

## Beach multi-risk assessment considering ecosystem services and coastal hazards: a tool for ICZM

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Natural hazards are recurrent events which can produce economic damages and the loss of human lives becoming natural disasters (Pérez-Maqueo *et al.* 2007). Caused by natural factors or induced by anthropogenic activities, they are the outcome of development process whereby societies have generated vulnerabilities and risks (World Economic Forum 2009). On the coastal zones, damages have been strong mainly because of massive human concentration and their associated infrastructures (Costanza & Farley 2007). In a near future, global warming processes will increase severity and frequency of such coastal damages (Raschky 2008).

Beach management has traditionally concentrated on geomorphic hazards and the recreational human-use of beaches, overlooking their ecological and broader environmental values (Ariza *et al.* 2008). As coastal management, risk reduction requires a systemic vision considering interactions between natural and socioeconomic variables (Ecosystem Approach). Coastal risk programs tend to be reactive and risk assessment still focuses on tangible damages to assets, overlooking other intangible damages associated to the ecosystem functions, which normally lead that risk management only manages a part of the total risk (Meyer *et al.* 2009).

In order to improve coastal zone management we have developed a beach multi-risk assessment approach, which integrates the beach ecosystem services and coastal hazards. The proposed methodology starts (Vulnerability profile) with the identification and characterization of ecosystem services (receptors) provided by the beach and the stressors (hazards). The potential exposure is defined through a conceptual model (DPSIR), prioritizing both ecosystem services and hazards.

The regulatory responsibilities, related to the hazards identified and the ecosystem services provided by the beach, were also analyzed in this step. An overview of

these key administrative aspects could be particularly useful in order to identify the appropriate jurisdictions which may be affected in a risk assessment.

In the next step (Risk Assessment) the economic valuation of ecosystem services and the hazards quantification was done, in order to obtain a risk characterization. Considering subsequent interactions with risk managers, this framework allows risk estimation per ecosystem service, per hazard and for the entire beach.

Risk Analysis is internationally recognized as an approach to assist decision making. This analysis provides managers with an objective, repeatable and documented assessment of the risks posed by a particular course of action, which can also be included into widely used environmental management systems applied today for planning and decision making (e.g. ISO 14001). In our case, a risk-based approach helps managers to prioritize ecosystem functions and services, and focus efforts when regulating hazards which are considered to have the greatest potential impact, improving and supporting an integrated coastal zone management process.

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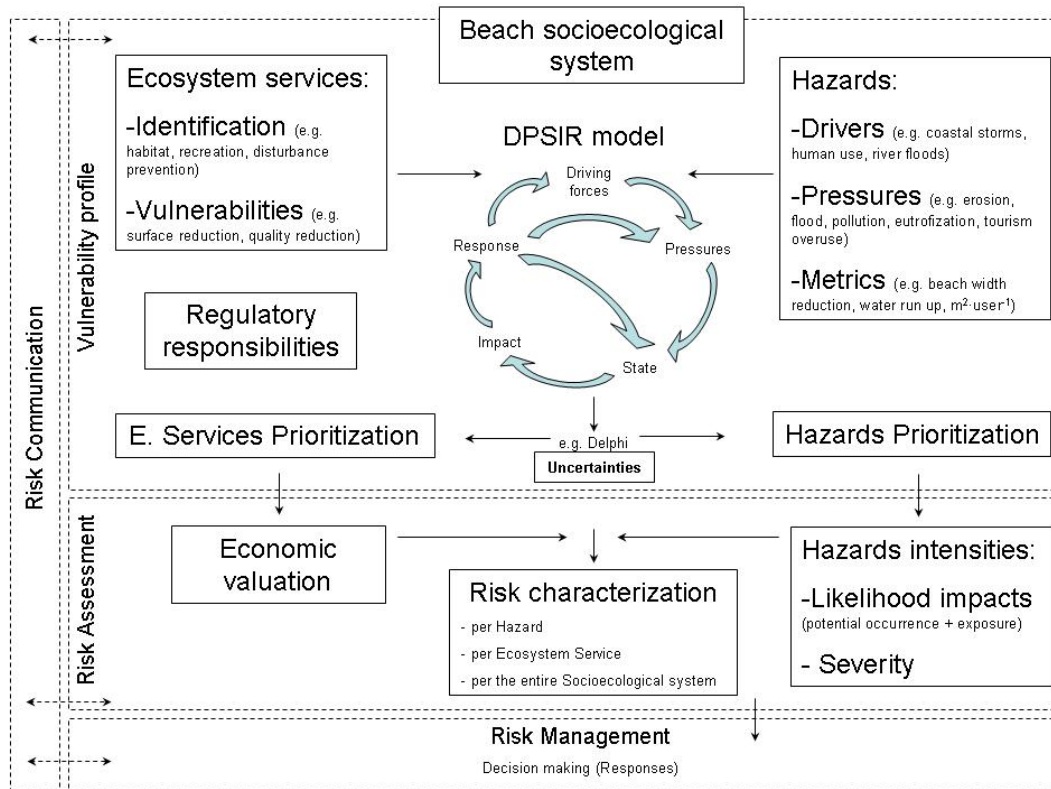


Diagram of the beach multi-risk assessment, presenting the main steps of the proposed methodology