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Analysis and preparation of participatory cartographies and climate risk perception maps in ICZM/MSP



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Abbreviations

CCA	Climate Change Adaptation
DMP	Data Management Plan
FAIR	Findable, Accessible, Interoperable, Reusable
GIS	Geographic Information System
ICZM	Integrated Coastal Zone Management
MCA	Multi-Criteria Analysis
MIT	Ministry of Infrastructure and Transport
MPA	Marine Protected Area
MSP	Maritime/Marine Spatial Planning
NBS	Nature-Based Solutions
NGO	Non-Governmental Organization
NM	Nautical Miles
PCs	Participatory Cartographies
PPGIS	Public Participation GIS
PPOL	<i>Pla de protecció i ordenació del litoral</i>
SWAP	Scenario Workshop and Adaptation Pathways



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Deliverable's Short Description

IUAV (lead of the activity), with the support of NKUA, will produce a report on participatory cartography and climate risk perception, examining how these approaches have been utilised in the past to enhance the definition and implementation of ICZM and MSP policies, particularly in the context of climate adaptation, resilience, and climate change.

The report will conclude with a set of recommendations for policymakers and local communities on technical and methodological tools to produce comprehensive participatory cartographies and climate risk perception maps, enabling partners to apply them to each pilot region and inform climate change adaptation plans.

Executive summary

This deliverable provides a structured analysis and operational framework for the use of Participatory Cartographies (PCs) and climate risk perception maps in Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP). Developed within the INCORE MED project, it examines how participatory mapping tools can strengthen inclusive climate adaptation processes in the coastal and maritime context and how they can be systematically integrated into the SWAP methodology. The study focuses on the pilot regions of Catalonia and Northern Sardinia, each characterised by distinct governance frameworks and climate related risks.

The deliverable begins by defining participatory cartographies within the broader field of critical cartography, emphasising their role in revealing power dynamics, integrating lived experiences with scientific data, and supporting more democratic and legitimate decision making. PCs are shown to enhance ICZM and MSP by capturing local knowledge, visualising spatial conflicts and cumulative risks, and enabling the co production of future scenarios. They support multiple stages of planning, particularly diagnostics, scenario creation, evaluation of trade offs, and monitoring. Their relevance for climate change adaptation is illustrated through international applications, including the MIRACLE project in Italy and the DeCyDe 4 SLR methodology in sites such as Venice, the Ebro Delta (in Spain) and Chalastra (in Greece). These cases demonstrate how PCs can translate projected hazards into concrete spatial consequences, improve risk literacy, and facilitate socially legitimate adaptation strategies.

The contextual analysis of pilot regions highlights the institutional, ecological and socio economic conditions shaping participatory processes. In Catalonia, PCs operate within an advanced ICZM framework anchored in Law 8 2020 and the forthcoming PPOL. The region faces severe erosion, high coastal exposure and accelerating sea level rise, making participatory mapping a valuable tool to identify local vulnerabilities, evaluate adaptation space, and integrate stakeholder perspectives into regulatory processes. In Northern Sardinia, PCs support MSP implementation under Italy's 2024 strategic national plans, particularly within the Tyrrhenian maritime area. The pilot region is characterised by strong seasonal tourism pressures, rich biodiversity, and climate risks related to sea rise temperature and acidification. Here PCs can reveal interactions between maritime uses, support anticipatory conflict management, and strengthen a multi scalar approach to adaptation in line with regional strategies such as the SRACC.

The deliverable then provides an operational pathway for embedding PCs within the SWAP methodology phases. In the preparation phase, analogue PCs are used to map existing uses, perceived risks and vulnerabilities. In the Scenario Workshop, digital platforms such as SeaSketch and Marxan support the co creation and comparison of alternative futures. In the Adaptation Pathways Workshop, mapping is reactivated to test sequences of measures, identify tipping



points, and refine strategies. In the final phase, participatory outputs might be transformed into digital atlas, storymaps and geoportal layers to ensure transparency, long term usability and iterative monitoring. This analysis emphasises the importance of facilitation, balanced representation of stakeholders, and the combination of analogue and digital tools.

A comprehensive review of PC related tools is provided, distinguishing between coastal oriented platforms such as Maptionnaire, Survey123, Ushahidi, MapMe and Impact chains tool for risk assessment, and maritime oriented systems such as SeaSketch and Marxan. Each tool is assessed based on its use case, level of participation, strengths, limitations, and suitability within the SWAP phases. The deliverable underlines that tool selection must be context specific and aligned with both governance requirements and stakeholder capacities. It also stresses the need for long term data management consistent with FAIR principles, and for integration with regional and national geoportals to ensure continuity across scales.

By defining a set of recommendations, resource allocation emerges as a critical enabling condition. Effective and legitimate participatory mapping requires trained facilitators, adequate technical infrastructure, multilingual communication, hybrid participation formats, and sustained investment beyond the project timeline. The deliverable emphasises that PCs must become institutionalised rather than episodic, evolving as living documents that are periodically updated as risks, data and local priorities change.

The deliverable concludes that participatory cartographies significantly enhance the credibility, inclusiveness and adaptive capacity of ICZM and MSP. By combining spatialised local knowledge with scientific assessments, PCs act as connective tissue between governance levels, sectors and knowledge domains. Their integration within the SWAP methodology creates a structured pathway for co producing adaptation strategies that are both technically robust and socially legitimate. In doing so, they support the transition toward more resilient and inclusive coastal and maritime governance systems in the Euro Mediterranean region.

Keywords

Participatory Cartographies (PCs); Climate Risk Perception Maps; Climate Change Adaptation; ICZM and MSP; SWAP Integration; Participatory Tools; Operational Recommendations

1. Introduction to the Deliverable

1.1 Objectives of the deliverable

This deliverable provides a structured operational analysis of PCs and climate risk perception maps within the frameworks of ICZM and MSP. Its main objective is to examine how these participatory tools have been used in previous contexts, assess their potential to address climate change adaptation (CCA), and identify conditions for their effective implementation in the INCORE-MED pilot regions.

The deliverable consolidates existing knowledge and practice into an analytical framework that clarifies the opportunities, challenges, and enabling factors associated with participatory cartographies and perception mapping. By doing so, it supports the operationalisation of SWAP processes, ensuring that participatory mapping can be effectively combined with scenario-building and adaptation planning.

Finally, to enhance operational effectiveness, the analysis focuses on the Catalonia and Sardinia pilot contexts of the INCORE-MED project, where the SWAP methodology will be implemented, to facilitate the integration of the most suitable participatory tools. In Catalonia, this means working within the ICZM framework to address coastal risks, particularly with respect to erosion and anticipated retreat due to sea-level rise. In Northern Sardinia, the focus is on MSP as the reference framework for tackling marine risks, including biodiversity loss due to rising sea surface temperatures and acidification. To this end, the document also provides a set of recommendations to guide the effective integration of these participatory tools into each institutional process and environmental context.

1.2 Alignment with ICZM and MSP frameworks

This deliverable fits within the broader institutional frameworks of ICZM and MSP, which represent the principal governance approaches for managing coastal and marine areas in the Euro-Mediterranean region. While both frameworks aim to integrate multiple sectors, reconcile socio-economic activities with ecological protection, and foster adaptive strategies to address climate-related risks, their effectiveness ultimately depends on the capacity to embed participatory practices and incorporate the knowledge of users and local actors (see par. 2.1).



ICZM, consolidated at the Mediterranean level through the 2008 Barcelona Convention Protocol, establishes a legally binding framework for the sustainable management of coastal zones. It calls for the integration of policies across sectors, governance levels, and temporal scales, recognising that the coast is a complex interface where terrestrial, marine, and human systems intersect. The Protocol underlines the need to manage land-sea interactions, reduce the impact of human pressures, and safeguard the resilience of coastal ecosystems and communities. It also emphasises the importance of participation, adaptive management, and ecosystem-based approaches, encouraging contracting parties to involve local stakeholders in decision-making and to monitor and adjust policies in response to changing conditions. By doing so, ICZM provides a structured pathway for addressing cumulative impacts, such as those arising from urbanisation, tourism, agriculture, and climate change, in a holistic and coordinated manner.

MSP, mandated at the EU level by the Maritime Spatial Planning Directive (2014/89/EU), sets the framework for organising maritime activities within national waters. Its primary objectives are to promote the sustainable development of the blue economy, ensure the coexistence of competing maritime uses, and contribute to the long-term protection of marine ecosystems. The Directive requires Member States to adopt ecosystem-based management, to take into account land-sea interactions, and to establish planning processes that are participatory, transparent, and adaptive. MSP also recognises the importance of cross-border cooperation, given the transnational nature of many maritime activities and environmental challenges. In practice, MSP provides a governance mechanism capable of anticipating and reducing spatial conflicts, coordinating sectoral policies, and integrating climate adaptation strategies into the management of marine spaces.

By framing participatory processes within these institutional contexts, the deliverable contributes to the operationalisation of the ICZM and MSP principles, ensuring coherence with European and Mediterranean policy objectives. It also directly supports the implementation of broader strategies such as the European Green Deal (European Commission, 2019), the EU Adaptation Strategy (European Commission, 2021), and the EU Sustainable Blue Economy Strategy (European Commission, 2021), all of which underline the importance of inclusive, knowledge-based, and adaptive governance for coastal and marine systems.

1.3 Deliverable Methodology

The methodology adopted for this deliverable is based on a structured operational analysis designed to systematise existing practices, evaluate their applicability, and provide practical recommendations for their integration into ICZM and MSP.

The methodology works on linking participatory mapping tools to three key analytical dimensions: the institutional processes that shape decision-making (ICZM and MSP), the geographical and

governance context in which planning is embedded, coastal and marine, and the specific -under investigation- climate risks relevant to each region. This approach moves beyond a simple review by operationalising correspondences between tools and contexts, ensuring that participatory methods are selected and adapted in ways that are technically robust, context-sensitive, and aligned with climate adaptation objectives.

The analytical process consists of three main steps:

1. Definition of PCs: A comprehensive review of experiences with participatory cartographies and climate risk perception mapping in Europe and the Mediterranean was undertaken. This included examining how such tools have been applied in the context of climate change adaptation, resilience-building, and participatory governance. The review highlighted both opportunities (e.g. improved legitimacy, visibility of conflicts, co-production of knowledge) and barriers (e.g. asymmetries of power, limited technical capacities, challenges in scaling-up) that need to be considered in the INCORE-MED pilot regions.
2. Contextualisation of the pilot regions: The second step focused on situating participatory cartographies within the specific institutional frameworks and environmental conditions of the pilot regions. This required analysing the policy structures guiding Integrated Coastal Zone Management (ICZM) and Maritime Spatial Planning (MSP), identifying the target climate risks most relevant to each context, and evaluating the scope for embedding participatory processes. This contextualisation ensures that the operational analysis does not remain generic but is instead tailored to the differentiated governance logics and risk profiles of the regions involved.
3. Formulation of operational recommendations: Building on the review and contextual analysis, the deliverable formulates a set of technical and methodological recommendations. These address not only the choice of analogue or digital mapping tools (e.g. printed maps, stickers, participatory GIS platforms such as SeaSketch, ArcGIS Survey123, or StoryMaps), but also the enabling factors required for their effective use. These include governance coordination, political commitment, resource allocation, stakeholder engagement strategies, facilitation methods, and capacity-building for both communities and institutions. The recommendations are intended to guide the integration of participatory cartographies and climate risk perception maps into the SWAP (Scenario Workshop and Adaptation Pathways) methodology, ensuring that mapping outputs can directly inform scenario-building, pathway design, and adaptive planning.

The deliverable employs an analytical methodology that bridges consolidated experiences with concrete institutional and environmental realities of the pilot regions. It intends to generate practical and transferable guidance that strengthens the participatory dimension of ICZM and MSP, supports the integration of climate risk knowledge, and contributes to the operationalisation



of inclusive and adaptive coastal and marine governance.

2. Definition of Participatory Cartographies (PCs)

While cartographies are frequently perceived as neutral and scientific by those without experience in map-making, they are, in reality, deeply influenced by power dynamics that often marginalise local knowledge (Davret & Trouillet, 2025). Criticism of decision-makers has grown for flattening complex realities into digital maps, that is, representing them in a singular way when different realities coexist. In response, critical cartographies emerge within the broader framework of citizen science, engaging non-scientists in the scientific process of knowledge production (James, 2025). By integrating social issues with quantitative data, these cartographies complement knowledge production and contribute to more legitimate decisions and wider public acceptance (Davret & Trouillet, 2025).

As defined by Denwood et al. (2022), participatory mapping is an umbrella term that encompasses a wide range of methods for engaging stakeholders in the collective creation of maps or geospatial data, particularly those with direct experience and significant knowledge of the area of interest. Emerging in the late 1970s from community-based mapping practices, it evolved in the early 1990s with the rise of GIS technologies into Participatory GIS (PGIS), while also including other approaches such as sketch mapping and mental mapping (James, 2025).

These participatory approaches aim to capture the diverse ways in which communities value their surroundings, recognizing that value extends beyond economic measures to include social, cultural, and ecological dimensions that are often intangible and difficult to quantify (Scully-Engelmeyer et al., 2021). Considering the multiple ways in which people assign value to their environment, including cultural, recreational, aesthetic, or ecological significance, participatory mapping enables these perspectives to be represented spatially. This multi-agent practice requires citizens to communicate their spatial knowledge, perceptions, or experiences in support of specific research objectives or decision-making processes, and is often connected to social justice, serving as a bridge between local knowledge and institutional planning (Denwood et al., 2022).

PCs, particularly those which originate climate risk perception maps, can co-produce spatial knowledge through laboratories that foreground local lived experiences. Beyond their representational function, they serve as instruments of epistemic justice, shaping collective imaginaries. By merging scientific assessments with community narratives, they reveal socio-

environmental vulnerabilities and perceptions of climate risk, acting as shared platforms for reflection and more responsive adaptation strategies.

2.1 Integration of PCs within ICZM and MSP Frameworks

Within ICZM and MSP frameworks, PCs serve as crucial tools to integrate local and socio-economic dimensions, including voices typically excluded from the decision-making process (Calado *et al.*, 2025; Tolvanen *et al.*, 2019). This participatory approach enhances the credibility, coherence, and social legitimacy of CCA strategies, supporting more informed and equitable long-term solutions for navigating such complex contexts (Coelho *et al.*, 2023a).

PCs can support planning processes in different ways, depending on the stage of work. In the diagnostic phase of analysis, they facilitate the mapping of existing uses, ecological features, vulnerabilities, climate hazards and risks, such as acidification and warming. They can serve as tools to uncover locally perceived values and risks, which are often absent from datasets. When scenarios are created, PCs can enable stakeholders to co-create alternative futures, supporting more democratic planning outcomes. Also, they serve as a tool to evaluate the implications and trade-offs of different management strategies for coastal and marine resources and anthropogenic uses.

During the decision-making phase, they help identify priority areas for protection, sustainable exploitation, or restoration. Different users can collaboratively explore the spatial benefits and consequences of mitigation and adaptation strategies, thereby increasing transparency and legitimacy in decision-making. Finally, when outcomes need to be monitored and adjusted, repeating PC processes can help track both ecological changes and evolving stakeholder values and perceptions over time, thereby informing adaptive management processes and supporting long-term resilience. In sum, PCs can act as instruments that link lived realities and scientific forecasting with collective priorities.

2.2 Relevance of PCs for Climate Change Mitigation and Adaptation

The integration of participatory cartographies, particularly through climate risk perception maps, is not merely a technical tool, but a means to support more democratic and context-sensitive approaches to climate adaptation. By proposing innovative methods for collecting local knowledge, these tools challenge top-down governance models and empower those who hold cultural, ecological, or economic ties with coastal and maritime regions to play a central role in shaping the policies that affect them. In doing so, they incorporate the local social dimension into



the decision-making process, contributing to more inclusive, equitable and just strategies (Jayakody *et al.*, 2025).

Recent case studies, such as the participatory mapping of climate risk perceptions along with landscape values on Tasmania's East Coast (Jayakody *et al.*, 2025), demonstrate how these tools can bridge the gap between lived experiences and projected climate models. In this case, local community members were first asked to spatially identify areas they associated with key landscape values (such as aesthetic, recreational, biological, social, economic, cultural/heritage, and wilderness values). Subsequently, they mapped perceived risk factors based on a predefined list reflecting projected climate change impacts in the region (e.g., bushfires, sea-level rise and biodiversity loss). The study aimed to assess the extent of spatial association between climate risk perceptions and landscape values. The co-occurrence, or 'bundling', of risks and values enabled planners to identify high-priority zones where adaptation strategies are both necessary and socially legitimate for the local community.

Among the experiences developed in the Mediterranean, a relevant example is offered by the MIRACLE (Multi-risk Integrated Resilience Approach for Coastal Landscapes and Environments) project, coordinated by Università Iuav di Venezia within the national RETURN partnership. MIRACLE explicitly addresses climate change as a systemic condition rather than an exceptional event, focusing on urban and coastal territories exposed to multiple, interacting risks, from sea-level rise and flooding to heatwaves and hydrogeological instability. The project develops a multi-risk and multi-scale framework, articulated across territorial transects ranging from Rimini to the Po Delta, from Venice to Naples and Castellammare di Stabia, selected for their high vulnerability to water-related hazards and compound socio-environmental stresses.

Participatory cartographies in MIRACLE were produced through urban labs and workshops with schools, universities, municipal technicians, and local institutions, primarily engaging educational and institutional stakeholders and not directly involving local community knowledge. The approach combined analogue and digital methods: maps were initially drawn manually by participants, then digitised into raster datasets and visualised through interactive platforms. Six thematic domains, socio-economic, demographic, geomorphological, infrastructural/services, ecological and threats, structured the mapping outputs, which integrated local perceptions with scientific risk assessments. The result was a series of perception maps, storymaps, thematic atlases and solution catalogues that revealed how climate risks are understood, prioritised, and spatialised by different actors. These outputs not only enriched the knowledge base but also triggered deliberation on alternative adaptation scenarios and supported the co-design of place-based strategies.

By treating the public space as a laboratory for hybrid solutions combining climate adaptation, urban regeneration, and social innovation, MIRACLE illustrates how participatory cartographies can foster a new grammar of risk: one that integrates hydrological and climatic drivers with socio-

cultural and institutional dimensions. In doing so, it aligns with international experiences while offering an operational reference for Mediterranean coastal contexts, demonstrating how participatory mapping can strengthen the legitimacy and effectiveness of adaptation planning.

Another Mediterranean case is provided by Loizidou et al. (2024), who explored how participatory and solution-oriented tools can strengthen adaptation to sea-level rise across four highly exposed areas: the Venice Lagoon, the Metaponto reclamation zone and Basento river mouth in Southern Italy, the Ebro Delta in Spain, and the coastal plain of Chalastra in the Axios Delta, Greece. These sites were chosen for their combined exposure to multiple hazards, including sea-level rise, subsidence, coastal erosion, and storm surges, which interact to threaten agricultural productivity, fisheries, ecosystems, and coastal infrastructure.

The methodology, known as *DeCyDe-4-SLR*, integrated semi-structured interviews, participatory workshops, and multi-criteria evaluations with the systematic use of visualisation tools. Stakeholders were asked to work with flood and inundation scenarios for different time horizons (2030, 2050, 2100), translating abstract projections into concrete spatial consequences for their local contexts. These mapping exercises facilitated structured discussions about the vulnerabilities of low-lying areas, the trade-offs between grey and nature-based solutions, and the feasibility of measures such as managed retreat. By engaging actors from local authorities, technical agencies, and community groups, the process produced Policy Tools that were site-specific, feasible, and collectively endorsed. Examples include the flexible management of flood barriers in Venice, the reinforcement of dunes and wetlands in the Ebro Delta, and the redesign of protective structures in Chalastra.

A key contribution of the study lies in its emphasis on social learning and knowledge exchange. The participatory process revealed mismatches between scientific risk assessments and community perceptions, allowing discrepancies to be reframed (Loizidou et al., 2024). It also illuminated barriers to adaptation, such as lack of awareness, political reluctance towards managed retreat, and uneven institutional capacities, while identifying enabling conditions like accessible communication tools, inclusive facilitation, and iterative engagement.

In conclusion, participatory cartographies act as transformative devices within climate adaptation governance. They move beyond the “mono-elementary” logic of top-down planning by weaving together diverse knowledge domains (e.g. scientific and experiential, technical and affective) into shared spatial representations. In doing so, they expand the epistemology of risk, making cumulative impacts visible and negotiable across institutional and community arenas. Rather than static outputs, they function as iterative and relational processes that foster inclusiveness, transparency, and adaptability. Ultimately, participatory cartographies enhance the legitimacy and effectiveness of ICZM and MSP by enabling collective agency in envisioning and co-producing resilient coastal and maritime futures.



2.3 Opportunities and potential barriers of PCs

One of the key opportunities offered by PCs is the ability to make spatial conflict explicit. When diverse actors are invited to map their uses, values, and perceptions of space, divergences often surface. Although conflicts can be disruptive, their potential to generate constructive change should not be overlooked. By rendering competing visions visible, PCs allow for the early identification of incompatibilities and potential synergies, thereby contributing to a more informed negotiation of spatial allocation. However, realising this potential requires sensitive facilitation and political commitment to acknowledge different voices, including those typically marginalised in top-down institutionalised processes. By integrating diverse voices in a process of co-production of knowledge, such cartographies also contribute to the legitimacy of the institutional processes (Davret & Trouillet, 2025).

In the case of MSP, given its relatively recent emergence as a discipline, planning is never developed on a tabula rasa. Instead, it must first recognise the legacy of existing socio-spatial practices and licenses, and then support adaptive approaches (Gee *et al.*, 2018). That way, PCs can help as a tool not only for rendering visible emerging conflicts, but also more profound interests, beliefs, needs, and values lying beneath (Gee *et al.*, 2023).

Moreover, PCs can support the anticipatory capacity of planning processes. Beyond resolving present disputes, effective planning must prevent future ones, ensuring that incompatible activities do not spatially overlap and that cumulative pressures are addressed early on. Therefore, PCs allow planners to visualise not only current uses, but also future scenarios.

However, several barriers might limit the full realisation of PCs. First, the spatial scale at which conflicts unfold (whether local, regional, or transboundary) often exceeds the operational capacity of participatory processes, especially when constrained by limited time, resources, or institutional frameworks. Thus, upscaling participatory processes may face procedural and logistical complexities.

Secondly, spatial conflicts are rarely balanced: different actors possess unequal access to decision-making arenas, technical knowledge, and spatial representation tools. For instance, these inequalities become particularly evident when considering how the so-called “hard” maritime uses, those requiring fixed long-term infrastructure, can constrain more “soft” or mobile ones (Gee *et al.*, 2018). PCs can help articulate the spatial dynamics and power asymmetries between these maritime uses, enabling planning processes that are both more equitable and more resilient.

Furthermore, even when mapped conflicts appear resolved on paper, they may persist in practice or re-emerge over time, particularly if solutions fail to resonate with the lived realities and values of affected communities. As Gee *et al.* (2018; 2023) note, not all conflicts can be transformed into positive coexistence, remaining unsolved, and the legitimacy of a solution is ultimately determined

by its acceptance among stakeholders.

3. Contextualisation of the pilot regions

The two pilot areas addressed in this project, Catalonia and Northern Sardinia, are situated within different planning frameworks and are exposed to different primary climate-related risks. For this reason, the methodological development of PCs is adapted to the specific governance context and institutional process of each pilot. In Catalonia, the preparation of PCs is informed by the ICZM framework, with an emphasis on analysing coastal erosion processes and exploring how spatial perception data can support adaptation strategies at the land-sea interface. In Northern Sardinia, the analysis of PCs is aligned with the MSP framework, where the focus is on understanding interactions among multiple maritime uses and assessing how socio-ecological considerations can be integrated into spatial decision-making. Both pilots seek to enhance risk awareness, stakeholder engagement and the co-production of spatial knowledge, while the analytical focus differs according to the risks under investigation. This approach ensures that the methodology remains context-sensitive, policy-relevant and aligned with the specific needs of each pilot area.

3.1 Catalonia's ICZM Framework and Target Risks

The governance of coastal areas in Catalonia has progressively evolved from fragmented competences to a more integrated framework, aligned with European directives on ICZM. Early initiatives in the late 1990s and early 2000s, including the development of municipal-scale environmental indicators, GIS-based decision-support systems and public information platforms, laid the groundwork for a prospective "National Strategy for the Catalan Coast," anticipating the European Commission's ICZM Recommendation (COM/2002/413) and providing a first baseline for integrated planning (Sardá *et al.*, 2005). These pioneering efforts sought to address acute pressures from urbanisation, tourism and shoreline regression by promoting systematic data collection and stronger institutional coordination.

A major step forward was the approval of Law 8/2020 on coastal protection and planning, which endowed Catalonia with a dedicated legal framework for ICZM (Generalitat de Catalunya, 2020). The law mandates the elaboration of a *Pla de protecció i ordenació del litoral* (PPOL), a comprehensive territorial instrument with binding force. As stated in Law 8/2020, the PPOL must include cartographic delimitation, regulatory norms, socio-economic impact assessments and a



dedicated section on climate-change adaptation. It also establishes governance mechanisms, such as a *Consell Rector*, to oversee its implementation, and strengthens inter-administrative coordination with Barcelona City and the Metropolitan Area of Barcelona. The statute further formalises cooperation between the PPOL and the *Consell Català de Cogestió Marítima*, ensuring coherence at the land-sea interface and linking ICZM with marine governance. Other measures include the creation of the *Conservatori del Litoral de Catalunya* to safeguard vulnerable stretches through land acquisition and ecological restoration, alongside transitory provisions that explicitly acknowledge the urgency of addressing accelerated shoreline retreat.

This institutional framework is reinforced by strategic guidance from the Catalan Advisory Council for Sustainable Development (CADS, 2021), which highlights the importance of dynamic risk assessments, long-term monitoring of coastal systems, restoration of sediment fluxes, and the use of open platforms to ensure transparency and citizen involvement. In parallel, the Climate Change Act 16/2017 and the Catalan Strategy for Adaptation to Climate Change 2021–2030 (ESCACC30) provide a comprehensive framework for adaptation across sectors, with explicit operational objectives and measures targeting coastal hazards such as erosion and sea-level rise.

Within this evolving framework, PCs and related GeoSurvey tools can provide an effective means to operationalise the participatory and adaptive principles already embedded in Catalan coastal policy. PCs can support the PPOL in multiple phases: in the diagnostic phase, by capturing georeferenced perceptions of erosion, flooding and adaptation space from residents, user groups and municipal staff; in the scenario-building phase, by overlaying participatory layers with hazard projections to evaluate trade-offs among protection, ecosystem-based and managed realignment strategies; and in the monitoring phase, by tracking shifts in risk perception and values and ensuring continuity through publication in regional geoportals.

As demonstrated by recent scientific assessments of the Catalan coast, cumulative pressures from shoreline retreat, concentrated socio-economic exposure and sediment-supply limitations demand integrated and adaptive governance (Jiménez *et al.*, 2017; Alves *et al.*, 2020). PCs offer a structured mechanism for embedding local knowledge within this governance system, consistent with the participatory guarantees of Law 8/2020 and with Catalonia's climate adaptation agenda.

The need for such integration is underscored by the environmental conditions of the Catalan coast, a paradigmatic hotspot in the north-western Mediterranean where high population density, economic concentration, and infrastructure development converge with climate-related hazards. Extending for around 600 km, of which approximately 270 km are sandy beaches, the coastal strip includes 12 administrative units that host about 62% of the regional population and generate 65% of Catalonia's GDP. Densities in coastal municipalities average 1,518 inhabitants per km², compared to 232 inhabitants per km² for the region as a whole. Tourism, which contributes around 11% of GDP, is highly coastal-dependent, with nearly two-thirds of overnight stays concentrated in seaside destinations (Jiménez *et al.*, 2017). This combination of geomorphic heterogeneity,

socio-economic exposure, and development pressure epitomises the condition of the Mediterranean basin as a climate change hotspot (UNEP, 2009; Newton *et al.*, 2012).

Observed shoreline changes along Catalonia are already consistent with an erosion signal amplified by sea-level rise (SLR). Approximately 70% of beaches are in retreat, with mean erosion rates close to 0.7 m yr⁻¹ over recent decades (Jiménez *et al.*, 2017). Notably, reported damages from extreme storm events have increased, even though no robust basin-wide trend toward greater storm intensity has been detected. This points to exposure and vulnerability as the primary drivers of escalating impacts (Lionello *et al.*, 2008; Conte & Lionello, 2013; Jiménez *et al.*, 2017).

In heavily urbanised stretches, rigid coastal infrastructure prevents landward beach migration, reducing the adaptive capacity of the system and translating hydrodynamic forcing into persistent shoreline retreat (Jiménez *et al.*, 2017). Erosion is strongly influenced by sediment dynamics: when the equilibrium between sediment supply and removal is disrupted, coastlines retreat, exposing both natural and built environments to increasing risk (Alves *et al.*, 2020). Climate change exacerbates these processes by intensifying extreme storm events and accelerating SLR, which increases the frequency and magnitude of coastal flooding (Zhu *et al.*, 2010).

At the same time, the global mean sea level has already risen by about 20 cm since the beginning of the 20th century, and projections suggest a further increase of 0.28 - 1.01 m by 2100, depending on emission scenarios (IPCC, 2021). Even moderate rises in sea level are expected to amplify multiple coastal hazards, leading to more frequent and severe flooding, storm surges, and saltwater intrusion into aquifers and soils, thereby threatening freshwater availability and agricultural productivity (Zhu *et al.*, 2010). SLR also accelerates shoreline retreat by enabling waves to reach further inland and by reducing the capacity of natural ecosystems, such as wetlands and mangroves, to buffer against erosion and flooding. In the Mediterranean, the area projected to be exposed to permanent submersion by 2100-2150 amounts to roughly 38,529 km², an extent comparable to the territory of Switzerland (Vecchio *et al.*, 2024).

Addressing this complexity requires integrated approaches that combine sediment management, space-for-adaptation strategies such as managed realignment, and risk-based prioritisation of interventions (Jiménez *et al.*, 2017; Sánchez-Arcilla *et al.*, 2011). By enabling stakeholders to spatially represent perceived vulnerabilities, such as recurrent flooding, erosion hotspots, or restricted adaptation space, and overlay these with scientific hazard projections, PCs make cumulative risks visible and tangible. This integration facilitates dialogue on trade-offs between protection, realignment, and ecosystem-based strategies, while also ensuring that local knowledge and priorities inform ICZM and MSP.



3.2 Sardinia's MSP Framework and Target Risks

Italy officially adopted its national Maritime Spatial Plans in September 2024, establishing a framework for sustainable use of maritime resources and uses an over 10-year horizon (Ministerial Decree No. 237/2024). The competent authority of the MSP process is the Ministry of Infrastructure and Transport (MIT), supported by an Inter-Ministerial Coordination Table that establishes guidelines and ensures compliance. A Technical Committee, coordinated by MIT and composed of representatives from relevant Ministries and coastal Regions, is responsible for developing the plans.

In accordance with the Marine Strategy Framework Directive (2008/56/EC), Italy is divided into three maritime areas: the Adriatic, the Ionian and Central Mediterranean, and the Tyrrhenian and Western Mediterranean. For each of these, and in line with the implementation of the MSPD, Italy has developed a dedicated strategic plans, three in total, through parallel and integrated planning processes. Each plan follows a six-phase structure: (1) Current status and future trends, (2) Analysis of interactions, (3) Vision and strategic objectives, (4) Strategic planning of sub-areas, (5) Monitoring, evaluation and adaptation, and (6) Setting the ground for MSP implementation.

In addition, each of the three major maritime areas has been further subdivided into a total of 27 sub-areas, which serve as the main spatial reference units for governance and planning. Of these, 18 are coastal sub-areas, extending up to the Territorial Waters limit (12 NM), and 9 are offshore sub-areas, covering the marine space from the 12 NM boundary to the limits of the continental shelf.

Each coastal sub-area corresponds to one of the Italian coastal Regions, whose terrestrial administrative boundaries have been projected seaward to define the sub-area's extent. This spatial configuration allows for strong alignment between land and sea multilevel governance systems, reinforcing vertical coordination between national and regional authorities and enabling horizontal integration across adjacent maritime uses and sectors. This multi-level governance arrangement is essential, as the State holds legislative power over some sectors, such as maritime transport, energy production and distribution, and cultural and environmental assets, while Regions are responsible for others, such as fisheries, aquaculture, coastal defence, and tourism (Ramieri *et al.*, 2024)

It also underpins a multiscalar approach to maritime spatial planning, structured across three nested levels, maritime areas, sub-areas, and ultimately Planning Units (PUs), through which strategic visions are progressively translated into concrete and spatially explicit operational decisions. PUs define the functional vocation of maritime space and are classified into four categories: Priority (P), Reserved (R), Limited (L), and Generic (G), the latter indicating no specific use (Carella *et al.*, 2024).

In the case of Northern Sardinia, the relevant plan is the Tyrrhenian one. The pilot area extends from the Gulf of Alghero on the western coast to the Gallura coastline in the northeast, encompassing the Territorial Waters covered by PUs MO/07_01 to MO/07_16.

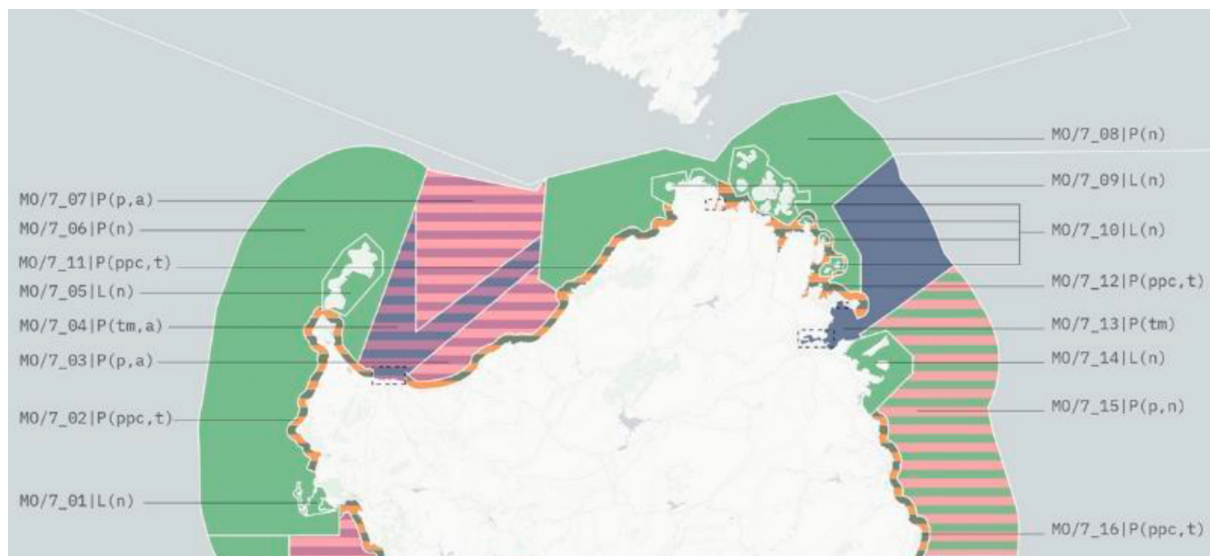


Fig. 1. Sardinia's area of interest and respective Planning Units. Source: Italian MSP Plan (2024).

Moreover, the MSP process in Italy is framed within a broader international and European commitment to environmental democracy. Key milestones, such as the Aarhus Convention (1998), which emphasised access to environmental information, participation in decision-making, and justice as fundamental pillars of governance, have shaped the EU MSP Directive. By incorporating these pillars, the Directive positions public participation as a procedural requirement.

Ensuring public participation has the potential to foster a deep understanding of marine environments, support capacity building, facilitate conflict resolution, and also plan quality, acceptability, and legitimacy (Tissière & Trouillet, 2022). Yet, the Directive provides little guidance on implementation, leading each country to interpret and apply different principles and methods for public participation, reflecting a diverse array of political and democratic backgrounds (Guyot-Téphany *et al.*, 2024).

For instance, in Italy, coastal authorities have established internal MSP working groups that integrate regional administrations, sectoral representatives, and civil society actors, at different levels of formalisation. These groups participated in local initiatives, bilateral or multilateral meetings, research and pilot projects, scientific workshops, informative events, and public consultations, providing both knowledge and legitimacy to the planning process. By using this multi-scalar approach, the plan aimed to promote co-creation among governance actors across various scales and sectors, and integrate their diverse claims, visions, and objectives (Ramieri *et*



al., 2024).

The strategy has an objective not only to enhance the accuracy and resolution of data, but also to prevent fragmentation across multiple scales. In Italy's context, it is particularly appropriate to address the country's heterogeneous governance and geographic characteristics, including regional socio-economic disparities and varying environmental conditions. Sardinia, as an autonomous region, adds further complexity to this governance landscape.

However, the multi-scalar approach faced challenges: its development is still in its early stages, and bureaucratic fragmentation, overlapping competencies, limited collaboration between authorities, and gaps in technical capacity have constrained participation (Ramieri *et al.*, 2024). As a result, while national and regional authorities, along with academia and research institutes, are actively engaged in the co-planning process, local authorities, representatives of the sectors, and civil society have not been sufficiently involved, and this is an element to be strengthened in the adaptations of the plan (Ramieri *et al.*, 2024).

In parallel with governance complexities, the environmental and socio-economic conditions of Northern Sardinia add another layer of specificity to the planning framework. The island, the second-largest in the Mediterranean, is defined by marked demographic contrasts. While the metropolitan area of Sassari concentrates much of the population, the north is characterised by sparsely populated territories such as Gallura (Decandia, 2017).

The sub-region's main towns, Olbia, Arzachena, Tempio Pausania, and La Maddalena, count between 10,000 and 60,000 inhabitants, yet the seasonal influx of visitors far exceeds resident populations. Every summer, Gallura receives nearly four million tourists, representing 40% of Sardinia's total arrivals, largely concentrated along the Emerald Coast (Regione Sardegna, 2022). The Port of Olbia alone records over three million passengers annually, while La Maddalena receives more than one million, underscoring the scale of seasonal pressures on coastal infrastructures (ISTAT, 2022).

Tourism has thus emerged as a central economic driver since the 1960s, reshaping coastal landscapes and intensifying demands on marine and terrestrial ecosystems (Decandia, 2017). Northern Sardinia's natural endowment both attracts tourism and necessitates careful governance. The region hosts several crucial areas in terms of biodiversity:

- National and Regional Parks: These are areas established by the Italian and regional authorities to protect both terrestrial and marine ecosystems, as well as cultural and historical heritage. Examples in Northern Sardinia include Asinara National Park and Maddalena Archipelago National Park.
- Sites of Community Importance (SIC): These are Natura 2000 Sites based on the Habitats and Birds Directive, their designation is approved at the EU level, and Italy is responsible

for implementing national protection measures. Examples in Northern Sardinia include Tavolara-Punta Coda Cavallo, Capo Testa-Punta Falcone, and Asinara Island.

- Biological Protection Zone (ZTB): The designation is done by the Italian government to protect biodiversity through regulated fishing and conservation activities. In the region, there is the Gulf of Asinara ZTB.
- Special Protection Zone (ZPS): These are Natura 2000 Sites based on the Habitats and Birds Directive, their designation is approved at the EU level, and Italy is responsible for implementing national protection measures. An example in Northern Sardinia is the Northeast Islands (Capo Ceraso-San Teodoro Lagoon) ZPS.
- Specially Protected Area of Mediterranean Importance (SPAMI): The designation is based on the UN Mediterranean Action Plan (UNEP-MAP). In the region, there is the Pelagos Sanctuary SPAMI.
- Particularly Sensitive Sea Area (PSSA): The designation is established by the International Maritime Organisation (IMO). In the region, there is the Strait of Bonifacio PSSA.
- International Marine Park: The Bonifacio Strait International Marine Park was established through a cross-border cooperation Agreement between Italy and France, with Italy's Maddalena Archipelago National Park and France's Corsica Regional Natural Park jointly managing conservation efforts.
- Ecologically or Biologically Significant Marine Areas (EBSAs): The designation is based on the Convention on Biological Diversity (CBD). In this region, there is the North Western Mediterranean EBSA.

The region's rich biodiversity is increasingly exposed to multiple effects of climate change, particularly ocean acidification and rising sea temperatures. Increasing anthropogenic greenhouse gas emissions have led the oceans to absorb approximately 25% of these emissions, resulting in an estimated 30% rise in surface ocean acidity (Bednarsek et al., 2023). This phenomenon is particularly critical in the Mediterranean, where limited buffering capacity and higher temperatures enhance CO₂ uptake and accelerate acidification. The variations threaten biodiversity hotspots and essential ecosystem services such as fisheries and aquaculture, with cascading effects on regional socio-ecological systems. Rising sea temperatures amplify these dynamics by altering species distributions, increasing marine heatwaves, and triggering coral bleaching. They reduce the resilience of key habitats such as seagrass meadows and kelp forests, which in turn weakens natural coastal defences (Cabana et al., 2023).

Furthermore, since the early 1980s, the Mediterranean Sea surface temperature has increased by about 1.3 °C, more than twice the global average, with the fastest warming in the Eastern Basin. Depending on emission scenarios, surface temperatures are projected to rise up to 3.7 °C by the



end of the century (Hassoun et al., 2025). The combined effect of warming and acidification accelerates biodiversity loss and diminishes the capacity of ecosystems to provide essential services, including food provision and shoreline protection. Such impacts are cumulative, compromising the resilience of marine socio-ecological systems, in particular in the analysed pilot region.

In Sardinia, these dynamics are reflected in projected variations of temperature and pH in territorial waters. According to projections elaborated by the International Marine Centre Foundation (IMC), compared to the island's baseline of 18.91°C, under scenario SSP2-4.5 the mean sea temperature is projected to increase to 19.58°C by 2030 and 19.77°C by 2050 (Bio-ORACLE, 2024; Assis, *et al.*, 2024). Under the more extreme SSP5-8.5, the projections indicate 19.47°C in 2030 and 19.85°C in 2050, with a variation of almost 1°C. Moreover, according with IMC, with a baseline mean pH of 8.077, projections under SSP2-4.5 show a decrease to 8.041 in 2030 and 8.020 in 2050, while under SSP5-8.5 the values are expected to reach 8.040 in 2030 and 8.011 in 2050 (Bio-ORACLE, 2024; Assis, *et al.*, 2024). These trends illustrate the tangible local manifestations of global climate change and highlight the urgency of adaptive measures.

In Northern Sardinia, the coexistence of ecologically significant areas and socio-economic pressures highlights the fragility of its coastal and maritime zones, particularly in the face of climate change risks. This context calls for a comprehensive MSP approach that coordinates maritime uses across scales, aligns European directives with national and regional competencies, and integrates local knowledge to improve planning outcomes.

Given this scenario, Sardinia has also developed a dedicated regional policy to guide adaptation efforts: the *Regional Climate Change Adaptation Strategy (SRACC)*. Initiated in 2015 and formally adopted in 2019, the SRACC provides a threefold strategic approach to support adaptation, incremental, systemic, and transformative, reflecting the varying intensity of climate risks and the spatial and temporal scales of potential impacts. Incremental adaptation focuses on enhancing the management of known risks based on historical variability, systemic adaptation addresses perceptible changes that challenge the sustainability of entire systems through coordinated action, while transformative adaptation anticipates profound changes and enables radical reconfiguration of systems to increase resilience.

In terms of objectives, the SRACC is fully aligned with the National Adaptation Strategy, and includes reducing climate-related risks, safeguarding human health and well-being, ensuring access to environmental resources, enhancing the adaptive capacity of social, economic, and ecological systems, and identifying opportunities arising from new climatic conditions. These objectives are articulated across two levels: cross-cutting strategic goals, which prioritise urgent and systemic measures to strengthen regional resilience in the short term, and sectoral objectives, which guide the integration of adaptation into regional plans, programmes, and projects over short, medium, and long terms. By combining approaches that encompass different temporal

scales and sectors, and fostering participatory mechanisms, the SRACC ensures that adaptation priorities are continuously refined by a diversity of stakeholders.

In the Sardinian context, this regional strategy complements the Italian MSP Plan, as it provides a structured basis for integrating adaptation into the framework. However, while existing participatory mechanisms at the regional level are promising, they remain limited, especially at the community level. The incorporation of innovative participatory tools, such as PCs, could enhance the legitimacy of the planning process, support informed decision-making and the development of adaptive strategies appropriate to this unique socio-ecological context.

4. Formulation of Operational Recommendations for the integration of the SWAP approach in the Pilot Region's

4.1 Preparatory Steps

The integration of PCs into both institutional processes (ICZM, MSP) depends on a series of preparatory steps. To start, as part of the understanding of PCs within the working groups, it is important to (i) **synthesise and share insights from previous participatory processes**. It can provide valuable contextual understanding and support more informed and grounded discussions.

Moreover, besides (ii) **data collection** on the pilot regions, in collaboration with research institutes, there is a need to **identify target climate risks**, such as ocean acidification, warming impacts on marine biodiversity, and develop a set of adaptation and mitigation measures to be discussed with selected stakeholders. These measures should then be spatially represented through base maps, taking into account the appropriate scale, data layers, and materials. Later on, the research group, together with the regional and local authorities, can (iii) **define the objectives** of the PCs, taking into consideration the set of perceived vulnerabilities to climate risks, and spatial conflict between emergent and traditional uses.

The following step includes the (iv) **identification of relevant stakeholders** with a balanced representation of sectors and interests, including diverse social groups. This stage ensures that the workshop is not only inclusive in principle but also accessible and effective in practice. In this step, it is also crucial to define the appropriate form and intensity of involvement for each group of actors, adjusting participation according to the nature of the issue and the specific phase of the planning process (Morf et al., 2019).



Additionally, particular attention should be given to gender and other underrepresented groups, ensuring their active and meaningful involvement throughout the process. This includes creating targeted strategies such as flexible meeting times, accessible materials, and engagement formats suited to their needs. In the recommendations phase, measures should be highlighted to empower these actors, fostering equity in decision-making and ensuring their perspectives shape both the outcomes and the planning process itself.

Additionally, particular attention should be given to gender and other underrepresented groups, ensuring their active and meaningful involvement throughout the process. To respect the diversity and context-specific challenges of a given location, different forms of ownership and engagement must be considered (Burke & Stephens, 2017). This includes creating targeted strategies such as flexible meeting times, accessible materials, and engagement formats suited to their needs. However, incorporating inclusive participation may generate conflicts and require time to build trust, a resource constrained by the pressing need for climate action.

Yet, it is essential for the legitimacy and relevance of adaptation strategies. Participatory processes must therefore be thoughtfully accelerated, and planning tools should be employed to balance the inevitable conflicts that emerge, transforming potential tensions into opportunities for innovative and resilient solutions. In the recommendations phase, measures should be highlighted to empower these actors, fostering equity in decision-making and ensuring their perspectives shape both the outcomes and the planning process itself.

In coastal contexts, mapping of stakeholders should go beyond the usual institutional actors to include those whose knowledge and interests are directly shaped by coastal dynamics — such as residents of flood-prone areas, local fishers, small tourism operators, cultural associations, NGOs, and schools.

In the maritime context, the selection must reflect the broad spectrum of marine uses and ecological concerns. Fisheries cooperatives, aquaculture enterprises, recreational boating associations, diving clubs, port authorities, shipping companies, offshore energy developers, environmental NGOs, and marine protected area managers all bring different forms of knowledge to the table. Particular attention should be devoted to small-scale, local actors, such as artisanal fishers or eco-tourism operators, whose voices are often marginalised in institutional processes but whose livelihoods are directly tied to ecosystem health.

Furthermore, in this context, there is a need to provide strategic mobilisation across different governance levels. National ministries can endorse the participatory process and provide legitimacy; regional administrations can adapt the process to local contexts; and municipal authorities or local port administrations can act as conduits to communities and businesses. In practice, aligning governance levels means ensuring that invitations to participate are backed by institutional recognition, which encourages stakeholders to invest time and effort. Furthermore,

EU-level guidance and reporting requirements can be used as leverage to justify the allocation of resources for broad participation, thereby anchoring the PC process within established governance structures.

Another preparatory task is the (v) **identification of a suitable venue**. The choice of space is not a neutral decision: it influences both the inclusiveness of the process and the quality of interactions. For coastal workshops, venues should be easily accessible to residents, ideally within or close to the areas most affected by climate risks. Community centres, municipal halls, or local schools often work well, as they are familiar spaces where participants feel ownership and comfort. The physical layout should allow for large tables or wall surfaces to display maps and to accommodate group work. Accessibility considerations, such as barrier-free entry for people with disabilities and availability of public transport connections, must be factored into venue selection. In cases where remote participation is necessary, hybrid formats combining on-site mapping with digital tools may also be considered.

In the maritime context, workshops should ideally be held in locations symbolically and functionally linked to the sea, such as port facilities, marine research stations, or community centres in fishing towns. This anchors the mapping exercise in familiar settings, making it more relevant and engaging. Hybrid participation formats should also be considered, especially given the wide geographic scope of marine stakeholders and the possibility of cross-border interests. Digital participation platforms can extend engagement to those unable to attend in person, ensuring inclusiveness across sectors and regions.

Equally critical is the (vi) **design of a communication and facilitation strategy**. Before the event, clear and accessible communication materials should be distributed, explaining the purpose of the workshop, the role of participatory cartographies within the broader SWAP process, and the expected benefits for local communities. Official letters and invitations may be effective for institutions and larger organisations, but face-to-face meetings, phone calls, or outreach through trusted intermediaries are often required to build trust with smaller, community-based stakeholders.

Visual materials such as flyers, infographics, or short videos can be effective in raising awareness and reducing the perceived complexity of the exercise (Davret & Trouillet, 2025). During the workshop, facilitators must manage communication carefully: they should encourage balanced contributions, ensure epistemic justice, and mediate between diverging perspectives. Also, communication is not limited to the event itself: follow-up messages, sharing of workshop outputs, and updates on how the results are used in planning are essential for maintaining trust and sustaining stakeholder engagement across multiple SWAP cycles.

In sum, the preparatory phase is not only logistical but strategic. By contacting stakeholders through multiple channels, selecting venues that foster openness and inclusion, and designing



communication that is transparent and iterative, the groundwork is laid for workshops that are perceived as credible and valuable to participants. These preparatory measures help ensure participatory cartographies become effective instruments of shared learning and adaptation planning in coastal contexts, while offering clear strategies that can be applied in other contexts.

4.2 Design of the PCs into the SWAP phases

The integration of PCs within the SWAP methodology is a decisive step to ensure that mapping exercises meaningfully support the co-creation of climate adaptation pathways. Unlike traditional consultation meetings, PC workshops are structured as co-creative laboratories, where stakeholders actively build shared spatial representations of risks, values, and possible futures. Literature on participatory design stresses that the form and flow of the workshop determine the quality of outcomes as much as the content (Sanders et al., 2010).

For this reason, careful attention must be devoted to the sequence of activities, the combination of analogue and digital tools, and the role of facilitation across all SWAP phases. PCs are not conceived as a one-off exercise but rather as a transversal component embedded into several SWAP phases, with differentiated objectives and instruments. Four key moments can be identified:

Phase I - Preparation (exploration and baseline mapping)

The preparation phase establishes the technical and relational foundations of the SWAP process. It involves stakeholder mapping, the collection of qualitative and quantitative data, the construction of a database of potential strategies, and a SWOT analysis of the participatory process. As Denwood *et al.* (2022) recommend, specifying the method for data collection, storage and sharing, as well as the people involved and the purpose, can foster the approach's transparency and replicability, in line with FAIR principles (Findable, Accessible, Interoperable, and Reusable).

Digital tools such as *Mentimeter* can be used to complement the inputs and capture more subjective and socio-economic dimensions. The tool is an interactive platform that allows participants to answer questions via their smartphones, generating instant word clouds, rankings, or polls. This contributes complementary data on perceptions, priorities, and lived experiences, enriching the mapping process beyond purely spatial inputs.

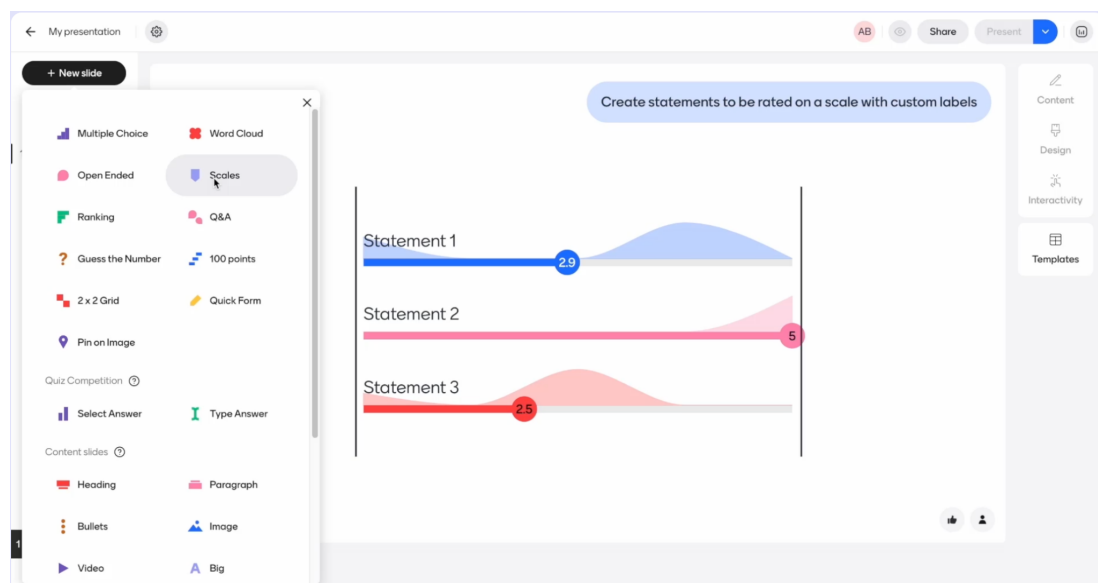


Fig. 2. Mentimeter interface.

PCs are introduced here as a first contact point with target groups, enabling them to express their perceptions of climate risks and priorities through visual and spatial means. This stage is crucial for aligning expectations and for ensuring that participants understand how their contributions will influence subsequent phases of scenario-making.

During this phase, facilitators present baseline information, including ecological maps (e.g., seagrass meadows, fish spawning areas), socio-economic layers (e.g., fishing zones, aquaculture sites, tourism hotspots), and governance constraints (e.g., protected areas, shipping corridors). Participants are also reminded that the mapping exercise is not limited to static features but extends to scenario maps that represent different temporal conditions, such as tidal variations, seasonal migrations, or projected changes in sea surface temperatures. This framing prepares stakeholders to think systemically and temporally, rather than only spatially.

This *first type of PC* is designed for stakeholders with limited access to digital tools and relies on analogue methods: colour-coded stickers and printed base maps are used to show expert assessments on climate risks, the measures, and overlapping spatial restrictions, marine traffic, and environmental values (Tolvanen *et al.*, 2019). Using stickers and markers, participants identify zones of conflict, opportunity, and vulnerability. For instance, they may delineate areas where fishing overlaps with tourism activities, where invasive species are spreading, or where warming waters threaten biodiversity.

Besides that, facilitators encourage participants to annotate these maps with narratives, linking spatial features to drivers, pressures, and potential adaptation strategies. These tools foster participants to connect their lived experiences with the broader climate narratives under discussion (Bagnoli, 2009). These materials provide a starting point for integrating traditional



knowledge and concerns about the complex realities of their urban environment and identifying areas exposed to compound risks.

Phase II - Scenario Workshop (mapping alternative futures)

This is the participatory core of the SWAP process, where stakeholders co-create and discuss alternative scenarios for future climate conditions. The workshop typically includes the presentation of 3-4 plausible scenarios, group discussions, and a consensus-building process to select guiding visions.

The activity involving the *second type of PC* can engage institutional and technical stakeholders, such as regional authorities, researchers, and NGOs, using the base maps as a common ground for providing feedback and proposals for the scenarios. This time, however, the process is designed through digital platforms. After an analysis, prioritisation and evaluation of the proposed measures in the SWAP process, participants can propose modifications in the digital cartography by adding their perceived opportunities, uncertainties, and threats related to climate risks.

Digital platforms such as SeaSketch (for maritime uses) and Marxan (for coastal and terrestrial dynamics) are used to produce layered cartographies that integrate ecological processes, socio-economic activities, and governance constraints. Through mapping, trade-offs and synergies across adaptation options become visible, supporting systemic and temporal thinking rather than static depictions of territory.

Whereas coastal mapping workshops often deal with relatively stable physical features, such as shorelines, maritime workshops must embrace the fact that the sea is a dynamic and layered space, where ecological processes (currents, tides, migrations) and human activities (shipping routes, fishing grounds, tourism corridors) intersect in a complex and ever-changing manner. That way, the design of PCs in the maritime context must account for the fluidity and complexity of marine environments, as well as the diversity of actors who depend on or regulate them.

Phase IV - Adaptation Pathways Workshop (review and refinement)

The fourth phase of the SWAP process is dedicated to consolidating the results of the scenario workshop and transforming them into concrete, time-sensitive strategies. After technical modelling and multi-criteria analysis carried out by Phase III (Adaptation Pathways Development), a second workshop is organised to refine and test the adaptation pathways.

This phase aims to identify sequences of actions, define tipping points, and ensure that strategies remain flexible over time. PCs are reactivated here to validate and adjust the cartographies created in Phase II, integrating technical results with stakeholder perspectives. Using again

SeaSketch and Marxan, participants revisit earlier maps, explore the timing of measures, and discuss thresholds beyond which strategies need to change. This iterative mapping process guarantees continuity between workshops and reinforces the credibility and legitimacy of the proposed pathways.

Mapping exercises during this phase may involve drawing alternative sequences of measures, overlaying critical thresholds on sensitive areas, or testing combinations of strategies across different time horizons. For instance, participants may discuss how beach nourishment, wetland restoration, and managed retreat interact spatially and temporally, identifying the conditions under which each option becomes necessary or feasible. By working directly on cartographic representations, stakeholders are able to visualise trade-offs and co-benefits, facilitating a more nuanced and systemic understanding of adaptation.

The iterative use of PCs at this stage also reinforces continuity between workshops. By returning to the same maps and tools, participants can trace how their earlier contributions have evolved, building trust in the process and ownership over the outcomes. At the same time, the visualisation of pathways helps to communicate the inherent uncertainty of climate adaptation: rather than fixed solutions, the maps illustrate branching trajectories that depend on how risks and social priorities evolve over time. This strengthens both the credibility and legitimacy of the proposed pathways, positioning them as flexible roadmaps co-created through a balanced integration of science and participation.

Phase V - Validation, Integration and Dissemination (communicating and archiving)

The final phase consolidates and communicates the results of the SWAP process. It includes the integration of pathways into existing policy frameworks, the validation of outputs with stakeholders, and their dissemination to the wider public. PCs contribute here by transforming workshop outputs into accessible and engaging communication products.

Documentation is ensured through photographs, facilitator notes, and, where possible, digital capture of the maps. These outputs are not treated as final products but as inputs to be further refined and integrated into digital participatory GIS platforms. Therefore, outputs are made available as accessible datasets, ensuring transparency and usability for both institutions and communities, and allowing them to be mobilised beyond the immediate scope of the workshops.

The workshop concludes with a commitment to continuity. Participants are informed of how the outputs will feed the broader SWAP process, and how results will be communicated back to them, for example, through digital atlases, online catalogues, or interactive Storymaps, web-based narratives that combine maps, images, and text into a dynamic format.

Beyond their communicative function, *Storymaps* can also act as living archives of the participatory



process. By layering spatial data with narratives, photographs, and testimonies, they preserve local knowledge that might otherwise be lost in technical reports. Their interactive structure allows users to navigate between scales, from regional overviews to site-specific stories, and to trace connections between ecological risks, social values, and proposed adaptation measures. In this way, Storymaps not only disseminate results back to communities but also invite continuous engagement.

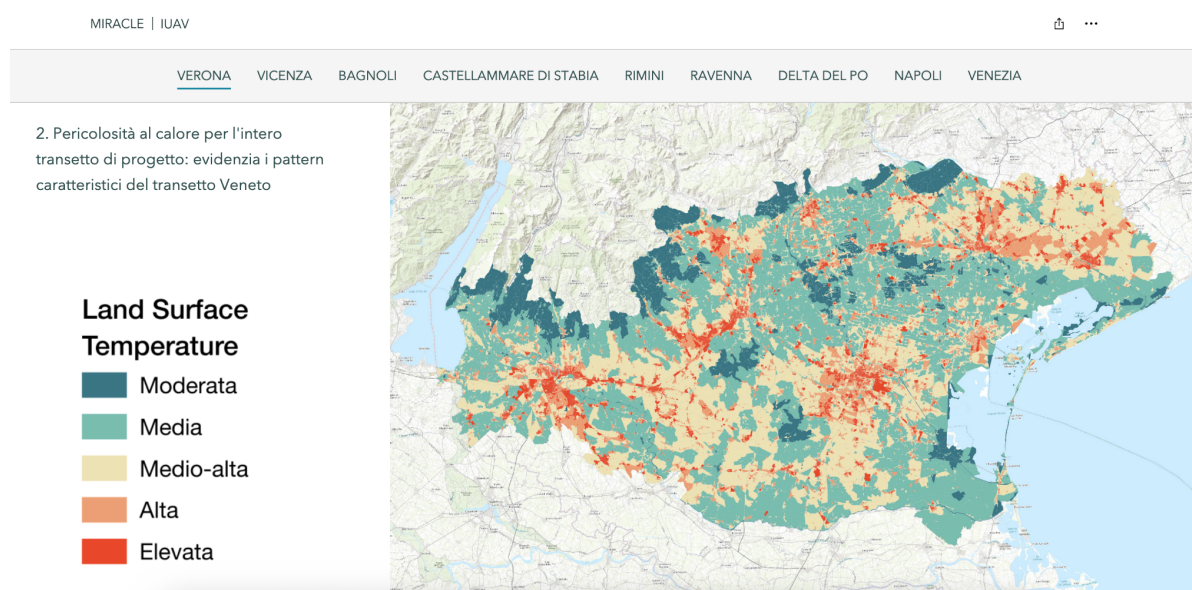


Fig. 3. Storymap of the MIRACLE project.

These tools can be coupled with monitoring and evaluation mechanisms, where PCs support long-term tracking of climate risk perceptions. This involves establishing indicators that reflect both ecological changes and shifts in local perceptions, setting baselines from the initial workshops, and scheduling iterative updates through periodic participatory sessions or digital feedback tools. By embedding these cycles of monitoring, communities and institutions can observe how perceptions evolve in response to new risks, adaptation measures, or extreme events, and adjust their strategies accordingly.

Such monitoring reinforces the role of participatory processes not as one-off exercises but as dynamic governance tools. PCs thus become part of a long-term infrastructure for dialogue, enabling knowledge to be continuously updated, accessible, and relevant. This closing step reinforces trust and assures stakeholders that their contributions will remain visible, comparable across time, and actionable in ongoing governance processes.

The workshop design thus serves a dual purpose: it generates tangible outputs, maps, narratives, and identified adaptation options, while also building intangible capacities, such as trust, mutual understanding, and systemic awareness among participants. These qualities are indispensable for navigating uncertainty and for ensuring that adaptation pathways are socially legitimate and

practically feasible.

4.3 Tools and Data Management

Participatory tools enable stakeholders to actively design and interact with planning inputs and outputs by using such spatial datasets, drawing polygons, adding contextual data, and overlaying additional information layers, thus enhancing collaborative decision-making and spatial understanding. In this setting, stakeholders can critically evaluate community-derived narratives, assessing their feasibility and developing adaptation pathways spatially represented on maps, which can inform strategies for integrated coastal and maritime adaptation.

The selection of participatory tools must be guided by the planning context and by the type of knowledge to be elicited, whether for ICZM or for MSP. In ICZM, which typically addresses terrestrial and land-sea interfaces, GeoSurvey and PPGIS platforms are particularly effective in capturing local perceptions and transforming them into usable spatial evidence. Platforms such as Maptionnaire and ArcGIS Survey123 have been successfully applied in coastal contexts to collect georeferenced inputs from residents, visitors, and local staff, generating evidence that can be directly integrated into planning documents (Hietala *et al.*, 2021; Tolvanen *et al.*, 2019). Other user-friendly instruments, such as Ushahidi for community reporting or MapMe for narrative presentation, further broaden participation by enabling contributions from citizens, NGOs, and schools, especially in areas with limited technical capacity.

By contrast, MSP requires tools appropriate to a more unified maritime arena, where multiple uses and ecological priorities must be jointly evaluated. In this context, web-based platforms such as SeaSketch allow stakeholders to design and compare spatial allocations interactively, while analytical instruments like Marxan provide optimisation functions to balance biodiversity conservation with socio-economic demands (Calado *et al.*, 2025; Ardron *et al.*, 2010).

Moreover, across both ICZM and MSP, it is important to ensure that outputs remain accessible and reusable. This is where national and regional geoportals play a central role, enabling the publication of participatory layers alongside official datasets and supporting continuity between different levels of governance (Hietala *et al.*, 2021). Taken together, these tools represent a continuum: some are primarily oriented to collecting data and perceptions, others to developing scenarios and analysing trade-offs, and others to monitoring or ensuring transparency over time.

The success of participatory cartographies in the coastal SWAP context depends on selecting tools that can both capture local knowledge and make it communicable to wider governance frameworks. Tools must allow communities to express their experiences and perceptions of risks while producing data that can be meaningfully layered with scientific and institutional datasets.



Equally important is the ability to manage outputs through multiple map layers ensuring clarity for both technical users and local communities. Transparent layering also supports communication, enabling results to be presented back to stakeholders in accessible formats and to decision-makers in more technical outputs.

Coastal-oriented tools

Ushahidi

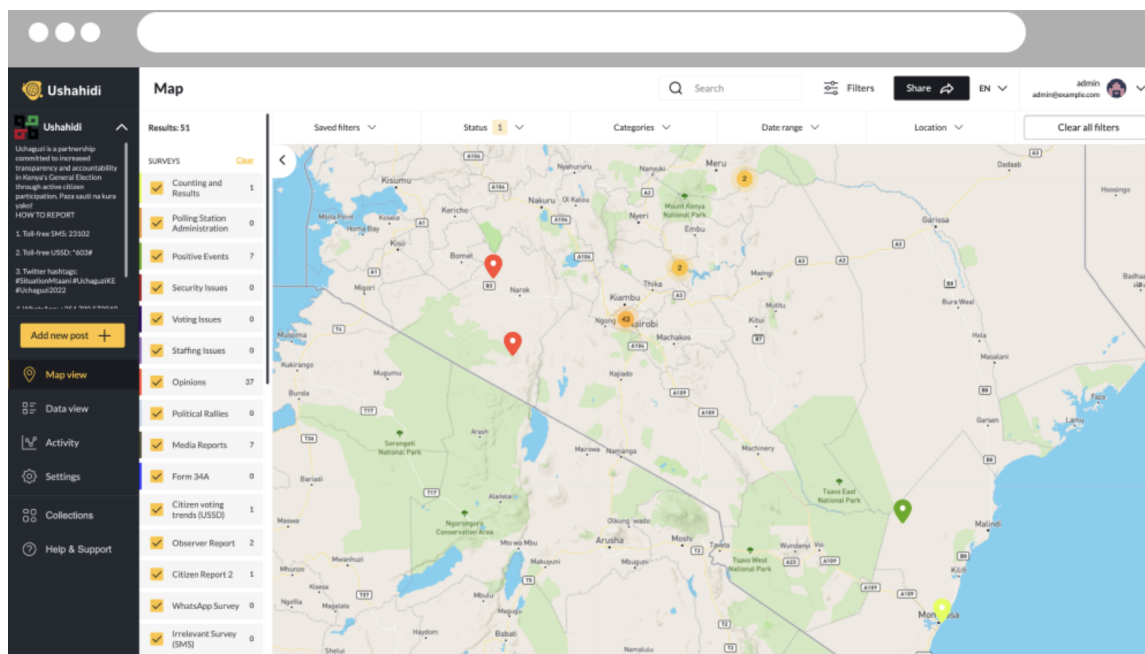


Fig. 4. Ushahidi interface.

Ushahidi is an open-source platform originally developed for crisis mapping, but increasingly used for environmental monitoring and local governance. In the coastal context, its strength lies in enabling citizen reporting: community members can submit geo-tagged reports, via mobile, web, email, or SMS, appearing on a shared interactive map. This makes it especially valuable for capturing distributed observations such as illegal dumping, fish die-offs, local flooding, or cultural events. The platform includes moderation tools, report categories, tagging, and time filters, which help validate and organise the inputs. Ushahidi is highly accessible: it functions under low-connectivity conditions, supports SMS-based participation, and requires no technical expertise. However, its limitations must be acknowledged: it is not designed for zoning or spatial planning, lacks GIS export functionality, and does not support complex spatial analysis. Thus, its best use in coastal SWAP lies in community-based monitoring, environmental alerts, and early-warning systems that complement more formal data sources (Ushahidi, n.d.).

Maptionnaire

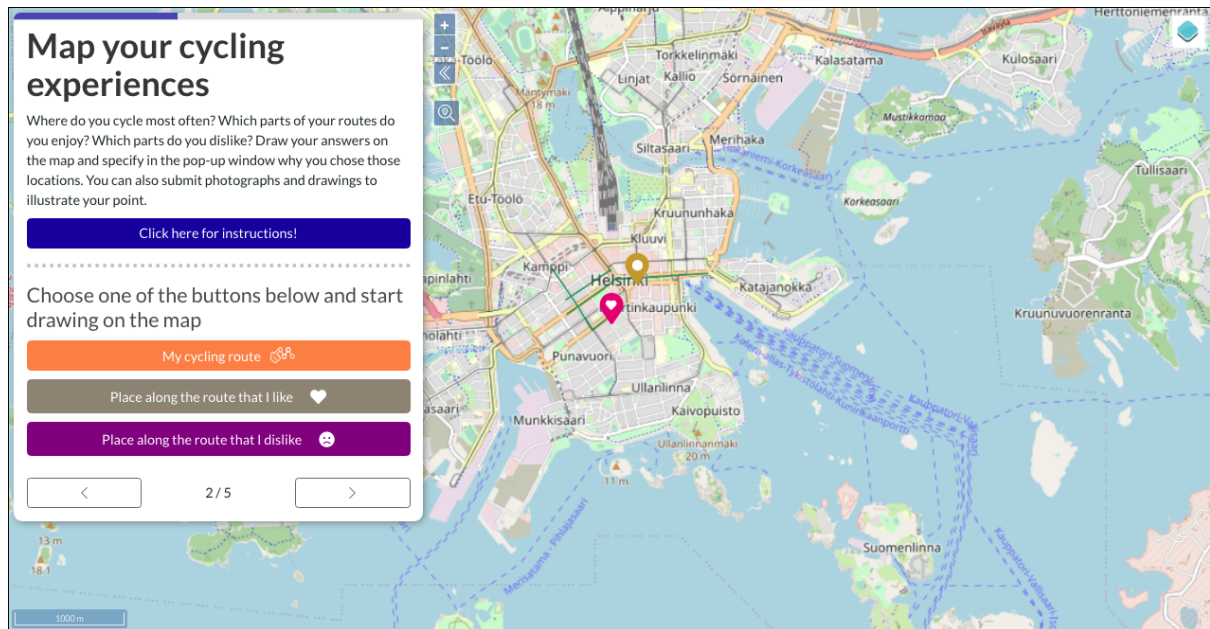


Fig. 5. Maptionnaire interface.

Maptionnaire is a professional-grade, map-based survey platform designed for perception mapping and stakeholder engagement. It allows participants to place points, draw lines or polygons on a map, and annotate them with text, ratings, images, or even video. The interface is highly intuitive and does not require GIS expertise, making it ideal for engaging residents, tourists, or local businesses in reflecting on coastal spaces. Outputs include heatmaps, visual summaries, and exports in formats compatible with GIS or statistical analysis. Maptionnaire has been widely used in urban and coastal contexts, including harbour planning and recreation zone mapping. Its main limitation is that it is not designed for offshore spatial planning or zoning, and it requires a paid licence. Nevertheless, it is particularly well suited to eliciting cultural values, mapping tourism and recreation uses, and gathering perceptions of environmental change (Maptionnaire, n.d.).

MapMe

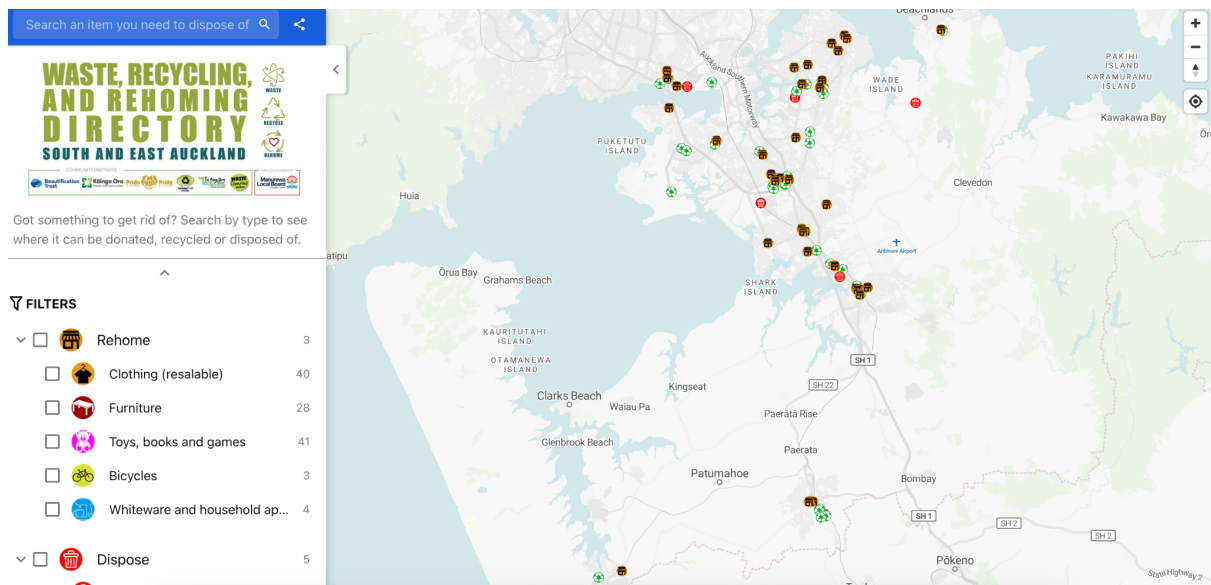


Fig. 6. MapMe interface.

MapMe offers a different kind of functionality, focusing on storytelling and communication rather than data collection or planning. The platform enables the creation of interactive maps where each location can be enriched with text, photos, videos, and links. It is easy to use, requires no coding, and is particularly attractive for NGOs, schools, or small community organisations that wish to showcase local knowledge in a visually compelling way. In the coastal SWAP process, MapMe can be employed to communicate the results of workshops and surveys, presenting community narratives and values in a digestible, public-facing format. Its limitations include the lack of spatial analysis tools, limited geometry editing (points only), and the absence of real-time data collection. Nonetheless, MapMe is a strong option for post-project communication, awareness raising, and cultural mapping (MapMe, n.d.).

Impact chains tool for risk assessment

Impact Chains (ICs) are a semi-quantitative tool used to visualise how climate hazards interact with exposure and vulnerability factors to generate risk (Lückerath et al., 2023). Their strength lies in breaking complex causal relationships into clear components, hazard, exposure, sensitivity, adaptive capacity, enabling practitioners to identify key drivers of climate impacts in coastal and marine contexts. In SWAP applications, ICs help assess risks such as sea-level rise, coastal erosion, etc. They support transparent weighting of factors and can combine scientific evidence with local knowledge (Lückerath et al., 2023). This tool contributes as PCs as they provide spatially grounded inputs that enhance the selection and weighting of vulnerability and exposure elements, especially where modelling is not feasible. It is accessible and usable in workshops or expert settings, although its semi-qualitative nature and limited modelling capacity should be acknowledged.

Legend

Area of the Impact Chain

- Hazard
- Exposure
- Consequence
- Risk
- Sensitivity
- Capacity
- Actionfields
- External Factors

Workings of Exposure

- Rhein-Neckar Port Authority
- Germany
- Europe
- Power Plant
- City of Mannheim

Consequences between parts of the Impact Chain

Other relevant actionfields:

- Fisheries
- Forestry
- Agriculture
- Construction industry

External Factors

- Energy turnaround
- Globalization
- Changes in urban planning
- Climate change
- Changes in land use
- Changes in water management

Miscellaneous

- Extension of research and development projects (Research)

Adaptation measures

- Technical measures
- Non-technical measures
- Organizational measures
- Legal measures
- Financial measures
- Information measures
- Communication measures
- Education measures
- Training measures
- Research measures
- Development measures
- Implementation measures
- Monitoring measures
- Evaluation measures
- Reporting measures
- Documentation measures
- Archiving measures
- Preservation measures
- Restoration measures
- Rehabilitation measures
- Renovation measures
- Replacement measures
- Removal measures
- Demolition measures
- Disposal measures
- Recycling measures
- Reuse measures
- Repair measures
- Replacement measures
- Renovation measures
- Restoration measures
- Rehabilitation measures
- Removal measures
- Demolition measures
- Disposal measures
- Recycling measures
- Reuse measures
- Repair measures

Action plan Low Water

- Creation of adaptation measures
- Implementation of adaptation measures
- Monitoring of adaptation measures
- Evaluation of adaptation measures
- Reporting of adaptation measures
- Documentation of adaptation measures
- Archiving of adaptation measures
- Preservation of adaptation measures
- Restoration of adaptation measures
- Rehabilitation of adaptation measures
- Removal of adaptation measures
- Demolition of adaptation measures
- Disposal of adaptation measures
- Recycling of adaptation measures
- Reuse of adaptation measures
- Repair of adaptation measures
- Replacement of adaptation measures
- Renovation of adaptation measures
- Restoration of adaptation measures
- Rehabilitation of adaptation measures
- Removal of adaptation measures
- Demolition of adaptation measures
- Disposal of adaptation measures
- Recycling of adaptation measures
- Reuse of adaptation measures
- Repair of adaptation measures

Risk

(Negative) Effects of prolonged periods of drought and low water of the Rhine on infrastructure and logistics in the Mannheim region

Maritime-oriented tools

SeaSketch

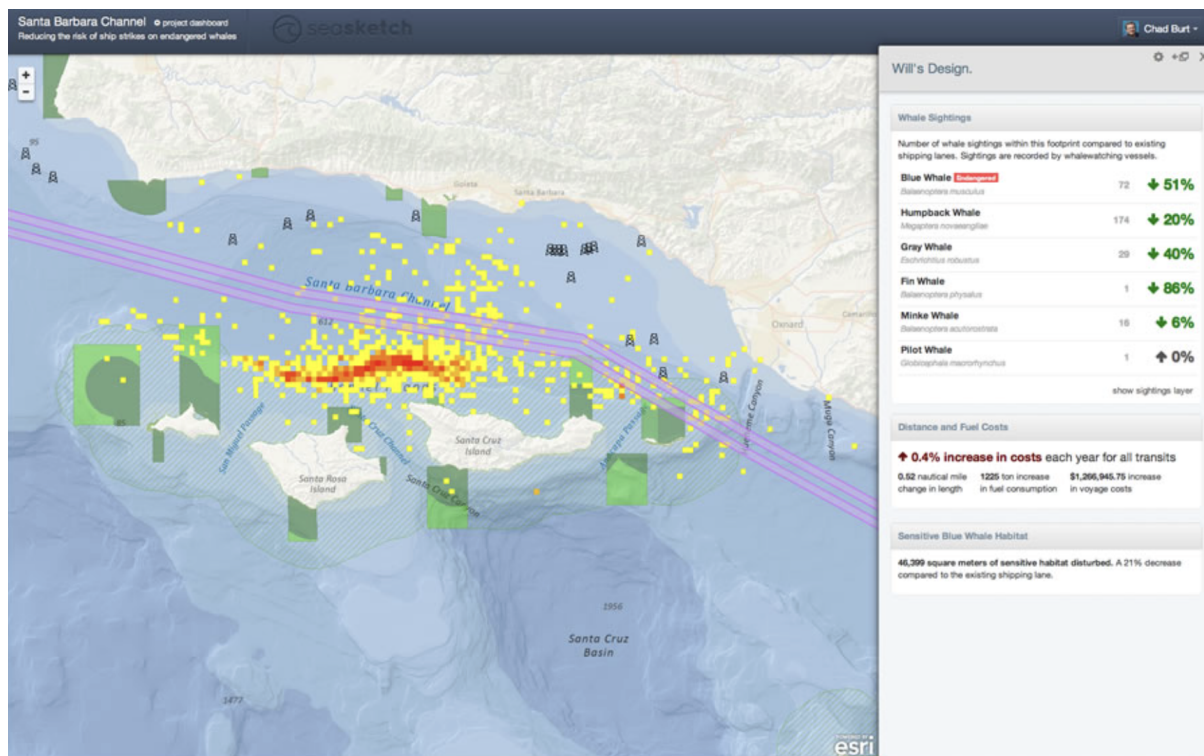


Fig. 8. SeaSketch interface.

SeaSketch remains the most comprehensive participatory platform for MSP. Originally developed for California and later applied in contexts such as Fiji, Vanuatu, Argentina, Uruguay, and New Zealand, it enables participants to draw polygons, lines, and points on interactive maps, develop zoning proposals, and engage in online discussions linked to specific spatial areas. Beyond its participatory interface, SeaSketch integrates relevant ecological and socio-economic datasets (e.g., habitats, currents, biodiversity hotspots) and supports decision-support functions including ecological metrics and automated reporting. This makes it uniquely suited for bridging the gap between stakeholder dialogue and scientifically grounded scenario analysis in the SWAP process.

Marxan

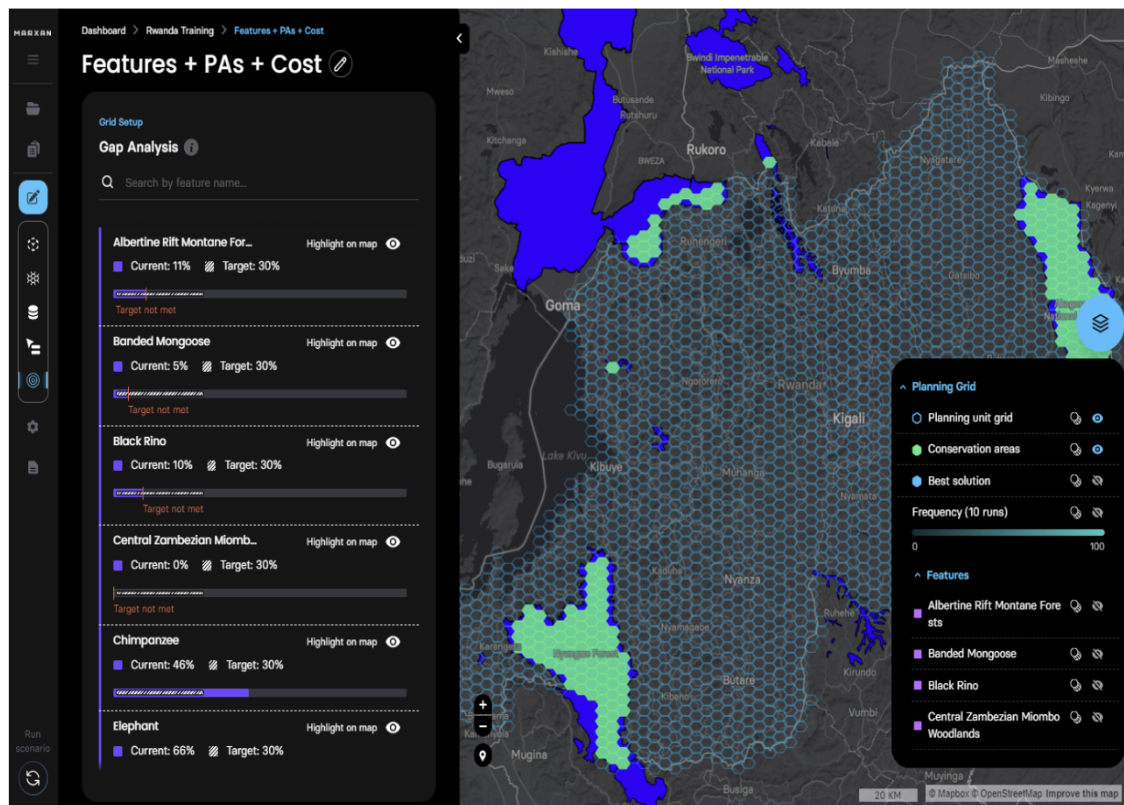


Fig. 9. Marxan interface.

Marxan provides a complementary but more technically focused function. It is a widely used decision-support tool for conservation planning and spatial optimisation, developed to identify networks of protected areas that achieve biodiversity goals at minimal cost. Marxan does not offer a participatory interface per se, but when integrated into processes such as SWAP, it provides the analytical backbone for evaluating the performance of zoning scenarios generated in workshops or through platforms like SeaSketch. By running simulations, planners can test how different spatial configurations of marine protected areas or activity zones perform against ecological targets, economic constraints, or climate scenarios. For Northern Sardinia, Marxan can be applied to examine how proposed pathways safeguard biodiversity under future warming or acidification, ensuring that participatory outputs are complemented by quantitative optimisation. Importantly, the tool has been widely used in MSP worldwide, making its integration both feasible and credible (Marxan Solutions, n.d.).

Survey123 (ArcGIS)



The screenshot displays the Survey123 web interface. At the top, there's a navigation bar with 'ArcGIS Survey123', 'My Surveys', 'Organization', and 'Help'. Below this is a green header for the 'Airport Noise Report' survey, with tabs for 'Overview', 'Design', 'Collaborate', 'Analyze', 'Data', and 'Settings'. The main content area shows a form titled 'Noise Report' with a description: 'Report airport-related noise in areas near airports. This data will assist planning officials assess the extent and impacts of airport-related noise and inform future planning.' The form includes a map titled 'Where were you when you heard the noise?' with a search bar and a world map. Below the map is a text field for 'What date and time did you hear the noise?'. On the right side, there's a 'Design' panel with various question types: Singleline Text, Multiline Text, Single Choice, Single Choice Grid, Multiple Choice, Dropdown, Rating, Likert, Number, Date, Time, DateTime, Image, File Upload, Map, Ranking, Email, Website, Signature, Note, Group, and Page.

Fig. 10. Survey123 interface.

Survey123 (ArcGIS) adds a third dimension by enabling field-based data collection. Fishers, divers, or citizen science groups can use the tool to record ecological features, invasive species, or pollution observations with geo-tagged photos and structured survey forms. The data can be collected offline, integrated into ArcGIS, and layered with outputs from SeaSketch or Marxan. This ensures that real-time ecological knowledge is captured and integrated into broader spatial analyses, reinforcing the monitoring and adaptive capacity of MSP.

PCs' Geo-tools overview

The effectiveness of participatory tools for ICZM and MSP depends less on their technical functions than on how they are embedded within governance frameworks and tailored to the context and actors involved. In ICZM, tools originally designed for terrestrial planning, such as Maptionnaire or Survey123, are highly effective in urbanised or land-based environments. They capture perceptions, values, and risks in places where infrastructures, administrative competencies, and social dynamics dominate, making them well-suited for coastal municipalities that deal with urban expansion, tourism, and shoreline pressures.

By contrast, tools developed in the marine planning arena, such as SeaSketch or Marxan, are not limited to offshore contexts. Precisely because they were conceived to manage multi-use conflicts and ecological connectivity at sea, they incorporate features that explicitly account for land-sea interactions. This makes them highly valuable for coastal governance as well, where risks such as

erosion, flooding, and biodiversity loss cannot be addressed without considering their marine drivers. For example, Marxan’s optimisation functions enable planners to evaluate conservation and socio-economic trade-offs across both terrestrial and marine domains, while SeaSketch provides participatory zoning functions that integrate coastal uses with offshore activities.

In this sense, MSP-oriented tools are particularly well-suited for adaptation strategies in coastal hotspots where ecological and socio-economic pressures converge. When combined with ICZM-oriented instruments, they help participatory cartographies act as true connective layers across contexts: linking scientific assessments, institutional requirements, and lived experiences into a shared spatial language. This integrated perspective allows risks, trade-offs, and uncertainties to be visualised and negotiated in ways that resonate with both local realities and broader planning objectives.

Equally important is the sequencing of these tools across the planning cycle. Their value emerges when they are mobilised iteratively, during diagnosis, scenario building, decision-making, and monitoring, so that stakeholders can follow how their contributions evolve into strategies and policies. Such continuity is essential to sustain trust, prevent participation fatigue, and ensure that participatory mapping supports long-term adaptation pathways rather than remaining an isolated consultation exercise.

The box below synthesises the tools examined in this chapter, outlining their suitability for specific phases of the planning cycle, their main user groups, and their functional roles within participatory cartographies.

Table 1. PC’s tools overview.



Tool	Use	Participation Type	Key Use Case	Strengths	Limitations	Target Stakeholders	Suitable Planning Phases	Function in PC Processes
Ushahidi	Coastal	Citizen reporting	Environmental alerts, distributed local monitoring	Open-source; works in low-connectivity; accessible via SMS/web	No spatial planning or GIS analysis	Local communities; NGOs & Civil society	(i) Diagnostic; (iv) Monitoring	Monitoring (real-time reporting); Collecting (distributed observations)
Maptionnaire	Coastal	Public perception mapping	Stakeholder engagement; cultural value mapping	Intuitive; combines surveys & mapping; GIS export	Paid licence; limited offshore uses	Local communities; Public authorities; NGOs & Civil society	(i) Diagnostic; (iv) Monitoring	Collecting (values, perceptions); Monitoring (tracking changes in perceptions)
MapMe	Coastal	Narrative presentation	Storytelling; awareness campaigns	Easy to use; multimedia-rich; visually appealing	No GIS analysis; not for data collection	Local communities; NGOs & Civil society	(iv) Monitoring	Communicating/ Monitoring (results dissemination, awareness raising)
Impact Chain Tool	Coastal	Decision-support analysis / expert facilitated	Climate risk assessment; vulnerability mapping	Systematic linkage of hazards, exposure, and vulnerability; transparent structure	Requires facilitation; less intuitive for non-experts	Experts/Researchers; Public authorities	(i) Diagnostic; (ii) Scenario-building	Collecting (climate sensitivity data); Developing (risk visualisation, impact pathways)
SeaSketch	Marine /Coastal	Participatory zoning	MSP processes; scenario analysis	Advanced participatory GIS; integrates scenarios & layers	Requires facilitation; complex interface	Experts/Researchers; Public authorities; NGOs & Civil society	(i) Diagnostic; (ii) Scenario-building; (iii) Decision-making	Developing (scenario comparison, zoning); Collecting (mapping marine uses)
Marxan	Marine /Coastal	Decision-support analysis	Conservation planning; optimisation of protected areas	Proven optimisation tool; balances biodiversity & costs	Not participatory itself; needs integration	Experts/Researchers; Public authorities; NGOs & Civil society	(ii) Scenario-building; (iii) Decision-making	Developing (optimisation, trade-off analysis)
Survey123 (ArcGIS)	General / Marine / Coastal	Citizen science / field survey	Shoreline & ecological monitoring	Mobile-friendly; GIS-integrated; offline-capable	Limited deliberation/storytelling; requires integration	Local communities; Experts/Researchers; Public authorities; NGOs & Civil society	(i) Diagnostic; (iv) Monitoring	Collecting (georeferenced data); Monitoring (field-based observation)

4.4 Resource Allocation

Ensuring that participatory cartographies become effective and sustainable components of the SWAP methodology requires not only methodological rigour but also dedicated and long-term resource allocation. Too often, participatory initiatives generate enthusiasm during the workshop phase but falter afterwards due to insufficient investment in facilitation, continuity, or dissemination (Corbett, 2009; IFAD, 2009). Both coastal and maritime contexts demand long-term investment, although the nature of the requirements differs.

Dedicated funding for professional facilitation, interpretation, and training is indispensable. In multilingual and culturally diverse regions, interpretation services and multilingual communication materials are required to ensure inclusiveness. For instance, as maritime governance frequently spans transboundary waters, additional resource commitments are needed to ensure inclusiveness across jurisdictions. These include translation and interpretation services, as well as hybrid participation formats that allow stakeholders from neighbouring countries to engage remotely when physical attendance is not possible. This dimension is particularly critical for fisheries, tourism, or shipping activities that extend across national boundaries, and its neglect can bias participation towards better-resourced or more localised actors.

Moreover, facilitators must be adequately trained to manage complex dialogues, mediate between technical experts and lay participants, and balance the asymmetries between powerful actors and smaller community-based stakeholders. Capacity-building programmes for municipal and regional staff should also be institutionalised, so that participatory mapping becomes a routine governance practice rather than a temporary experiment. Embedding this capacity within administrations transforms PCs into durable instruments of adaptive governance.

From a technical perspective, coastal and maritime PCs both require investment in digital infrastructures and iterative mapping cycles. Platforms such as Maptionnaire, Survey123, or Ushahidi are particularly effective on the coast for collecting perceptions and reporting distributed observations, while SeaSketch and Marxan play a central role in the maritime arena for zoning and scenario optimisation. Despite these differences in application, both domains demand continuity: hosting, maintaining, and updating platforms; integrating participatory outputs into official datasets; and ensuring interoperability with regional geoportals or European systems such as EMODnet. Crucially, PCs must be conceived as “living documents” that evolve with changing risks, stakeholder perceptions, and policy priorities.

Equally important in both contexts is investment in communication and exchange mechanisms that extend beyond the workshop itself. Stakeholders must not only be invited to contribute but also be kept informed of how their contributions shape decisions. These can take the form of:



- Digital atlases, compiling participatory maps into layered, interactive products accessible to both experts and laypersons;
- Online catalogues or repositories, where stakeholders can revisit outputs, track how their inputs were incorporated, and consult updates on planning outcomes;
- Storymaps or visual dashboards, tailored to different audiences, provide accessible summaries for the public while preserving technical depth for planners and scientists;
- Follow-up meetings or webinars, where results are presented back to stakeholders and discussed before being finalised into policy processes.

In short, resource allocation in both contexts must be multi-dimensional: supporting skilled facilitation, robust digital infrastructures, cross-border inclusiveness, and iterative communication. Only by embedding these elements structurally can participatory cartographies evolve from project-bound exercises into durable governance instruments that continually inform ICZM and MSP processes in line with ecological realities and stakeholder needs.

Recommendations toolbox

Priority Actions for Policymakers

- Integrate PCs into institutional processes (ICZM, MSP) to co-create climate adaptation pathways.
- Identify and map climate risks (e.g., ocean acidification, biodiversity loss) and develop adaptation/mitigation measures.
- Define objectives of PCs based on perceived vulnerabilities and spatial conflicts between emergent and traditional uses.
- Ensure inclusive stakeholder engagement, including gender and underrepresented groups, small-scale fishers, local tourism operators, cultural associations, schools, and NGOs.
- Sequence participatory cartographies across SWAP phases:
 - Preparation: baseline mapping and stakeholder orientation
 - Scenario Workshop: co-creation of alternative futures
 - Adaptation Pathways Workshop: iterative adjustment of strategies
 - Validation, Integration, and Dissemination: embedding outputs into policy and monitoring

- Communicate pre-event materials, visual aids, facilitation during workshops, and post-event follow-ups.
- Resource allocation for long-term facilitation, multilingual support, hybrid participation, and digital infrastructure.
- Mandate integration of participatory outputs into regional/national geoportals and databases to ensure continuity and traceability.

Key Enabling Conditions

- **Resources**
 - Dedicated funding for trained facilitators, multilingual communication, and interpretation services.
 - Training and capacity-building for facilitators and administration staff to manage complex dialogues and balance conflicts among actors.
 - Investment in digital infrastructures (e.g., platforms like SeaSketch, Maptionnaire, Survey123) and long-term hosting/maintenance.
 - Investment in communication and dissemination mechanisms, such as digital atlases, online catalogues, Storymaps, webinars, and follow-up meetings to sustain stakeholder engagement beyond workshops.
- **Governance**
 - Cross-level alignment and clear allocation of roles, such as institutional leadership (regional authorities), scientific rigour (research institutes), and territorial anchoring (local organisations).
 - Transparent decision-making rules, systematic documentation, and iterative communication.
 - Capacity-building for municipal and regional staff to embed participatory mapping as a part of governance practice.
- **Tool Selection**
 - Select tools according to planning domain and technical capacity of stakeholders.
 - Diagnosis: analogue tools to maximize accessibility and inclusion.
 - Coastal contexts: tools for citizen perception mapping (e.g. Maptionnaire, Survey123, Ushahidi).



- Maritime contexts: data collection and zoning platforms (e.g. SeaSketch, Marxan).
- Communication and dissemination: Storymaps and MapMe to translate results into accessible formats for wider publics.
- Ensure interoperability: outputs must be aligned with FAIR principles (Findable, Accessible, Interoperable, and Reusable).

Transferability Lessons for Other Euro-Med Regions

- Contextual adaptation is key, for instance, by tailoring participation formats, tools, and venue selection to local socio-ecological and cultural contexts.
- Digital tools can bridge multiple scales, connect actors across jurisdictions, and support transboundary governance.
- Align multi-level governance and include non-institutional stakeholders (e.g. artisanal fishers, residents in climate-sensitive areas, NGOs, and schools), with appropriate form and intensity of involvement for each group of actors.
- Combine ICZM- and MSP-oriented tools to bridge land-sea interactions, enabling a holistic view of adaptation strategies.
- Successful transfer requires continuity beyond projects, therefore, participatory maps must evolve as “living documents” updated with new risks, data, and community inputs.
- Embedding participatory processes within regional and EU-level reporting frameworks strengthens sustainability and possibility of replication.

Conclusions

The integration of participatory cartographies (PCs) into the SWAP methodology strengthens the capacity of both coastal and maritime planning to address climate-related risks under conditions of uncertainty and complexity. In coastal regions such as Catalonia, where erosion, flooding and sea-level rise pose acute threats, PCs serve as instruments not only to visualise vulnerabilities and adaptation space but also to mediate among diverse knowledge systems, bridging scientific assessments and lived experiences. Their contribution goes beyond the production of technical maps: they function as platforms of epistemic justice and democratic deliberation, enabling

communities to see their perspectives reflected in official strategies (La Rosa, Ruecker, & Giraldo Nohora, 2021). Embedding PCs in the mapping phase of the SWAP methodology reinforces the Aarhus Convention principles on access to information and public participation, while providing ICZM with richer and more legitimate knowledge bases. In coastal contexts, where land-sea interactions are particularly intense and urban assets are often at stake, land-based cartography and climate risk representation acquire central importance.

In the maritime domain, participatory cartographies (PCs) support the SWAP methodology by addressing risks and challenges that differ from those in coastal zones. For instance, Northern Sardinia, as a pilot region, faces pressures related to biodiversity loss, rising sea surface temperatures, fisheries management, and competing uses of marine space. The institutional reference framework is the EU Maritime Spatial Planning (MSP) Directive (2014/89/EU), which requires member states to apply ecosystem-based management, integrate land-sea interactions, and ensure participatory planning processes. Within this context, PCs are valuable not only for making spatial conflicts visible but also for fostering cross-sectoral negotiation, and transboundary harmonisation, building shared visions of the future, and grounding scenario narratives in tangible marine geographies. Also, the consideration of marine ecosystems as a mobile environment represented by the sea influences the mapping exercise.

Taken together, these experiences highlight that the effectiveness of PCs does not lie in the maps themselves but in the participatory processes and governance frameworks that give them meaning. By sequencing tools across the diagnostic, scenario-building, decision-making and monitoring phases of SWAP, participatory cartographies become more than static representations: they act as dynamic instruments for co-producing adaptation pathways, strengthening both the scientific credibility and the social legitimacy of ICZM and MSP in the Mediterranean.



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