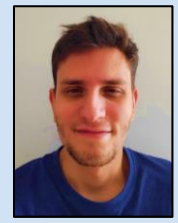
Analysis of coastal dynamics at regional scale in Sicily and defense approaches against coastal erosion

Università degli Studi di Palermo
dipartimento di ingegneria unipa



Pietro Scala
pietro.scala@unipa.it

Coastal hydraulics and erosion; land cover change, coastal defense and sustainable management

Climate change, such as sea level rise and storm surge, poses a significant challenge to coastal regions, directly impacting coastal erosion and beach surface loss (Martins et al., 2017; Pisano et al., 2020; Toimil et al., 2020). The impact of climate change on land also affects the land-sea system, further exacerbated by human activities (Borrelli et al., 2020; Froese and Schilling, 2019; Jia et al., 2019; Zhai et al., 2020). Coastal engineering, particularly coastal hydraulic research, studies the dynamics of shorelines, including waves, currents, tides, and sediments, which are essential for coastal management. In this scenario, coastal erosion, accelerated by human activities and climate change, threatens infrastructure, habitats and communities. Coastal urbanization, which will increase significantly in the coming decades (Merkens et al., 2016) has reduced over time and reduces the availability of natural sediments. Changes in land use and land cover therefore become crucial in littoral sediment dynamics. Wave analysis is also critical to understanding the natural transport of sediment and the impact of storms on the coast. Monitoring shoreline changes as a proxy for erosion, through increasingly innovative technologies, is therefore essential to assess the advancement or erosion of shorelines. With this in mind, coastal protection works, such as breakwaters and beach nourishment, are vital to mitigate erosion and protect beaches. Integrated coastal management, combining advanced scientific approaches and management policies, is essential to ensure the resilience and sustainability of coastal ecosystems.

Our scientific approach involves the use of advanced technologies to monitor and analyze the coastal dynamics of the entire Siicilian region. We use high-resolution satellite imagery processed through a semantic segmentation convolutional neural network model to track shoreline changes over time. A GIS plugin we developed automates the analysis of shoreline advances and retreats, providing metrics for coastal erosion assessment. The artificial intelligence model also allows us to obtain land cover trends in the coastal environment having been trained for the first time with a purely coastal image dataset, Coast Train (Buscombee et al., 2023) providing high and reliable performance in classification. The analysis thus allows us to map and analyze land use and its transformations, highlighting how urbanization affects coastal erosion. These data are then integrated with significant wave, direction, and period data to simulate the impact of waves, currents, and tides on sediment transport. Finally, we evaluate the effectiveness of coastal protection works through field data of existing works and the development of a predictive model of shoreline evolution in the presence of protection works, examining sustainable solutions such as beach nourishments and natural barriers. This integrated approach allows us to develop strategies for coastal analysis and management based on sound scientific evidence.

Research Objectives:

- Monitor and analyze shoreline changes as a proxy for erosion through the use of innovative technologies.
- Study the impact of urbanization and land use changes in the coastal environment on sediment availability and coastal erosion.
- Analyze wave climate and its effect on sediment transport along the coast.
- Assess the effectiveness of coastal protection structures and develop sustainable solutions to mitigate erosion.in vulnerable areas.