

ENHANCING COASTAL FLOODING RESILIENCE IN IZMIR BAY DUE TO SEA LEVEL RISE USING SOFT MEASURES

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INTRODUCTION

Climate change remains an ongoing global phenomenon, with one of its most significant consequences being the rising sea levels. This has led to an increased occurrence of coastal floods in both magnitude and frequency, thereby heightening the susceptibility of coastal cities. Izmir, a pivotal metropolis in the Aegean Region, features a natural coastline along its outer bay and an extensively urbanized shoreline within its inner bay. This urban landscape is dotted with various coastal structures utilized for diverse purposes such as social activities, tourism, and transportation. It is imperative that municipalities in coastal cities such as Izmir proactively address the heightened risk levels associated with these environmental shifts.

METHODOLOGY

Two primary measures are commonly employed for mitigating coastal floods: hard and soft solutions. Within the inner bay of the Izmir province, it has been observed that protective measures such as revetment walls and rock armors have predominantly been employed to counteract coastal flooding. The outer bay of this region has natural coastlines, often acclaimed for their touristic appeal, resulting in a high population density near shores.

The utilization of soft solutions for coastal flood prevention is distinguished by its environmental friendliness, as it refrains from employing artificial structures that might compromise the natural aesthetics of these coastlines. Natural shorelines possess the inherent capacity to adapt to evolving sea level conditions, thereby minimizing the impact of incident wave energy. Central to this approach is determining flood levels behind the shoreline, whether they surpass or fall below specified threshold values. Accordingly, suitable solutions can be applied. In scenarios presenting a risk of coastal flooding, beach nourishment emerges as a soft solution.

Beach nourishment, a soft solution approach, establishes a protective buffer zone designed to dissipate the energy of incoming waves and accommodate rising sea levels, effectively safeguarding the new beach. Figure 1 shows the areas along the natural coastlines of Izmir Bay suitable for beach nourishment, where soft solutions will be tailored to the unique characteristics of the selected region.



Figure 1- Areas Suitable for Soft Solution in Izmir Bay

The initial phase of this study entailed thoroughly examining bathymetry data, as provided by Navionics and İzmir Water and Sewerage Administration (IZSU) to assess the seabed slope directly in front of the shoreline (Figure 2). Also, sieve analysis outcomes from sand samples retrieved from the bay were examined, establishing the D_{50} value of the material for use in the numerical model as 0.01 mm.

The wave climate at the bay's entrance was calculated based on wind data from ECMWF. Then SWAN model was used to get the wave data in the bay along the coastlines. It was found that the wave heights range within 0.5-1.5m. The expected sea level rise was found around 1.0m (Kisacık, D., & Kaboglu, G. 2020).

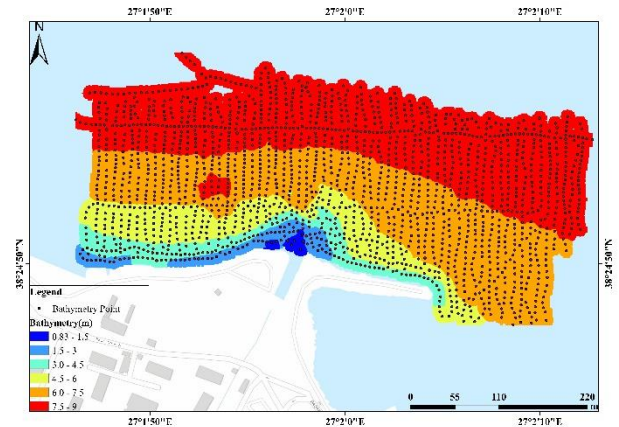


Figure 2- Bathymetry of the selected study area

The transformation of the seabed under the influence of evolving hydrodynamic conditions attributed to sea level rise will be explored using numerical models. XBeach, a

numerical analysis program developed at Delft University. It is a powerful tool capable of simulating morphological changes under dispersive and non-dispersive wave conditions (Roelvink, et al., 2009). This study employed XBeach to perform one-dimensional cross-shore profile morphological changes perpendicular to the shoreline. Laboratory experiments simulations were carried out in 1D using both the Non-Hydrostatic mode and Surfbeat mode of XBeach, focusing on the morphodynamics.

Initially, the shoreline's natural evolution without implementing beach nourishment, a soft solution, was examined to ascertain whether coastal flooding levels exceeded the prescribed threshold value. Subsequently, the numerical analysis was extended to include the alternative solution of beach nourishment.

In the next phase of this study, a comprehensive long-term analysis of longshore sediment transport was conducted using the open-source MATLAB code, ShorelineS. ShorelineS employed shoreline modifications corresponding to the proposed solutions, leveraging the CERC (1984) formula.

The XBeach numerical model was calibrated by referencing physical model tests carried out in the wave flume at the Middle East Technical University (METU) (Işık, 2019). This wave flume, shown in Figure 3, spans 29.0m in length, 6.0m in width, and 1.0m in depth. The physical tests replicated seabed alterations under various wave conditions, featuring an artificial shoreline comprised of uniform sand. Bathymetry measurements were executed to capture the evolving seabed geometry after each experiment. The magnitude of beach erosion, depending on wave height, sediment grain diameter, and wave steepness, was quantified during these physical experiments, utilizing three distinct wave heights (H_s in meters), wave periods (T_s in seconds), and a constant grain diameter (D_{50} meters), as summarized in Table 1.

Subsequently, the results of the XBeach model were validated against different physical test scenarios, which had not been considered in the calibration process. Numerous model parameters that are important to the simulation have been identified. It is observed that these parameters had a significant impact on the bed level change predictions. Therefore, a sensitivity analysis of the parameters was carried out. The calibrated model was then employed to assess the effectiveness of the soft solution option in mitigating coastal flooding under changing sea levels and extreme wave conditions along the natural coastline of Izmir Bay.

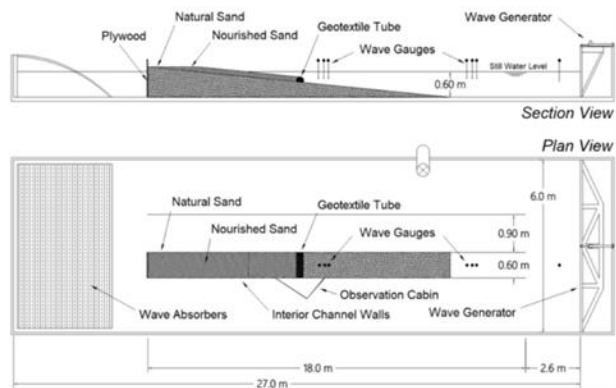


Figure 3- Section and Plan Views of Wave Flume

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Table 1- Different Wave Conditions Used in Physical Experiment

H_s (m)	T_s (m)	D_{50}
0.062	1.00	0.20
0.125	1.41	0.20
0.188	1.73	0.20