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A review of cumulative impact assessment approaches and their applications for integrated management of marine and coastal ecosystems

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Abstract

Cumulative impacts increasingly threaten marine and coastal ecosystems. The growing interplay between climate change hazards and human-induced pressures from land-based and maritime activities are exacerbating environmental risks, resulting in severe water quality degradation, biodiversity loss and decline in the provisioning of ecosystem services for human well-being. To address these issues, the research community has started designing and testing different methodological approaches and tools that apply cumulative impact appraisal schemes for a sound evaluation of the complex interactions and dynamics among multiple pressures affecting marine and coastal ecosystems.

Through an iterative scientometric and systematic review, this study provides a state of the art of these methods, giving a specific emphasis to the identification of cutting-edge approaches (e.g., machine learning-based models) exploring and modeling inter-relations among climatic and anthropogenic pressures, vulnerability and resilience of marine coastal ecosystems to these pressures, and the resulting changes in the ecosystem services flow. Despite the recent advancements in computer sciences and the rising availability of big data for environmental monitoring and management, this review revealed a limited implementation of advanced complex system methods. Moreover, only recently experts have started integrating ecosystem services flow into cumulative impact appraisal frameworks, as generally assessments endpoint within the overall evaluation process (changes in the bundle of ES against cumulative impacts).

The present two-tiered review also highlighted a lack of integrated approaches and complex tools able to frame, explain, and model spatio-temporal dynamics of marine coastal ecosystems' response to multiple pressures, as required under relevant EU acquis (e.g., Water Framework and Marine Strategy Framework Directives). Progress in understanding cumulative impacts, exploiting the functionalities of more sophisticated machine learning-based approaches (e.g., big data integration), will support decision-makers in the achievement of environmental and sustainability targets.

Keywords

Cumulative impacts, Marine Coastal ecosystems, Multi-risk, Ecosystem services