Evaluating the effectiveness of nature-based solutions to climate change adaptation: A literature review of existing frameworks and indicators

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1. INTRODUCTION

Climate change is generating a broad range of negative impacts worldwide, particularly on marine and coastal ecosystems (MCE) (IPCC-SROCC, 2019 and IPBES-IPCC, 2021). These impacts include coastal flooding and erosion, sea-level rise and storm surges. To adapt to these adverse effects and improve the well-being of coastal communities, engineered approaches have traditionally been used; however, there is growing recognition of the potential of Nature-based Solutions (NbS) to address these impacts while enhancing biodiversity (Baustian et al., 2020 and Chausson et al., 2020). NbS are actions that aim to address societal challenges and provide social-ecological benefits by harnessing ecological processes (Cohen-Shacham et al., 2016). They have the potential to support climate change adaptation, for example, through storm surge attenuation, wave height reduction and flood protection; thus, enhancing ecosystem resilience and the provision of ecosystem services (i.e., improved fish stocks, biodiversity conservation, coastal tourism and recreation) (Chausson et al., 2020; Seddon et al., 2020; UNEP, 2021).

Despite their growing political traction, NbS for climate change adaptation still face numerous challenges and uncertainties that obstruct their wider acceptance by policymakers and effective implementation (Seddon et al., 2020 and UNEP, 2021). Uncertainties are linked to their performance and effectiveness compared to grey and engineered interventions. Another challenge is identifying appropriate indicators to evaluate their effectiveness in supporting climate change adaptation and ecosystem service provision (Seddon et al., 2020).

Through this work, we aim to better understand existing frameworks to evaluate the socio-economic effectiveness of NbS, inform the design of future monitoring and evaluation plans, and address challenges linked to their performance.

2. METHODS

We carried out a comprehensive literature review to identify frameworks used to evaluate the socio-economic effectiveness of NbS within MCE. After selecting relevant articles, we extracted and examined the frameworks' key characteristics. These characteristics included the purpose of the frameworks, their time of application (before, after or during the NbS implementation), the assessed social or economic benefits and the indicators used to measure the socio-economic performance of NbS.

3. MAIN RESULTS

All relevant articles analysed are recent studies dating from 2016 to 2022, which highlights the recent growing interest in NbS worldwide.

Among all studies, only one (Takavakoglou et al., 2021) evaluated the effectiveness of NbS within the marine environment. This study assessed the economic performance of floating wetlands constructed for marine pollution control in Lerissos Port (Northern Greece). In addition, only one article (Kumar et al., 2021) took into account coastal ecosystems among various environments. The authors developed socio-economic performance/impact indicators to monitor NbS performance against five hydro-meteorological risks through a global analysis. Some articles presented case studies within urban environments, the case of Pugliese et al. (2022), Dumitru et al. (2020) and Liquete et al. (2016). Others presented theoretical frameworks without an applied case study (Sowińska-Świerkosz and García, 2021) and (Calliari et al., 2019).

Most frameworks propose NbS effectiveness assessment of specific social and/or economic benefits and can be categorised as theoretical or applied to a particular case study or solution. Theoretical frameworks provide principles to guide the design of evaluation schemes and impact evaluation frameworks for NbS with broad guidelines and indicators (Dumitru et al., 2020 and Kumar et al., 2021), whereas applied frameworks provide ex-post assessments. The latter offer a list of specific quantitative indicators to evaluate the socio-economic effectiveness of a solution that could be replicated and applied to assess NbS interventions (Pugliese et al. (2022), Takavakoglou et al. (2021) and, Liquete et al. (2016)).

For example, Pugliese et al. (2022) developed a comprehensive assessment framework tool composed of a set of key performance indicators to evaluate the restoration of the urban extension of the Isar river in the city of Munich against traditional solutions from different perspectives. From the social and economic perspective, the authors evaluated the community involvement and governance, the quality of life and the revitalization of marginal areas using indicators such as the number of public-private partnerships activated, the number of new restaurants opened, the length of new pedestrians and cycling paths created, etc.

The exception to this rule was the study carried out by Sowińska-Świerkosz and García (2021), where although the authors didn't present an application to a specific case study, they provided an exhaustive list of quantitative and qualitative indicators that could be useful to support the design of frameworks to evaluate the socio-economic effectiveness of NbS at the stage of the project selection.

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