FUZZY-BASED COASTAL VULNERABILITY MODEL APPLICATION ON TURKISH COASTS WITH HERITAGE SITES

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INTRODUCTION

Global sea level rise severely threatens the "Coastal Cultural Heritage Areas" and "Natural Conservation Zones". Considering the long shorelines and Anatolia's history, Turkey has many of these areas at its shores. The importance of these areas to Turkey's economic and social development goals cannot be disregarded. Thus, as a part of the TUBITAK-funded project (No: 122M613), the shorelines where nature conservation and coastal cultural heritage areas exist are to be studied for their vulnerability to the impacts of sea level rise. Although impact analysis of sea level rise, such as coastal erosion rate and flooded areas due to extreme water levels, indicate the vulnerability of shoreline, a holistic approach considering human activities and physical characteristics of the coastline presents a much more accurate representation of coastal vulnerability. Therefore, two shorelines with cultural and natural heritage characteristics (Elaia Ancient City, Izmir, and Sile, Istanbul) are analyzed in this study to show the advantages of the holistic approach, as the consequences of impacts could be irreversible for shorelines with heritage properties. Based on satellite imagery data, the selected sites have high coastal erosion rates (EMODnet coastal behavior dataset, https://emodnet.ec.europa.eu/). Sile is an urban environment, whereas Elaia Ancient City is part of a wetland.

FUZZY COASTAL VULNERABILITY ASSESSMENT

The coastal vulnerability is assessed by "Coastal Vulnerability Index (CVI)" which is determined by "Fuzzy Coastal Vulnerability Assessment Model (FCVAM)" (Ozyurt, 2010). The setup of the FCVAM model is moved from MATLAB to Python environment for open-source distribution of the model by modifying the simpful library (Spolaor et al., 2020) to define the fuzzy logic rulesets. Additionally, a Python-QGIS link is being developed to accelerate the assessment process by taking the inputs from the GIS environment directly for pre-processing and automatically getting the inputs of the model. While FCVAM model assesses sea level rise impacts on land, groundwater, and rivers along the coast, this study only focuses on coastal erosion, flooding due to storm surges, and inundation. Therefore, 12 input parameters out of 20 of the original parameter group of FCVAM model are used in the assessment (Table 1). The output of FCVAM model application provides CVI scores of individual impacts and a cumulative impact score. To ensure to reflect the local site conditions in the assessment, an extensive database is being collected and processed within GIS environment for each model input parameter.

Table 1 - Input Parameters of FCVAM model

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

RESULTS

The initial results show that although erosion rates via the EMODnet database indicate coastal erosion is a significant problem for these sites, Sile has higher vulnerability (4.00 vs. 3.11 out of 5.00) in terms of coastal erosion vulnerability, including the influence of sea level rise. In contrast, the wetland geomorphology improves the resilience of Elaia. On the other hand, flooding due to extreme water levels and inundation for both sites are similar, with higher vulnerability scores than coastal erosion. Overall CVI scores indicate moderate vulnerability (3.36) for Elaia shoreline and high vulnerability (3.79) for Sile considering the impacts of sea level rise on land. The results highlight the importance of a holistic approach rather than focusing on a single or narrow set of indicators.

This study also showed the importance of validating global/regional datasets at local levels. The coastal erosion rates by EMODnet database only sometimes reflect the local conditions. Similarly, datasets used as inputs have their advantages and drawbacks in the context of Turkey and for the project. This study will also present such examples in addition to the utilization of FCVAM model in the context of vulnerability of heritage sites to sea level rise. Additionally, alternative scenarios within the datasets (such as sea level rise scenarios) will be shown to provide an overview of the future vulnerability, which is valuable for decision-makers and stakeholders for adaptation measures.

REFERENCES

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