Coastal Risk Evolution and Changes in Coastal Systems: case study of north beaches in Costa de Caparica, Portugal

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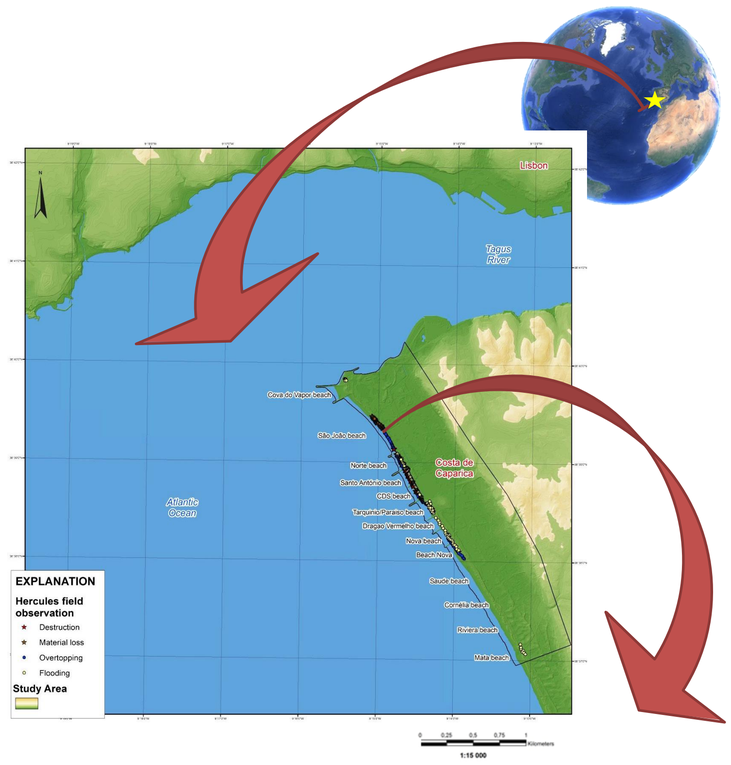
Overview

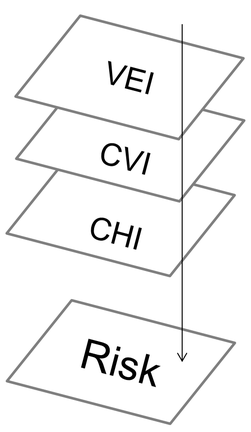
Costa de Caparica is a coastal city covered by 13 km of sandy beaches in the front Atlantic and is located south of the Tagus River approximately 17 km from the capital of Portugal (Lisbon). Since the 30's the city represents an important relevance in tourism and urban area occupation, specially during the summer. According to Veloso-Gomes et al., (2006) in the final of XIX century, was registered an important physiographic transformations (sand balance between river-land-ocean) and coastline retreat, leaving the urban front exposed to direct actions of the sea. Consequently, the adoption for heavy engineering works in the front of the urban area have been materialized, where the periods between 1959-1963 and 1968-1971 were the most significant with an introduction of a seawall of 2.5 km length and 7 jetties (180 m of length each). Despite the stabilization, the coastline retreated again on the winter of 2001, causing erosion and overtopping the dune system in São João da Caparica beach. On March 2007, a new storm with 5 meters waves height, reach the coast breaking the seawall in the south of São João da Caparica beach and flooding 70 meters of campsites located less than a 5 km from the beach. During this year, on January 6th (at 6:28pm UTC) and 7th (at 2:30pm UTC) the Hercules's storm reached Costa de Caparica with waves over than 7m height, predominant direction WNW and temporal period above 20 seconds, creating a massive flooding and overtopping in the urban central area and erosion through the south of natural beaches. Despite the negative coastal impacts have not resulted in loss of human life, the question emerged in turn of *"What is risk arising from the sea actions on coastal city?"*, "*Is it changing over the years?"* and *"What measures should we take?"* The present assessment of coastal risk fits into the 4th stage of HIDRALERTA project and takes in account the analysis of coastal hazards, coastal vulnerability and coastal exposure between 2014 and 1995, in order to identify the most critical areas linking to the alert system designed to support proper authorities in emergency situations, specially those occurring during storm season.



During Hercules's Storm (2014, January)

Consequences

Conceptual Model



Values of Exposed Elements (VEI) (Adapted *Pereira and Coelho (2013), Julião, et. al. (2009), Raposeiro, et al. (2010)*

$$VEI = \sqrt{Natural\ Protection\ Status * Heritage * Built\ density * Population\ density * Land\ Use}\Big/_{5}$$

Coastal Hazards Index (CHI)

$$CHI = \sqrt{Distance\ to\ coastline * Elevation}\Big/_{2} * \left(\left(\sum_{i=1}^{n} Flood\ Area\ i\right) * total\ of\ years\ analized\right)\Big/_{100}$$

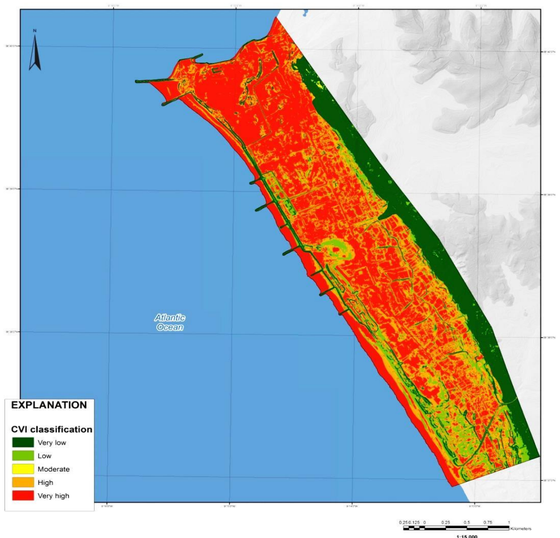
Coastal Vulnerability Index (CVI) (Adapted from *Dwarakisk, et al., 2009*)

$$CVI = \sqrt{Geomorphology * ShorelineChangeRate * Slopes * MeanTideRange * MeanSignificantWaveHeight * SeaLevelRise}\Big/_{6}$$

Preliminary Results

The model is based on coastal vulnerability of physical and geologic characteristics using CVI in which the difference from 1995 to 2014 between coastal areas with relatively high or low exposure to erosion and inundation during extreme events was none.

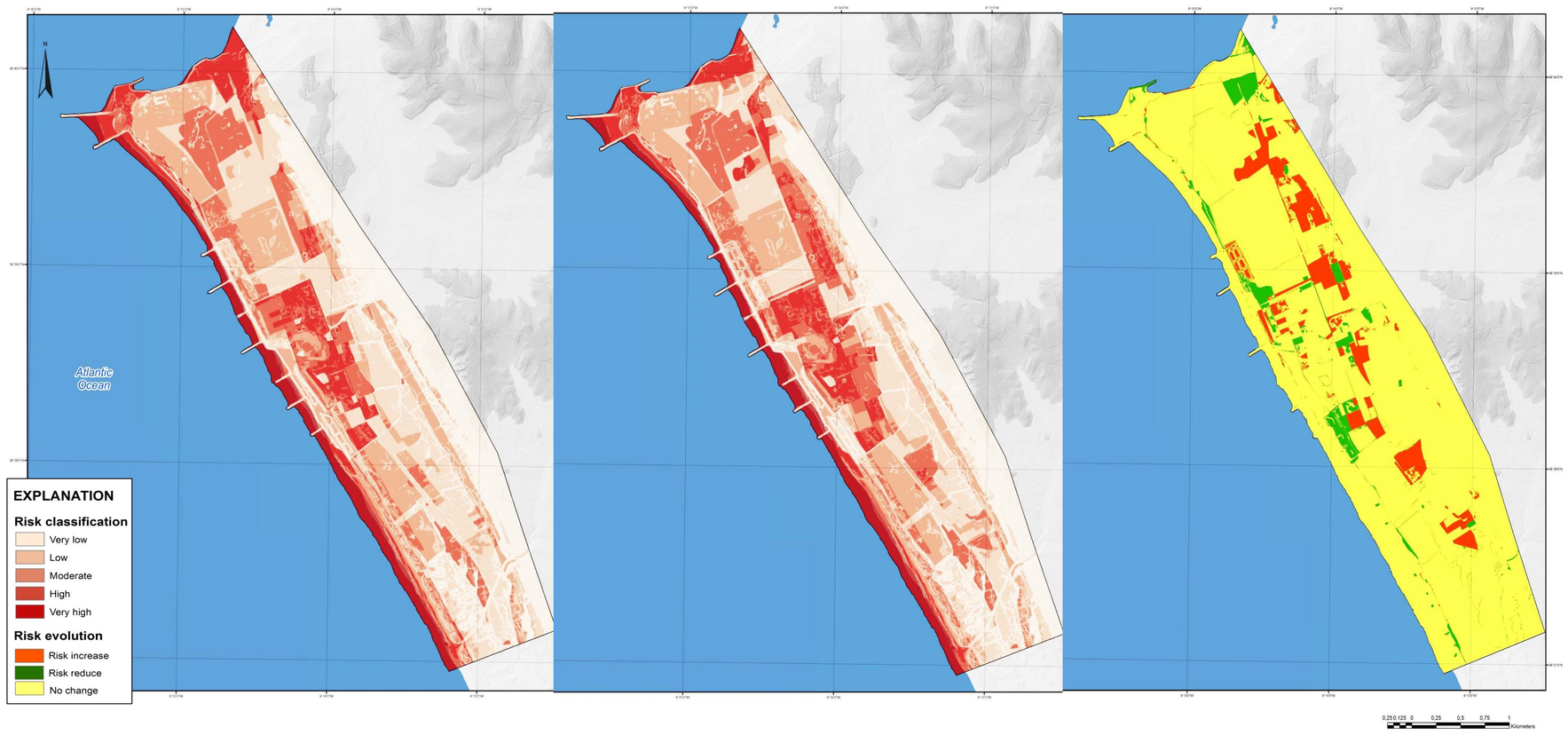
Coastal Vulnerability Index (1995 and 2014)



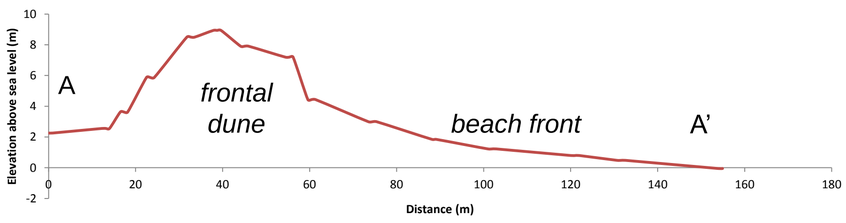
Coastal Risk 1995

Coastal Risk 2014

Coastal Risk Evolution

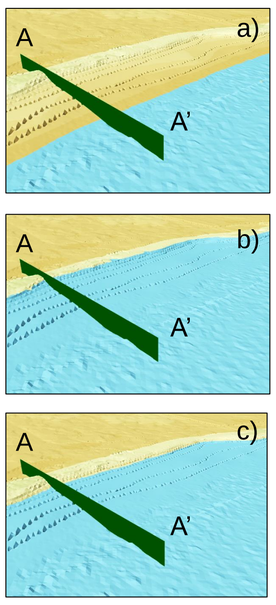


Validation of run-up formulations and flooding limits for São João da Caparica beach during Hercules



DD-MM-AA	06-01-14	07-01-2014	07-01-14
TIME	6pm	12pm	6am
Guza & Thornton (1982)	5,5	2,9	5,1
Teixeira (2009)	5,5	2,5	4,7
Stockdon, et al (2006)	7,9 c)	4,9 b)	7,4

a) Normal condition (run-up 1m)



Estimated value of the elements on the surface exposed to the sea actions

VEI CLASSIFICATION		Very low	Low	Medium	High	Very high
RANK		I	II	III	IV	V
%	2014	37,7	15,2	16,1	19,0	12,0
	1995	42,7	13,8	15,5	16,9	11,1

Changes occur in VEI due to the increase of urban area, population and built density. The natural protected status and heritage presence reduced to beach shacks related to the culture of local fishing remained the same until nowadays. Moreover, the requalification of Polis Program near to the beach areas in urban zone decrease the population density decreasing the risk of human loss in those urban areas of illegal genesis.

The proposed CHI relates the sea wave projections from 1979 to 2014, obtained through WAve Model (WAM) and Simulation WAves Nearshore (SWAN) to empirical formulations of run-up and structures overtopping on the coast. At the present we are facing the CHI validation process by comparing the results obtain from run-up formulations with the 16 beaches profiles collected on April, 2014 along the coast and the corresponding flooding limits collected during the Hercules' storm. As far the risk, preliminary results of 1995 and 2014 without assessing historical flooding areas until Hercules', shows critical areas in beach and frontal dune systems, density urban area, mainly in the north (near to the jetty) and the city.

Acknowledgements

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