal fire material, exposing mismanaged archaeological sites to fire incidents.

Furthermore, the specific microclimatic conditions and topographic characteristics play a vital role in the initiation and spread of wildfires. Among the study sites, the most significant fire damage during the period 2000-2021 was recorded in the area of Grammatiko compared to the other study areas. This is probably due to the high percentage of woodland cover in the wider area, combined with the hilly, semi-mountainous topography and the absence of water, especially during the summer months. In contrast, fire damage and fire incidents were significantly lower in areas with water (marshy ecosystems of Brexiza and Schinias, Oinoi stream). Therefore, the presence of water appears to be an inhibiting factor in the spread of fires because it constitutes a natural barrier to fire. It also improves the area's microclimate by reducing air temperature and increasing the relative humidity of the atmosphere [13].

At the same time, land management remains another inhibiting factor in the occurrence and spread of fire [11]. The region of Oinoi is characterized by semi-mountainous topography with gentle to steeper slopes. Despite the significant coverage of the area with perennials and some spotted forest cover, only two fire incidents were recorded between 2000 and 2021 because of successful management. A significant portion of the landscape is covered by agricultural land, which is appropriately managed by removing dry and flammable plant debris. Furthermore, in

the same area, the presence of water from the neighboring streams enriches the water table and improves the microclimate, hindering the spread of fire to a certain extent, especially in the summer months.

On the other hand, although fewer fire incidents have been recorded during the last 20 years on sites like Oinoi, Schinias, and Brexiza with significant presence of water than in woodlands like Grammatiko, fire incidents are a potentially irreparable threat for all study sites for the following reasons. First, wildfire poses a risk to the surrounding areas and not exclusively to the area where the incident started and was recorded due to its ability to spread with weather conditions. This was proven with the most recent disastrous fires of August 11, 2024. Examples of severe wildfires have been recorded, such as on 21 August 2009 in Sesi Grammatiko, where only one incident was enough to destroy 175,000 acres of woodland that had not been burnt in 10 years (Table 1). At the same time, several incidents of catastrophic fires in urban areas have been recorded, the most tragic being the fire in Mati on 23 July 2018 with a toll of 104 human lives, while according to statistics, the rate of fire disasters in urban areas remains low and equal to 0.8% [12].

Table 1. The most destructive fires that affected areas of East Attica in the period 1981-2024 [14-17]

Date	Affected Areas	Total Burned Area (acres) (approx.)	Comments
1981	Penteli-Kokkinaras Kifisias	6.000	
1982	Dionysos – Penteli – Pikermi – Gerakas – Marathonas	25.000	
8-1985	Pikermi – Pallini – Drafi – Anthousa – Pendeli – Neos Voutzas – Oropos	200.000	One of the most devastating fires in Attica
1986	Penteli	40.000	
1992	Avlonas – Malakasa – Kiourka – Marathonas – Kapandriti – Grammatiko – Kalamos – Oropos	170.000	
1993	Agios Stefanos – Sounio – Marathonas – Stamata – Dionysos – Mandra – Pallini – Pendeli – Drafi	11.000	
1998	Neos Voutzas – Anthousa – Penteli	130.000	
8-2000	Penteli	6.000	
2005	Rafina – Kallitechnoupoli – Neos Voutzas	10.000	
2007	Parnitha – Penteli	10.000	
8-2009	Marathonas – Grammatiko – Pikermi – Pallini	210.000	One of the most devastating fires in Greece
8-2017	Kalamos – Sesi – Agioi Apostoloi – Grammatiko – Varnavas	3.300	
7-2018	Penteli – Mati – Neos Voutzas – Rafina	150,000	The deadliest fire in Greece, with 100 dead
8-2019	Marathonas	6,000	
9-2021	Marathonas – Nea Makri	10,000	
8-2024	Varnavas – Grammatiko – Marathonas – Lake Marathona – Oinoi – Nea Makri – Dionysos – Pendeli – Chalandri	150.000 -200.000	Burned area estimated from fire maps

Evidence of the fire of August 2024 also indicates severe damage within the study areas. The fire burned a large part of the archaeological site of Oinoi (Fig. 3) and posed a serious threat without damaging the archaeological site of Ramnountas in the fire-affected area of Grammatiko. The data relating to the fire could not be included in the preceding statistical analysis of this study, as the damage recording process is still in progress at the time of the writing. However, it is certain that much of the natural resources of the municipality of Marathon have been seriously affected, with the tangible cultural heritage being at risk from the fire effects for several years. Nevertheless, it is essential to make an initial reference to an event that highlights the issues raised in this study.

Another threat to ecosystems [19] and tangible cultural heritage is the layer of soot deposited after the fire outbreak and spread by the wind. The soot deposits create a cover of ash on surfaces. Therefore, materials with porous surfaces are especially susceptible to ash infiltration, which can penetrate deep layers. Any negligence in maintenance can create an additional threat as soot becomes more difficult to remove over the years. In addition, soot due to air transport can cause surface damage to cultural assets located several kilometers outside the fire zone [20]. Finally, soot contains potentially toxic elements for humans and ecosystems [21]. Nevertheless, further research is necessary in the municipality of Marathon and the wider Attica region to determine the effects of toxic elements from fire debris on tangible cultural heritage and natural systems, constituting an important cultural asset [22].

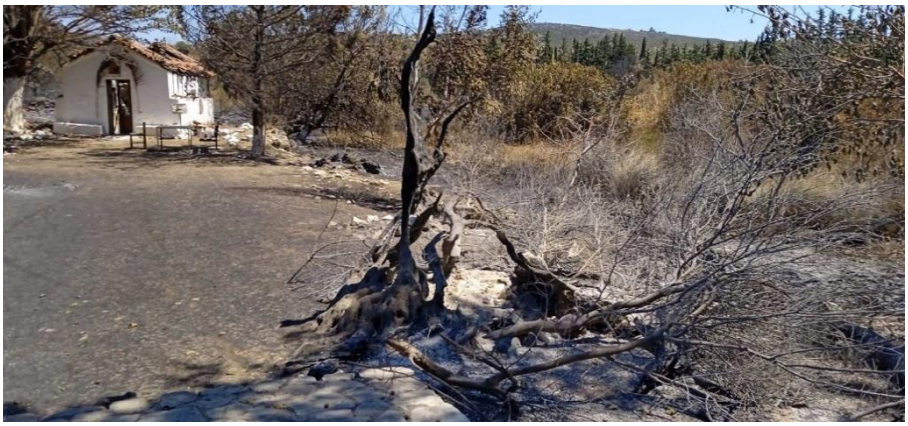


Fig. 3. The results of the August 11th, 2024, fire in Oinoi. The fire entered the archaeological site of Oinoi, burned the post-Byzantine temple of Agioi Apostoloi, and destroyed a large area of vegetation cover, including old olive trees that were part of the historic agricultural landscape of the area [18]

In conclusion, archaeological sites in Greece are usually located within natural landscapes, which are combined with worsening weather conditions such as strong winds, extreme dryness, and heat waves that make them highly vulnerable to fire. All study areas are situated in the broader region of eastern Attica, which is characterized as a high-risk area for fire outbreaks and spread during the summer period. Climate change also favors the creation, spread, and intensification of fire events. For these reasons, fire should be treated as a potential risk for all study areas.

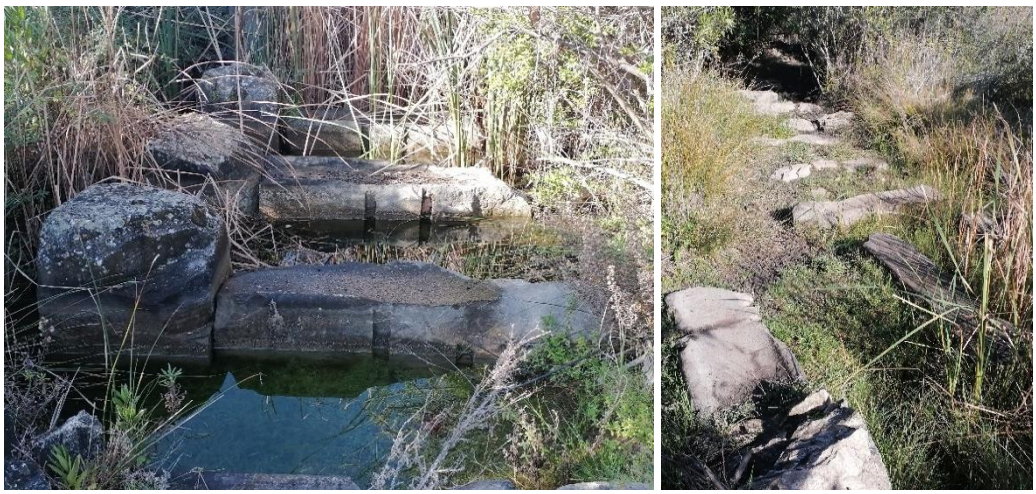
Flood Events

The negative impacts of flooding phenomena extend beyond cities to include agricultural land, settlements, and cultural heritage sites [23, 24]. The possibility of flooding can have a significant impact on both tangible and intangible cultural heritage, as well as protected natural ecosystems [25, 26]. Flood events can disrupt the balance of these areas to the point of changing their characteristics. In more severe cases, these areas can slowly deteriorate and ultimately collapse [2].

Climate change in Greece is manifested by intense rainfall phenomena that often lead to flooding. In recent years, there has been a significant increase in flood events. The causes of the destructive consequences of flooding appear to be due to changes in the rainfall system, the intensity of the phenomena, and human activity [2]. A study by the Special Secretariat for Water includes an assessment of the deteriorating conditions due to climate change and identifies vulnerable areas in Attica with assessed flood risks. The results delineate nine potentially high flood risk zones. These include the low-lying zone of the Marathon artificial lake basin, the area of Mesogeia, and the coastal lowland areas of Marathon and Nea Makri [24]. In 2010, Diakakis [27] published a study on the hydrology of the wider Marathon area and the assessment of flood risk. The research relied on historical records of flood events as a dependable source for estimating the course of the event. Additionally, studying the historical behavior of streams and

rivers is crucial to understanding the evolution of hydrology and assessing extreme flood events. Water has a memory and leaves traces that greatly influence the future behavior of streams and rivers. The study of the hydrology of dry or wet streams in Greece is crucial because many flood events are caused by chronic and accumulated problems, degradation, and mismanagement. Therefore, analyzing historical flood events, especially those with extreme characteristics, is a realistic and reliable approach to this issue.

The municipality of Marathon comprises three watersheds – Rapentosa, Haradros, and Kato Souli or Myrtia – with a long history of flooding. The region's geomorphology is characterized by hilly terrain with varying degrees of slopes that culminate in the famous Marathon plain to the east. This plain is known for the historical battle of Marathon and has a network of streams that eventually flow into the sea. Historical records demonstrate that the Rapentosa basin caused the most severe flood events in the past compared to the two other catchments. The areas of Patitiria, Chepi, Timvos, and Agios Georgios are mainly damaged by recorded flood events and remain at a higher risk for future flooding [27]. In these areas, human activities that occur within the course of the streams obstruct local hydrological processes and increase the likelihood of flooding. Furthermore, extensive residential development along the coast and around marshy ecosystems degrades natural drainage processes [22].



(a) (b)

Fig. 4. (a), (b) Views of the flooded archaeological site of Oinoi in November 2023. The plain topography of the site acts as a water collector for local streams. A large portion of water may come from an ancient unidentified underground water source. Maintenance issues are also obvious, threatening the monument [7]

From the above, it can be concluded that the marsh ecosystems in Schinias and Brexiza are prone to flooding since they act as water collectors and drainage basins of the local streams and rivers at the eastern lowlands. Additionally, the plain area surrounded by hills and mountains, where the city of Marathonas and archaeological sites in Oinoi are located, can act as a water collector of the Charadros River and the local streams, increasing the likelihood of flooding, especially in extreme rainfall events. (Fig. 4) The historical records confirm that the modern city of Marathonas has experienced flood events in the past [27]. On the other hand, the hilly topography of the Ramnoundas archaeological site indicates a low flooding risk [28]. The impacts of floods on the natural and cultural landscapes, flora, and fauna can be significant and depend on the severity of the event and the mechanisms for assimilating the risk and restoring ecosystem functions. Aquatic ecosystems are generally more resilient to flooding events than dryland. However, water salinity poses a serious risk. In the event of a flood from the sea, the freshwater of terrestrial ecosystems can mix with saltwater from the sea, causing dynamic changes in flora

and fauna. These changes can significantly alter ecosystem characteristics and functions, favoring salinity-tolerant species. The coastal zone of the Municipality of Marathon that includes cultural and natural sites like Schinias, Paralia, Brexiza, and Nea Makri is likely to face such a threat.

Regarding the preservation of cultural heritage, flood events can potentially cause damage to the structure due to the force of water and lead to its collapse. The saturation of the soil with water, combined with the force of the water, can also cause the foundation of the structure to fail. The resistance of materials to water exposure depends on their nature. Organic materials are the most vulnerable, while inorganic materials, such as stone, can suffer from prolonged contact with water, resulting in dirt, stains, salt crystallization, and mortar loss. Additionally, due to salt exposure, clay and ceramic elements can develop a salt patina, discoloration, stains, and cracks [20]. Sites with rich, tangible cultural reserves that are in direct contact with water, like the archeological site of Oinoi, the findings along the Kinosoura peninsula, and the coastal site of Brexiza, where a large portion remains underwater, are more likely to experience structural issues and material degradation [29].

It is crucial to take steps towards addressing the flooding problem. The reduction of human intervention in areas with natural hydrological processes is essential. This would involve gradually phasing out intense human activities from the active floodplain and replacing them with more compatible and moderate activities that do not negatively impact the hydrological processes. Currently, relying solely on developing flood defenses is proving to be insufficient, as demonstrated by the November 2005 Marathon flood [27]. It is essential to consider that natural and human-made factors can gradually alter flood occurrences, the hydrological process, and the natural dynamics in a short period of time. Therefore, any findings obtained from research should be re-evaluated whenever new information becomes available.

Sea Level Rise - Coastal Erosion

Sea level rise is a natural process already evolving in the region south of Evia and the coast of Marathon. This phenomenon is also responsible for other effects, such as coastal erosion and sea flooding events [26]. The problem is being intensified due to climate change and the high level of human activity in the region.

No studies have been conducted on the northern Evian Gulf area, where Marathon's coast is situated, in relation to coastal erosion and sea level rise. Nevertheless, several European and Greek projects cover the broader region of the central and southern Aegean, providing information on climate change and sea level rise concerns. The ESPON CLIMATE 2013 project [30], which focuses on climate change and its impact on regions and local economies in Europe, estimates the vulnerability of coastal areas. The maps of Greece, specifically the Attica prefecture, show negative impacts of moderate intensity due to factors like erosion and Average Sea Level Rise. Specifically, negative results are obtained when assessing the overall impact of climate change using indicators of physical, social, economic, environmental, and cultural sensitivity, with the Attica prefecture being in the worst position [31]. The Fourth Assessment Report of the Intergovernmental Panel on Climate Change [32] estimates that the sea level could rise between 0.2 and 0.59m by 2099. However, some experts predict the rise could be as high as 2m. The central and southern Aegean areas are expected to experience a higher rise in sea level than the northern Aegean. Nevertheless, the Aegean coastline is likely to be significantly affected by the rise in sea level, leading to an increase in coastal erosion phenomena and marine flooding events in the future. In 2014, the Special Secretariat for Water [23] created maps for the Greek territory to assess the risks of marine flooding and a potential increase in sea level. The assessment was based on modeling and considered various factors, such as astronomical and meteorological flood forecasts and estimates of the Average Sea Level Rise due to wave action. The maps provide important information about the coastal areas of Nea Makri and Marathon.

It is clear that the height of waves at the coast and at sea depends on the direction of the wind. The coastal area of Marathon and the South Evian Gulf are particularly vulnerable to southern and southeastern winds due to their geographical location. In fact, when winds blow

from the southeast, the highest wave heights affecting these areas are estimated to be between 5 and 6 meters. Consequently, these areas are more susceptible to sea flooding and erosion during southern and southeastern winds. However, the prevailing winds in this study area tend to be from the northwest, where the lowest wave height values have been calculated at the coast and sea according to the modeling study. In the same study, maps were created to predict the Average Sea Level (ASL) increase due to tides along the Aegean coast. Although the modeling map is not entirely accurate for the Marathon coastal areas, some estimated conclusions can be drawn for the South Evian Gulf coastal area. The study recorded the maximum elevation of the ASL for a return period of T=50 years in the study areas, with a range of 0.30-0.50m for a south wind direction. The rise of the ASL and the potential increase in wave height at the coast will undoubtedly have an impact on coastal towns and areas with intense residential development, such as Nea Makri and the coastal areas of the municipality of Marathon. Vulnerable sites that are identified include gently sloping estuaries, which often encompass particularly vital coastal habitats. The floods in these areas are expected to increase, and erosion will likely be more pronounced [33].

Two of the study areas, Brexiza and Schinias National Park, share similar characteristics, such as gently sloping topography, estuaries, streams, and water concentration basins. These areas are highly likely to be vulnerable to an upcoming rise in sea level. Similar areas have shown that in the long run, several coastal wetlands may disappear due to sea level rise and sea floods, which can lead to the conversion of existing vegetation into marine-type, salt-tolerant vegetation and change the ecological characteristics of the area. At the same time, the semi-mountainous regions of Oinoi and Ramnounta are threatened by erosion. Heavy rainfall or strong winds can lead to soil erosion and soil movement, which becomes worse if there is a lack of vegetation cover due to summer fires. The Oinoi area poses risks of erosive sediment due to the ground's low slope and the proximity of the Haradros River. The archeological site, locally known as the sanctuary of Apollo Pythios, is vulnerable to heavy rainfalls and flood events followed by soil concentration due to the site's plain topography.

Sequence of Hazards – Extreme Weather Events

Environmental hazards can pose a threat to our cultural and natural heritage [26]. These hazards can occur individually or in combination with other natural phenomena. Sometimes, these events can be sequenced in a way that exacerbates the damage. For instance, a wildfire during the summer months triggered by drought, heat waves, and strong winds can create convenient conditions that lead to a series of flood events in autumn. Moreover, these sequences may exhibit a cyclical pattern preventing natural systems from being restored [9].

Rising temperatures are an environmental phenomenon linked to climate change and favor the occurrence of other phenomena in a succession of processes caught in a vicious circle, which includes excessive dryness, heat waves, wildfires, floods, soil erosion, and desertification. Climate studies come to ominous conclusions for Greece, where a temperature rise of up to 2.5°C is estimated by 2065, with more significant increases in summer and autumn. An increase in the heat wave index and an increase in the occurrence of heat wave events during the summer period are also estimated [34]. According to the study conducted by the Bank of Greece in 2011 [35], there are estimates of extreme events in Greece. These include an increase in the frequency, intensity, and duration of heat waves during the summer months. Additionally, there is an expected rise in the intensity of drought periods during summer and an extension of the annual dry periods. There may also be an increase in the frequency and intensity of rainfall and flood events, particularly in urban areas. Wind intensity is also expected to increase. The effects of climate change in Greece are likely to be more significant due to the changes in the frequency and intensity of extreme weather events rather than the long-term changes in the average climate [31].

In the Mediterranean ecosystem of Greece, a sequence of events is triggered during the summer months. At the beginning of the dry season, an increase in the air temperature is observed. These dry thermal conditions favor the occurrence of fires that accelerate overheating and destroy

vegetation. Further increase in the air temperature is recorded during fire events because of the heat load, which significantly affects the microclimate of the surrounding area. It has been observed that the absence of rainfall during the dry season and the increase of air temperature lead to a decrease in air and soil moisture. This causes the upper soil layers to become dry and hydrophobic. The hydrophobic soil conditions and the destruction of vegetation cover following a forest fire create ideal conditions for autumn flooding events that typically occur afterward. Soil erosion, substantial runoff, and degradation of ecosystems are consequences of forest fires, often followed by changes in land uses due to human intervention. In addition, areas that have been affected by fire are at risk of successive floods for several years, dramatically altering the landscape and its hydrological characteristics. The post-fire flooding events are usually more extensive and more intense than before, in the absence of vegetation, which controls the runoff and favors water absorption by the soil, enriching the underground water table [22].

The record data analysis of fires and floods highlights a sequence of hazards that result in flooding events, particularly in the study areas. For instance, the fire in Penteli during the summer of 1986 caused flooding events that impacted the municipality of Marathon for several years. These events occurred in November 1987 and February 1988 in locations such as Patitiria, Chepi, Tymvos, and Paralia. Similarly, the fire in Penteli during the summer of 1998 led to a series of flooding events in November 1998, affecting locations such as Patitiria, Chepi, Tymvos, and Valaria, among others. In March 1999, flooding events occurred in several locations on the eastern coast, such as Brexiza. In some cases, the floodwater contained abundant vegetation debris and sediment content, which can be attributed to the forest fires that occurred in 1995 and 1998 [27]. Finally, the fire in 2005 in Rafina and Neos Voutzas led to flooding phenomena in several areas of the Municipality of Marathon in the fall of the same year. The fires caused significant damage to the forest cover in the mountainous Rapentosa and Haradros basins, resulting in an increased risk of flooding in the study areas of Brexiza, Oinoi, and Schinias [28]. For the Mediterranean ecosystem of Greece, the frequency and duration of rainfall tend to decrease while its intensity increases. These precipitation characteristics lead to long periods of drought, which result in desertification conditions [9]. Also, the decrease in rainfall throughout the year contributes to the reduction of sediment from inland to the beach, leading to coastal erosion due to insufficient sediment supply [36].

In semi-mountainous areas, heavy rainfall and the destruction of vegetation due to fires can lead to soil erosion [37]. This is further aggravated in mountainous areas and on the coast due to the change in rainfall characteristics, which are recorded as high in intensity, short in duration, and more frequent. In the study areas of Ramnounda and Oinoi, there is a potential risk of soil erosion due to heavy rainfall and strong winds, especially if there has been a reduction in vegetation cover due to previous fires. (Fig. 5) In addition, the rising tides pose a coastal erosion risk, particularly in areas with low altitudes and gently sloping ground, such as the Brexiza and Schinias. Areas located along rivers and streams are also susceptible to this type of erosion [31].

Other Hazards

Several potential risks examined by the literature review are likely to be relevant to the study areas. Those risks affect the matter, leading to the initiation of the decomposition process related to changing climate parameters in an indoor or outdoor environment [26]. The progression of this degradation is determined by several factors, such as environmental exposure, intrinsic material properties, and construction methods, leading to various degrees of vulnerability. Nowadays, these risks become increasingly important due to the frequency and intensity of weather phenomena, the greater exposure of matter to such events, and the natural aging of materials. The changes in the climate characterized by greater intensity and duration can increase the physical, chemical, and biological mechanisms, which cause degradation, affecting the structure and composition of matter [38].

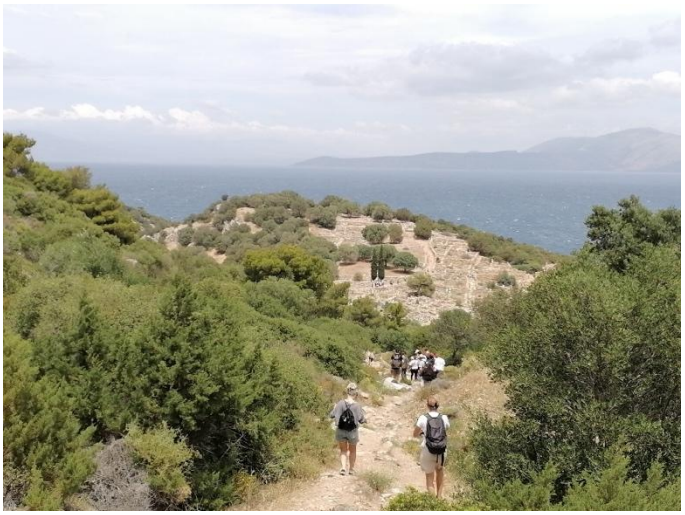


Fig. 5. View of the archaeological site of Ramnoundas in Grammatiko in May 2024 [7]

Material decomposition is also observed in Oinoi and Brexiza due to the activity of microorganisms, mainly in cases of buried or underwater archaeology. The presence of moisture and oxygen are decisive factors for the activity of microorganisms by stimulating natural biological mechanisms [29, 38]. Such microorganisms can gradually degrade organic materials and layers of coating, finishing, refining, and color. Climate change is an additional threat, as it exacerbates the expected rates of material decay and contributes to the emergence of new decay phenomena [26, 39].

Recent research has highlighted the possibility of a shift in the geographic location where physical, chemical, and biological processes occur due to climate change. This shift is expected to cause new types of damage to cultural heritage sites that were not previously present in the area but now appear due to a shift of climate stressors. *M.P. Nastou and S. Zerefos* [40], among other researchers, state the importance of studying the deterioration of tangible cultural heritage and using it as evidence of environmental changes. This applies to the possibility of gathering information about climate variability by observing the physical changes to archaeological monuments exposed to environmental factors. Site evaluation is critical for better understanding the relationship between climate change and cultural heritage. More specific research in this field is necessary.

At a smaller scale, the local climate is greatly affected by various factors, including the unique topography of each region and land use. This indicates a significant interaction between the weather and microclimate, the particular topographical features of each area, and the community's role in the area's functioning and land use [8]. Every cultural heritage site requires a tailored heritage intervention and management plan, as each specific area has unique characteristics [40]. However, material degradation can be caused by various factors, such as environmental changes, climate change, and pollutants released by human activities [1]. In addition, inappropriate conservation and restoration interventions, theft, and desecration are also factors that can contribute to material deterioration. Human activities can intensify the effect of environmental factors on material degradation. Understanding the mechanisms that cause material deterioration and their impact on heritage is crucial in developing effective conservation strategies and predicting material behavior. This can lead to better prevention, management, and material restoration [39].

On the other hand, more research is needed on the direct link between intangible cultural heritage and the impacts of climate change [1]. This type of heritage includes living heritage, which refers to places that have not undergone significant changes in their organization and

function from their original purpose. For instance, preserving agricultural heritage in traditional rural settlements can contribute to social cohesion, environmental balance, rural development, and cultural preservation [41]. Living heritage is a human-centered system that carries cultural values and is linked and adapted to the specific economic and environmental conditions of its region. Therefore, these systems are essential for the mechanisms that enable them to adapt to mild environmental changes and are worthy of study and conservation.

Human Threats

Climate change triggers severe environmental hazards that threaten cultural and natural heritage. However, these environmental events can be caused by human activities. The distinction between man-made and environmental threats is sometimes difficult, as their boundaries are often unclear.

Residential Development

Eastern Attica, including the Marathon municipality, has become a suburb of Athens due to its proximity to the city and the relatively good commute network it offers. Over the last few decades, the population has increased due to urban sprawl toward suburban areas. This movement of people from urban centers to the suburbs is a dynamic and complex phenomenon mostly driven by social, economic, and environmental factors and has significant consequences for these areas [4]. In the municipality of Marathon, the recorded population growth from 2011 to 2020 was caused by permanent housing. In the 1980s, a similar increase in residential development was observed as this area was popular for holidays, leisure, and tourism. The population growth has led to intense construction, particularly in the area of Nea Makri and the city of Marathon [4]. However, much of this residential development has been carried out without any urban planning, leading to an increase in the arbitrary building phenomenon [42]. Such practices are still prevalent in Greece, decreasing the natural processes, producing discomfort, degrading residents' quality of life, and endangering the natural environment and the pre-existing cultural heritage. Intensive construction with the use of hard materials and impermeable surfaces is contributing to a change in the microclimate within cities and their surrounding areas. These changes include increased temperatures, thermal radiation, and decreased atmospheric humidity, especially in the summer [13]. These issues have become more severe with the expansion of cities. In addition, poor management of natural streams and stormwater runoff can lead to flood events within cities. As a result, natural ecosystems within or near urban centers are under huge pressure, are being degraded, and can become imbalanced or even collapse.

The marshy ecosystem of Brexiza, along with an adjacent archaeological site, remains under significant pressure due to the intensive and unplanned residential development of the city of Nea Makri. In this area, mismanagement of natural streams has been observed, including chronic tactics like diversion and enclosure practices, as well as sediment deposition within the marshy ecosystem due to residential development. The neglect of the natural environment and archaeological sites for urban expansion is a common practice within the major cities of the municipality. The consequences of residential development in these areas, which began decades ago, are evident today with the degradation of natural ecosystems, alterations in the hydrology of the wider area, frequent flooding, rising temperatures, and changes in the microclimate. Additionally, there are severe consequences for the nearby archaeological sites. Another outcome of residential development and population growth in the study area of Brexiza is the deposition of organic and other waste materials, as well as the poor prevention and management by municipal authorities. Such practices of depositing products of pruning, tree branches, leaves, and grass indiscriminately with household garbage and construction waste are found in places within the settlements of the municipality of Marathon and in areas on the outskirts. These actions result in environmental degradation, poor quality of public space and everyday life aesthetics, and increased fire risk due to waste ignition, particularly during the summer period.

It is crucial to bring attention to the issue of air pollution that arises due to the burning of hydrocarbons for heating, transportation, and other human activities in urban areas. With the

development of local city centers within the municipality of Marathon and its proximity to the metropolitan area of Athens, Marathon is facing air pollution due to an exponential traffic increase on main roads, which often causes congestion. This could also be triggered by wind movement and acid rain transfer from urban centers, posing a significant risk to the natural environment and cultural heritage [13].

Intensification of Agriculture

In the northern and mountainous areas of the municipality, agricultural uses are mixed with the natural landscapes of the Mediterranean ecosystem. Some urban development, intensive farming systems, and non-irrigated farms can also be observed [42]. However, residential development, tourism, and trade have put pressure on the agricultural sector, which has shrunk considerably over time. Despite this, agriculture still covers 28% of the municipality's economic activities, with many agricultural developments being intensive in nature, producing both plant- and animal-based products.

Farm intensification is a process that aims to increase agricultural production per hectare. However, this often leads to farmers' excessive use of pesticides and fertilizers. These chemicals used by conventional agriculture are usually toxic and can harm the environment and human health. They have a long residual life, and the included metal elements pollute the environment, making them hazardous over extended periods of time. A common agricultural practice is the application of higher concentrations of agrochemicals than recommended, which leads to the contamination of surface rainwater, subsoil, and the groundwater table. Furthermore, in flood events, these substances can be transported through streams and contaminate other high flood risk sites, including the eastern lowlands and coastal areas of Nea Makri and Schinias. This potentially threatens the natural ecosystems, which are valuable cultural assets. Additionally, the contact of agrochemicals with cultural structures can cause surface deterioration of the material, creating an acidic or alkaline environment.

Monoculture is a standard practice as part of the intensification of agricultural production so as to increase yields per hectare. To achieve this, a large number of domestic plant species have been displaced by human intervention and replaced by cultivated species. As a result, rural agricultural areas with monoculture practices face ecological threats like ecosystem degradation, alteration of natural processes, displacement of natural vegetation, and reduction of flora and fauna populations. These practices are more common in the northern part of the municipality, especially in suburban areas with gentle slopes, ideal for agricultural uses, like in the outskirts of Marathon and Nea Makri, but also in areas around Varnavas and Grammatiko. Overgrazing poses another potential risk to the regeneration of the ecosystem. It is a common practice in livestock production and has previously caused fires to create new pastures. In the municipality of Marathon, livestock production accounts for a small part of the economic activity. However, if this practice is not subject to an integrated ecosystem management plan and is carried out without discretion, it can become another source of pressure on the natural and cultural landscapes [9]. Another major threat relates to water drilling for agricultural or civic uses, which has begun to deplete the water table, resulting in the gradual intrusion of the sea.

Tourism Development

Tourism to cultural sites and urban destinations is becoming increasingly popular [25, 43]. The municipality's local economy heavily relies on the tertiary sector, which accounted for 57% of local employment in 2011 [42]. This sector includes trade, tourism, and various services. The tourism industry is concentrated in the coastal areas of the municipality, as well as in city centers like Nea Makri and Marathon. While there are also places of cultural interest that attract visitors, the coastal areas are the most popular. Therefore, hotels, restaurants, and entertainment services have been developed to accommodate tourists. The number of visitors increases exponentially during the summer season. The Marathon coast is a popular tourist destination. The wetlands and woodlands in the Schinias National Park are of unique ecological value, but they have suffered degradation due to pollution, vandalism, disturbance of natural ecosystems, and the risk of fire

incidents from the high volume of visitors and cars, posing a risk to the natural environment and cultural heritage of the area. Tourist services are typically developed along the coast using interventions with hard and impermeable materials. However, the scenario of further expansion could create significant problems for the natural processes of the seashore, including coastal erosion and sea flood events [31].

Less intense forms of tourism can be witnessed in the municipality's semi-mountainous and mountainous regions, although these remain the initiatives of individuals or groups and have not been exploited or planned. Popular activities in these areas include hiking, climbing, and appreciating natural beauty. The areas of Oinoi, Ramnoundas, and the Marathon Dam site are popular among visitors for their cultural value, archaeological sites, and natural beauty. However, during the summer, the number of visitors increases significantly, enhancing the risk of pollution, natural disturbance, and wildfire incidents.

Thefts and Vandalism

Theft and vandalism pose another risk to tangible cultural heritage [25, 43]. The motives behind such actions can be varied, including financial gain, political conflicts, revenge, devaluation, prestige, religious matters, anger, or malice. The reasons that make theft or vandalism possible are poor promotion and management of archaeological sites, lack of security, and easy accessibility. Antiquities located outdoors are more vulnerable than those in museums, where security and accessibility are controlled. The selection of targets depends on several factors, such as the value of an object, the perceived interest in the object, the level of security at the site, and the likelihood of the perpetrators to escape. The size of objects is another crucial factor in determining their vulnerability to theft or vandalism. Smaller objects are more accessible to steal or vandalize, as they can be easily transported and sold. They are also in high demand for private collections. However, larger objects are also at risk, especially those made of valuable materials. Some large-scale objects are dismantled and sold off in parts due to the demand for their materials [20].

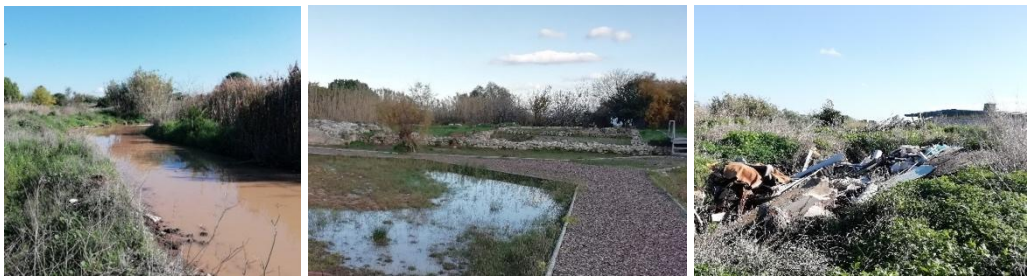
At the municipality of Marathon, evidence illustrates that incidents of vandalism mainly occur outdoors. However, since these incidents are generally small scale, they are not usually reported in the press or recorded in official statistics. For instance, in October 2014, several cultural facilities owned by the municipality were vandalized and set on fire for political reasons, but this incident was not widely known. Similarly, in June 2018, unknown individuals caused damage to replicas of the statues of the gods Isis and Osiris at the sanctuary of the Egyptian gods in Brexiza. While these incidents may not be well documented, they do occur from time to time. It is essential to mention that the archaeological sites in the Oinoi and Brexiza study areas are susceptible to vandalism because of their easy access and poor security. The archaeological site at Brexiza, in particular, is situated on a coastal road with high traffic, especially during summer. The site's perimeter has a rudimentary boundary that is almost destroyed in some areas.

Pressure from Past Uses

Anthropogenic activities pose a serious threat to the environment and cultural heritage. Even after they cease, they continue to exert indirect pressure on natural ecosystems and tangible cultural reserves. The lack of an organized sewerage and wastewater treatment system in the Municipality of Marathon causes a significant deterioration in water quality, resulting in an influx of increased organic and microbial load into the sea [42]. Furthermore, poor stream management due to unplanned residential development has altered the municipality's hydrology and natural runoff channels. The arbitrary practices in the natural stream and river network, such as soil embankments for reconstruction purposes, dumping of construction materials, unauthorized uses, and other uncontrolled interventions that started in the 50s and 60s, continue to cause flood events during periods of heavy rainfall [28].

The wetlands in the study area of Brexiza have continuously deteriorated due to human interference since the 1930s. This natural marshland was partially drained by soil deposit practices for military operations, followed by waste deposits from the municipality, significantly

impacting the aquatic ecosystem. The operation of the US military base in part of the drained marshland from 1953 to 1990 also contributed to the degradation of the natural ecosystem. The military activities, which included the operations of heavy vehicles, filling, and covering the soil with hard materials, left the subsoil compacted and possibly contaminated with toxic military waste that remained for several years. After the end of the military activities, inappropriate interventions by the Nea Makri District Council with insufficient flood protection works in 2004, followed by practices of dumping construction leftovers and housing waste until 2008, have put further pressure on the vulnerable wetlands. Consequently, most parts of the marshy ecosystem have collapsed, and flood events due to the alteration of the hydrology in the area are frequent, posing a threat to the adjacent archaeological site of Brexiza (Fig. 6).



(a) (b) (c)

Fig. 6. (a), (b) Views of the archaeological site of Brexiza flooded after a light rain on December 4th, 2021, due to the absence of management, lack of coordination between stakeholders, unresolved abuse, and ongoing irresponsible practices of the territory [7], (c) Practices of dumping construction leftovers and housing waste at a height of 5-6 meters inside the wetlands of Brexiza have dramatically altered the hydrology, topography, and ecology of this vulnerable ecosystem [7]

Discussion

The risks and threats that natural and cultural heritage face remain a complicated issue involving several interacting heterogeneous factors. The municipality of Marathon is subject to a range of intense and successive natural phenomena that are triggered by climate change. These can cause stress to natural ecosystems and cultural resources, exposing them to threats and leaving them highly vulnerable. One of the most significant environmental hazards in the area is wildfires, which can have long-lasting effects on the environment. Fire data analysis shows that some regions of the municipality are more threatened than others due to local characteristics such as terrain slope, vegetation type, hydrology, fire protection, and landscape maintenance. However, it is essential to consider fires as a potential risk for all areas of the municipality because of their ability to spread and downgrade the Mediterranean ecosystem in the wider Marathon area. Climate change also facilitates the spread and severity of fires by increasing the intensity of heat waves and strong winds in the summer.

Flooding is also a serious threat that usually succeeds fires, as bare ground with no vegetation cover is prone to flood events and stormwater erosion. In the municipality area of Marathon, the plain lowland and coastal areas are especially vulnerable to flooding and erosion because of their role as catchment areas for rainwater. The urban and denser areas of Marathon and Nea Makri are also at high flood risk due to poor town planning and incorrect management of natural streams and rivers. Furthermore, in mountainous locations, erosion of terrestrial soils is a post-fire risk caused by either stormwater or wind. Coastal areas are also at risk of flooding, which may be caused by a sea level rise due to climate change and high winds. The eastern coastal area of Marathon is exposed to southern and southeastern winds, with shore waves that can reach up to 5 or 6 meters. The flat topography of coastal areas makes them even more vulnerable to flooding [23]. Waterlogging is a risk in the event of sea flooding. It can cause significant changes

to the characteristics and functions of ecosystems, which can benefit salt-tolerant species. The ecosystems and cultural assets along the coastal zone of the municipality of Marathon are highly vulnerable to these changes. Flooding can cause structural damage to buildings due to dynamic loads from water and wind, soil degradation due to high salinity, and damage to materials leading to deterioration and discoloration. In addition, materials may be damaged due to exposure to animals, vegetation, and microorganisms, particularly in the case of buried antiquities or underwater archeology [38, 39].

On the other hand, the suburbanization of Athens has led to a large residential development in the area of Marathon in the last 50 years. Unfortunately, this development was characterized by poor planning, arbitrary construction, inadequate or absent management of natural streams and rivers, and the use of hard, non-permeable materials. These practices have impeded natural environmental processes such as stormwater runoff and water drainage. As a result, urban centers in the area are becoming more vulnerable to flood events and changes in urban microclimate. At the same time, tourism has also contributed to the problem, particularly in the area of Nea Makri and along the Marathon coast, which are popular weekend getaways and leisure destinations for the Athenians. The high number of visitors is more likely to create threats to natural landscapes like noise, air pollution, fire risk, and intensive car use, especially in the summer. Along with population growth comes an increased risk of theft and vandalism, which mainly endangers tangible cultural heritage [20]. Further development of tourist facilities and harsh interventions along the coastal front of Marathonas have also caused erosive phenomena from the sea, which endanger natural ecosystems and cultural heritage sites [31].

Over the last few decades, population growth with residential and tourist development has led to waste aggregation problems in the municipality of Marathon. Organic waste, household waste, and other materials are often dumped indiscriminately in open areas and archeological sites, which may cause pollution and fire events. In addition, as the urban areas of Marathon expand and are close to the metropolitan city of Athens, they increasingly contribute to the air pollution, with harmful consequences for both the natural and tangible cultural heritage. Another source of pollution is the intensification of the agricultural sector, which has increased the use of agrochemicals with high toxicity and residual durability. Indiscriminate use of toxic pesticides, insecticides, and fertilizers has resulted in soil, air, rainwater, and groundwater pollution, causing damage to ecosystems and cultural assets. On a smaller scale, the degree of impact of the risks in the study areas can vary considerably due to the unique characteristics of each area. As a result, different degrees of vulnerability can be observed between the risks in the various examples. From the above, we conclude that cultural and natural heritage sites belonging to the municipality of Marathon are under pressure from different and intensifying hazards that are characterized by sequence and succession. This sequence of events increases the duration of stressors affecting natural ecosystems and cultural resources to varying degrees, making them more vulnerable. Lastly, climate change and human interventions can intensify the effects of natural phenomena and increase the vulnerability of natural and tangible cultural assets.

Conclusion

The contemporary area of Marathon boasts a rich cultural and natural heritage reserve with immense historical, sociocultural, and environmental value for Greece, Europe, and, it would be safe to say, the world at large, as it has lent its name to more than 800 marathon runs that take place all over the world. The preservation and promotion of these valuable tangible and intangible assets are crucial, as they are currently at risk from various environmental threats and human activities. These dangers cause the deterioration of the tangible cultural reserve and the ecological degradation of cultural landscapes, leading to decline and collapse. The municipality of Marathon is at high risk of experiencing severe, even irreparable damage to its significant cultural and natural heritage due to climate change, poor management and lack of any clear strategy, and

finally, lack of adequate resources. Several measures, social, managerial, and physical, that could contribute to mitigating the risks are suggested. It should be noted that this is an outline of the major areas that, in our view, should be addressed, and that their full development would be the outcome of a lengthy multidisciplinary study, which urgently needs to take place. These mitigation categories are complementary and dependent on one another and are outlined below:

a. Social involvement proceeds with an array of measures that would make the cultural heritage visible and would make it appreciated in the collective imaginary of residents and visitors alike. This would promote different behavior patterns supplemented by the adoption and promotion of recommended or mandatory guidelines that could be instituted.
b. The managerial aspect would require undertaking a midterm and a long-term strategic plan, which would devise measures of protection, accessibility, connectivity, and visibility.
c. Finally, due to the intensifying degradation of the natural resources, which has been in effect for at least the past two decades, an extensive and carefully designed plan of regeneration of the mountains is urgently needed, which includes reforestation and water retention, with a diversification of species that would better withstand temperature rise and dryness and would be resistant to bushfires. A reforestation program, which would be part of the above-mentioned regeneration, is a complex endeavor that requires a multidisciplinary approach. Proceeding with preemptive measures of revealing the enclosed streams and allowing for flood basins to exist for the protection of urban areas. The above could be complemented by several other localized nature-based solutions towards making the natural and man-made areas more sustainable and resilient.

Further research and analysis of specific cultural and natural sites is essential towards targeted management policies and practices by the municipality. The resources allocated for this purpose by the municipality remain problematic, leading to a lack of clarity regarding responsibilities, planning, management, and action. Administrative restructuring to promote and protect natural ecosystems and cultural heritage sites should become a top priority.

References

[1] S.A. Orr, J. Richards, S. Fatorić, *Climate Change and Cultural Heritage: A Systematic Literature Review (2016–2020)*, **The Historic Environment: Policy & Practice**, **12**, 2021, pp. 434-477. https://doi.org/10.1080/17567505.2021.1957264.
[2] M. Ciski, K. Rząsa, *Threats to Cultural Heritage Caused by the Global Sea Level Rise as a Result of the Global Warming*, **Water**, **13**, 2021, Article Number: 2577. https://doi.org/10.3390/w13182577.
[3] J. Kapsomenakis, C. Douvis, A. Poupkou, S. Zerefos, S. Solomos, T. Stavraka, N.S. Melis, E. Kyriakidis, G. Kremlis, C. Zerefos, *Climate change threats to cultural and natural heritage UNESCO sites in the Mediterranean*, **Environment. Development and Sustainability**, **25**, 2022, pp. 14519-14544. https://doi.org/10.1007/s10668-022-02677-w.
[4] M. Dandoulaki, M. Lazoglou, N. Pangas, K. Serraos, *Disaster Risk Management and Spatial Planning: Evidence from the Fire-Stricken Area of Mati, Greece*, **Sustainability**, **15**, 2023, Article Number: 9776. https://doi.org/10.3390/su15129776.
[5] N. Stournaras, (Photographer, Iokastis 27, 10444, Athens, Greece). Personal photographic file, Marathon, Unpublished work, 2024.
[6] N. Anastasopoulos, (Prof. of Architecture, National Technical University of Athens, 106 82 Athens, Greece). Personal Photographic files, Plasi, Nea Makri, Unpublished work, 2024.
[7] I. Stergiopoulos, (Landscape Architect-Architecture student, National Technical University of Athens, 106 82 Athens, Greece). Personal Photographic files: Oinoi, Ramnoundas, and Brexiza, Unpublished work, 2024.

[8] M. Cassar, R. Pender, *The impact of climate change on cultural heritage: evidence and response*, **ICOM Committee of Conservation. 14th Triennial Meeting the Hague Preprints**, **2**, 2005, pp. 610-616.
[9] M. Karandinos, **University Notes on Ecology and Environmental Protection**, Laboratory of Ecology and Environmental Protection, Agricultural University of Athens, Athens, Greece, 1996, pp. 8-152 (in Greek).
[10] G. Aktürk, A.S. Dastgerdi, *Cultural Landscapes under the Threat of Climate Change: A Systematic Study of Barriers to Resilience*, **Sustainability**, **13**, 2021, Article Number: 9974. https://doi.org/10.3390/su13179974.
[11] K. Tsagari, G. Karetsos, N. Proutsos, **Forest Fires in Central Greece 1983-2005,** WWF Greece and National Agricultural Research Foundation, Athens, Greece, 2011, (in Greek).
[12] K. Tsagari, G. Karetsos, N. Proutsos, **Forest Fires in Central Greece 1983-2008**, WWF Greece and National Agricultural Research Foundation, Athens, Greece, 2011, (in Greek).
[13] R.A. Karandinou, **Ecology and Bioclimatology of Urban Environment: University notes**, Agricultural University of Athens, Athens, Greece, 1995, pp. 12-135, (in Greek).
[14] * * *, **The Most Destructive Fires in the History of Greece**. Available online: https://eleftherostypos.gr/ellada/271692-oi-pio-katastrofikes-pyrkagies-stin-istoria-tis-elladas [accessed 17.6.22] (in Greek).
[15] * * *, **40 Years of fires in Eastern Attica**. Available online: https://www.efsyn.gr/ellada/koinonia/158586_40-hronia-foties-stin-attiki [accessed 17.6.22] (in Greek).
[16] * * *, **Fire in Nea Makri: No active front, many scattered outbreaks**. Available online: https://www.kathimerini.gr/society/561506194/fotia-sti-nea-makri-choris-energo-metopo-polles-diaspartes-esties/ [accessed 17.6.22] (in Greek).
[17] * * *, **Fire in Marathonas.** Available online: https://www.kathimerini.gr/society/1037908/pyrkagia-ston-marathona-vinteo-fotografies/ [accessed 17.6.22] (in Greek).
[18] M. Kreeb, (Prof. of Archaeology, Department of Theatre Studies, University of Patras, 26500, Patra, Greece), Personal Photographic File, Oinoi, Unpublished work, 2024.
[19] M. Doufexi, D.E. Gamvroula, D.E. Alexakis, *Elements' Content in Stream Sediment and Wildfire Ash of Suburban Areas in West Attica (Greece)*, **Water**, **14**, 2022, pp. 1-15. https://doi.org/10.3390/w14030310.
[20] X. Kontopoulou, **Dangers that Threat Cultural Heritage**. Thesis, University of West Attica, Athens, Greece, 2021 (in Greek).
[21] D. Alexakis, *Suburban areas in flames: Dispersion of potentially toxic elements from burned vegetation and buildings. Estimation of the associated ecological and human health risk*, **Environmental Research**, 183, 2020, Article Number: 109153. https://doi.org/10.1016/j.envres.2020.109153.
[22] D. Skilodimou, D. Bathrellos, E. Alexakis, *Flood Hazard Assessment Mapping in Burned and Urban Areas,* **Sustainability**, **13**, 2021, Article Number: 4455. https://doi.org/10.3390/su13084455.
[23] * * *, Special Secretariat for Water. **Implementation of Directive 2007/60/EC: Preliminary Assessment of Flood Risks from the Sea and Estimation of Potential Sea Level Rise for the Purpose of Sea Level Rise Risk Assessment**, Ministry of Environment, Energy and Climate Change, 2014, Athens, Greece (in Greek).
[24] * * *, Special Secretariat for Water. **Implementation of Directive 2007/60/EC Preliminary Flood Risk Assessment**. Ministry of Environment, Energy and Climate Change, 2012, Athens, Greece (in Greek).
[25] L. Bosher, D. Kim, T. Okubo, K. Chmutina, R. Jigyasu, *Dealing with multiple hazards and threats on cultural heritage sites: an assessment of 80 case studies*, **Disaster Prevention and Management**, **29**, 2019, pp. 109-128. https://doi.org/10.1108/DPM-08-2018-0245.
[26] I.C. Nicu, *Natural Hazards – A Threat for Immovable Cultural Heritage. A Review.* **International Journal of Conservation Science**, **8**, 2017, pp. 375-388.

[27] M. Diakakis, *Flood History Analysis and its Contribution to Flood Hazard Assessment. The Case of Marathonas, Greece*, **Presented at the 12th International Congress, Geological Society of Greece**, Patra, Greece, 2010, pp. 1-12.
[28] * * *, Special Secretariat for Water. **Flood Risk Management Plan - Stage 1 - Flood Risk Maps**, Ministry of Environment and Energy, 2020, Athens, Greece (in Greek).
[29] G. Hutchinson, *Threats to underwater cultural heritage. The problems of unprotected archaeological and historic sites, wrecks and objects found at sea,* **Marine Policy**, **20**, 1996, pp. 287-290. https://doi.org/10.1016/0308-597X(96)00017-6.
[30] * * *, ESPON Climate. **Climate Change and Territorial Effects on Regions and Local Economies. Draft Final Report**, ESPON & IRPUD, TU Dortmund, 2011.
[31] H. Chondrogiannis, **Coastal Infrastructure Vulnerability Index for Managing the Impacts of Climate Change**, Diploma Thesis, National Technical University of Athens, Athens, Greece, 2019 (in Greek).
[32] * * *, IPCC. **Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change**, Cambridge University Press, Cambridge, UK, 2007.
[33] A. Papathanasopoulou, *Policies and Legislation to Address Coastal Erosion and Climate Change in the Coastal Zone*, **Postgraduate Thesis**, Democritus University of Thrace, Komotini, Greece, 2021 (in Greek).
[34] * * *, **National Adaptation Strategy to Climate Change**. Available online: https://www.depa.gr/wp-content/uploads/2020/02/06.04.2016-espka-teliko_.pdf (accessed 20.7.24) (in Greek).
[35] * * *, *Study Committee of Climate Change Impact Assessment*, **The Environmental, Economic, and Social Impacts of Climate Change in Greece**, Bank of Greece, Athens, Greece, 2011 (in Greek).
[36] I. Monioudi, *Integrated Assessment of Coastal Erosion due to Sea Level Rise*, **Ph.D. Thesis**, Aegean University, Mytilini, Greece, 2011 (in Greek).
[37] A. Saha, S.C. Pal, M. Santosh, S. Janizadeh, I. Chowdhuri, A. Norouzi, P. Roy, R. Chakrabortty, *Modelling multi-hazard threats to cultural heritage sites and environmental sustainability: The present and future scenarios,* **Journal of Cleaner Production**, **320**, 2021, Article Number: 128713. https://doi.org/10.1016/j.jclepro.2021.128713.
[38] E. Sesana, A.S. Gagnon, C. Ciantelli, J. Cassar, J.J. Hughes, *Climate change impacts on cultural heritage: A literature review*, **WIREs Climate Change**, **12**, 2021, pp. 1-29. https://doi.org/10.1002/wcc.710.
[39] C. Bertolin, *Preservation of Cultural Heritage and Resources Threatened by Climate Change*, **Geosciences**, **9**, 2019, Article Number: 250. DOI:10.3390/geosciences9060250.
[40] M.P. Nastou, S. Zerefos, *Impacts of climate change on cultural heritage. The case of the Greek theatre of Dionysus*, **IOP Conference Series: Earth and Environmental Science**, **899**, 2021, Article Number: 012020. DOI:10.1088/1755-1315/899/1/012020.
[41] A. Vythoulka, E.T. Delegou, C. Caradimas, *A.* Moropoulou, *Protection and Revealing of Traditional Settlements and Cultural Assets as a Tool for Sustainable Development: The Case of Kythera Island in Greece,* **Land**, **10**, 2021, Article Number: 1324. DOI: 10.3390/land10121324.
[42] E. Asimaki, *Culture as a Tool for Restarting Development Design of Cultural Routes in the Municipality of Marathon*, **PhD Thesis**, National Technical University of Athens, Athens, Greece, 2018 (in Greek).
[43] B.A. Adie, M. Falk, M. Savioli, *Overtourism as a perceived threat to cultural heritage in Europe*, **Current Issues in Tourism**, **23**(14), 2020, pp. 1737-1741. DOI: 10.1080/13683500.2019.1687661.

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