Heritage management and sustainability of heritage sites. The case of ancient Greek theatre of Dodoni, Epirus, Greece

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Abstract. Heritage is composed of tangible and intangible assets, as well as cultural and natural sites threatened by the effects of climate change. The sustainability of heritage is significant for its transmission to the next generations, future progress, cultural development and diversity. Thus, this paper is focused on the protection and management of heritage, presenting as case study the ancient Greek Theatre of Dodoni, located in Epirus. Stakeholders are related to scientists for climate change, heritage managers, society (including educational organizations), local community as well as the visitors. The interaction of these groups offers a management plan focused on the needs of the place. Moreover, the research of the local identity of the landscape should be combined with climatic data showing the course of the climate change and its effects on the site of study. This information of climate indices is retrieved by meteorological stations in North-Western Greece. In particular, we analyze climatological data of temperature, humidity and precipitation, collected by the meteorological station of Ioannina (Hellenic National Meteorological Service) for the period 1956-2022. Therefore, the assessment of measurements and extremities can be combined with the vulnerability approach and the risk assessment for the structure of heritage management and the dissemination.

1 Introduction

The aim of this study is to present the connection of heritage sites with climate change and the need of heritage management for creating a sustainable approach on heritage management. Recognizing the urgency of the situation, international organizations, governments, and heritage conservation bodies have started taking steps to address the im-pacts of climate change on heritage. The United Nations Educational, Scientific and Cultural Organization (UNESCO) [1] has been actively working to raise awareness and develop strategies for protecting vulnerable cultural heritage sites. The International Council on Monuments and Sites (ICOMOS) [2] has also been involved in re-search, advocacy, and policy development related to climate change and heritage. Greek theatres hold a significant place in the history of performing arts and entertainment. Originating in ancient Greece, these open-air amphitheatres served as venues for theatrical performances, religious ceremonies, and civic events. These architectural wonders, with their semicircular seating arrangement and remarkable acoustics, they were an integral part of ancient Greek culture, serving as venues for dramatic performances and religious festivals. These open-air structures played a significant role in shaping the development of theatre as an art form [3]. The case study is the ancient Greek Theatre of Dodoni, located in Epirus, Greece.

2 Materials and Methods

The main methodology used for this research is literature review which is correlated with vulnerability approach and risk assessment. These methodologies are dedicated to the heritage values and appropriate management, elaborating as data climatic measurements from the meteorological station of Ioannina (Hellenic National Meteorological Service).

2.1 Vulnerability approach

The intersection of cultural heritage conservation and environmental sustainability emphasizes the vulnerability of heritage sites to environmental changes and the importance of incorporating sustainable practices [4]. The Intergovernmental Panel on Climate Change (IPCC) report examines the vulnerability approach in the context of climate change impacts and adaptation, providing insights into the multidimensional nature of vulnerability [5]. This approach is a tool contributing to the understanding of vulnerability in the context of heritage conservation and in particular of the heritage landscape of an open-air theatre, as the ancient Greek Theatre of Dodoni, in the context of the specific paper.
In the case of cultural assets, vulnerability approach is vital for the design of heritage management as it offers

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collected information for interpretation of the heritage for the following characteristics [6,7]:

- Environmental Factors: climate change and natural disasters
- Physical Deterioration: aging infrastructure and pollution and industrialization
- Human-Induced Threats: urbanization and development as well as vandalism and theft
- Socio-Economic Factors: lack of funding and resources and tourism pressures.

2.2 Risk assessment

Risk assessment of heritage involves identifying and evaluating potential risks that may impact cultural heritage sites, objects, or intangible heritage, as at the time of climate change heritage is facing a crisis of threat and damage [8]. These risks can range from natural disasters to urban development and inadequate maintenance. Conducting a risk assessment allows heritage managers to prioritize and implement preventive measures and mitigation strategies to safeguard heritage for future generations.

ICOMOS has published resources on risk assessment, including the "Risks to Cultural Heritage" publication, which provides insights into assessing risks faced by heritage sites [9]. Additionally, UNESCO offers guidelines and reports on risk assessment and resilience strategies for heritage sites, such as the "Managing Disaster Risks for World Heritage" manual and the "Climate Change and World Heritage" series (UNESCO, various publications).

2.3 Ancient Greek Theatre of Dodoni

Fig. 1. The theatre of Dodoni in 1959 [10]

The kind of heritage which is studied in this paper is the Ancient Greek theatre, which is an integral part of Greek culture with significance in the development of theatre as an art form. More specifically, the case study is the ancient Greek theatre of Dodoni, located in northwestern Greece near the modern village of Dodoni and it was one of the most important theatres in ancient Greece. Theatre construction consisting of earthen-laid orchestra around which are found preserved a stone-made underground drainage pipe for rainwater, limestone-covered cavea sectioned by two concentric corridors-tiers in three parts and a rectangular stone-made stage of elaborate isodomic masonry [10].

Fig. 2. The theatre of Dodoni and its landscape [10]

The selection of Dodoni as a case study for this study combines and includes the cultural landscape, the connection of culture and nature with embodied heritage values and it is exposed to the weather conditions, as it is an open-air theatre with recognizable shape and specific historical value in Greek culture. Also, information can be retrieved by meteorological stations in North-Western Greece in order to research some important climate indices. In particular, we analyze climatological data of temperature, humidity and precipitation, collected by the meteorological station of Ioannina (Hellenic National Meteorological Service) for the period 1956-2022.

3 Results and Discussion

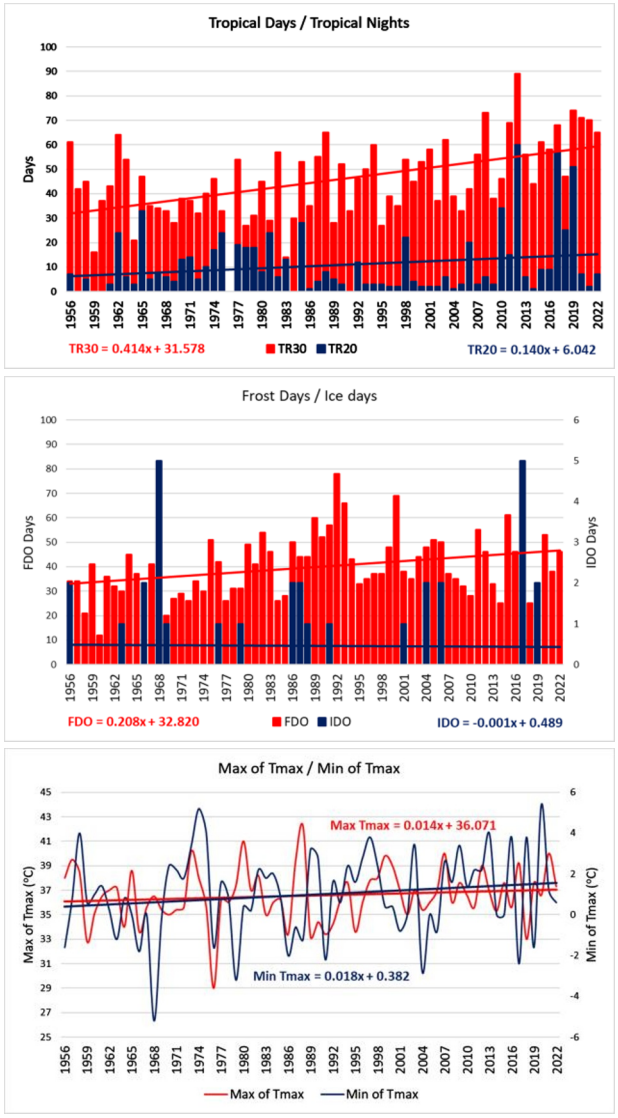
Taking into consideration the vulnerability of the ancient Greek Theatre of Dodoni to climate change, stakeholders should conclude to a management plan for its safeguarding. It is implied that the character of the landscape and the special needs of the location of this heritage site are significant for an adequate management plan.

As far as the collected measurements are concerned, the datasets used in the analysis concern 3h observations of air temperature, relative humidity and precipitation for Ioannina station (latitude: 39.6964°, longitude: 20.8225°, elevation: 483m) within the period 1955-2022, provided by the Hellenic National Meteorological Service [11].

The air temperature indices concern: i) tropical days, SU30 (number of days with daily maximum temperature above 30 oC); ii) tropical nights, TR20 (number of days with daily minimum temperature above 20 oC); iii) frost days FDO (number of days with daily minimum temperature below 0 oC); iv) ice days IDO (number of days with daily maximum temperature below 0 oC); v) the maximum daily maximum air temperature, TXx; vi) the minimum daily maximum air temperature TXn; vii) the maximum daily minimum air temperature TNx; viii) the minimum daily minimum air temperature TNn; ix) maximum diurnal air temperature range, Max DTR and minimum diurnal air temperature range, Min TDR.

The relative humidity indices concern: maximum diurnal relative humidity range, Max DRH and minimum diurnal relative humidity range, Min DRH.

The precipitation indices concern: i) dry days (number of days with precipitation below 1mm); wet days (number of days with precipitation above 1mm); ii) very wet days, R95p (number of wet days with precipitation above the 95th percentile on wet days); iii) extremely wet days, R99p (number of wet days with precipitation above the 99th percentile on wet days); iv) the annual precipitation; v) the simple daily intensity index, SDII (the total daily precipitation amount on wet days divided by the number of wet days); vi) heavy precipitation days, R10 (the number of days with daily precipitation above 10mm); vii) very heavy precipitation days, R20 (the number of days with daily precipitation above 20mm) and extremely precipitation days R30 (the number of days with daily precipitation above 30mm) [12,13].



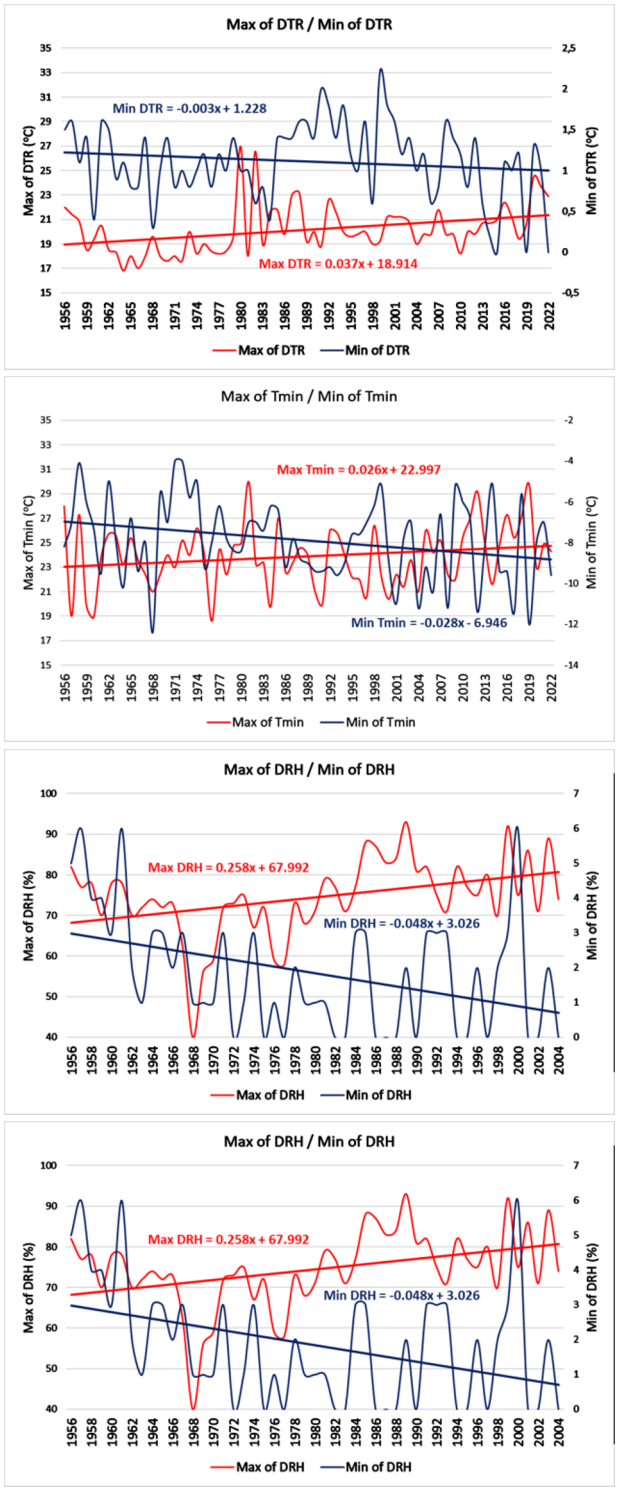


Fig. 3. Time series of Tropical Days (TR30) and Tropical Nights (TR20) (1st graph), Frost Days (FDO) and Ice Days (IDO) (2nd graph), Max of Tmax and Min of Tmax (3rd graph), Max of Tmin and Min of Tmin (4th graph), Max of DTR and Min of DTR (5th graph), Max of DRH and Min of DRH (6th graph) for Ioannina station, period 1956-2022 (The period for DRH is 1956-2004).

The climate extremes are depicted in Figure 3 (air temperature and humidity extremes) and in Figure 4 (precipitation extremes).

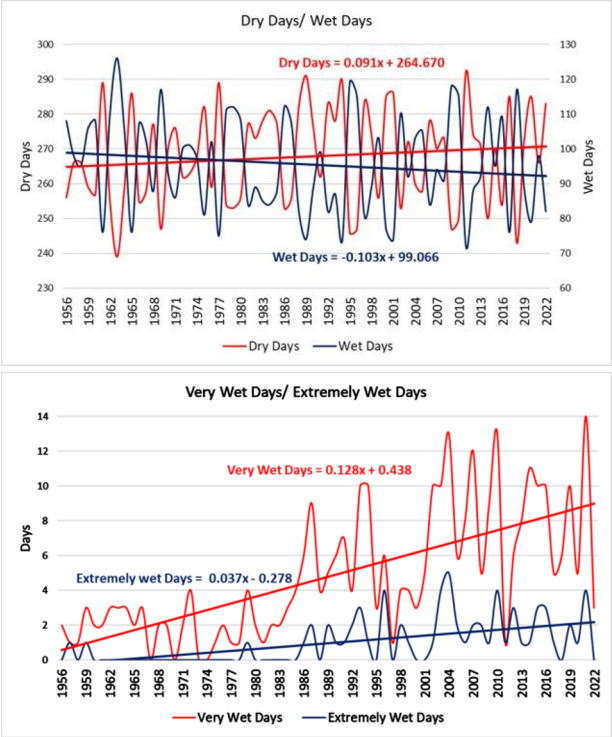


Fig. 4. Time series of Dry Days and Wet Days (upper graph), Very Wet Days and Extremely Wet Days (lower graph), for Ioannina station, period 1956-2022.

4 Conclusions

Nowadays, the topic of adaptation in heritage management is becoming even more significant as it is threatened by the effects of climate change. This study suggests management actions for the mitigation of the effects of climate change on the case study and its place, as well as adaptation actions to the current climate conditions. The consistent presence of climate change and the variety of its effects provoke difficulty and sometimes even adverse conditions to the continuity of human activities. Heritage sites create evidence for the history of societies with their contribution to cultural diversity. The collection of cultural and scientific information about the theatre of Dodoni includes architectural data (designs, structural methods, environmental factors of the plan of landscape, restoration and protection conditions and means), climatic measurements and indices, which can be valuable input for the vulnerability approach and the risk assessment. These tools could be capable of revealing the danger of the effects, concluding to the assessment of the measurements (temperature, humidity and precipitation). Thus, there is interaction between the heritage management and the sustainability of the open-air theatre of Dodoni and the immediate awareness and the dissemination are vital for the cultural protection.

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