Multicriteria GIS-based estimation of coastal erosion risk: Implementation to Aveiro sandy coast, Portugal

Pedro Narra, Carlos Coelho & Francisco Sancho. Ocean & Coastal Management, 2019.

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The research

The research is about finding a better methodology for coastal erosion risks assessment. The “Coastal Erosion Risk Assessment” (CERA 2.0) is a new enhanced methodology designed by Narra et al. (2019) with reference to their previously proposed methodology CERA 1.0 (Narra et al., 2017) which was addressing the shortcomings of the first Coastal Erosion Risk Assessment methodology (CERA) proposed by Coelho (Narra et al. 2017 citing Coelho, 2005).

Coastal regions are essential to be protected and appropriate mitigations must be planned if required as major population around the world lives in coastal regions.

Aims:

- Introduce a methodology for identifying risk for short-term and long-term coastal erosion.
- Support coastal management for wave dominated sandy beaches with risk evaluation.

Objectives:

- Define and implement risk propagation process with module driven design by using comprehensive set of indicators with QGIS.
- Apply the methodology to Aveiro sandy coast and identify high risk areas.

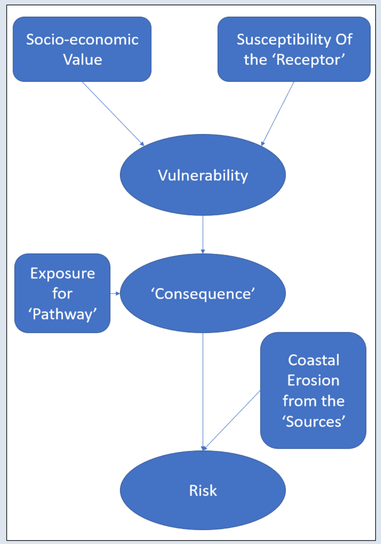

Fig. 1. Risk Map for Aveiro and Fig. 2. Framework of CERA 2.0 (Narra et al., 2019)

Method and Modules

The CERA 2.0 follows Source-Pathway-Receptor-Consequence model (Narra et al., 2019 cites Samuels and Gouldby, 2009) which identifies a source of the hazard, a path it follows to reach the receptor to cause harm as a consequence (Narra et al., 2019). Refer Fig. 2, Fig. 3 and Table 1 below for the implementation of SPRC process.

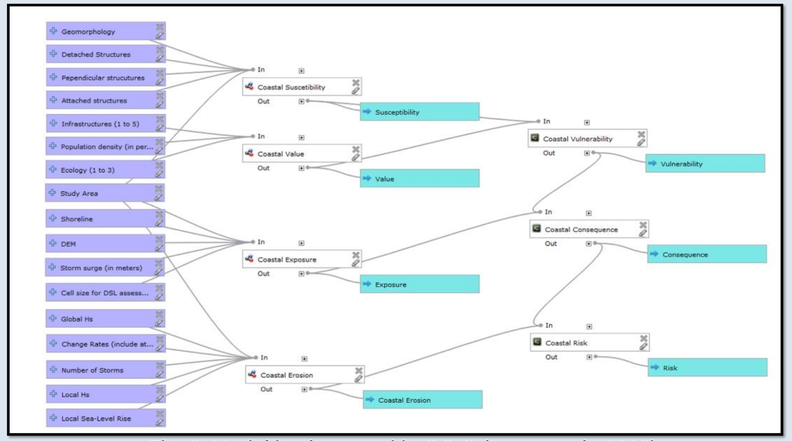

Fig. 3. Model implemented in QGIS (Narra et al., 2019)

Indicators	Data Measurements / Classification
Geomorphology	Geologic composition, topography using aerial images.
Coastal Defenses	Resistance introduced to prevent erosion
Infrastructure	No structure, urban agglomeration towns/cities, highly populated area or critical infrastructure.
Population Density	5 classes with different density measured in people/km^2
Ecology	None, moderate or high ecological relevance.
Distance to the shoreline	5 classes with different distances measured in meters.
Topography	5 classes for different elevations.
Storm Surge	Abnormal rise in seawater during the storm (measured in meters).
Mean Significant Wave Height (WH)	Measured in meters, divided in 5 classes.
Number of Storms per year (St)	0, 1-5, 5-10, 11-15 and 16+
Shoreline change rates (Scr)	Shoreline under accretion, stable, erosion, intense or severe erosion.
Local Sea-level Trends (Slt)	Changes in sea-level trend measured in mm/year.

Table 1. Indicators used in the model(Narra et al., 2019)

Results, Discussion, Analysis & Evaluation

The research uses QGIS software (Graphical Module) with custom plugin to process through the data collected for all indicators from Aveiro coast in Portugal. Overall, the research offers many likable positives and shortcomings as well.

One of the positives is that the CERA 2.0 is **improved and structured** by using 12 indicators and 4 modules compared to CERA 1.0 which used 9 vulnerability and 4 consequence parameters only. Moreover, the model is performance tested with **controlled sensitivity analysis** using 1 million samples for each indicator. The study also found that **shoreline erosion rate** indicator had the most effects to the risk value calculated followed by other indicators related to natural phenomenon such as storm surge, distance to shoreline etc. Whereas the population and infrastructure in the region were observed to have lesser impact for coastal erosion risk value.

About the shortcomings, it can be noted that real world **data gathering was kept limited** to North Atlantic Ocean only for the wave climate indicator. It would have been better if data samples were collected from multiple regions across the world for more reliability. Furthermore importantly, when all the indices of all the indicators are calculated, **0.055 constant is added to all the equations** to avoid asymmetrical distribution. It is understood that without this additional constant normal distribution would not be achieved. However, it raises question that how reliable it is to add a constant to all the equations for the accuracy of the overall risk evaluation.

Also, to find **better alternative**, it is necessary to see what are the proposed methodology lacks to address. To do so, first, **neither CERA 2.0 nor its predecessors use traditional multicriteria analysis techniques** which proposes finding best alternative by using multiple criteria which are scored, weighted and ranked to find the closest one to meet a desired goal. Where as, there are other methodologies proposed for erosion assessment which uses more than one multicriteria analysis techniques including Weighted Linear Combination and Analytical Hierarchy Process along with other models (Cartwright et al., 2022). The research conducted by Cartwright et al. (2022) for watershed erosion is for assessing total erosion considering land sensitivity, physical erodibility, and precipitation erosivity factors (Cartwright et al., 2022, p. 6). Comparatively, such methods account for much larger area for finding erosion potential. On the contrary, the methodology has **limited applicability to only sandy coastal beaches** as it is not directly applicable to other coastal regions where erosion could also be a threat. Thus, **a better alternative** to this would be a methodology **which introduces a builds up on multicriteria analysis technique** to propose a new process that is **applicable to all types of coastal erosions**.

References

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