Received: 6 November 2024 | Accepted: 23 January 2026

DOI: 10.1002/pan3.70261

BRITISH ECOLOGICAL SOCIETY People and Nature

RESEARCH ARTICLE

Synergizing scientific and local knowledge for ecosystem services assessments: A case study in northern Portugal

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Funding information
European Union Horizon Europe, Grant/Award Number: Project Mar2Protect (101082048); FCT-Fundação para a Ciência e a Tecnologia; European Commission's Recovery and Resilience Facility; Centre for the Research and Technology of Agro-Environmental and Biological Sciences

Handling Editor: Nibedita Mukherjee

Abstract

1. Integrating scientific and local ecological knowledge on ecosystem services (ES) is essential for effective and inclusive environmental management. Such an integration strengthens societal engagement, supports policy implementation and helps reduce sectoral conflicts across marine sectors.
2. This study explored this synergy by assessing stakeholder perceptions of local ES and comparing them with existing scientific assessments in the NW coastal area of Portugal. Stakeholders representing four societal sectors (Quadruple Helix framework) prioritized regulation and maintenance ES (RMES), identified RMES supply areas and pressures, and outlined a 20-year vision for the region.
3. Stakeholders classified 16 of the 20 RMES as 'Very Important', particularly *erosion control, buffering mass movements, coastal protection, or climate regulation*. Estuaries and northern coastal areas were identified as RMES supply hotspots. Ten major activities were identified, as well as conflict areas in coastal and estuarine regions, and some marine areas, particularly where fishing, tourism and potential future offshore wind farms overlapped. The stakeholder 20-year vision aligned with environmental policies, advocating an increase in ecosystem-based management (EBM) approaches and effective management of human activities to ensure the maintenance of natural capital.
4. Comparisons between stakeholder and scientific-based maps revealed broad agreement in nearshore areas but discrepancies offshore. While for nearshore regions stakeholders were able to complement the information of the scientific-based maps for ES supply and pressures, less knowledge of offshore regions was observed from the stakeholders.

5. This study highlighted the value of integrating scientific and local stakeholder knowledge to support informed decision-making, filling knowledge gaps and establishing stakeholder priorities for ecosystem management in marine regions that can support more complete, equitable and effective marine planning.

KEYWORDS
maritime spatial planning, participatory mapping, regulation and maintenance ecosystem services, social–ecological systems, stakeholder perceptions

1 | INTRODUCTION

A sustainable functioning of marine ecosystems is required to the production of Ecosystem Services (ES) in the natural domain and the delivery of associated Societal Goods and Benefits (SGB) in the human domain (Elliott, 2013). To ensure the sustainable flow of SGB from marine ecosystems, recent policies require the assessment, evaluation and reporting of ecosystems and their services (Bouwma et al., 2018; European Commission, 2011). Such assessments are critical for informing planning and ecosystem-based management (EBM) processes (Elliott et al., 2025). However, despite policy advance, ES have not yet been fully integrated into Maritime Spatial Planning (MSP) (Frazão Santos et al., 2018; Friess & Grémaud-Colombier, 2021; Galparsoro et al., 2021; Nahuelhual et al., 2020). As European and worldwide strategies increasingly promote Blue Growth and a Blue Economy (Alder & Castaño-Isaza, 2022; European Commission, 2012), embedding ES mapping and assessment, and their resulting SGB, into MSP becomes essential to ensure that expanding marine uses remain compatible with the good environmental status of marine ecosystems (European Commission, 2011, 2012; Sumaila & Villasante, 2025). Advancing such integration aligns with the broader need for transformative change (IPBES, 2024), involving systemic governance shifts that reconcile economic development with long-term ecological resilience. Integrating the best available scientific knowledge in MSP is essential for implementing robust ES assessments (Friedrich et al., 2020; Galparsoro et al., 2021). However, this assessment and identification of priority areas for ES supply and SGB delivery therefore requires alignment with local socio–ecological contexts and incorporation of the needs and demands of regional stakeholders (Haines-Young & Potschin, 2010). Community needs, demands and priorities vary across regions and may not be adequately captured by assessments conducted at coarser spatial scales (Custodio et al., 2022; Díaz et al., 2015; Pascual et al., 2023; Pingarroni et al., 2022). Thus, there is an increasing need to incorporate stakeholder knowledge and values, thereby enhancing the effectiveness of MSP by promoting knowledge exchange, increasing transparency and reducing conflicts between decision-makers and the beneficiaries of SGB (Frederiksen et al., 2021; Mackenzie et al., 2019; Rey-Valette et al., 2017). Such inclusive processes additionally support transformative change (Bennett et al., 2025; Penca et al., 2025), by fostering more participatory, equitable and adaptive forms of marine governance and ensure the functioning and holistic management of the social-ecological system (Smith et al., 2025; Villasante et al., 2025).

Linking scientific evidence with other types of knowledge, especially stakeholder knowledge, provides complementary insights into marine socio-ecological systems and strengthens the integration of science, policy and society, particularly when stakeholders are engaged early in the process (Barton et al., 2024; Borja et al., 2025; Burdon et al., 2019; Caniglia et al., 2021; Smith et al., 2025). Such an integration can reveal previously unrecognized issues or conflicts, enhance stakeholders understanding of ES and SGB concepts, and strengthen the relevance and uptake of these concepts into management (Frederiksen et al., 2021; Hölting et al., 2020; Slater et al., 2020). This is particularly important in regions with intense marine activities, where ES generate diverse societal benefits, and trade-offs in ES supply are more likely to emerge (Cord et al., 2017; Koko et al., 2020; McShane et al., 2011). Although including stakeholder knowledge is necessary, systematic comparisons between scientific ES assessments, derived from biophysical modelling or indicator-based methods, and participatory mapping remain rare (Schwartz et al., 2022). To the best of our knowledge, such integrated comparisons have not yet been conducted within a single study for marine and coastal systems, limiting our understanding of the complementarities and discrepancies between these two knowledge sources. Filling this gap is particularly important for Regulation and Maintenance ES (RMES), whose ecological processes and contributions to SGB are often less tangible to stakeholders. Given the need for decision-makers to account for the ecosystem dynamics underlying RMES supply (Cunha, Cabecinha, et al., 2025), assessing the alignment between scientific indicators and stakeholder perceptions is essential for informed and robust marine management.

In this context, this study aimed to fill this gap, assess stakeholder perceptions, priorities and perceived pressures related to RMES, and compare these with existing indicator-based assessments. Specifically, a regional participatory workshop was organized to address the following questions: (1) What RMES do stakeholders prioritize, and where do they perceive key supply areas? (2) What pressures and conflicts do they identify affecting RMES supply? (3) What is the stakeholder 20-year vision for the region, and which measures are needed to reach it? and (4) How do stakeholder-derived spatial outputs compare with and complement indicator-based scientific assessments? The workshop established a baseline understanding of stakeholder needs and expectations regarding RMES in the case study area, which can inform and guide management decisions within this socio-ecological system.

2 | METHODS

2.1 | Study area

This study examines the coastal and marine area of northern Portugal, stretching from the Minho River estuary to the southern border of the Porto municipality (Figure 1). It includes national territorial waters, a 500 m buffer around estuaries and the coastline, and protected areas within this region. The region serves as a hub for maritime and industrial activities, with major commercial ports in Matosinhos and Viana do Castelo, and urbanized areas around the coast and the estuaries. This area includes regions governed by existing coastal and estuarine management plans as well as two Marine Protected Areas (MPAs).

2.2 | Selection of stakeholders

The selection of key stakeholders to participate in the workshop followed the Quadruple Helix model (Carayannis & Campbell, 2009), which includes representatives from the four main societal sectors: academia, industry, public (governance/administration), and civil society. A comprehensive pre-selection process was undertaken ($n=119$), considering the diverse range of relevant socio-economic activities, administrative agencies and civil entities, including those involved in the national Maritime Spatial Plan. Following the pre-selection process, five stakeholders were selected from each societal sector, aiming to recruit between 15 and 20 stakeholders in total (Campagne & Roche, 2018), and invitations were sent by email, and whenever possible, by personal contact. From the total 20 invitations sent, 15 stakeholders confirmed their attendance, allowing the workshop to proceed. Despite additional contacts made, no other stakeholders responded to our inquiries. However, on the day of the workshop, only 9 stakeholders appeared, including three researchers from two research institutes, two representatives from the public sector, two from civil society, and two from the private sector. Participants contributed expertise spanning fisheries, the blue economy, maritime operations, marine technology, environmental education, and social-ecological systems, as well as detailed knowledge of local ecosystems and of the case study area. Although this number was lower than expected, all four main sectors were represented.

2.3 | Participatory approach

The participants were divided into two groups, each comprising representatives from the four societal sectors, to facilitate robust discussions and productive exchanges among stakeholders, and foster consensus on the workshop goals. Prior to the workshop, all participants were required to provide written informed consent, thereby confirming their willingness to participate in the study and allowing their responses to be used for research purposes. Throughout the data analysis process, the confidentiality of all participants was ensured.

The workshop design comprised four main sections and was conducted in Portuguese, including: introduction, prioritization and mapping of RMES, identification and mapping of pressures, and definition of the future shared vision for the study area. The introductory session was designed to present the workshop objectives and exercises, provide stakeholders with the necessary background on ES, RMES and the case study area, thereby establishing a common understanding among stakeholders.

In the second section of the workshop, participants were requested to assign a ranking to their perceived importance of RMES in the region and to map RMES potential supply areas. Each group ranked the RMES from a predefined list of 20 RMES, based on CICES version 5.1 (Haines-Young & Potschin, 2018), into three categories of importance levels: 'Less Important', 'Moderately Important', and 'Very Important'. Participants then identified and numbered the areas on the case study area map which they associated as supply areas of the RMES previously classified as 'Very Important' (Figures S1–S3).

In the third section, participants identified the most significant major sources of pressures, both current and future, to the supply of the RMES, which they classified as 'Very Important', and mapped areas of pressure and conflict with RMES supply. Pressures are defined as the mechanisms of adverse change on the natural and societal systems due to human activities; measures are the management responses designed to address those adverse consequences (Elliott et al., 2017). In this third section, the participants used the table of the RMES ranking from the previous exercise, a new table for the identification of pressures and areas of conflict and a new map of the study area (Figure S4).

In the fourth, final section of the workshop, the participants developed a 20-year vision for the region, building on insights from previous exercises. A table was provided to the participants to fill with their vision for the region, and to identify potential measures that would be necessary to achieve it (Figure S5). This exercise allowed stakeholders to consolidate their discussions into a clear vision for the region's future. The workshop concluded with a plenary session, in which the participants collectively discussed the exercise outcomes. After the workshop, both the results and the map outputs derived from stakeholder contributions were summarized, and a workshop report was prepared and shared with all participants to obtain feedback and confirm that their inputs were accurately represented.

2.4 | Data analysis

The ranking exercise results were analysed by calculating the mean ranking for each RMES across both stakeholder groups. The

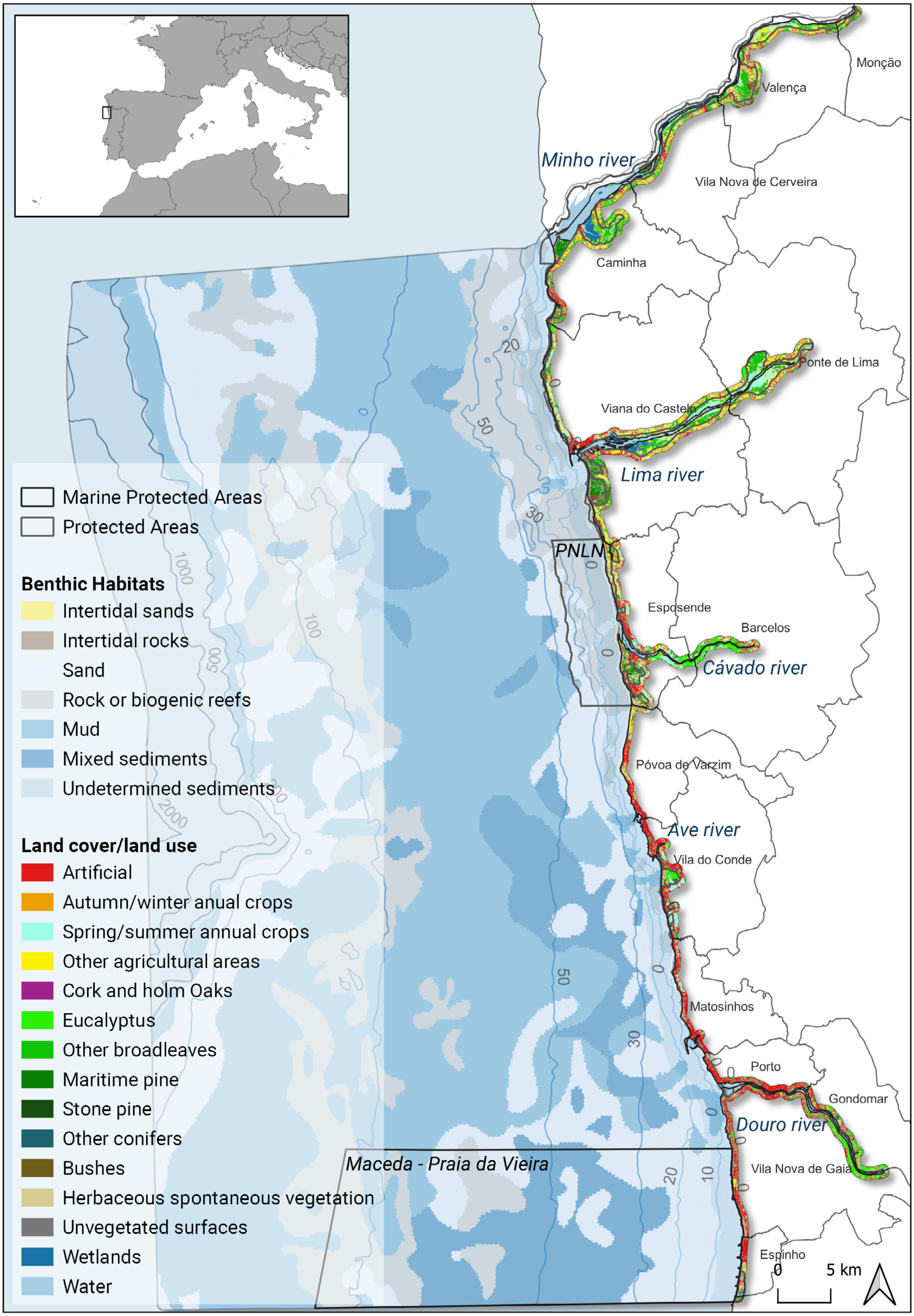

FIGURE 1 Map of the study area, highlighting the main estuaries in the region, the main benthic habitats and the land cover/land use of the coastal area included in the study area.

ranking score of 1, 2 and 3 was attributed to the three rankings, namely 'Less Important' (1), 'Moderately Important' (2), and 'Very Important' (3). The participatory mapping results were used to obtain qualitative spatial data on RMES supply, pressures, and conflict areas. The stakeholder maps were digitized using QGIS (version 3.26), following the recommendations from Burkhard (2017), and using the spatial location of each RMES or pressures independently, based on the classification assigned by each group. The results were aggregated into a 1km INSPIRE EEA reference grid (EEA, 2013), using a spatial join, resulting in two datasets: one with the number of unique RMES supply in each grid cell, and one with the number of unique pressures. It is important to highlight that, if the two groups identify the same RMES supplied in the same delimited area, the specific RMES was only counted once to prevent double-counting errors.

In order to compare the stakeholder localization of RMES supply areas and pressures with scientific assessments, previous studies by the research team were used (Cunha et al., 2023; Cunha, Elliott, et al., 2025). Comparisons were made between the RMES supply maps created by the stakeholders (number of RMES provided in each grid cell) and those from Cunha et al. (2023) (also the number of RMES provided in each grid cell). Cunha et al. (2023) assessed hotspots of RMES supply in the study area using available scientific data, in specific regional spatial-explicit biophysical indicators for 9 RMES. The stakeholder pressure maps (number of pressures or sources of pressure on each grid cell) were compared with data from Cunha, Elliott, et al. (2025). The available spatial extent of existing sources of pressures from the various maritime and coastal activities and uses were mapped, with the objective of assessing the risk across the study area. The data used for comparison also included the number of pressures per grid cell. Prior to map comparisons, RMES supply and pressures values were normalized to dimensionless values. Map comparisons used the Similarity in Mean (SIM) from the Structural Similarity (SSIM) index (Jones et al., 2016; Wang et al., 2004). This cell-by-cell comparison method compares two map output values, while accounting for the values of neighbouring pixels that may mitigate deviations between the focal pixels, thereby generating spatially explicit results (Hagen-Zanker, 2006). The SIM statistic, defined as the ratio of twice the product of the local means and their summed squares (Jones et al., 2016), ranges from 0 to 1, with 1 indicating similarity in both maps (e.g. similar local numbers of RMES supply or number of pressures) and 0 indicating dissimilarity between the two maps (e.g. different local numbers of RMES supply or number of pressures).

2.5 | Ethics statement

In accordance with the local legislation, ethical approval was not required for this study with the participants. All the participants gave written informed consent to participate in the study and to have their responses used for research purposes.

3 | RESULTS

3.1 | Stakeholders perceptions

3.1.1 | Perceived importance and supply maps of RMES by stakeholders

The combined results of the two working groups indicated that 16 of the 20 RMES were classified as 'Very Important', although there were some variations in priority between stakeholder groups (Figure 2). With the exception of a few RMES, stakeholders classified as 'Very Important' the majority of RMES within the scope of this study. Nevertheless, the two stakeholder groups gave similar classifications for only 10 RMES, namely 8 classified as 'Very Important' and 2 as 'Moderately Important' (Figure 2). The eight RMES that were identified as being of the greatest importance were 'Control of erosion rates', 'Buffering and attenuation of mass movement', 'Hydrological cycle and water flow regulation (including flood control and coastal protection)', 'Maintaining or regulating nursery populations and habitats or breeding grounds (including gene pool protection)', 'Maintaining or regulating refuge habitats', 'Maintaining or regulating feeding grounds', 'Regulation of the chemical condition of freshwaters or saltwaters', and 'Regulation of the chemical composition of atmosphere and oceans'. Conversely, some RMES were assigned contrasting ranking scores. For example, 'Fire protection', 'Disease control' and 'Regulation of formation, structure and soil quality', were classified as the lowest priority by one group, but as the highest priority by another.

The participatory mapping exercise revealed that stakeholders identified estuarine areas as suppliers of more RMES (Figure 3). They also highlighted the coastal region as a significant supply area, with a higher RMES supply than the southern section, creating a distinct north–south gradient (Figure 3). Furthermore, one group also identified the Maceda-Praia da Vieira MPA as a significant RMES supply region.

3.1.2 | Perceived pressures and conflicts RMES by stakeholders

The stakeholders identified ten pressures or sources of pressure occurring in the study area, mostly from terrestrial sources (Figure 4): 'Agriculture', 'Dams', 'Offshore energy', 'Climate change', 'Commercial fishing', 'Maritime traffic', 'Pollution', (poor) 'Spatial planning', 'Tourism', 'Urban development/Human pressure'. Key challenges in the supply of RMES included urban development and increased human activity, with the additional pressures of tourism in the coastal zones. Furthermore, it was indicated that inadequate spatial planning further exacerbates these pressures. Agriculture, pollution (in its various forms—air, water and soil contamination) and climate change were identified as significant pressures across coastal and marine areas, while dams were noted as affecting estuaries and hydrographic basins. Stakeholders identified maritime

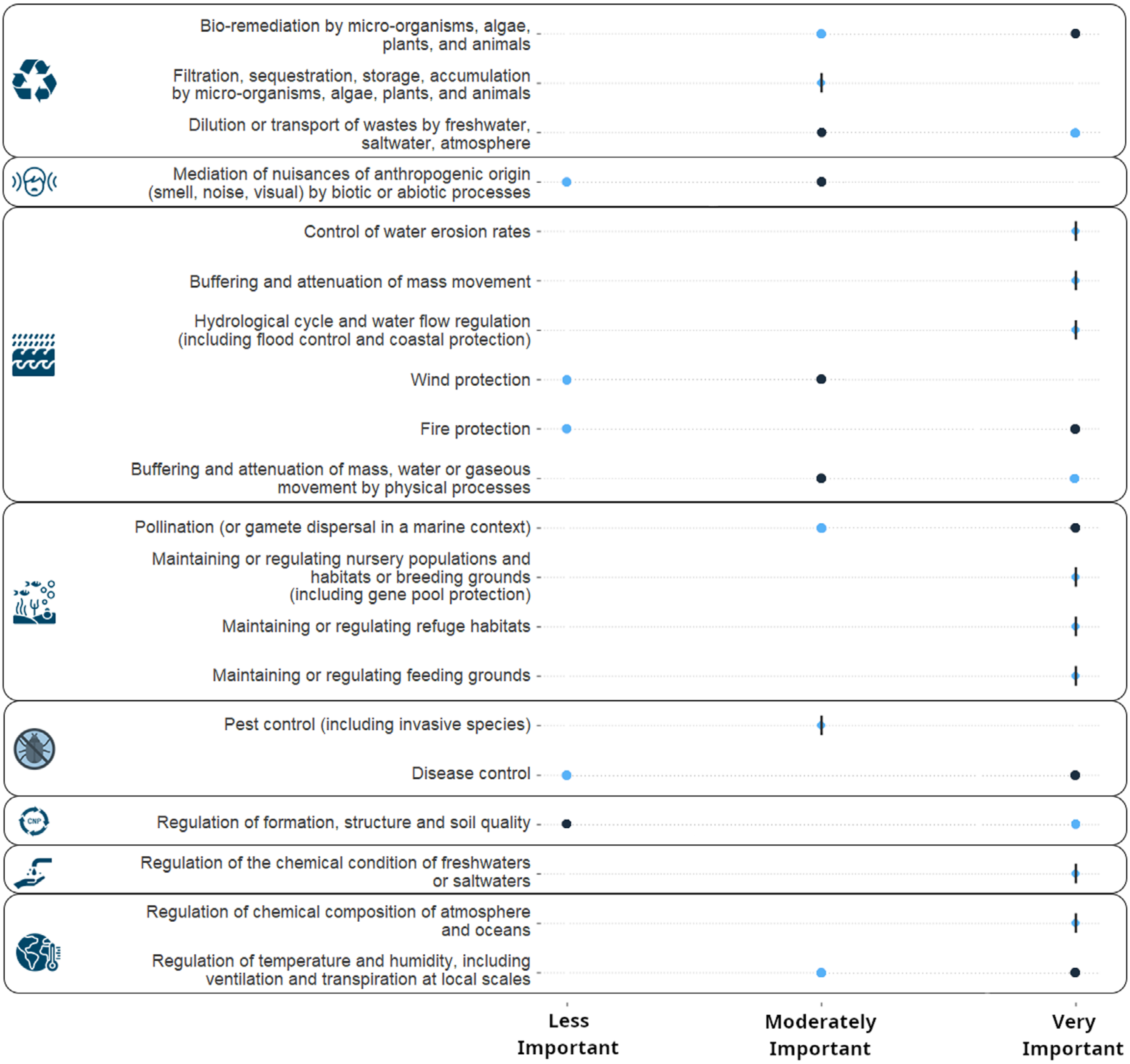

FIGURE 2 The rankings for each RMES, as assessed by stakeholders, from Less Important to Very Important. Dark blue points represent the rankings from Group 1, while light blue points represent the rankings from Group 2. Light blue points with a vertical bar indicate identical ranking between the two groups.

traffic, commercial fishing, and offshore energy facilities and their operations as significant pressures for RMES supply in marine areas. Stakeholders recognized coastal zones, particularly in the northern section of the study area and its main estuaries, as areas of potential conflict between RMES supply and human activities (Figure 5).

Some areas of the photic zone (≤30 m depth) were identified as potential locations for conflicts between the supply of nursery and feeding areas for fish and the fisheries sector. Additionally, stakeholders also identified potential conflicts between human uses and activities, namely between: 'Urban development/Human pressure' and 'Tourism' in coastal areas; 'Pollution' and 'Tourism' in the estuaries; 'and 'Maritime traffic' and the existence of 'Dams'. Conflicts were also identified between 'Commercial fishing' and 'Tourism', and between 'Commercial fishing' and 'Offshore energy'. In addition, the potential for conflict uses between MPAs and the conservation of fish stocks and certain fishing activities was highlighted.

3.1.3 | Shared vision

Stakeholders expressed a shared vision for enhancing terrestrial and marine ecosystems, characterized as "More Green" and "More

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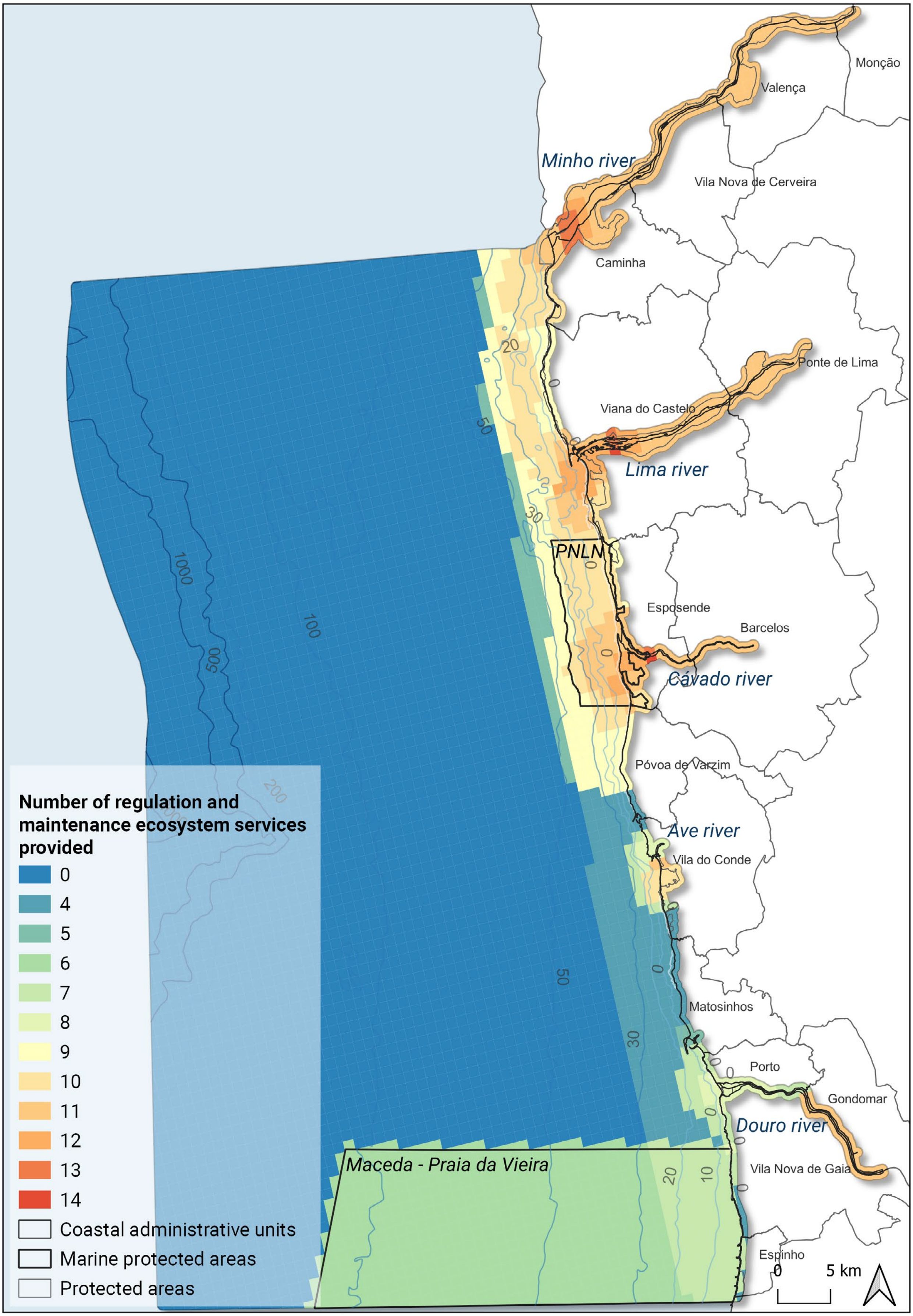

FIGURE 3 Distribution of the perceived supply areas of Regulation and Maintenance Ecosystem Services as mapped by the stakeholders, on a 1 km square grid.

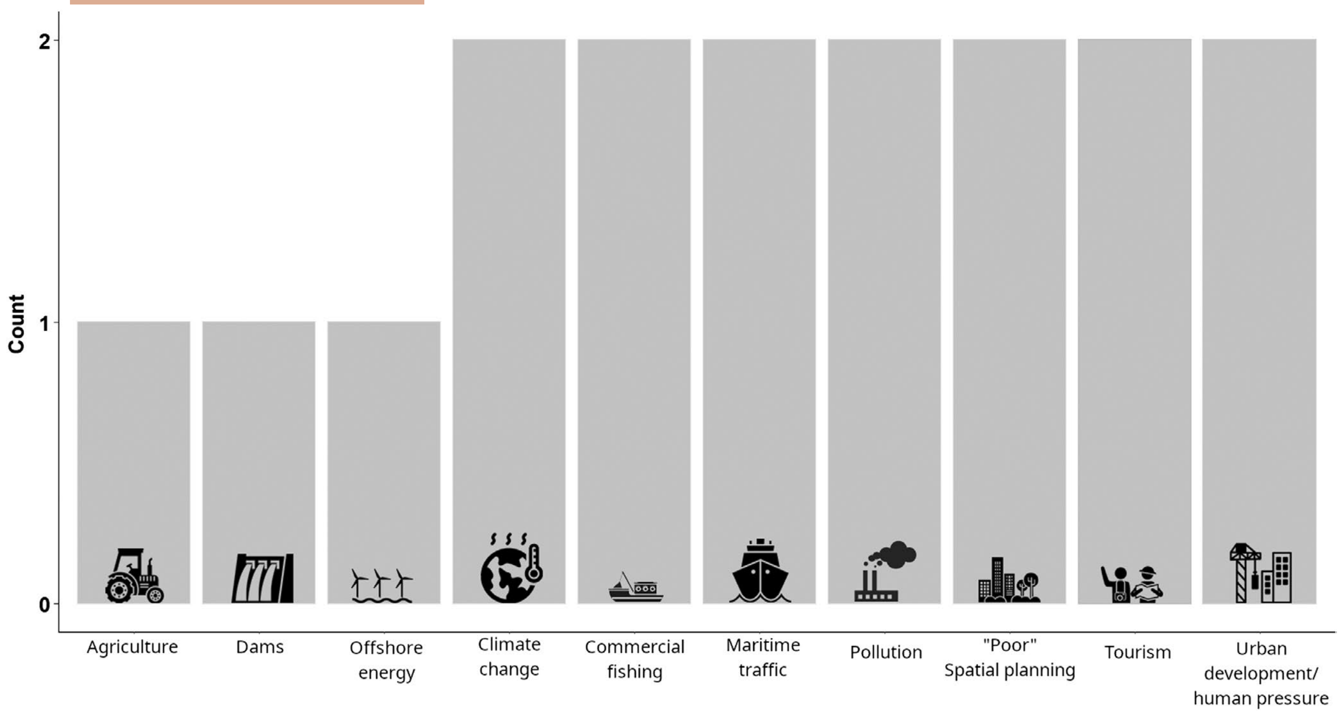

FIGURE 4 Activities and pressures identified by the two stakeholder groups affecting the supply of RMES in the case study region. The *y*-axis represents the count of each source of pressure from the stakeholder groups.

Blue." This vision emphasized fostering "More wildlife" through the maintenance and promotion of biodiversity (Figure 6). They emphasized the importance of increasing ES supply and maximizing compatibility between human activities, natural capital exploitation and ES provision. In addition, stakeholders aspired to enhance public participation in decision-making processes. This included proposing several measures (Figure 6), including promoting environmental and marine literacy, implementing increased monitoring efforts, and facilitating greater public involvement in decision-making. Other measures included incorporating "long-term thinking" into regional spatial plans, enhancing sustainable human activities, and increasing research on the impacts of human activities on ecosystems.

3.2 | Stakeholder versus scientific assessment comparisons

The comparison of stakeholder and scientific RMES supply maps revealed differences mainly in the offshore areas (Figure 7). Both maps identify nearshore areas as RMES supply hotspots, although stakeholders indicated a higher number of RMES provisioned in these areas than those reported by Cunha et al. (2023). This was evident, for example, within the PNLN MPA, the nearshore area to the north of the Lima estuary and in upper parts of estuaries. In contrast, offshore areas exhibited divergent outcomes, with the stakeholders' maps indicating lesser perceived supply of RMES compared to Cunha et al. (2023).

Regarding pressures, stakeholder participatory maps generally aligned with scientific assessments, except in offshore regions (Figure 5). Stakeholders identified fewer pressures in offshore areas than those reported by Cunha, Elliott, et al. (2025) (Figure 7). In contrast, stakeholders indicated more pressures in estuarine areas, particularly in the Minho and Lima estuaries. While nearshore areas generally matched the scientific assessment findings of Cunha, Elliott, et al. (2025), stakeholder maps indicated higher pressure prevalence in areas closer to the shoreline.

4 | DISCUSSION

This study examined stakeholder priorities, perceptions of RMES supply areas, and perceived pressures on these services in a coastal–marine socio-ecological system, while also comparing the participatory mapping outputs with previous scientific assessments. By integrating these two knowledge sources, the study illustrates how co-produced ES and pressures information can help fill existing knowledge gaps and support more effective, inclusive, and transformative EBM and maritime spatial planning.

4.1 | Stakeholder priorities for regulation and maintenance ES

Although the pivotal role of RMES in regulating the natural system and supporting the supply of other ES and SGB, they remain largely unacknowledged by society, making their assessment complex (Potschin-Young et al., 2017; Sutherland et al., 2018). In contrast, other types of ES, such as the provisioning or cultural SGB, are more readily recognizable, with their material and socio-economic value

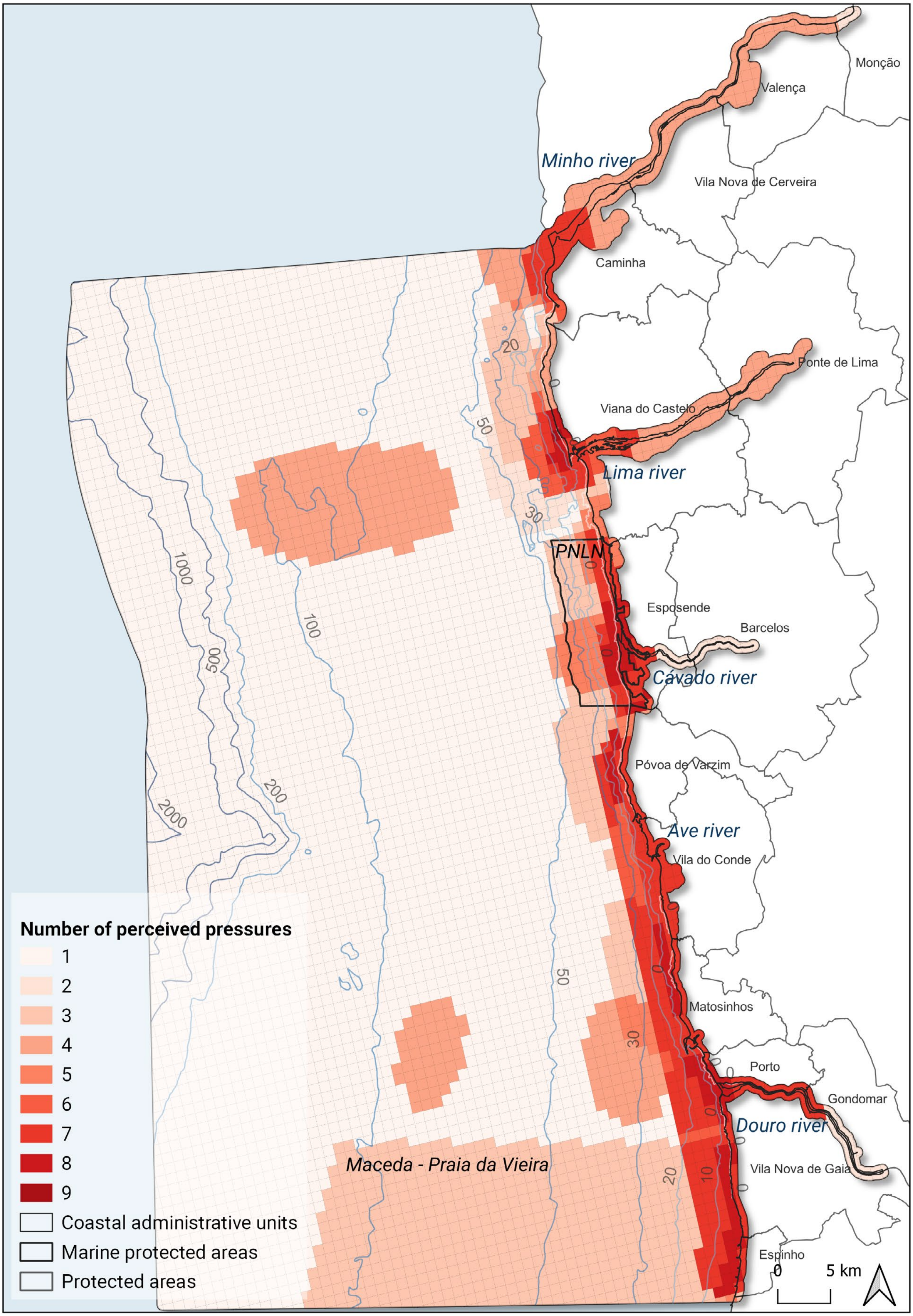

FIGURE 5 The distribution of the cumulative perceived pressures affecting the provision of Regulation and Maintenance Ecosystem Services classified as 'Very Important', as mapped by the two stakeholder groups, on a 1 km square grid.

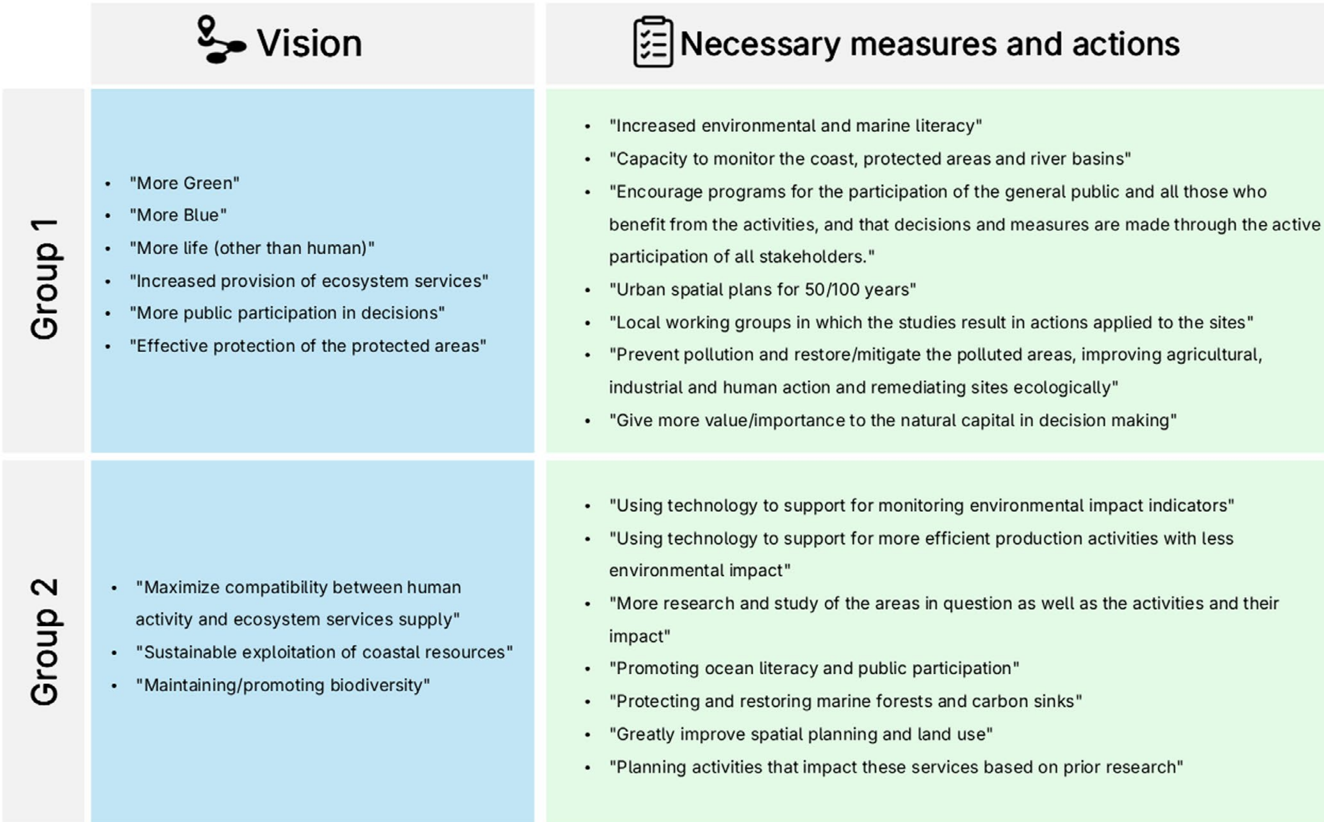

FIGURE 6 The 20-year shared vision for the case study area developed by the two stakeholder groups (left), and examples of the measures and actions they identified as necessary to achieve it (right). The original wording and phrasing provided by stakeholders were preserved, with only translation into English being applied.

better understood (Hummel et al., 2017). The stakeholder priorities on RMES supply were found to reflect the local societal demands for these types of ES. The regionally most important sectors (e.g. fishing, tourism, urban areas) might explain the shared consensus on the higher importance results of the RMES related to the coastal protection (Cunha et al., 2021; Marinho et al., 2019), water quality regulation and the provision of habitats for the lifecycle of species (Amorim et al., 2017, 2018), in which some are shared with other coastal communities (Arkema et al., 2015; Custodio et al., 2022). In contrast, RMES such as 'Disease control' or 'Regulation of soil quality' showed contradictory results between the two groups, that might be associated with the heterogeneous profiles of stakeholders, independently of representing the Quadruple Helix of the society. Furthermore, despite the favourable reception and interest demonstrated by the stakeholders, there was a notable absence of representatives from the governmental sector, perhaps resulting in a lesser perspective from region territorial management bodies.

4.2 | Perceived pressures

Stakeholders identified a suite of pressures affecting RMES supply in the region, such as the increased urban development/human pressures (Almeida et al., 2014; Marinho et al., 2019; Stronkhorst et al., 2018), and increasing human activities such as maritime traffic (Nunes et al., 2017; Rocha et al., 2021), tourism (Cunha et al., 2018), and pollution (Espincho et al., 2024; Ramos et al., 2015; Rodrigues et al., 2019, 2020). This reinforces the global trends of threats to the coastal zone, as the 'triple whammy' of increased urbanization and industrialisation, increased use of physical and biological resources, and decreased resistance and resilience to climate change (Defeo & Elliott, 2021). These can adversely affect RMES supply, especially in areas and species that are potentially more susceptible to change, such as those nearshore (Viitasalo & Bonsdorff, 2022; Wernberg et al., 2016). These areas, together with estuarine areas, serve as vital nurseries, refuge, and feeding grounds for many fish and their communities (Ramos et al., 2010, 2017), and they contain important saltmarshes providing numerous RMES (Almeida et al., 2011; Cunha et al., 2024; Ribeiro et al., 2015).

Climate change was also perceived as a major and escalating threat. In fact, according to the recent IPCC projections (IPCC, 2023), the NW coast of Portugal is expected to be greatly affected by climate change; for example, affecting coastal vulnerability and erosion (Cunha et al., 2021, 2024; Marinho et al., 2019), flooding events (Iglesias et al., 2022), changes in macroalgae assemblages (Chabrerie & Arenas, 2024; de Azevedo et al., 2023), and the spread of invasive

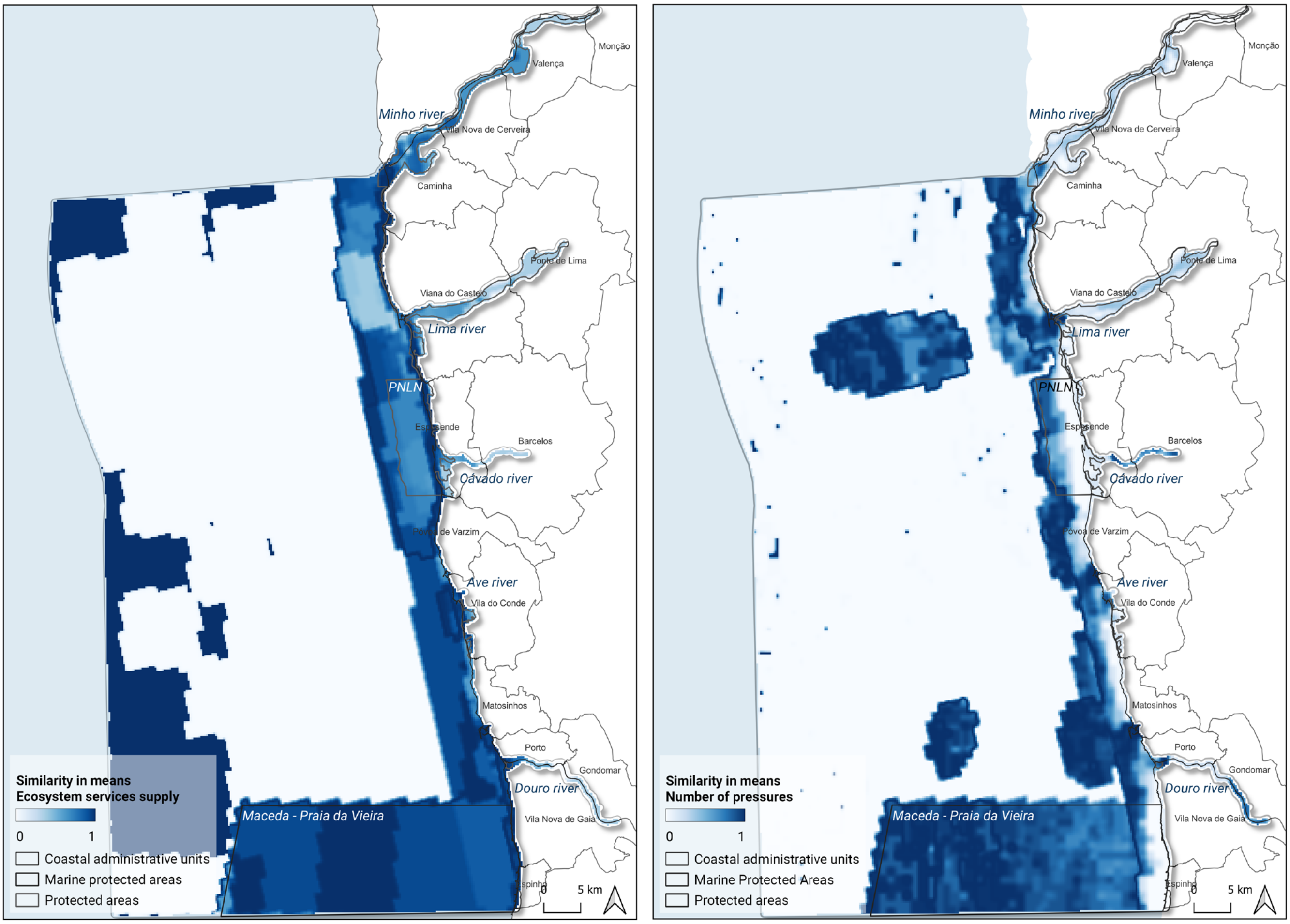

FIGURE 7 The similarity in means (SIM) results for the map comparisons of the perceived supply of Regulation and Maintenance Ecosystem Services (left) and the number of sources of pressures (right) between the stakeholder participative maps and the scientific assessments of Cunha et al. (2023) and Cunha, Elliott, et al. (2025). SIM values range from 0 to 1; 0- dissimilarity between the two maps; 1- similarity in both maps.

species (Martins et al., 2019). This study reinforced the need to adopt a medium to long-term perspective in the management of the area, with the aim of addressing these exogenic sources of pressure (Borja et al., 2024; Capela Lourenço et al., 2019; Elliott, 2011; Queirós et al., 2021).

Although stakeholders did not explicitly discuss RMES trade-offs, they did identify conflicts among activity sectors, particularly between fisheries, tourism, conservation, and offshore wind development. These conflicts are expected in systems where multiple activities depend on overlapping natural capital, and it is expected that trade-offs occur (Ungaro et al., 2014). Recognizing such conflicts and trade-offs is essential for aligning regional planning with ecosystem capacities and user needs, an important step toward legitimacy of management and conflict-avoidant governance (e.g. see Polette et al., 2026).

4.3 | Map comparisons

Stakeholder maps of RMES supply showed strong convergence with scientific assessments of ES supply, identifying estuaries, nearshore photic zones and sensitive coastal habitats as key RMES hotspots (Amorim et al., 2018; Cunha et al., 2023; Gomes et al., 2018). For example, these areas enhance biodiversity by providing essential nursery, spawning, and refuge habitats for marine organisms (Amorim et al., 2018; Gomes et al., 2018), as well as carbon sequestration and storage (Cunha et al., 2024), thus playing foundational roles in regional ecological functioning. In contrast, participatory maps tended to underestimate the supply of RMES in offshore areas when compared to previous scientific assessments, reflecting knowledge gaps noted in other studies (Liquete et al., 2013; Watson et al., 2024). This reflects the limited stakeholder familiarity with deeper-water ecosystems, where ecological processes are less visible or less directly connected to society. Nevertheless, the stakeholder maps complement the scientific assessment from Cunha et al. (2023), in particular, by indicating areas for which no data are currently available, such as for existing benthic habitats within the PNLN MPA (Cunha et al., 2023), highlighting the importance of using various sources of knowledge when assessing ES.

This study revealed a significant overlap between the areas deemed most important for RMES supply by stakeholders and those with the highest number of sources of pressures. The spatial coincidence of ecological importance and socio-economic activities highlights the urgent need to improve the management of human activities in coastal and marine ecosystems to balance the regions' socio-economic activities and the maintenance of a productive system (Elliott, 2013, 2023; Elliott & O'Higgins, 2020). This is particularly important in regions experiencing higher pressure intensity, such as the coastal zone or the most intense fishing locations (Cunha et al., 2021; Marinho et al., 2019). However, the effectiveness of this management will also depend on the locations of the actual beneficiaries of the SGB, as some benefits are realized outside their supply regions (Drakou et al., 2018; Nahuelhual et al., 2020; O'Higgins et al., 2019; Schröter et al., 2018).

The comparison between pressures maps and the participatory maps obtained in this study also highlight knowledge gaps for offshore regions identified above. Although participants identified some locations where activities such as fishing and shipping may disrupt RMES supply, these activities occur far more widely than indicated by the participants, as shown in regional activity maps (Cunha, Elliott, et al., 2025). Additionally, it is important to note that the pressure footprints of those same activities can be (and are expected to be) larger than the spatial footprints of the activities themselves (Elliott et al., 2020). Conversely, and similar to the mapping of RMES, the uptake of information from stakeholders allowed filling knowledge gaps regarding the extent of some activities, thereby providing a more comprehensive understanding of the pressures exerted on areas closer to the shore (Nahuelhual et al., 2020). For example, stakeholders draw attention to the fishing grounds closer to shore used by small scale fishers that lacked spatial extent information as used by Cunha, Cabecinha, et al. (2025). Overall, these results underscore the value of integrating local knowledge with scientific information, as co-produced insights can reveal pressures and spatial dynamics that might otherwise remain overlooked (Barton et al., 2024; Bonnevie et al., 2023; Zulian et al., 2018).

4.4 | Future vision and management

The 20-year vision and measures proposed by the stakeholders closely align with major European and global environmental legislative instruments and the principles of EBM, which emphasize the importance of valuing the region natural capital in management decisions (Barton et al., 2024; Papadopoulou et al., 2025; Pascual et al., 2023). The group envisaged a greener and bluer region that would protect its natural capital, in line with the objective of maximizing the compatibility of human activities with the protection of natural resources as set out by, for example, the Marine Strategy Framework Directive (MSFD) (European Commission, 2008), the Maritime Spatial Planning Directive (MSP, 2014/89/EU), and the UN Sustainable Development Goals (Cormier & Elliott, 2017; United Nations, 2015). The stakeholders emphasis on habitat conservation, restoration, and nature-based solutions reflects alignment with initiatives such as the EU Nature Restoration Regulation (European Parliament, 2023). Stakeholders also emphasized the importance of improving public awareness through ocean literacy, which is usually poor (Costa & Caldeira, 2018), recognizing that stronger connections between ecosystems and human well-being can support more informed decision-making and foster environmentally responsible societies. (Barracosa et al., 2019; McKinley et al., 2023).

Moreover, an increased environmental literacy facilitates the implementation of local and regional bottom-up approaches to coastal and marine management, addressing the needs of local communities (Díaz et al., 2015; Garcia Rodrigues et al., 2022; Terêncio et al., 2021; Villasante et al., 2022). The integration of societal values into decision-making processes, advocated by the stakeholders, is a fundamental aspect that must be addressed by environmental policies in general. This is important to avoid conflicting views between those managing the system and the users and beneficiaries of its natural capital (Cormier, Elliott & Borja 2022; Díaz et al., 2015; Elliott et al., 2023; Pascual et al., 2023; Zulian et al., 2018). Overall, the findings here reinforce the need for MSFD and MSP processes to integrate scientific and local knowledge with active stakeholder engagement to reduce conflicts, ensure equitable resource use and maintain good ecological status in coastal and marine systems.

5 | CONCLUSIONS

This study demonstrates the value of integrating stakeholder knowledge with scientific assessments to improve the understanding and management of RMES in coastal and marine socio-ecological systems. The participatory workshop performed in this study revealed that stakeholders possess place-based knowledge, particularly in nearshore areas, that complements scientific assessments and helps fill important gaps in spatial datasets. At the same time, discrepancies between stakeholder perceptions and scientific assessments, especially in offshore areas and in the identification of pressure footprints, underscore the need for combining multiple knowledge sources to obtain a more accurate and operational picture of service supply and the pressures affecting it.

Stakeholders highlighted priority RMES, identified key pressures and conflicts, and articulated a shared 20-year vision centred on nature protection, sustainable uses, and enhanced environmental literacy. Their proposed measures align closely with major EU policies and global sustainability targets, demonstrating strong regional readiness to advance ecosystem-based management and contributing to transformative change in marine governance. By comparing participatory mapping outputs with existing indicator-based scientific assessments, this study provides new insights into their complementarities and limitations. The results emphasize that co-produced knowledge, rooted in both scientific evidence and stakeholder expertise, is essential for improving the relevance, transparency, and legitimacy of MSP and marine EBM.

Overall, the study establishes a baseline understanding of stakeholder priorities and perceptions of RMES and highlights practical pathways for integrating local knowledge into marine decision-making. This integrative approach strengthens the capacity of coastal governance to anticipate trade-offs, reduce conflicts and support the long-term sustainability of marine natural capital and the societal benefits it underpins.

AUTHOR CONTRIBUTIONS

Jacinto Cunha, Edna Cabecinha, Sebastian Villasante and Sandra Ramos were involved in conceptualisation. Jacinto Cunha was involved in data curation, visualization and software. Jacinto Cunha and Sandra Ramos were involved in formal analysis and resources. Edna Cabecinha, Sebastian Villasante, Stefano Balbi, Michael Elliott and Sandra Ramos were involved in funding acquisition and supervision. Jacinto Cunha, Edna Cabecinha, Sebastian Villasante and Sandra Ramos were involved in investigation, methodology, project administration and validation. Jacinto Cunha, Edna Cabecinha, Sebastian Villasante, Stefano Balbi, Michael Elliott and Sandra Ramos were involved in Writing—original draft and Writing—review and editing.

ACKNOWLEDGEMENTS

This research was supported by National Funds through FCT-Fundação para a Ciência e a Tecnologia, I.P., and by the European Commission's Recovery and Resilience Facility, within the scope of UID/04423/2025 (https://doi.org/10.54499/UID/04423/2025), UID/PRR/04423/2025 (https://doi.org/10.54499/UID/PRR/04423/2025), LA/P/0101/2020 (https://doi.org/10.54499/LA/P/0101/2020); and under the projects UID/04033/2025: Centre for the Research and Technology of Agro-Environmental and Biological Sciences (https://doi.org/10.54499/UID/04033/2025) and LA/P/0126/2020 (https://doi.org/10.54499/LA/P/0126/2020). This project was also supported the ATLANTIDA II project (ref. NORTE2030-FEDER-01799200), co-financed by the European Union through the NORTE 2030 Regional Program and the European Regional Development Fund (ERDF). J.C. was supported by a Ph.D. fellowship from FCT Do*Mar (ref. PD/BD/150359/2019, co-financed by FSE through Programa Operacional Regional Norte), and SR a research contract (https://doi.org/10.54499/CEECINSTLA/00028/2022/CP2990/CT0004). This study has also received support from the European Union's Horizon Europe research and innovation programme under the grant agreement N° GA 101082048. The contribution of M.E. was funded in part under the EU Horizon Europe MARBEFES project (MARine Biodiversity and Ecosystem Functioning leading to Ecosystem Services, https://www.marbefes.eu/) through the UKRI Grant Agreement N° 10048815. SV thanks the financial support of the EU Atlanteco project through the Grant Agreement N° 862923. The authors thank Rúben Pereira, Sabrina Rodrigues and Diogo Silva for their help in the organization of the workshop. The authors acknowledge the time and constructive feedback from two anonymous reviewers that greatly helped to improve the quality of this manuscript.

FUNDING INFORMATION

This research was funded by the project Mar2Protect (GA N° 101082048) funded by the European Union Horizon Europe.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests. Sebastian Villasante is an Associate Editor for People and Nature, but was not involved in the peer review and decision-making process.

DATA AVAILABILITY STATEMENT

All supporting data are archived on Dryad Digital Repository https://doi.org/10.5061/dryad.prr4xgz21.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

Figure S1. Workshop Exercise 1 table for stakeholders ranking of the importance of regulation and maintenance ecosystem services (RMES) in the region. The table was translated from the original in portuguese.

Figure S2. List of the RMES provided to stakeholders to support exercise 1, adapted from Haines-Young and Potschin (2018) and translated to Portuguese for the workshop. Here is shown the original English version.

Figure S3. Map of the study area for the workshop participatory mapping exercise 1 where participants were tasked with mapping areas of Very Important Service Supply.

Figure S4. Workshop exercise 2 table for stakeholders to identify the pressures and conflict areas in the region. The table was translated from the original in portuguese.

Figure S5. Workshop exercise 3 table for stakeholders to share their vision for the region over the next 20 years and identify potential actions and measures to achieve it. The table was translated from the original in portuguese.

How to cite this article: Cunha, J., Cabecinha, E., Villasante, S., Balbi, S., Elliott, M., & Ramos, S. (2026). Synergizing scientific and local knowledge for ecosystem services assessments: A case study in northern Portugal. *People and Nature*, *8*, 633–649. https://doi.org/10.1002/pan3.70261