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A Multicriteria Analysis to Integrate Stakeholder Perceptions of Ecosystem-Based Flood Adaptations in Coastal Urban Areas

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Abstract

Inland and coastal floods are becoming more frequent and severe, affecting natural and socioeconomic systems. Local adaptation to climate change involves complex decisions which benefit from the integration of opinions from different stakeholders in the design and decision process. This study contributes to the incorporation of stakeholders' views and preferences in the decision-making process. It uses a living lab (LL) approach to develop a multicriteria analysis (MCA) and is flexible enough to adapt to different geographical contexts and needs. Living lab enables innovative solutions to specific problems to be defined, designed and created through a social-iterative approach. MCA is a suitable

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decision-making tool, as it allows qualitative parameters to be quantified and evaluation criteria to be weighted. This study presents the results of a MCA applied to the evaluation of Ecosystem-based Adaptation (EbA) to flooding in three coastal city living labs: Vilanova i la Geltrú and Benidorm (Spain) and Oeiras (Portugal). Stabilisation of the riverbed and riverbanks and the planting of riparian vegetation were considered suitable adaptation options to reduce the risk of flooding, particularly in the context of intermittent and perennial rivers, while contributing to significant co-benefits such as biodiversity conservation and improvement, and landscape aesthetic value.

Keywords: sustainability; flooding; ecosystem-based adaptation (EbA); Living Labs; Multicriteria Analysis (MCA)

Resum. *Una anàlisi multicriteri per integrar les percepcions dels actors clau en l'adaptació basada en ecosistemes per a inundacions en zones urbanes costaneres*

Les inundacions continentals i costaneres són cada cop més freqüents i greus, i afecten els sistemes naturals i socioeconòmics. L'adaptació local al canvi climàtic comporta decisions complexes que es beneficien de la integració de les opinions de les diferents parts interessades en el procés de disseny i de decisió. Aquest estudi contribueix a la incorporació de les opinions i preferències de les parts interessades en el procés de presa de decisions basant-se en un enfocament de laboratori viu (LV) per desenvolupar una anàlisi multicriteri (AMC), flexible per adaptar-se a diferents contextos geogràfics i necessitats. Els LV permeten definir, dissenyar i crear solucions innovadores a problemes específics a través d'un enfocament social i iteratiu. L'AMC és una eina adequada per prendre decisions, ja que permet quantificar paràmetres qualitatius i ponderar els criteris d'avaluació. Aquest estudi presenta els resultats d'una AMC aplicada a l'avaluació de l'adaptació basada en ecosistemes (AbE) a les inundacions en tres laboratoris vius de ciutats costaneres: Vilanova i la Geltrú i Benidorm (Espanya) i Oeiras (Portugal). L'estabilització de la llera i les riberes, o la plantació de vegetació de ribera s'han considerat opcions d'adaptació adequades per reduir el risc d'inundacions, especialment en el context de rius intermitents i perennes, alhora que contribueixen a obtenir beneficis col·laterals importants, com ara la conservació i millora de la biodiversitat i el valor estètic del paisatge.

Paraules clau: sostenibilitat; inundacions; adaptació basada en ecosistemes; laboratoris vius; anàlisi multicriteri (AMC)

Resumen. *Un análisis multicriterio para integrar las percepciones de actores clave en la adaptación basada en ecosistemas para inundaciones en zonas urbanas costeras*

Las inundaciones continentales y costeras son cada vez más frecuentes y graves, y afectan a los sistemas naturales y socioeconómicos. La adaptación local al cambio climático conlleva decisiones complejas que se benefician de la integración de las opiniones de las distintas partes interesadas en el proceso de diseño y decisión. Este estudio contribuye a la incorporación de las opiniones y preferencias de las partes interesadas en el proceso de toma de decisiones basándose en un enfoque de laboratorio vivo (LV) para desarrollar un análisis multicriterio (MCA), flexible para adaptarse a diferentes contextos geográficos y necesidades. Los LV permiten definir, diseñar y crear soluciones innovadoras a problemas específicos a través de un enfoque social e iterativo. El AMC es una herramienta adecuada para la toma de decisiones, ya que permite cuantificar parámetros cualitativos y ponderar los criterios de evaluación. Este estudio presenta los resultados de un AMC aplicado a la evaluación de la adaptación basada en ecosistemas (AbE) a las inundaciones en tres laboratorios vivos de ciudades costeras: Vilanova i la Geltrú y Benidorm (España) y Oeiras

(Portugal). La estabilización del cauce y las riberas, o la plantación de vegetación de ribera se han considerado opciones de adaptación adecuadas para reducir el riesgo de inundaciones, especialmente en el contexto de ríos intermitentes y perennes, al tiempo que contribuyen a importantes beneficios colaterales, como la conservación y mejora de la biodiversidad y el valor estético del paisaje.

Palabras clave: sostenibilidad; inundaciones; adaptación basada en ecosistemas; laboratorios vivos; análisis multicriterio (AMC)

Résumé. *Une analyse multicritère pour intégrer les perceptions des parties prenantes dans l'adaptation basée sur l'écosystème pour les inondations dans les zones côtières urbaines*

Les inondations intérieures et côtières sont de plus en plus fréquentes et graves, affectant les systèmes naturels et socio-économiques. L'adaptation locale au changement climatique implique des décisions complexes qui bénéficient de l'intégration des opinions des différentes parties prenantes dans le processus de conception et de décision. Cette étude contribue à l'intégration des opinions et des préférences des parties prenantes dans le processus de prise de décision en s'appuyant sur une approche de laboratoire vivant (LL) pour développer une analyse multicritère (AMC), flexible pour s'adapter à différents contextes et besoins géographiques. Les LL permettent de définir, de concevoir et de créer des solutions innovantes à des problèmes spécifiques par le biais d'une approche sociale et itérative. L'AMC est un outil d'aide à la décision approprié, car il permet de quantifier les paramètres qualitatifs et de pondérer les critères d'évaluation. Cette étude présente les résultats d'une AMC appliquée à l'évaluation de l'adaptation basée sur l'écosystème (EbA) aux inondations dans trois Living Labs de villes côtières : Vilanova i la Geltrú, Benidorm (Espagne) et Oeiras (Portugal). La stabilisation du lit et des berges des rivières ou la plantation de végétation riveraine ont été considérées comme des options d'adaptation appropriées pour réduire le risque d'inondation, en particulier dans le contexte des rivières intermittentes et pérennes, tout en contribuant à des avantages connexes significatifs tels que la conservation et l'amélioration de la biodiversité et la valeur esthétique du paysage.

Mots-clés : durabilité ; inondations ; adaptation basée sur les écosystèmes (EbA) ; Living Labs ; Analyse multicritère (AMC)

Summary

1. Introduction

Flooding is one of the most significant climate risks threatening coastal towns and cities, with more frequent and severe storm surges and intense rainfall (Xu et al., 2023). Future climate scenarios predict greater impact from flooding due to an increase in flood extent, depth and duration, together with rainfall changes (Sánchez-Almodóvar et al., 2023). Coastal towns and cities in topographically low and flat regions are particularly vulnerable to these compound risks, highlighting the need for integrated responses and adaptation measures. Ecosystem-based Adaptation (EbA) measures such as dune restoration, floodable parks or other sustainable drainage systems (SuDS) can contribute to reducing flood risk and adapting to climate change.

Planning and implementing these measures involves certain challenges throughout the decision-making process. These include the lack of political will, financial constraints, limited knowledge and awareness, stakeholder engagement, and differing perspectives on the role of ecosystems in adaptation to climate change (Wedding et al., 2022). Integrating scientific knowledge into decision-making can clarify the ecological and social benefits of EbA, support assessment of its effectiveness and aid in scenario planning (Balzan, 2023). Interdisciplinary research and collaboration among EbA stakeholders can contribute to overcoming these challenges and making advances in effective adaptation.

Co-creative approaches emerge as an optimal framework for planning EbA by involving a wide range of stakeholders and promoting inclusive governance models. Co-creation enables decision-making to be tailored to user needs, fostering mutual learning and shared vision among participants, thus enhancing equality and managing the complexity of EbA solutions (Mahmoud and Morello, 2021). This collaborative work with different actors can enhance knowledge production (Eckhardt et al., 2021), facilitating social learning, innovation and cooperation, as well as promoting the effectiveness and sustainability of EbA measures (Ariza-Montobbio and Cuvi, 2020). Living Labs are increasingly recognised as suitable co-creative and collaborative platforms, emphasising user participation in the development of innovative solutions (Ferreira, Chapagain and Mikkelsen, 2023; Massari et al., 2023; Wehrmann et al., 2023). These structures enhance stakeholder involvement in designing and evaluating EbA options by involving diverse participants (academia, industry, government and citizens) to address societal challenges such as climate change adaptation (Delosríos-White et al., 2020; Wickenberg et al., 2022). Guiding decision-makers and providing tools on how to articulate participatory processes into science and policy remains a research gap (Bradley, Mahmoud and Arlati, 2022; Hügel and Davies, 2020; Martin et al., 2021).

Despite broad recognition at European Union level of EbA as a strategy to address climate change, fostering stakeholder engagement – an essential component for its successful implementation – remains a significant challenge (Calliari et al., 2022; Lupp et al., 2021). However, flood risk management involves complex decisions associated with uncertainties inherent to flood scenarios and conflicting values (e.g. social vs. economic interests) (Schlumberger et al., 2024; Loos and Rogers, 2016). Planning for flood adaptation very often focuses on traditional tools such as modelling, which rely exclusively on specialist knowledge (Alves et al., 2020; Axelsson, Give and Soriani, 2021). Unlike other decision frameworks based on optimisation algorithms, multicriteria analysis (MCA) performs a quantitative assessment of intangible and uncertain elements relating to climate change adaptation (Alves et., al 2020; van Ierland, Bruin and De Watkiss, 2013). Though MCA has been widely applied to combine multiple stakeholders in group decision-making (Saaty and Kułakowski, 2016), little research has been done on applying this method to rank EbA options (Nguyen and Bleys, 2021). By incorporating stakeholders' preferences, MCA promotes a transparent and participatory approach to EbA planning (Randelović et al., 2023). This method allows stakeholders to assess adaptation measures proposed through multiple evaluation criteria, including the perception of hazard-risk reduction and socioeconomic or environmental aspects (Jiménez-Ariza et al., 2023). Challenges in developing a reliable MCA include ensuring participant representativeness and adopting appropriate tools to capture perceptions and foster discussions, as not all stakeholders might have extensive direct engagement with flood decision-making processes. There will always be some stakeholders who either choose not to engage with the methodology or are unable to follow it (Axelsson, Give and Soriani, 2021). In addressing these challenges, we propose a method that offers adaptability across diverse social and geographical contexts, supporting decision-making by accommodating different levels of knowledge and expertise.

MCA provides a structured framework for flood adaptation by including stakeholders' perceptions in the long-term adaptation plans. The method helps to identify vulnerable areas and to prioritise interventions by quantifying qualitative parameters such as landscape aesthetic values (Coulombe et al., 2022; Silva et al., 2022). This facilitates informed decision-making, leading to more robust flood management strategies. The effectiveness of the model is very much related to the quality of input data and to stakeholder engagement (Jiménez-Ariza et al., 2023). This article builds on the living lab (LL) platform to ensure stakeholder involvement in an iterative feedback process to prioritise EbA measures, facilitating real-life interventions within the MCA approach and increasing the likelihood of user contributions in innovation projects (Schuurman, De Marez and Ballon, 2016).

This study assesses stakeholders' perceptions regarding EbA measures in three coastal towns on the Iberian Peninsula: Vilanova i la Geltrú and Benidorm in Spain, and Oeiras in Portugal. Unlike several studies that focus on a single case study (Sterling et al., 2017), this study goes further by examining multiple locations. Our research applies MCA and has the following specific objectives: (i) to understand how stakeholders evaluate the potential impact of different EbA options in relation to flood risk reduction; (ii) to identify the additional environmental and socioeconomic benefits of the proposed measures that are most relevant for stakeholders; (iii) to determine the importance assigned by stakeholders to the selected criteria; (iv) to explore how the living labs approach can enhance stakeholder engagement in EbA planning.

This study aims to enhance stakeholders' understanding of urban flood-related vulnerabilities and promote the integration of EbA measures into the adaptation planning process by providing tools to articulate participation and stakeholder engagement.

2. Materials and methods

2.1. Methodological approach

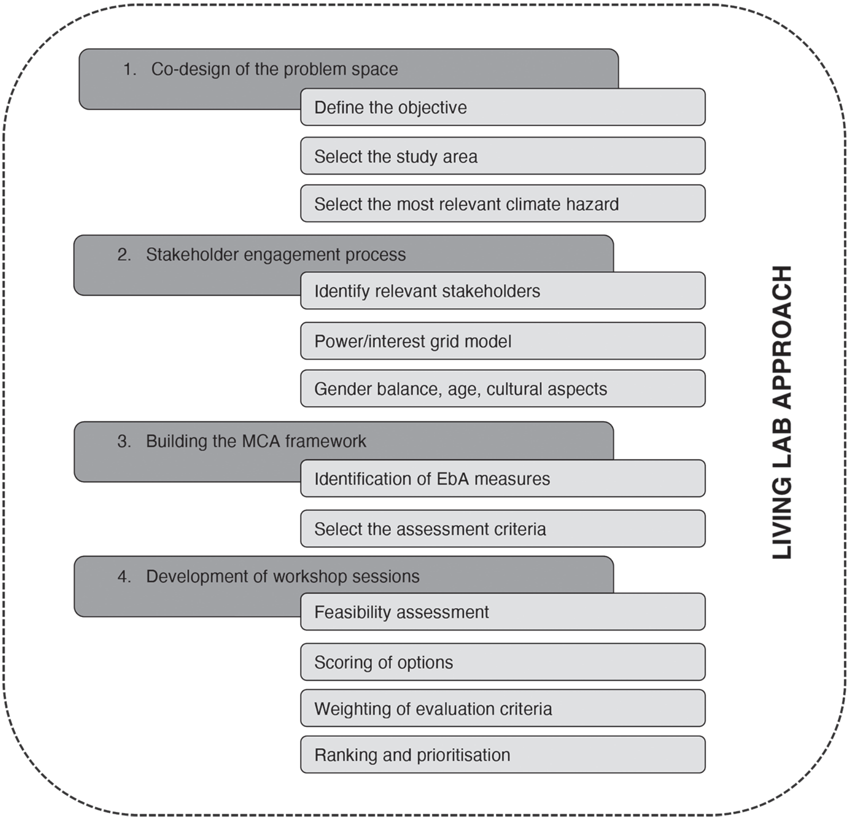
This study proposes a MCA approach that is readily adaptable to diverse contexts, to evaluate individual decision-making regarding the selection of ecosystem-based flood adaptation options. MCA provides a structured framework for assessing options across a spectrum of criteria, ranking them from the most to the least preferred. This approach is particularly beneficial for addressing EbA options, which may differ in their ability to achieve different co-benefits or may involve trade-offs (Department for Communities and Local Government, 2009). While some measures may provide short-term benefits at a higher cost, others may have greater uncertainty regarding their long-term performance. This transparent and structured evaluation process facilitates the integration of diverse stakeholder interests, perspectives and levels of knowledge into the decision-making process, which makes it a valuable complement when assessing the technical feasibility of EbA measures.

The Living Lab Integrative Process is a methodology which ensures that participants have ownership of solutions by involving them effectively and systematically throughout the entire process, including emphasis, co-design/co-creation, experimentation and testing, and co-implementation (Hossain, Leminen and Westerlund, 2019). The iterative feedback approach embedded in this method focuses on co-creating proposed solutions, and then prototyping, testing and implementing them. This approach enables the scaling-up of innovations, fostering sustainable impact and joint value for all the stakeholders involved (Iturriza et al., 2022). In this study, we move one step forward on this well-established concept. Within the context of the EU Horizon 2020 project SCORE (Smart Control of the Climate Resilience in European Coastal Cities), the Living Lab concept has been expanded to Coastal City Living Labs (CCLL). These Labs focus on the co-design and co-development of coastal city interventions and activities to adapt to climate change through EbA, involving all relevant stakeholders.

To prioritise the set of EbA options to alleviate flooding risk, MCA was embedded within the living labs approach in four key phases (Figure 1):

1. *Co-design the problem space:* This phase involved different meetings between the research team, members of city councils and local academic institutions representing the CCLLs of Vilanova i la Geltrú/Province of Barcelona, Oeiras and Benidorm. The purpose of these meetings was threefold: to define the objective of the analysis; to select the study area (whether to focus on a specific location or the entire municipality); and to select the most significant climate change hazard(s) affecting the study area (e.g. inland flooding, coastal flooding, coastal erosion).
2. *Stakeholder engagement process:* The quadruple helix model of stakeholder interaction promotes equal participation and open collaboration of stakeholders throughout the living labs life cycle (Yun and Liu, 2019). Following this model, the three CCLLs under study engaged relevant representatives

Figure 1. Methodological approach



Source: Own elaboration.

from the public sector (i.e. the city council and the regional government), academia (i.e. research centres and universities), industry (i.e. engineering companies and tourism operators) and local communities (i.e. environmental organisations and primary and secondary schools). This approach allowed multiple perspectives from stakeholders to be included, giving them an active role in the selection of adaptation options. The selection of stakeholders was guided by the power/interest grid model (Johnson, Scholes and Whittington, 2008), which helped identify those actors with more influence and interest in following the process closely. Furthermore, stakeholder selection took into consideration gender balance, age and cultural aspects.

3. *Build the MCA framework:* This phase initially focused on identifying potential EbA options to mitigate the hazard(s) identified for each study area. An initial proposal of EbA measures originated from the review of the SCORE

EbA catalogue,[1] complemented by an analysis of existing references on the topic (Kabisch et al., 2017; Morello et al., 2019). Sterling et al. (2017) acknowledge the increasing level of complexity of the decision-making process when the diversity of options increases. Therefore, adaptation measures were selected and accurately described according to the following: description, related benefits, potential location, main climate risks addressed, governance level responsible for its management, timeline from implementation to the main benefits derived, approximate cost range, and life expectancy.

The next step involved defining the assessment criteria, which would later be validated by stakeholders during the workshop. The criteria were clustered within four broad categories: risk reduction and other social, economic and environmental implications (Liquete et al., 2016; Maes et al., 2016). The selection of specific criteria was influenced by the 'Catalogue of Nature-Based Solutions for Urban Resilience' (Jongman et al., 2021), which provides an analysis of potential co-benefits associated with different EbA measures. The process of criteria selection also considered the following requirements: completeness (capture all key aspects), redundancy (avoid unnecessary criteria), operationality, mutual independence of preference (scores assigned to one option do not depend on a preference for others), double counting (clustered in categories), and size (the greater number of criteria, the larger the complexity of the analysis) (Department for Communities and Local Government, 2009). An optimal number of criteria, close to six, was considered (Ivanova Boncheva and Hernández-Morales, 2022). The initial set of socioeconomic and environmental criteria defined for each category and later agreed with participants were (Liquete et al., 2016; Maes et al., 2016; Jongman et al., 2021):

i) Risk reduction: perception of flood risk reduction.
ii) Environmental sphere: biodiversity conservation and improvement, water quality improvement, carbon capture and sequestration, heat stress reduction.
iii) Social sphere: increase in recreational opportunities, landscape aesthetics, human health improvement.
iv) Economic sphere: increase in job opportunities, resources production.

The main communication tools employed were: open discussion (to reach consensus after each step and validate criteria); online voting tool (applied during the feasibility assessment, scoring and weighting of options); and visual prioritisation technique (to facilitate discussion of the final ranking and the prioritisation of alternatives).

4. *Hold workshop sessions:* These sessions were held between February and December 2023 and employed two formats: an online and in-person session conducted on different days or a one-day in-person session. The first format

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[1] SCORE EbA catalogue describes a list of EbA options which can be filtered according to the main hazard addressed (i.e. coastal erosion, flooding, drought) and/or land category (i.e. coastline, urban settlement, riverine) <https://score-eu-project.eu/eba-catalogue/>.

was applied in Vilanova i la Geltrú and Benidorm, where an *ex ante* MCA focused on the evaluation of hypothetical and already planned measures respectively. In this case, stakeholders undertook the EbA feasibility assessment and discussed the proposed criteria during the online session. The subsequent in-person session then allowed all participants to assess the measures against the criteria and to assign weighting. The second format was selected to evaluate measures already implemented in Oeiras (*ex post* analysis). For this case study, it was not necessary to do the feasibility assessment prior to the final selection of EbA options, as had occurred in the previous two case studies. For all three case studies, we evaluated the stakeholders' perceptions of the level contribution of EbA options towards flood risk reduction.

The MCA followed a rank-based method (Saarikoski et al., 2016) based on the selection and weighting of criteria by a stakeholder panel. It was implemented using a workshop format and was divided into four main steps: feasibility assessment, scoring of options, weighting the evaluation criteria, and ranking and prioritisation of alternatives. The feasibility assessment was designed to select a shortlist of EbA options to be further assessed from an extended preliminary list. The scoring of options involved an initial assessment, in which participants had to assign a value on a scale from 1 to 5, representing, respectively, the minimum and maximum levels of contribution of the measures to each criterion. Subsequently, weighting was related to the assignment of values to each criterion to indicate the degree of importance. The total sum of weighting should be 100%. To come up with the final ranking and prioritisation of options, a linear aggregation rule was defined in which each score was weighted and added linearly. In equation (1), WS_j stands for the weighted score of option j, W_i refers to the weighted criterion i, and S_{ji} stands for a score of option j to criterion i.

$$WSj = Wi * Sji \tag{1}$$

To calculate the final ranking of options, we proceeded with the linear aggregation using the weighted sum equation (2), in which FS_j stands for the final score of option j and $\sum$ indicates the sum of a weighted score of option j.

$$FSj = \sum WSji \tag{2}$$

The results generated a useful discussion on the suitability of the ranked options and included the value judgments of different contributors.

2.2. Case study areas

This study focuses on the municipalities of Vilanova i la Geltrú and Benidorm in Spain, and Oeiras in Portugal (Figure 2). The selection of these three study areas is aligned with the CCLLs defined by the EU Horizon 2020 SCORE

Figure 2. Geographical setting of the study areas

Key: The specific study areas are mapped as follows. In (1) Vilanova i la Geltrú (Spain): (a) refers to the lower section of the course of the river Torrent de la Piera. In (2) Oeiras (Portugal): (b) the dashed black line corresponds to the section of the Green and Blue Axis (Eixo Verde e Azul) developed in the first stage. In (3) Benidorm (Spain), various sites and measures are identified: (c) urban dune near the promenade of the beach of Poniente; (d) sand dike, located next to the mouths of four intermittent rivers (Murtal, Xixó, Lliriet and Barceló), on Poniente and Levant beaches; (e) floodable park near the intermittent river Lliriet; (f) permeable pavements, close to the car parking area of Salto del Agua; (g) riparian reforestation in Murtal and Aigüera intermittent rivers; and (h) tree planting at the Playmon Park residential area.

Source: Instituto Geográfico Nacional, Esri, TomTom, Garmin, Foursquare, GeoTechnologies, Inc., METI/NASA, and USGS <https://www.arcgis.com/apps/mapviewer/index.html>.

project (Smart Control of the Climate Resilience in European Coastal Cities). The study areas share geographical characteristics and climate change impacts, which makes them suitable for further comparative analysis. Specifically, the selection criteria were (i) medium-sized coastal towns, (ii) located on the Iberian Peninsula and (iii) vulnerable to flooding.

Vilanova i la Geltrú (province of Barcelona, Spain) is a Mediterranean city bounded by the Garraf mountain range to the north and north-west and three intermittent watercourses running through the municipality to the north-west (Torrent de la Pastera and Torrent de la Piera) and south-east (Torrent de Sant Joan). The city has a coastline of 6km and a population of 68,768 (Idescat, 2023). The hydrologic structure of the city and exposure to the sea make it susceptible to flooding after intense precipitation and storm surge episodes, especially in locations such as Torrent de la Piera. We explore the lower section of this intermittent river, which extends for about 240 meters and lies closer to the sea. In periods of heavy rain, the water overspills into the adjacent sidewalk and road known as Ronda Europa. This road is the main connection between the north and the east of the city, where the harbour is located. These flooding episodes interrupt traffic and pedestrian movements, thereby impeding the connection between these areas. During the MCA workshop, different measures were explored to address this problem.

Oeiras (Metropolitan Area of Lisbon, Portugal), between the municipalities of Lisbon and Cascais, has a coastline of 10km. The city stands at the mouth of the Tagus River, where it opens into the Atlantic Ocean. With 171,658 inhabitants (INE, 2021), Oeiras held the second-highest per capita purchasing power in 2021 (INE, 2023), just behind Lisbon. Additionally, Oeiras is an important economic, research and innovation hub, as well as an attractive tourist destination thanks to its architectural and environmental heritage. The municipality is affected by severe flooding and heat wave episodes. The Green and Blue Axis (Eixo Verde e Azul) is a green restoration project along the Jamor River aimed at improving water quality and promoting recreational opportunities and human wellbeing. This project involves an intermunicipal area under the jurisdiction of Sintra, Amadora and Oeiras. In 2016, all three municipalities signed a memorandum of understanding with Sintra Parks to collaborate and develop this project (Vale et al., 2017). The area has been highly affected by flooding. The project aimed to restore its ecological value and rehabilitate the surrounding area (Vale et al., 2017). The MCA carried out in this study evaluated some of the measures implemented along a length of 2,800 metres, from Santuário de Nossa Senhora da Rocha to Cruz Quebrada.

Benidorm (province of Alicante, Spain) is a well-known tourist destination beside the Mediterranean Sea. This city is home to 69,738 permanent residents (IVE, 2023), but the population swells to nearly 300,000 inhabitants during the summer season. It is surrounded by various mountains, including Sierra Helada to the east, Sierra Cortina and Puig Campana to the north, and Teso de la Cala to the west, which generate a stable climate during the four seasons. Despite the limited rainfall related to the warm, semiarid climate, the frequency and intensity of storm surges and heavy rainfall are increasing, exposing the city to more flooding episodes. Floods primarily affect areas adjacent to the intermittent rivers throughout the city and its coastline, while coastal erosion affects its two main beaches, Levante and Poniente (Laíño and Iglesias, 2021). These areas were addressed in this study.

Workshops were held for each case study area. In the case of Vilanova i la Geltrú and Benidorm, one on-line session was held to present the EbA measures, undertake the feasibility assessment and select the assessment criteria. An in-person session was then held to score the options, apply weighting to the criteria and rank the measures. In the case of Oeiras, all these steps were completed in a single one-day session. A total of 55 participants took part in this process. To ensure age balance, organisations from high schools to retirement centres were invited to the workshops. For cultural balance, neighbourhood associations representing different cultures were invited to the workshops. In terms of gender balance, and including all case studies, a participation rate of

Table 1. Number of participants and quadruple helix group per case study area

Case study area	Total MCA participants	Quadruple Helix Group			
		Citizens	Government	Industry	Academy
Vilanova i la Geltrú	29	11	11	3	4
Oeiras	20	2	6	0	12
Benidorm	21	0	9	9	3

Source: Own elaboration.

45% of women was achieved. Table 1 shows the number of participants and a quadruple helix group for each workshop.

3. Results

Results presented in this section include different EbA options to alleviate flooding problems in urban coastal areas. During the workshops, participants assessed the performance of each of the proposed adaptation measures for an intermittent river in Vilanova i la Geltrú, a perennial river in Oeiras and different urban locations in Benidorm. They compared these measures using the evaluation criteria, compared to the status quo (no action). The following sub-sections show the individual workshop results. Detailed results are provided as supplementary material.

3.1. Assessment of proposed EbA measures to improve flood resilience along an intermittent river in Vilanova i la Geltrú

The objective of this workshop was to propose EbA measures to alleviate the impact of flooding episodes in the study area. Initially, four interventions were proposed, which were approved during the feasibility assessment:

- Renaturing and stabilising riverbed and channel based on planting indigenous and climate-resistant species along the riverbanks.
- Restoring riverbed depth to its original (lower) level.
- Elevation of the right riverbank with natural materials.
- Creation of a filter strip of vegetation along the right riverbank.

Following discussion among stakeholders, a fifth option was proposed. This was based on a combination of some of the previous measures (renaturing, restoring riverbed depth, raising height of riverbank), as the combination of the three was perceived to be more effective in terms of flooding.

Participants evaluated these measures using the following criteria: perception of flood risk reduction; biodiversity conservation and improvement; water quality improvement; carbon capture and sequestration; landscape aesthetic value; and heat stress reduction. Table 2 shows the mean results of the assessment of EbA measures against the proposed criteria, along with

Table 2. Main results of the MCA workshop in Vilanova i la Geltrú

		Criteria and average weighting (%)							
		Perception of flood risk reduction	Biodiversity conservation and improvement	Landscape aesthetic value	Heat stress reduction	Water quality improvement	Carbon capture and sequestration		
EbA		45.5%	18.3%	13.1%	8.1%	8.0%	7.0%	Overall score	Ranking
Combination of measures*	Weighted results	1.9	0.7	0.5	0.3	0.3	0.3	**4.0**	**1**
	Initial assessment	4.3	4.1	4.0	3.4	3.7	3.6	3.8	1
Re-naturalisation and stabilisation of riverbed and channel	Weighted results	1.6	0.7	0.5	0.3	0.3	0.2	**3.6**	**2**
	Initial assessment	3.6	3.9	4.2	3.6	3.2	3.5	3.7	2
Restoring original depth of riverbed	Weighted results	1.7	0.6	0.4	0.2	0.2	0.3	**3.3**	**3**
	Initial assessment	3.9	3.4	2.7	2.3	2.7	2.5	2.9	3
Raising height of banks	Weighted results	1.7	0.5	0.4	0.2	0.2	0.2	**3.1**	**4**
	Initial assessment	3.7	2.9	2.9	2.3	2.2	2.5	2.8	4
Creating a filter strip	Weighted results	1.1	0.5	0.4	0.2	0.2	0.2	**2.6**	**5**
	Initial assessment	2.5	2.7	3.0	2.7	2.3	2.5	2.6	5

* Refers to the combination of all measures apart from the creation of a filter strip. The initial scores are obtained by multiplying the initial individual scores with the weighting (Equation 1). Additionally, the weighted results are presented as a weighted sum for the final assessment (Equation 2), while the initial scoring is represented as an average of individual scores.

Source: Own elaboration.

corresponding weighting and final scores. Based on the initial scoring (without weighting), only renaturing and the combined option (reforestation, restoring riverbed depth and raising riverbank height) achieved a score above 3 in all criteria.

All measures were perceived to be relevant for reducing flood risk (mean score over 3.6), except for the filter strip (mean score of 2.5). The best approach for mitigating flood risk was perceived to be a combination of renaturing, restoring riverbed depth and raising riverbank height (mean score of 4.3). Regarding other criteria, improving biodiversity and conservation scored particularly highly across various measures, whereas reducing heat stress or improving water quality obtained lower scores.

After applying weighting to the initial scores using Equation 1, the options corresponding to combined measures and renaturing achieved the first and second highest scores, respectively. Restoring riverbed depth, raising riverbank height, and creating a filter strip came next. The rankings remained unchanged between the initial and final assessments, regardless of the inclusion of weighting. This was consistent and accurate with participants' stated preferences. The workshop also allowed stakeholders to give their opinions on additional interventions. Several participants advocated installing water collection tanks in the upper sections of the watercourse to reduce overflows in the section under discussion. They also proposed expanding the green area around the watercourse to enhance permeability and promote social interaction and installing retention basins in the upper sections of the watercourse.

3.2. Assessment of EbA measures implemented to alleviate flooding episodes in a perennial river in Oeiras

This case study evaluated EbA measures already implemented under the initiative "Eixo Verde Azul" (The Green and Blue Axis). Six measures with flood mitigation potential were selected with the support of the Oeiras CCLL:

- River regularisation, involving desilting the riverbed and unblocking and reconfiguring the flow section.
- Stabilisation of riverbanks using wooden and rock-based structures.
- Planting native riparian vegetation with a high degree of adaptation to wet soils and periods of flooding, combined with the elimination of invasive exotic species.
- Maintenance of the river network, including periodic cleaning and clearing of river sections.
- Floodplain enlargement, while ensuring compatibility with leisure and sports areas.
- Creation of permeable pavements alongside some sections of the river, designed for soft mobility (e.g. pedestrian, cycle mobility) and leisure purposes.

These measures were analysed according to the following criteria: perception of flood risk reduction; biodiversity conservation and improvement; water quality improvement; carbon capture and sequestration; increased recreational opportunities; improved human health; and increased job opportunities. The feasibility assessment was not conducted in this case study as all measures had already been implemented.

The initial assessment (without weighting) indicated that the top-scoring measure for flood risk reduction was river regularisation (4.4), whereas the planting of riparian vegetation and the creation of permeable pavements both obtained the lowest score (3.3). Most measures scored three or higher in at least half of the criteria. However, there were exceptions. For instance, in the case of riverbank stabilisation, only the criterion "perception of flood risk reduction" scored above 3. Additionally, permeable pavements had four criteria with values below that level. The three highest average scores for the criteria beyond flood risk reduction were associated with biodiversity conservation and improvement through the planting of riparian vegetation (4.8), the increase in recreational opportunities resulting from floodplain enlargement (4.5), and the improvement of human health with floodplain enlargement (4.3). In contrast, the three lowest average scores were linked to carbon capture and sequestration (1.6) and job opportunities (1.9) related to permeable pavements, as well as to carbon capture and sequestration in the context of riverbank stabilisation (1.7) (Table 2).

After the initial assessment, participants assigned weighting to the criteria, showing their preference for them. The criteria with the highest signifi-

Table 3. Main results of the MCA workshop in Oeiras

		Criteria and average weighting (%)								
		Perception of flood risk reduction	Biodiversity conservation and improvement	Improve human health	Water quality improvement	Carbon capture and sequestration	Increase recreational opportunities	Increase job opportunities		
EbA		38.0%	15.7%	16.0%	10.7%	9.3%	7.0%	3.3%	Overall score	Ranking
River regularisation	Weighted results	1.7	0.5	0.4	0.4	0.2	0.2	0.1	**3.09**	**4**
	Initial scoring	4.4	3.0	2.6	3.3	1.8	3.0	2.7	3.0	4
Riverbank stabilisation	Weighted results	1.4	0.4	0.4	0.3	0.2	0.2	0.1	**2.59**	**5**
	Initial scoring	*3.6*	*2.4*	*2.4*	*2.8*	*1.7*	*2.9*	2.4	*2.6*	*5*
Planting of riparian vegetation	Weighted results	1.2	0.8	0.6	0.4	0.3	0.2	0.1	**3.32**	**1**
	Initial scoring	*3.3*	*4.8*	*3.5*	*3.9*	*3.8*	*2.7*	2.9	*3.6*	*1*
Maintenance of the river network	Weighted results	1.5	0.6	0.5	0.4	0.2	0.2	0.1	**3.18**	**3**
	Initial scoring	*4.0*	*3.6*	*3.2*	*3.5*	*2.3*	*3.0*	3.4	*3.3*	*3*
Floodplain enlargement	Weighted results	1.6	0.5	0.7	0.3	0.2	0.3	0.1	**3.24**	**2**
	Initial scoring	*4.2*	*3.0*	*4.3*	*2.4*	*2.6*	*4.5*	3.0	*3.4*	*2*
Permeable pavements	Weighted results	1.2	0.3	0.5	0.3	0.1	0.2	0.1	**2.53**	**6**
	Initial scoring	3.3	2.2	3.3	2.6	1.6	3.3	1.9	2.6	6

Notes: The initial scoring is obtained by multiplying the initial individual scores with the weighting (Equation 1). Additionally, the weighted scores are presented as a weighted sum for the final assessment (Equation 2), while the initial scoring is represented as an average of individual scores.

Source: Own elaboration.

cance, as determined by average weighting, included the perception of flood risk reduction (38%), followed by the improvement in human health, as well as biodiversity conservation and improvement, both criteria with 16%. On the contrary, the criteria associated with increased job opportunities revealed the lowest preference (3%). The final ranking, taking weighting into account, remained consistent with the initial assessment. Notably, the measures were ordered in descending priority as follows: planting of native riparian vegetation; floodplain enlargement; maintenance of the river network; river regularisation; riverbanks stabilisation; and permeable pavements.

3.3. Assessment of planned EbA measures to address flooding problems in the coastal urban area of Benidorm

The municipality of Benidorm has several EbA interventions planned to alleviate flooding episodes in various hotspots across the city (Ajuntament de Benidorm, 2021). These interventions are primarily focused on intermittent rivers and adjacent areas. Moreover, dealing with coastal erosion affecting the shoreline was a further objective of some of the proposed measures. Based on the interventions included in the Climate Change Adaptation Plan of Benidorm (Benidorm, 2021) and in accordance with the CCLL, a total of six planned measures were assessed:

- Urban dunes at the Poniente beach.
- Sand dikes at the mouths of four intermittent rivers (Murtal, Xixó, Lliriet, and Barceló).
- Floodable park near the intermittent river Lliriet.
- Permeable pavements close to the car parking area of Salto del Agua.
- Planting of riparian vegetation along the intermittent rivers Murtal and Aigüera.
- Tree planting in the Playmon residential area.

After analysing the most significant co-benefits of the proposed EbA measures, the following criteria were considered: perception of flood risk reduction; biodiversity conservation and improvement; water quality improvement; carbon capture and sequestration; increased recreational opportunities; and landscape aesthetic value.

All measures achieved a satisfactory overall score in the initial assessment (without weighting), with values ranging from 2.8 (sand dikes) to 4.3 (floodable park). When looking at the criteria and measures individually, the floodable park scored highly in all criteria, emerging as the measure with the highest average values in three criteria: flood risk reduction, water quality improvement, and the increase in recreational opportunities. The planting of riparian vegetation also obtained satisfactory results across all criteria, being especially significant for biodiversity conservation and improvement, carbon capture and sequestration, and landscape aesthetic value. Urban dunes and sand dikes attained a favourable performance regarding the perception of flood risk reduction and landscape aesthetic value. However, they did not excel in water quality improvement, carbon capture and sequestration, and increased recreational opportunities. This was also the case with permeable pavements regarding biodiversity conservation and improvement, carbon capture and sequestration, and increased recreational opportunities. Lastly, tree planting had the lowest average score in flood risk reduction (2.6) but obtained the highest values in biodiversity conservation and improvement, carbon capture and sequestration, and landscape aesthetic value.

According to the weighting assigned by stakeholders in Benidorm, the perception of flood risk reduction had the highest weighting (41%), followed by biodiversity conservation and improvement (15%), and water quality improvement (14%). Landscape aesthetic value and increased recreational opportunities had the lowest weighting, notably 8% and 9%, respectively. After combining the scores and the weighting, the final ranking revealed floodable parks as the most appropriate measure to address flooding problems and to contribute to other co-benefits in the city, with an overall score of 3.9. Planting riparian vegetation and tree planting ranked second and third, respectively. The final ranking was consistent with the initial assessment only for the first and last positions.

The MCA was designed to address flooding as the main hazard. Nevertheless, it also incorporated measures suitable for coastal erosion, such as urban dunes and sand dikes. It is worth noting that this dual focus may have

Table 4. Main results of the MCA workshop in Benidorm

		Criteria and average weighting (%)							
		Perception of flood risk reduction	Biodiversity conservation and improvement	Water quality improvement	Carbon capture and sequestration	Increased recreational opportunities	Landscape aesthetic value		
EbA		41.0%	15.0%	14.0%	13.0%	9.0%	8.0%	Overall score	Ranking
Urban dune	Weighted results	1.7	0.5	0.4	0.3	0.2	0.3	**3.1**	**4**
	Initial scoring	4.1	3.2	2.5	2.5	2.5	3.8	3.1	5
Sand dikes	Weighted results	1.5	0.5	0.3	0.3	0.2	0.3	**2.8**	**6**
	Initial scoring	3.7	3.0	2.4	2.2	2.2	3.5	2.8	6
Floodable Park	Weighted results	1.7	0.6	0.6	0.5	0.4	0.4	**3.9**	**1**
	Initial scoring	4.2	4.2	4.1	3.8	4.8	4.6	4.3	1
Permeable pavements	Weighted results	1.4	0.4	0.5	0.4	0.2	0.3	**3.0**	**5**
	Initial scoring	3.5	2.9	3.7	2.8	2.6	3.5	3.2	4
Planting of riparian vegetation	Weighted results	1.3	0.7	0.5	0.6	0.3	0.3	**3.4**	**2**
	Initial scoring	3.3	4.6	3.5	4.3	3.5	4.3	3.9	3
Tree planting	Weighted results	1.1	0.7	0.5	0.6	0.4	0.4	**3.2**	**3**
	Initial scoring	2.6	4.6	3.5	4.5	3.9	4.8	4.0	2

Notes: The initial scoring is obtained by multiplying the initial individual scores with the weighting (Equation 1). Additionally, the weighted results are presented as a weighted sum for the final assessment (Equation 2), while the initial scoring is represented as an average of individual scores.

Source: Own elaboration.

contributed to these measures receiving a less favourable ranking. However, the discussion among participants revealed that both urban dunes and sand dikes are considered measures with a high potential to address flooding and coastal erosion in Benidorm.

4. Discussion

4.1. Stakeholder evaluation of EbA options to address flooding

Perceptions towards adaptation options are often related to existing knowledge and experiences (Gallo et al., 2020; Qi et al., 2020). Different perceptions of the co-benefits of the EbA measures assessed and other attributes relating to the uncertainty of climate change create differing perspectives which might result in conflicting situations when planning for adaptation (Schlumberger et al., 2024; Loos and Rogers, 2016). The approachability of the proposed method for experts and non-experts alike, and presenting the contents in a general way, encouraged deeper stakeholder engagement with the decision-making process, ensuring all users understood the tool and the contents under discussion.

Although it explored various urban land types, the predominant focus of the EbA measures examined in this study was on the context of intermittent and perennial rivers that connect to the sea and play an important role in managing high water flows. This enables a comparative analysis, as presented

Table 5. Comparative analysis of EbA measures in the context of intermittent and perennial rivers

	Effect on flood management						Initial assessment of co-benefits	
EbA[a]	Enhance water absorption/ infiltration	Enhance water storage capacity	Increase conveyance capacity/ maintain river connectivity	Protect adjacent areas against floods	Ensure channel stability	Buffering/ reduction of water flow speed	Top rated	Lowest rated
River regularisation[b]	–	–	✓	–	–	–	Water quality improvement	Carbon capture and sequestration
Floodplain enlargement	✓	✓	–	✓	–	✓	Increase in recreational opportunities	Water quality improvement
Floodable park	✓	✓	–	–	–	✓	Increase in recreational opportunities	Carbon capture and sequestration
Maintenance of the river network[c]	–	–	✓	–	–	–	Biodiversity conservation and improvement	Carbon capture and sequestration
Restoring depth of riverbed to its original level	–	–	✓	–	–	–	Biodiversity improvement and conservation	Heat stress reduction
Raising height of the riverbank/ sand dikes	–	–	✓	✓	✓	–	Landscape aesthetic value, and biodiversity conservation and improvement	Water quality improvement, carbon capture and sequestration, and increase in recreational opportunities
Riverbank stabilisation	–	–	✓	–	✓	–	Increase in recreational opportunities	Carbon capture and sequestration
Renaturing/ planting of native riparian vegetation	✓	–	–	–	✓	✓	Biodiversity conservation and improvement, and landscape aesthetic value	Increase in recreational opportunities, and water quality improvement
Permeable pavements[d]	✓	–	–	–	–	–	Landscape aesthetic value, and increase in recreational opportunities	Carbon capture and sequestration
Filter strip	✓	–	–	–	–	✓	Landscape aesthetic value	Water quality improvement

Notes: [a] This table focuses exclusively on individual options, which means that the combined option (including renaturing, restoring riverbed depth and raising height of riverbank) evaluated in Vilanova i la Geltrú was not considered; [b] This measure refers to desilting the riverbed and unblocking and reconfiguring the flow section; [c] It includes periodic cleaning and clearing of river sections; [d] This measure was also analysed in Benidorm, but not in the context of intermittent or perennial rivers.

Source: All content is derived from the MCA results, except for the qualitative analysis relating to the impact of the measures assessed on flood management. The latter analysis was based on the EbA SCORE catalogue, Bezak et al. (2021), Moore et al. (2016), Roca et al. (2017), as well as input from the CCLLs.

in Table 4. A closer look at the different EbA measures reveals a wide variety of solutions, which translates into a significant potential to contribute to flood management in multiple ways (e.g. enhancing water absorption, storage capacity and conveyance). Measures such as river regularisation, floodplain enlargement, floodable parks and maintenance of the river network are all able to cover large areas and can potentially lead to significant improvements in water storage and conveyance capacity, among other effects (Bezak et al., 2021; Roca et al., 2017). In contrast, permeable pavements and filter strips, which obtained lower scores, were perceived to contribute to a more modest impact on flood mitigation and flood management functions, mainly relating to water absorption and infiltration (Moore et al., 2016).

Furthermore, the analysis shows that similar measures addressed in multiple case studies, such as raising riverbank heights/sand dikes and renaturing/planting native riparian vegetation, obtained comparable scores. This suggests an approximate consensus among different stakeholders regarding the impact of these measures on flood management. In terms of co-benefits associated with the different measures as expressed by the assessment criteria, biodiversity conservation and improvement, along with increased recreational opportunities and landscape aesthetic values, were particularly highlighted by participants, whereas carbon capture and sequestration and improving water quality received less emphasis (Table 4).

4.2. Importance assigned by stakeholders to co-benefits relating to the proposed measures

Despite the diversity in assessment contexts, participants at all three workshops highlighted certain common co-benefits relating to the proposed measures: flood risk reduction, biodiversity conservation and improvement, water quality improvement, and carbon capture and sequestration. The weighting process revealed the relative preferences of stakeholders concerning the previous criteria (see Tables 1 to 3). Despite subtle to moderate variations in the weighting attributed, there is an expected stronger inclination towards flood risk reduction, which was the primary focus of the analysis. The weighting for this criterion ranged from 38% to 45%. This preference was followed by biodiversity conservation and improvement, with weighting varying slightly, from 15% to 18%. One hypothesis for this outcome is the potentially straightforward relationship recognised by stakeholders regarding the link between EbA which relies on natural or semi-natural components and the promotion of habitats and species. The difference in the weighting assigned might be linked to the locations of the study areas. In Vilanova i la Geltrú, this was an intermittent river next to a road with limited pedestrian access; in Oeiras, the Eixo Verde Azul is a green corridor with multiple environmental and recreational purposes. In contrast, the Benidorm case study focused on the entire city, and gave greater importance to water quality improvement (14%) due to the variety of the proposed measures.

Landscape aesthetic value and increased recreational opportunities were assessed in two CCLLs. Landscape aesthetic value came third in Vilanova i la Geltrú (13%) and last in Benidorm (8%), while Oeiras and Benidorm increased recreational opportunities was in second-to-last position in both CCLLs, with weighting of 7% and 9%, respectively. Despite these results, both criteria were recognised as important benefits deriving from various measures in the initial assessment (without weighting), as presented in Tables 1 to 4.

4.3. Insights from applying multicriteria analysis (MCA) within the living lab (LL) approach for ecosystem-based adaptation

Co-creation has been recognised as essential in the uptake of EbA due to its ability to involve diverse stakeholders in the planning and implementation process, leading to more effective and sustainable outcomes (Delosríos-White et al., 2020; Frantzeskaki, 2019; Nesshöver et al., 2017). Designing this MCA under the living labs umbrella enabled effective identification of stakeholders in the assessment process, while being easily adaptable to different contexts for a comparative assessment. Discussions around this iterative process brought important perspectives of different types and backgrounds to the decision-making process. The integrative nature of the living labs approach, involving stakeholders from different backgrounds, frequently allows the same actors to participate across various stages of the process. This helps them to familiarise themselves with and better understand the concepts, methods and problems under discussion. Moreover, this represents an advantage of co-creation, which avoids overlooking considerations or preferences, as could be the case with top-down approaches. In the case of Vilanova i la Geltrú, the input from experts on river restoration during the discussion was central to the proposal for an additional measure. In Benidorm, experts linked to climate change adaptation and city planners contributed to the selection of which measures to prioritise.

Co-creative processes contribute to understanding concepts such as resilience (Wijsman et al., 2021). How the concept is defined and operationalised is essential in shaping who benefits and who does not (Meerow and Newell, 2016). This MCA process was specially designed to prioritise a set of EbA options to improve the flooding resilience of three coastal Iberian towns. The main challenge was how to promote discussions about flooding risk and EbA measures using accessible terminology, methods and dynamics. This was the case when designing the proposed MCA. Involving stakeholders from very early stages helped all participants better understand the topics under discussion. The different group affiliations and knowledge levels of the living labs actors called for an easily adaptable MCA, which could be tailored to the alternative scenarios considered. This approach allowed for the co-definition of the most appropriate assessment criteria, as described by the co-benefits of the proposed measures, such as biodiversity improvement, carbon capture and sequestration, water quality improvement or landscape aesthetic values.

In all three case studies, stakeholders selected and agreed on the final list of assessment criteria, straight after conducting the feasibility assessment.

Local knowledge offers valuable insights derived from experiences and observations, and this complements scientific knowledge that uses rigorous methods and principles to understand ecosystems and climate impacts. By combining these two domains, it is possible to achieve a more holistic understanding of ecosystems and their resilience to climate change and thus enhance the effectiveness of EbA planning (Cebrián-Piqueras et al., 2020; Dias Pereira and Simões, 2023; Marcos-Garcia et al., 2023). Embracing participatory approaches that involve local stakeholders in the decision-making process facilitates the identification of locally relevant adaptation alternatives that address the specific needs of local communities in the face of environmental challenges, as was the case in Vilanova i la Geltrú. The knowledge and expertise of some stakeholders facilitated the consideration of an additional measure which had not been considered initially. This was the combination of three measures proposed and was understood to increase their effectiveness in flood management.

5. Conclusions

This study used an MCA methodology to assist decision-makers in evaluating EbA options to improve flooding resilience of three Iberian coastal towns (Vilanova i la Geltrú, Benidorm, and Oeiras), as well as identifying other environmental and socioeconomic benefits. The outcomes of the study provided insight into the different stakeholder perceptions in relation to the benefits assigned to the proposed measures in three different environments. The results bring a better understanding of the effectiveness and preferences for flood resilience strategies. Each workshop evaluated specific interventions tailored to their own context, before indicating which interventions they preferred. The study demonstrates the complexity of flood risk adaptation and the need for locally appropriate solutions to be considered in the decision-making process. All proposed measures for flood risk reduction were considered relevant, with particular emphasis on riverbank stabilisation, riparian vegetation and permeable pavements in the urban locations assessed.

Stakeholders highlighted several key environmental and socioeconomic co-benefits. In descending order of prioritisation, these included biodiversity conservation, water quality improvement, carbon sequestration, enhanced landscape aesthetics, and increased recreational opportunities. Additionally, the study underscored the value of living labs as collaborative platforms that bring together stakeholders from diverse backgrounds to co-create adaptation solutions. These platforms ensure continuous and inclusive engagement throughout the planning process, adapting to varying levels of interest and fostering innovation and experimentation.

The user-friendly tool presented in this study contributes to articulating science and policy by articulating the environmental and social benefits of EbA and facilitating the involvement of stakeholders to inform decision-making in climate change adaptation strategies. Presenting a method and concepts that are easy for users to understand reduces the barriers that often prevent non-experts and non-technical stakeholders from engaging in flood management planning strategies. Involving stakeholders in the process can contribute to increasing understanding and acceptance of the flood management interventions proposed. Policymakers can develop appropriate holistic and contextualised strategies to enhance flood resilience and promote sustainable development by integrating local knowledge, stakeholder input and scientific evidence.

This method is contextually and geographically flexible. It was applied to flooding, but it could be adapted to address other urban adaptation problems. Future research could enhance the validity and reliability of current findings and, in turn, provide more robust insights for climate change adaptation. The assessment of scores and weighting to the evaluated criteria could be influenced by various factors, including stakeholder preferences, their level of knowledge on the subject, and personal and sectoral interests. These factors, which could lead to an evaluation bias, warrant further research beyond what has been carried out in the current analysis. This study addressed criteria relating to hazard risk reduction and other environmental and socioeconomic benefits. Nevertheless, it did not fully cover all potential impacts of the assessed measures, such as potential disadvantages relating to some interventions (e.g., allergies to vegetation, mosquitos in wet areas, etc.). Finally, the analysis narrowed its focus to specific EbA measures. However, it is important to recognise that adaptation encompasses a broader range of strategies, including both soft and hard (or engineering) approaches. These alternative strategies can also complement EbA, an idea that was also put forward by workshop participants.

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