

NATIONAL ASSESSMENT OF SEA LEVEL RISE VULNERABILITY OF ARCHEOLOGICAL HERITAGE SITES OF TURKIYE

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INTRODUCTION

The coastal cultural heritage sites are expected to be affected negatively by sea-level rise, although these impacts will be observed at different levels in different areas. ICOMOS (2019) has urged the member states to determine and assess the vulnerability and risks of those cultural heritage sites that are under threat and increase the efforts to protect and adapt these locations to the impacts of climate change. Turkey has many significant natural and archeological heritage sites with outstanding values, and these areas are protected by law. The Scientific and Technological Research Council of Türkiye (TUBITAK) funded project "Vulnerability of Coastal Cultural Heritage Areas to Sea Level Rise and Its Impacts" (No: 122M613) focused on assessing the vulnerability of the coastal areas with heritage sites (both natural and cultural sites protected by law) to sea level rise and its impacts (coastal erosion, inundation and coastal flooding due to extreme water levels) using the Fuzzy Coastal Vulnerability Assessment Model, FCVAM (Ozyurt, 2010). Within the project, an additional module is developed to determine the vulnerability of coastal cultural heritage sites based on their interaction with the coastal area and the coastal vulnerability. The assessments use several sea level rise projections based on different climate change scenarios to ensure that the vulnerability of these sites reflects the latest sea level rise research and the uncertainty ranges. Thus, the coastal cultural heritage sites of Türkiye will be prioritized according to their vulnerability at a national level and using a multi-dimensional approach. This study will present these Turkish coastal archeological heritage sites exposed to impacts of sea level rise, their respective coastal vulnerability indices, and the heritage vulnerability results based on the heritage site characteristics and their interaction with the coastal vulnerability.

METHODOLOGY

All the archeological sites protected by law based on their characteristics are assessed on their vulnerability to the impacts of sea level rise. The heritage sites exposed to the impacts of sea level rise are determined based on the definition of the coastal area. The zone below 10 m elevation and within 1 km from the shoreline was defined as the exposure zone. The archeological heritage site database is updated rigorously based on the Ministry of

Culture and Tourism protected sites database and the mesoscale Environmental Order plans of the coastal provinces of the Ministry of Environment, Urbanization, and Climate Change. The coastal vulnerability of the associated shorelines of each archeological heritage site is assessed through the 12 indicator parameters of FCVAM (Table 1). The FCVAM Model (Ozyurt, 2010) is an index-based model based on fuzzy logic that can assess the impacts of sea level rise (coastal erosion, inundation, and coastal flooding due to extreme water levels) in a systematic approach. Built in Python environment and GIS, FCVAM integrates physical processes with the human activities that affect the susceptibility of the shoreline. The human-nature integration of the FCVAM approach considers the adaptive capacity of the coastline, considering coastal protection measures. The vulnerability is considered in 5 levels, from very low to very high, based on the coastal vulnerability index (CVI) out of the highest possible score (5).

Table 1 - Input Parameters of FCVAM model

Physical Parameters	Human Impact Parameters
Rate of Sea Level Rise	Reduction of Sediment Supply
Geomorphology	River Flow Regulation
Beach Slope	Engineered Frontage
Wave Climate	Natural Protection Degradation
Sediment Budget	Coastal Protection Structures
Tidal Amplitude	
Extreme Water Level	

The archeological heritage vulnerability module uses distance to the shoreline, the average elevation of the heritage site, and the directly exposed area as indicators to represent the site's interaction with the shoreline vulnerability determined by FCVAM results. Additionally, indicators such as the degree of protection, level of accessibility, tourism, economic importance, heritage typology, and land use pressure are considered to assess the susceptibility of the heritage site to understand the overall heritage vulnerability under the impacts of sea level rise. The heritage vulnerability module output will help prioritize the archeological heritage sites for adaptation planning and resource allocation.

RESULTS

Within the coastal area defined by the project, Türkiye has 1573 archeological and 1936 natural heritage sites located at the coast under possible risks of sea level rise. 22% of these heritage sites are located in the Mediterranean, 40% in the Aegean, 32% in the Marmara, and 6% in the Black Sea Region. First-degree heritage sites with the highest protection level constitute 33% of natural and 55% of the archeological sites at the coast. 362 of the archeological sites have elevations less than 10m, as shown in Figure 1.

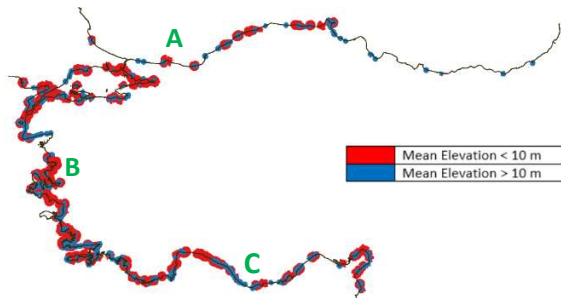


Figure 1 - Coastal archeological sites of Türkiye grouped by mean elevation.

Initial FVCAM model results are presented for three archeological sites from the Black Sea (Site A), the Aegean (Site B), and the Mediterranean (Site C) to provide an example of the use of FVCAM within the project. Data related to the sites are obtained from the open-source databases of Copernicus (<https://marine.copernicus.eu/>) and EMODnet (<https://emodnet.ec.europa.eu/>). Site A and Site C are urban areas with heritage zones, whereas Site B is a rural area with a heritage within a wetland. While Site A and Site C are exposed to waves directly, Site B is naturally protected but located in a very low-lying area. Therefore, these sites are expected to be vulnerable to different impacts of sea level rise. Results in Figure 2 indicate that the FVCAM model can reflect each site's local characteristics concerning varying impacts of sea level rise. Although overall vulnerability scores (CVI) determine moderate vulnerability (3.27-3.35 out of 5) for all sites, the high contribution of human activities to the vulnerability is present in the human impact score for coastal erosion (CE-HI=2.6) in Site A. On the other hand, physical parameter scores for inundation for Site B are very high (I-PP=4.2), reflecting wetland condition (periodically inundated) and mild slope of the region. Therefore, the vulnerability score for inundation (I) for Site B is much higher than the other two sites. The field observations also validate these results, with Site B having higher inundation episodes, whereas Site A and Site C already have coastal erosion problems driven by physical processes and human interventions. These sample results indicate the necessity to consider all the processes related to sea level rise to analyze the vulnerability of a site.

Integrating each site's archeological heritage characteristics will further differentiate the vulnerability levels of these sites. The implementation of the heritage

module is an ongoing process. The results of the heritage module will determine the final vulnerability ranking of archeological heritage sites. These ranking results will be presented with further discussions based on different sea level rise scenarios.

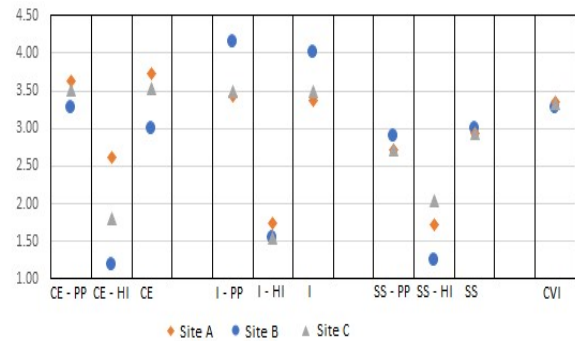


Figure 2 - FVCAM Vulnerability Scores (y-axis) for selected sites. CE: Coastal Erosion, I: Inundation, SS: Coastal Flooding due to EWL, CVI: Total vulnerability, PP: Physical Parameters, HI: Human Impact Parameters

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