

Climate-Related Vulnerability and Risk Assessment of Main Ocean Uses: An Overview

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Introduction

The concepts of vulnerability and risk have long been applied in a variety of contexts, including the assessment of anthropogenic and natural hazards to human, health, nature, or economic growth^{1,2}. More recently, vulnerability and risk analyses have been increasingly used to address climate change effects on the ocean^{3,4}. However, finding definitions of vulnerability and risk that are consistently applied and accepted is not straightforward, due to the myriad of existing designations and interpretations, and the variety of fields in which they are applied (e.g., environmental, social, economic)³. As well, while some frameworks define vulnerability as the result of a system's sensitivity, exposure, and ability to adapt to a given hazard⁵, others consider exposure to be external to vulnerability⁶. Still, these analyses – particularly when developed in a spatially explicit way⁷ – allow for a deeper understanding of how environmental goods and services, dependent economies, and human communities are impacted by climate change effects, together with their ability to respond and adapt³. They are, therefore, fundamental tools to properly inform and support marine spatial management processes⁸, thus contributing to the conservation and sustainable use of the ocean⁹. Of particular importance, is the relevance of these tools to marine spatial planning (MSP). Recognized as a vital process to achieve global ocean governance goals and currently expanding worldwide, MSP initiatives organize the spatial use of the ocean, striving to balance multiple human needs and nature conservation¹⁰. In order to be sustainable and relevant under a changing climate, MSP requires information on where changes in ocean uses and ecosystems are most relevant – a type of information that is typically acquired through spatial assessments of vulnerability and risk⁸.

In such context, a key question arises:

What are the main trends, challenges, and limitations of existing assessments, and what are the potential pathways to overcome them?

Methodology

In the present study, we developed a systematic literature review to analyze and discuss the key concepts, methodologies, and limitations of existing vulnerability and risk assessments of main ocean uses to global climate change. Selected publications were analyzed regarding the main ocean uses and climate-related drivers of change addressed, and existing references to ocean planning and management or the blue economy. For “case study-based” publications – that is, studies developing an explicit assessment for a particular area resulting in specific risk/vulnerability values (instead of only discussing conceptual aspects, in which case they were considered as “conceptual” publications) – an in-depth analysis was carried based on: spatial scale (local to global); elements considered in the analysis (e.g., exposure, sensitivity, adaptive capacity); dimensions focused by the analysis (ecological, social, economic); and type of indicator used (qualitative, quantitative).

In this Mini Review, we summarize evidence from 314 scientific articles and reports published until 2020. The primary source of data used was the Web of Science (WoS) collection. Studies available in a language other than English were translated with Google Translate prior to being processed.

Results

A total of 77 conceptual publications and 237 case study-based publications were identified.

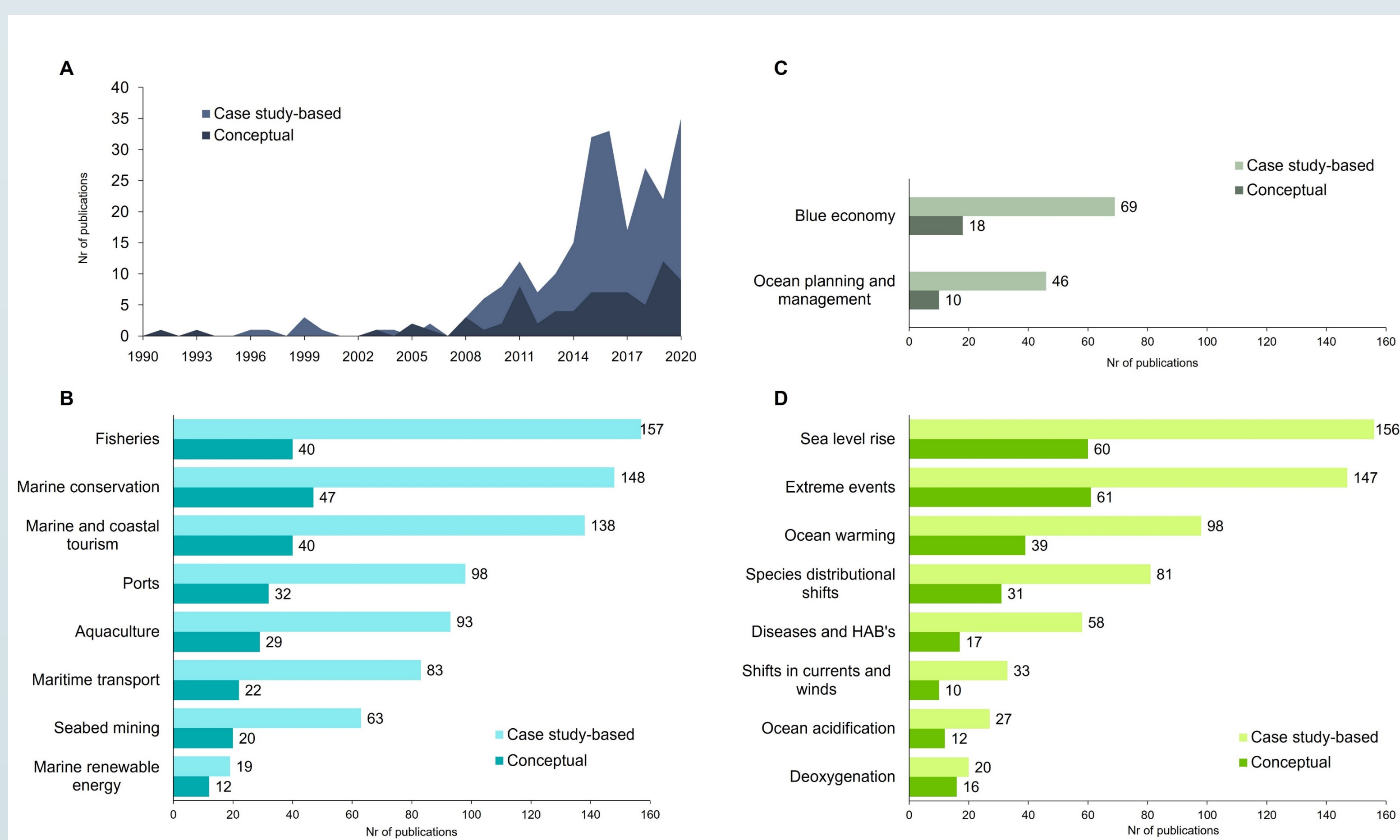


FIGURE 1 | Number of publications included in the analysis according to the year of publication (A), ocean uses addressed (B), references to ocean planning and management, or the blue economy (C), and climate-related drivers of change addressed (D). Case study-based publications (n = 237) pertain to those developing a clear assessment for a particular area resulting in specific risk/vulnerability estimates; conceptual publications (n = 77) pertain to the ones discussing conceptual aspects only. Nr, number; HABs, harmful algae blooms.

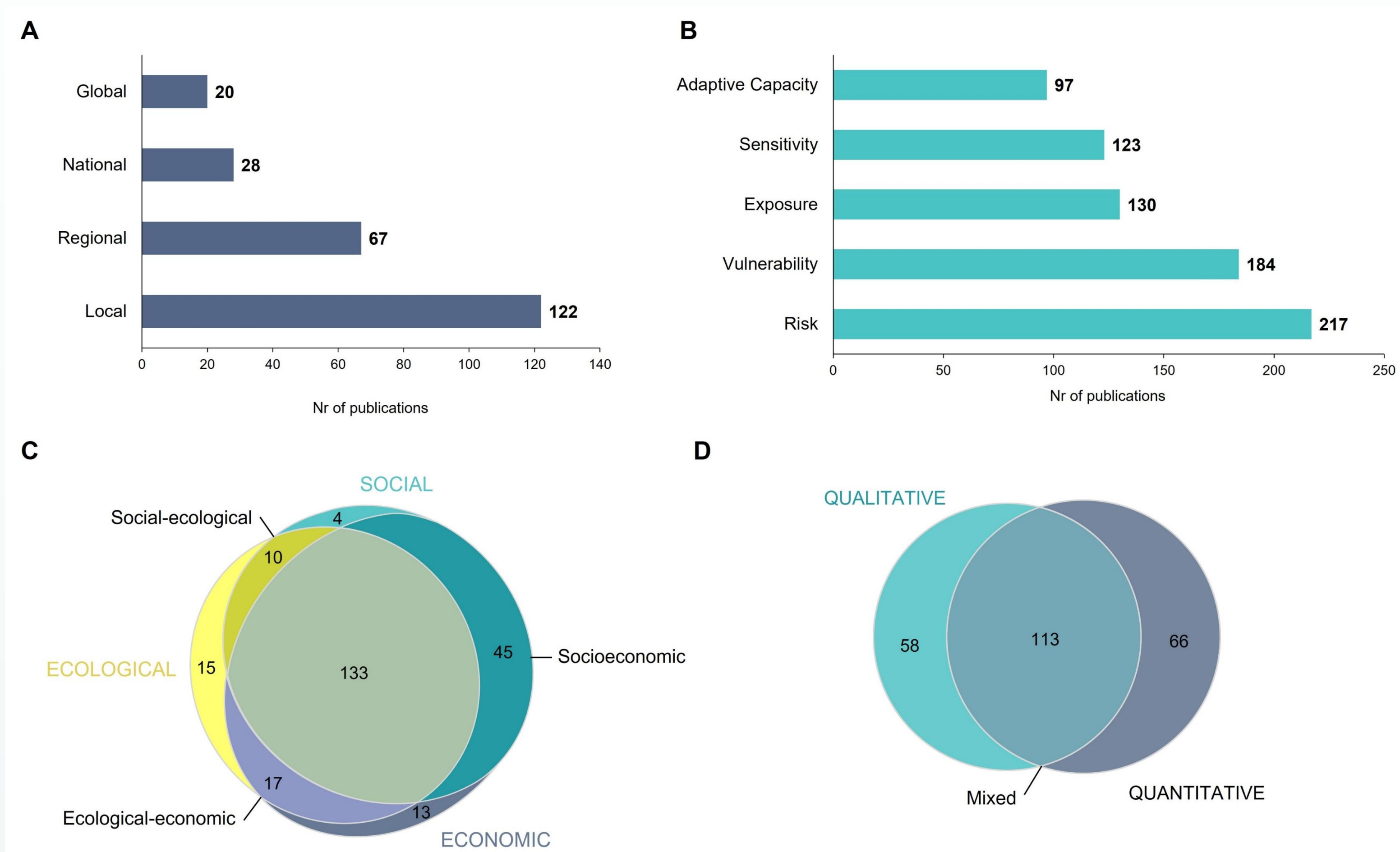


FIGURE 2 | Number of case study-based publications according to the spatial scale of the publication (A), risk and vulnerability-related elements considered in the analysis (B), dimensions focused by the analysis (C), and type of indicator used (D). Proportional Venn diagrams (C,D) were developed using R Statistical Software.

Conclusion

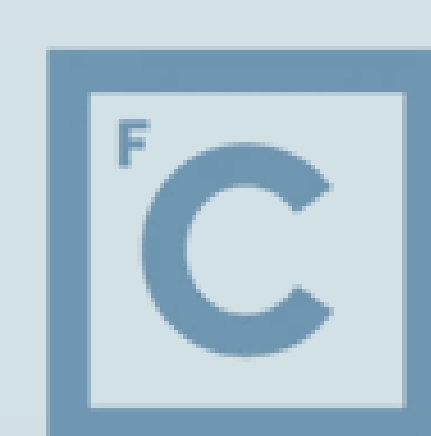
- This review found that the most used and accepted definition of vulnerability was the one from the fourth assessment report by the Intergovernmental Panel on Climate Change (IPCC) – where vulnerability is defined as the result of the interaction between exposure, sensitivity, and adaptive capacity⁵;
- There is a great focus of assessments on ocean uses such as fisheries, marine conservation, and marine and coastal tourism, and specific drivers of change, such as extreme events and sea-level rise;
- Different ocean uses tend to be analyzed individually, on a sector-by-sector basis, which explains the observed little reference to multi-objective, holistic management approaches, including MSP or the development of a sustainable blue economy;
- There is an ongoing transition from purely quantitative studies focused on one or two dimensions of vulnerability, to more integrated studies focused on assessing adaptive capacity, social resilience, or the vulnerability of the systems as a whole, considering various stress factors and exploring combined effects.

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