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Coastal vulnerability assessment using Fuzzy Logic and Bayesian Belief Network approaches

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Natural hazards such as sea surge are threatening low-lying coastal plains. In order to deal with disturbances a deeper understanding of benefits deriving from ecosystem services assessment, management and planning can contribute to enhance the resilience of coastal systems.
In this frame assessing current and future vulnerability is a key concern of many Systems Of Systems SOS (social, ecological, institutional) that deals with several challenges like the definition of Essential Variables (EVs) able to synthesize the required information, the assignment of different weight to be attributed to each considered variable, the selection of method for combining the relevant variables.
It is widely recognized that ecosystems contribute to human wellbeing and then their conservation increases the resilience capacities and could play a key role in reducing climate related risk and thus physical and economic losses. A way to fully exploit ecosystems potential, i.e. their so called ecopotential (see H2020 EU funded project "ECOPOTENTIAL"), is the Ecosystem based Adaptation (EbA): the use of ecosystem services as part of an adaptation strategy. In order to provide insight in understanding regulating ecosystem services to surge and which variables influence them and to make the best use of available data and information (EO products, in situ data and modelling), we propose a multi-component surge vulnerability assessment, focusing on coastal sandy dunes as natural barriers. The aim is to combine together eco-geomorphological and socio-economic variables with the hazard component on the base of different approaches: 1) Fuzzy Logic; 2) Bayesian Belief Networks (BBN).
The Fuzzy Logic approach is very useful to get a spatialized information and it can easily combine variables coming from different sources. It provides information on vulnerability moving along-shore and across-shore (beach-dune transect), highlighting the variability of vulnerability conditions in the spatial dimension. According to the results using fuzzy operators, the analysis greatest weakness is the limited capacity to represent the relation among the different considered variables.
The BBN approach, based on the definition of conditional probabilities, has allowed determining the trend of distributions of vulnerability along-shore, highlighting which parts of the coast are most likely to have higher or lower vulnerability than others. In BBN analysis, the greatest weakness emerge in the case of arbitrary definition of conditional probabilities (i.e. when there is a lack of information on the past hazardous events) because it is not possible to derive the individual contribution of each variable.
As conclusion, the two approaches could be used together in the perspective of enhancing the multiple components in vulnerability assessment: the BBN as a preliminary assessment to provide a coarse description of the vulnerability distribution, and the Fuzzy Logic as an extended assessment to provide more space based information.