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Coastal Vulnerability to Storms in the Catalan Coast

Memoria presentada por

Ernesto Tonatiuh Mendoza Ponce

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Director:

José Antonio Jiménez Quintana

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Chapter 7

Summary and conclusions

In this thesis, a methodological framework to assess the coastal vulnerability to storm impacts has been developed. It has been devised to be implemented at two spatial scales: regional and local –beach- scale and has been applied to the Catalan coast where a first vulnerability analysis to Mediterranean coastal storms has been obtained.

The methodology is based on the use of indicators to assess the coastal vulnerability to processes taking place during storm impacts. Two separate indicators were developed to quantify vulnerability in terms of storm induced erosion and flooding. In both cases, the developed indicators combine information about the impact (magnitude of the process/response) and capacity of adaptation/ resilience (characteristics of the coast such as beach width and/or elevation). Finally, the combined and synergic effect of both processes is taken into account through a global coastal vulnerability index.

The first step in the analysis was the characterization of the forcing. To perform this, a classification was specifically derived for recorded storms. This resulted in a five class storm category, dependant on the wave energy content ranging from weak to extreme events. The followed procedure including definition of storms, type of analysis and results –final classification- can be seen in **Chapter 3**.

To analyse the magnitude of the storm impact, the two main induced processes: flooding and erosion were separately considered.

The flood potential of the storms was quantified through the maximum water level associated to each storm including meteorological effects -storm surge- and wave induced run-up. Because this includes a site -specific- dependant variable (run-up), the analysis is done for the range of the existing beach profiles in Catalonia. Results show that the main component contributing to inundation along the Catalan coast is the wave induced one (run-up). The magnitude of the expected flood potential for each storm class for the Catalan coast can be seen in **Chapter 4**.

The erosion potential of the storms was quantified through the magnitude of the induced profile changes. In order to perform this, we combined the use of a beach profile evolution model -SBEACH- with beach profile predictors. Results showed the need to include beach initial slope and storm duration as key variables to properly predict the erosion potential. The magnitude of the expected erosion potential for each storm class for the Catalan coast can be seen in **Chapter 4**.

The two processes were used to estimate the respective vulnerability to each one. In both cases, two indicators were developed which combined the magnitude of the response –flood or inundation- and the capacity of adaptation or resilience (elevation or width). The Flood Vulnerability Indicator ***FVI*** and the Erosion Vulnerability Indicator ***EVI***, the indicators were formulated in a scale from 0 to 1 and qualitatively classified in 5 groups from 0 (*Very low* vulnerability) to 1 (*Very high* vulnerability). The development of both indicators including the formulation of the used conceptual model is presented in **Chapter 5**.

Both partial vulnerabilities were integrated into a total Coastal Vulnerability Index ***CVI***, to quantify the integrated (and synergic) effects of both processes. The proposed method assigns weights to the different classes of partial vulnerabilities to each process as a function of the expected impact on the total response.

Finally, once the methodological framework was developed, it was applied to the Catalan coast at two scales: regional and local. To do this assigned task, a GIS database for Catalan beaches was built including all the relevant information to be used in the analysis.

The relevant scale application permits coastal managers to associate a given set of wave conditions to one storm class and to obtain the corresponding vulnerability map of the Catalan coast where sensitive areas are clearly identified.

Because beach properties such as width and elevation strongly affect the estimated vulnerability, it is highly recommended to update the information as significant beach changes are detected. Otherwise, the obtained coastal vulnerability indicators will not properly reflect the capacity of adaptation /resilience of the beaches.

For the extreme storm conditions (class V), the application assessment results show that the most representative coastal vulnerability class for the Catalan coast is *High* with about 38% of the Catalan beaches within this category. If we also add the *Very high* class, this increases up to 55%.

Looking at the spatial distribution of the vulnerability, we identify a different response depending on the analysed process. Thus, for storm induced erosion the most vulnerable areas are located in the N part of Catalonia where reflective beaches dominate. If we consider flooding, a similar spatial pattern is observed with the addition of the Ebro Delta in the S, due to its very low lying profile.

In both cases (erosion and flooding), some local variations due to coastal orientation, sheltering or beach dimensions will determine the degree of vulnerability. Full details of the analysis can be seen in **Chapter 6**.

Finally the vulnerability analysis was downscaled to the beach scale and applied to Malgrat. The analysis permitted to combine the regional scale estimation of storm induced processes with detailed info of the beach characteristics.

Malgart beach was found to be more vulnerable to flooding than to erosion, being the most sensitive areas found on the edges of the beach (N and S boundaries). In terms of flooding, the most energetic storms (class IV and V) affected the entire beach, while in terms of erosion the same storms only affected the northernmost and southernmost parts of the beach. The full description can be seen in **Chapter 6**.

To summarise, this thesis shows that it is possible to quantitatively asses the vulnerability of the coast to a given process (storm impacts on this case). It also shows that this can be done with a limited amount of information and with a simplification of the involved dynamics. It also demonstrates that the obtained results can be helpful for the decision making process in coastal management.

Further research

Several challenges have been identified to improve the present methods and results.

- To extend-apply-develop approach to other processes inducing coastal hazards.

- Integrate socio-economic and natural values which would provide a broader view of the coastal system and thus, obtaining global vulnerability values.

- Advancing into the construction of a Decision Support System integrating the results with the “k*now how*” of Coastal managers.

- Put into practice the use of a model builder within the GIS in order to automate the series of steps involved in the geoprocessing work flow which would permit to update important information of the beaches and obtain a new assessment in a small amount of time.

- Implement this tool into a web map server that would allow executing the vulnerability index in a real time basis.