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The main aim of the research presented herein is to define and implement an integrated methodological framework to identify and assess potential adaptation strategies to the impacts of sea level rise on coastal areas, and in particular on the Grado-Marano lagoon, in north-eastern Italy.

The approach analyses the potential synergies of combining elements belonging to different research fields, with the aim of contributing to the management of the complexity and uncertainty characterizing climate change issues.

The proposed methodology is built upon the sequential use of specific tools, which are based on the integrated application of conceptual modelling and expert judgment elicitation techniques, decision analysis and probabilistic modelling, within the broader framework of the NetSyMoD methodology (Giupponi et al. 2008; www.netsymod.eu/), previously developed, facilitating the involvement of stakeholders or experts in policy- or decision-making processes.

The assessment of the impacts of sea level rise on the lagoon of Grado and Marano is characterized by the involvement of a high number of disciplines, which apply different measurement and analysis methods, and produce a huge amount of heterogeneous data that need to be analysed jointly to constitute an appropriate support for the definition of effective adaptation policies. Uncertainty is pervasive in the definition of future projections of sea-level change and of technological and socio-economic development. Several attempts have been made to assess the complexity and incorporate the uncertainty in climate change policy analyses and, despite their different perspectives, they all agree on the importance to identify and implement an integrated approach to formally structure environmental and socio-economic issues into a single assessment framework.

The methodology developed for the Grado-Marano case study, proposes a suite of tools, which starts from the definition of a shared conceptual model for the local socio-ecosystem analysis, by means of participatory modelling techniques allowing the integration of knowledge of experts belonging to distinct disciplines. In particular, the main vulnerability factors of the area were discussed during a workshop in which the system's components were identified and the relationships existing among them were collected and discussed using cognitive maps, and then formalized into the DPSIR causal framework.

Later on, a Bayesian Decision Network (BDN) model was built, where nodes represented the main variables of the system and arcs made each cause-effect link explicit. The

conditional probability tables underlying each node were populated using judgments elicited from the experts through interviews and specific questionnaires. Value nodes measuring the expected gain or loss of each economic sector were inserted as outputs of the BN. The propagation of probabilities through the connected nodes made it possible to analyse different scenarios of sea level rise and to assess the effectiveness of alternative adaptation strategies, according to their consequences on the factors of the systems and on the value nodes.

Drawing on the application of the methodology to the case study, the main advantages and the possible shortcomings arising from the development and application of the integrated approach can be preliminarily discussed. The use of cognitive maps enhances the interaction among the experts and the consequent integration of different domains of knowledge into a shared framework of analysis. Its formalization into a Bayesian Decision Network allows the incorporation of expert subjective knowledge with empirical data and information coming from models, improving the management of issues characterized by lack of data. Alternative management approaches can be tested through the development of BNs, and different future scenarios can be studied by entering new information into the network, since this change is propagated throughout the BN, to the endpoints. The updating process of the BN and the use of conditional probabilities within the model implicitly incorporate uncertainty in the outcomes. The Bayesian decision network developed for the case study combines probabilistic reasoning with value functions, allowing to make decisions that maximize the expected value, which could also be expressed in monetary values. Together with the advantages of the tool, a number of issues should also be considered, such as BNs' difficulties in dealing with situations where the complexity needs to be represented in great detail or where feedback loops must be incorporated into the analysis, or the limited potential of the tool to incorporate continuous variables, and the risks linked to the use of experts judgments. Alternative solutions are then proposed to overcome the above limits.

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