Environmental Science and Policy 177 (2026) 104334

Contents lists available at ScienceDirect

Environmental Science and Policy

journal homepage: www.elsevier.com/locate/envsci

Enabling cross-sectoral transformation for coastal climate adaptation in Europe: Four directions for interdisciplinary efforts

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ARTICLE INFO

Keywords:
Climate adaptation
Climate change
Coast
Cross-sectoral
Nature-based solutions
Transformation

ABSTRACT

Coastal areas in Europe are of immense value – not only to their residents but also to communities further inland. At the same time, they are particularly vulnerable to the impacts of climate change. The current pace of coastal climate adaptation remains slow, constrained by underfunding and the fragmented, sectoral nature of many initiatives. This calls for radically new yet practical approaches. In this perspective, a group of European researchers from diverse disciplines explores what cross-sectoral transformation could mean in the context of coastal climate adaptation. Drawing on expertise in environmental science, spatial planning, law, ecology, health, and tourism, we propose four directions for interdisciplinary research to enable such transformation: (1) developing dynamic and holistic understandings of climate impacts and adaptation responses; (2) establishing shared adaptation objectives and priorities across sectors; (3) promoting ecosystem-based development; and (4) adapting legal and institutional systems to support integration and flexibility. We invite scholars and practitioners to engage with these interdependent directions to advance adaptation efforts for European coasts.

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https://doi.org/10.1016/j.envsci.2026.104334
Received 21 May 2025; Received in revised form 3 February 2026; Accepted 8 February 2026

1. Introduction

Today, approximately 40 % of the global population resides within the first 100 km of shoreline, while in Europe a similar proportion of population lives within 50 km of the shore (Collet and Engelbert, 2013; Cosby et al., 2024). In addition to permanent populations, coastal regions also support large numbers of visitors. In Europe alone, there were 1.4 billion overnight tourist stays in coastal areas in 2023 (Eurostat, 2024). As biodiversity hotspots, transportation hubs, areas of food production, and critical elements of the water cycle, coastal regions serve as critical socioeconomic and ecological interfaces, playing a pivotal role in enabling human settlements, infrastructure, and economic activities both along the coast and inland (Kantamaneni et al., 2024). In other words, coasts and coastal areas are of immense value to humans and humanity – economically, environmentally, culturally and symbolically, for health and recreation (Khakzad et al., 2015; Kuhl et al., 2021; Martin et al., 2016; Martínez et al., 2007; White et al., 2020).

It is therefore of particular concern that coastal areas are highly vulnerable to climate change. Combined with climate change, the active use of coastal areas by humans threatens the geophysical and environmental features of coasts that made them favourable for human settlement and development in the first place (Magnan et al., 2023). Various forms of anthropogenic pressure have already led to a progressive degradation of natural coastal systems, which in turn reduces their resilience to extreme weather events and long-term climatic shifts (Barnard et al., 2021; Hülsen et al., 2023). For example, the anthropogenic transformation of dunes, wetlands, and beaches into urbanized landscapes significantly undermines their function as natural protective barriers, increasing the vulnerability of coastal communities to climate-related phenomena such as storm flooding, storm surges, coastal erosion, and sea level rise (Silva et al., 2024; Vazquez-Gonzalez et al., 2019). Such dynamic changes pose a serious threat not only to human infrastructure, but also to biodiversity and ecosystem services, upon which humans rely, both on land and in the open ocean (IPBES, 2019; see for instance Gernez et al., 2023).

The ongoing warming of the climate will inevitably lead to significant environmental changes over the coming decades; these changes will affect the productivity and function of coastal ecosystems, threatening their health and the services they provide (IPCC, 2023). It will also lead to higher mortality rates, economic hardship and losses that affect people's livelihoods (Berman et al., 2020; Masselot et al., 2025). The extent of these impacts will depend on the ability of communities to survive and thrive under the new conditions, or in other words, to adapt (Berman et al., 2020; Frankopan, 2023). Unfortunately, while the anthropogenic pressures on the environment and climate continue, the rate of adaptation is much slower. As indicated in the Synthesis Report of its Sixth Assessment Report, the Intergovernmental Panel on Climate Change concludes that current climate change adaptation measures and policies are inadequate and, at current rates, the adaptation gap is expected to widen globally (IPCC, 2023). In fact, population concentration in coastal areas continues to increase, impeding mitigation efforts (Schuerch et al., 2018) and amplifying coastal flood risk (Reimann et al., 2023). We need new, practical approaches to coastal adaptation that can reverse this trend (Gonçalves and Pinho, 2024).

Recognizing the gap between fragmented scales, levels, domains, and jurisdictions that shape human–climate relations on one side, and the dynamic integrity of coastal socio-ecological systems on the other, we argue in this perspective that coastal adaptation in Europe can be accelerated through *cross-sectoral transformation* (CST). We develop this concept through interdisciplinary dialogue among researchers from climate and environmental science, ecology, geography, spatial planning, law, health, and tourism, drawing on our collective expertise across Denmark, France, the Netherlands, Spain, Slovenia, and the United Kingdom. Our expertise builds on engagements with climate and coastal issues across Europe within the sectors we specialize in, including transport, agriculture, fisheries, healthcare, and tourism as well as our previous work with national policy advisory bodies and EU-level initiatives. First, we sketch out the latent need for CST based on the persistent challenges to coastal adaptation. Then, we define CST and contrast it to other tools and approaches. Finally, we identify specific directions of interdisciplinary research and practical efforts that can help enable CST for more effective coastal climate adaptation in the European context.

2. Persistent challenges for coastal climate adaptation

Coastal regions may appear to be at the forefront of climate adaptation: in high-income countries, "climate-proofing" communities through technology-based measures against sea-level rise and flooding is common (IPCC, 2023; Storbjörk and Hjerpe, 2021; Wannewitz et al., 2024). Yet these measures are resource intensive, address only short-term risks, and can cause long-term maladaptation (IPCC, 2023; Wannewitz et al., 2024). Crucially, they focus on protecting property and other tangible assets while overlooking impacts on ecosystems and services that underpin coastal livelihoods and values (Schuerch et al., 2018). Such approaches may also reduce coastal attractiveness for tourism, harming local economies (Rangel-Buitrago et al., 2018), and threatening livelihoods and health both locally and beyond (Clay et al., 2020; Drakou et al., 2017; Smith et al., 2025; Ward et al., 2020).

For these indirect but damaging impacts, incremental adaptation is insufficient. Transformative adaptation, that is radical, relatively rapid systemic changes across individual, institutional, procedural and governance levels, is widely seen as necessary, but remains rare in coastal regions (IPCC, 2023; Kuhl et al., 2021; Magnan et al., 2023; van der Plank, 2024; Shi and Moser, 2021; Wannewitz et al., 2024). Barriers include many factors, but two stand out: lack of funding and lack of cross-sector and cross-scale efforts, and these two factors are closely connected (Cabana et al., 2023; Kuhl et al., 2021).

The United Nations Environment Programme's (UNEP) Adaptation Gap Report (2023) estimates that globally, adaptation finance needs are 10–18 times greater than current public funds, creating a widening adaptation gap. While especially critical for developing countries, this also underscores the need for more efficient use of resources in developed ones, freeing funds for UNFCCC commitments (UNEP, 2023; Tollin et al., 2024). Because funding is largely public, it favours top-down approaches that restrict local flexibility, despite highly localised climate impacts (Fankhauser, 2018; Fenton et al., 2014; IPCC, 2023; UNEP, 2023). Public funding also tends to support technological flood-protection projects framed as public goods (Woodruff et al., 2020). Such arrangements discourage private investment in coastal adaptation that goes beyond narrow organisational or sectoral interests — even though pooled private investment would be more effective and reduce pressure on stretched public budgets.

Structural constraints are also clearly reflected in existing governance practices used for coastal management. Tools and approaches developed to integrate coastal sectors, such as integrated coastal zone management (ICZM) and marine spatial planning (MSP), were not designed with climate adaptation at their core. They often fail to address deep climate uncertainties, particularly in the long term, and they frequently lack the ability to motivate substantial adaptive action or foster ownership of it (Queirós et al., 2025). Adopting a bird's-eye, system-level view, or a "view from nowhere" as philosophers of science call it (Nagel, 1986), obscures the agency and motivations of specific actors such as businesses, local organisations, and municipalities, and overlooks the "messy" ways in which change is initiated, negotiated, and enacted by them. MSP is frequently criticized for its top-down and technocratic practice, often driven by sectoral economic logics rather than exploring synergies across diverse actors and sectors (Flannery et al., 2019; Trouillet, 2020). ICZM, while formally voluntary, has similarly been found to suffer from a "democratic deficit" due to limited participatory and inclusive processes, further complicated by institutional fragmentation and operational vagueness (Falaleeva et al., 2011;

Shipman and Stojanovic, 2007). Together, these critiques highlight the need for approaches that can both motivate actors to take adaptive action and maintain coordinated action that benefits both the actors themselves and the broader coastal communities.

3. The latent need for cross-sectoral transformation

There are different approaches to identifying coastal sectors. They typically include economic sectors, such as agriculture, fisheries and aquaculture, forestry, maritime transport, tourism, and energy, as well as other sectors closely related to land-sea interactions in coastal areas, such as water services (including irrigation) and health (Cabana et al., 2023; Innocenti and Musco, 2023; Nicholls et al., 2007). In addition, spatial planning, law, governance and environmental management can also be considered as sectors relevant to coasts in the context of their development. The very fact that we make such a clear distinction between these sectors illustrates that dominant knowledge discourses, governance structures and practices favour viewing them as discrete units. This does not mean that sectors do not have a transformative capacity in principle. For example, as a result of the ongoing war, tourism in Ukraine has developed new functions beyond recreation, such as humanitarian efforts, rehabilitation, community and nation building (Tomej and Bilynets, 2024).

What unites all coastal sectors is that they are all affected by climate change, and many of them use or rely on the same resources, resulting in complex feedback loops. As coastal areas comprise a complex web of interconnected economic, social, legal and ecological sub-systems, the impacts of climate change cannot be isolated from each other (Janßen et al., 2018), nor can they be localised (Cabana et al., 2023; Drakou et al., 2017). Instead, given that the common resources and foundations of all sectors are simultaneously affected by climate change, it would be much more effective if the response of the affected sectors is carried out in coordination and creative collaboration between actors in the different sectors, so that symbiotic effects are achieved and transformation costs – both financial and otherwise – are reduced.

Therefore, to foster coastal climate adaptation, we bring forward the concept of *cross-sectoral transformation* (CST), which we define as processes in which sectoral actors, such as businesses, public agencies, and organizations, collaborate both within and across sectors to reconfigure their own roles, practices, and relationships in ways that change sectoral structures and functions in response to the current and projected impacts of climate change. In the context of coastal climate adaptation, CST aims to promote mutual adaptation, enabling human activities and ecosystems to adapt together in ways that strengthen long-term resilience and wellbeing. Based on this definition, CST can be described through four key characteristics that highlight its relevance for addressing the challenges of coastal climate adaptation and distinguish it from other concepts and approaches.

1. *CST is practiced through cross-sector collaboration*, or the "linking or sharing of information, resources, activities, and capabilities by organizations in two or more sectors" (Bryson et al., 2006, p. 44), oriented toward transformative outcomes – changes in structures, functions, and relationships that enable communities and ecosystems to adapt to new climatic conditions (Westley et al., 2002; Drack, 2015). Creative collaboration involves the joint design of new practices, governance mechanisms, or knowledge systems that no single sector could generate alone. In practice, this might involve relocating or shifting activities (e.g., through managed retreat), taking on or abandoning roles (Kuhl et al., 2021; Mach and Siders, 2021), creating hybrid sectors or blurring traditional boundaries, as well as establishing new institutional arrangements.
2. *CST is based on viewing local resources as common.* This is similar to the notion of industrial symbiosis, which is focused on a collective approach to a more efficient use of resources across organizations and sectors (Neves et al., 2020). However, the transformation perspective acknowledges the complexity of coastal socio-ecological systems and recognizes the crucial role of ecosystems in adaptation. It highlights the need for mutually beneficial relations between human activity and ecosystems, rather than their exploitation. Importantly, this perspective considers not only the current availability of resources, but also how they will be affected by climate change in the future.
3. *CST is actor-centred.* CST shares with system transformation approaches a concern for changing structures and functions, but it explicitly foregrounds actors as carriers of transformation. It considers how organisations and individuals from different sectors perceive risks and opportunities, how they reconfigure their roles and practices, and how they collaborate with others in ways that can accumulate incrementally and scale up to effect broader system change. According to this perspective, transformation is both a system-level outcome and a process experienced, contested and shaped through interactions at the level of actors that ultimately reshape sectoral structures, governance arrangements and socio-ecological functions.
4. *CST is embedded in both everyday practices and strategic development.* We understand CST as part of climate mainstreaming, that is the integration of adaptation objectives into existing processes, programs and policies (Biesbroek, 2021; Runhaar et al., 2018). CST helps actors in coastal sectors not only to survive through climate adaptation but also to perceive development possibilities and trajectories enabled by joint action and the joint and long-term consideration of coastal resources.

CST stands out by focusing on the internal reconfiguration of sectoral roles, practices, and responsibilities in relation to shared coastal resources, not just coordination between sectors. It is developed for the context of coasts where multiple sectors depend on shared, climate-sensitive resources and where interdependencies and externalities are high. This includes cases involving coordinated managed retreat, multifunctional nature-based solutions (NbS), or trade-offs between coastal protection, tourism, fisheries and ecosystem restoration. CST is particularly relevant where governance is fragmented across sectors and levels, requiring cross-sector and cross-jurisdictional alignment to prevent maladaptation. Conversely, it is less applicable in situations where climate impacts and responses are largely confined to a single sector, where interdependencies are limited, or where sector-specific governance instruments are sufficient to address the adaptation challenge. We adopt a functional definition of the coast as a coupled socio-ecological system, encompassing coastal, near-coastal and connected inland or offshore areas where land–sea interactions, ecosystem processes, human activities and governance arrangements are interdependent. The relevant boundary is defined by adaptation-relevant interdependencies rather than by fixed geographical or administrative distances from the shoreline.

We do not intend CST to be a silver bullet for coastal climate adaptation, nor should CST and coastal adaptation be viewed as synonymous. Instead, CST offers a conceptual lens that addresses some of the persistent challenges of coastal adaptation and a pathway towards more effective adaptation. However, enabling CST for coastal climate adaptation in itself requires new practices, new governance structures, and new knowledge that cuts across not only the various sectors but also scientific disciplines. Based on our own research expertise and experience, we propose the following directions for enabling CST, also illustrated in Fig. 1.

4. Proposed directions to enabling cross-sectoral transformation

To leverage the benefits of CST for the future, it must be realistic in the present. By definition, transformations are rare, because of the way social processes are maintained and reproduced (Sharpe et al., 2016), and because actors do not have the capacities and methods to facilitate

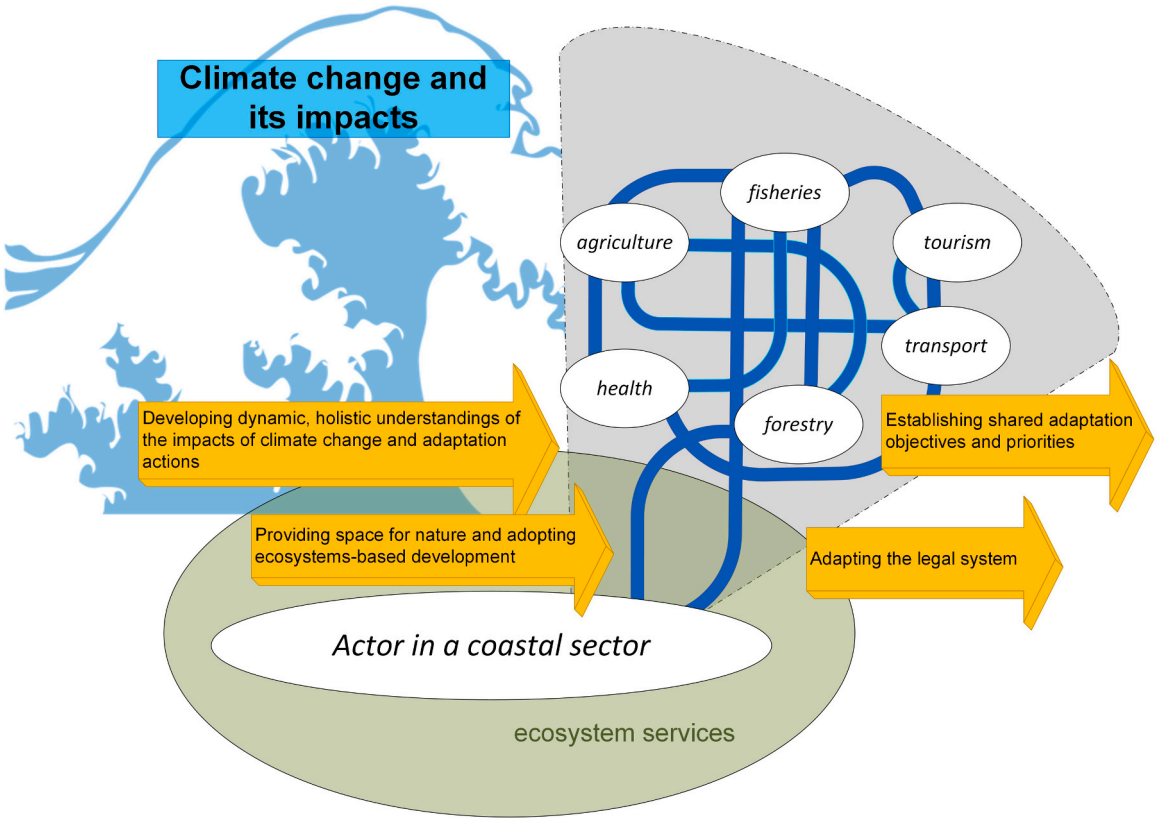

Fig. 1. Visual illustration of cross-sectoral transformation for coastal climate adaptation from the perspective of an actor in a coastal sector and the proposed directions for enabling cross-sectoral transformation.

change (Fazey et al., 2018). Therefore, enabling CST will require efforts at both the structural and actor capacity levels, pointing to several challenges that can only be addressed through interdisciplinary efforts. Importantly, as climate change and coastal adaptation are constantly evolving, these efforts can only be impactful if research and knowledge development are closely linked to policy development and experimentation (Nursey-Bray et al., 2014).

4.1. Developing dynamic, holistic understandings of the impacts of climate change and adaptation actions

While there is a lot of knowledge about climate change, and efforts are being made to make this knowledge more accessible, stakeholders still have a limited understanding of its impacts. This is more due to the way scientific knowledge is produced and transferred to decision-makers than a lack of available knowledge (Loehr and Becken, 2021). It is difficult to assess the impact of climate change on specific communities, sectors and organisations because stakeholder actions and development scenarios are not static and can influence the specific manifestations of climate change. For example, local climate models may provide information on sea level rise, rainfall and air temperature, but the perceived impacts would be different in a coastal community that prioritises maritime transport or protects nature along the coast, or if its economic system depended on local agriculture or digital nomads. Development pathways for communities are not fixed, and it is possible to proactively create more favourable conditions for community well-being. However, not understanding how changes or investments affect climate change impacts and how other actors' actions interact with one's own may limit motivation for change.

Professionals in different sectors need a way to model different scenarios and link alternative choices to decisions. Information tools that enable this could not only promote transformation, but also communication and collaboration across sectors. A better understanding of how decisions made by different actors interact would facilitate negotiation and thus promote CST. In this regard, a knowledge system perspective on the production, availability, transfer and use of scientific climate data is particularly useful. Loehr and Becken (2021) used this approach to reveal that despite the abundance of climate data and knowledge for tourism, this knowledge was not context-specific and omitted elements of the tourism system. This, in turn, hampered local decision-making.

Past initiatives such as the CLIMSAVE integrated assessment platform (Harrison et al., 2013) can provide valuable insights into how data can be integrated and presented to decision makers. However, it is crucial to use the decision-maker's context as a starting point and also consider non-digital solutions for scenario representations and negotiations that are more aligned with real-world decision making, which is often informal (Bleda et al., 2023). It is also important to create knowledge formats that can be understood and used by actors in multiple coastal sectors and encompass activities and impacts – both real and modelled ones – across them. For example, participatory scenario tools (Da Luz Fernandes et al., 2017) can translate climate projections into sector-relevant indicators such as fish stocks, crop yields, tourist arrivals and coastal habitat health, allowing actors in fisheries, agriculture, and tourism to see both the direct impacts on their operations and the cascading effects on ecosystem services that underpin multiple sectors.

4.2. Establishing shared adaptation objectives and priorities to guide the actions and responsibilities of various actors

Sectoral decisions continue to be made under the assumption of stable environmental, political and social conditions, but these assumptions are being challenged by climate change. For multiple actors

to engage in coordinated transformation, they need a common direction and goals. Crucially, these goals must not be perceived as benefiting only certain actors and must be trustworthy. Failing to develop shared norms across diverse actors is likely to lead to coordination failures, stalled progress or opportunistic behaviour (Fedele et al., 2019). The decentralised nature of CST also makes it dependent on existing power relations, in which more powerful actors (in terms of economic, political and social power) may prioritise their own interests.

More aligned and coordinated action can be engendered by scaling up small-scale initiatives, established by motivated actors who choose to collaborate where they see value. This encourages more aligned priorities and may shift interactions away from formal power hierarchies towards negotiation centred on specific problems, as participants join based on mutual benefits, such as shared coastal risk management. Collaboration can be initiated around specific issues with a limited scope, facilitating discussions about joint objectives (Serrao-Neumann et al., 2014). Developing a dynamic and holistic understanding of the impacts of climate change jointly (discussed in 4.1) may be a necessary, though not sufficient, condition for establishing shared visions. As trust between actors develops over time, contractual agreements, as seen in industrial symbiosis cases, can formalise joint priorities through legally binding pacts that outline responsibilities, terms for sharing resources, and dispute resolution, thus enabling self-regulation mechanisms. In other words, collaboration may emerge even in the presence of power asymmetries when actors perceive overlapping interests; however, the form, scope and outcomes of such collaboration will be shaped by existing power relations.

While CST is envisaged as a decentralised process, it still requires facilitation. Context-specific participatory processes and methodologies need to be developed and embedded in coastal communities. They must be able to address not only the explicit arguments for decisions, but also the implicit sociocultural values of the decision-makers, which often remain unknown to them and yet drive their decisions (see Liburd et al., 2024). They also need to be embedded in legal frameworks that initiate, activate and regulate these processes, especially in the likely cases of disagreement (Verschuuren and McDonald, 2012). Local knowledge should be used and local perspectives considered, as they offer insights into the area (Berkes et al., 2000). Such knowledge may be marginalised in expert systems, so inclusive participation rules are necessary to address the unequal power relations associated with self-selection and self-regulation. These rules should be coupled with practical support for groups that would otherwise be unlikely to participate, as well as accountability mechanisms that prevent powerful interests from taking control. Shared objectives can facilitate and accelerate the process of adapting legal and governance frameworks to make them more conducive to CST (Russel et al., 2018).

4.3. Providing space for nature and adopting ecosystem-based development

Coastal ecosystems are vital for human life, livelihoods and health, so it is crucial to have space for them in any adaptation effort. Restoring and conserving coastal ecosystems is imperative as these systems not only mitigate coastal risks, but also support biodiversity and ecosystem services locally, as well as on wider scales in the open ocean and inland. They also enhance long-term socio-ecological resilience (Drakou et al., 2017; Duarte et al., 2020; Gernez et al., 2023). Ecosystems can also be incorporated into multifunctional NbS-based adaptation frameworks, helping preserve the protective functions of coastal environments, delivering ecological, socio-economic, and health benefits to the communities that depend on them, and providing value to various sectors and motivating their involvement in their establishment (Louarn et al., 2025; Perricone et al., 2023).

The central role of NbS and nature restoration in coastal adaptation is already recognized by the European Union, e.g., in the Biodiversity Strategy 2030 and the European Commission's Communication entitled "Forging a climate-resilient Europe: the new EU strategy for adaptation to climate change", or the recent EU regulation on nature restoration (Regulation (EU) 2024/1991). Article 4 of the latter sets out targets for restoring degraded coastal ecosystems with a focus on those that can prevent and mitigate natural disasters (Articles 5 and 9). However, the implementation of these solutions is hindered by a lack of common definitions, lack of broad understanding of NbS, and the lack of site-specific data, which together can lead to misinterpretations and implementation challenges. Furthermore, the promotion of ecosystem-based adaptation, especially multifunctional solutions, requires a legal framework that allows for and governs joint use of such infrastructures and clarifies the benefits of investments into them.

Although NbS are increasingly mainstream in coastal adaptation, they are typically project-based and limited to public land and financing (Tedeschini et al., 2024). Embedding NbS within multi-scalar, cross-sectoral governance and financing frameworks constitutes an innovative implementation model that maximises their multifunctional potential by coordinating benefits across multiple sectors simultaneously. This model shifts NbS deployment from isolated projects to integrated programming that links coastal ecosystem restoration with spatial planning, tourism, public health, disaster risk management and blue economy development. The model also aligns with internationally recognised process verification tools for NbS, such as the IUCN Global Standard (IUCN, 2020), which provide a framework to ensure that NbS are environmentally sustainable, socially equitable, economically viable, transparently manage trade-offs, apply adaptive management, and are integrated into policy and regulatory frameworks for long-term scaling.

Unlike conventional NbS implementation that relies on sector-specific funding and governance structures, this approach requires new legal frameworks that mandate cross-sectoral performance metrics and accountability mechanisms. This embedded implementation approach can be reinforced by legal instruments that establish binding cross-sectoral outcome requirements, moving beyond traditional environmental compliance to mandate measurable contributions across economic, social, and ecological domains, and hybrid financial mechanisms, such as revolving funds and targeted tax incentives, designed to incentivise and sustain deployment (Lise et al., 2025; Sieber et al., 2024). Institutionalising NbS through these mechanisms enables scaling, ensures equitable benefit distribution, and establishes the structural conditions for systemic, transformative change in coastal adaptation (EEA, 2023).

4.4. Adapting the legal system and processes of inclusion and exclusion

Any transformation is dependent on the structures of law and governance. Law may be an enabler of transformation, but may also function as a brake, prioritizing the status quo (Soininen et al., 2021). In the European Union, multi-level governance structures often lead to persistent implementation barriers. EU directives and regulations, national adaptation strategies, restoration and management plans, and local management plans often lack integration. This creates jurisdictional gaps and conflicting requirements that hinder collaboration.

Adaptive management depends on adaptive law to function and while it is impossible to change maladaptive legal structures quickly, the existing possibilities for adaptive management and participation need to be explored and exploited based on the best available knowledge of climate change (4.1), developments in the environment (4.3), and shared objectives (4.2) (Garmestani et al., 2013). To address these challenges, new legal mechanisms are needed that establish binding frameworks for cross-jurisdictional coordination, create legal incentives for multi-sectoral partnerships, and develop adaptive regulatory processes that can respond to evolving coastal conditions while maintaining legal certainty.

For effective cross-sectoral arrangements, formal legal structures should be understood in combination with informal institutional arrangements. Informal institutions, such as professional networks,

collaborative practices, trust-building mechanisms, and shared cultural norms, can reinforce formal legal frameworks by providing more flexibility and relationship-building capacity. Conversely, formal legal structures can legitimize and stabilize informal collaborative practices, creating feedback loops where legal reforms enable new forms of cooperation and generate pressure for further institutional adaptation. Thus, an adapted legal system could produce and be maintained by an improved governance structure in coastal areas that involves the private sectors and society through this dynamic interplay of formal and informal mechanisms. Public policies in all economic sectors should be integrated with shared adaptation objectives, encouraging collaboration between the different levels of governance and jurisdictions, and improving the capacity of public, private and social decision-makers to implement necessary adaptation measures.

5. Conclusions

It is widely recognised that collaboration is necessary to address the challenges that both communities and humanity as a whole face due to climate change. However, experience has shown that the pace of collaboration to address climate change is not matched by its impact. This has been particularly evident in efforts to mitigate climate change, but the damage will only be greater if opportunities for adaptation are missed. With CST, we propose a different way of looking at adaptation in coastal areas, one that seeks to link individual interests, collaboration across coastal sectors and the well-being of communities with respect to ecosystem health and services. Building on existing concepts, we have shaped CST to address the distinctive complexity of European coastal socio-ecological systems. CST prioritises actor-level change, governance innovation and the deployment of ecosystem-based solutions. In many cases, CST for climate adaptation can also have positive consequences for climate change mitigation.

We recognise that the status quo in European coastal regions is not yet conducive to CST. We have therefore proposed four areas for enabling and encouraging it through interdisciplinary research and policy development. All of these rely on capacity development, particularly at the local level. We argue that developing and activating local human capacity would also enable access to necessary financial resources by creating more efficient adaptation efforts through cross-sectoral synergies and coordination. This capacity development requires two components: the willingness of local leaders to collaborate across traditional sectoral boundaries, and the availability of professionals capable of working effectively across sectors. Practically, the willingness could be demonstrated by dedicating special *cross-sectoral boundary roles* within their own organisation and sector, whose mandate explicitly includes reconfiguring that sector's relationships with others and with coastal commons.

Researchers would be required to develop training for individuals taking on such roles, especially those with in-depth knowledge of the sector. This training would challenge and expand their perspectives through new analytical tools (such as those referenced in 4) and cross-sectoral methodologies. Researchers could also help equip future professionals with specific CST tools, such as scenario platforms anchored to explicit policy and planning decision points; standardised contractual clauses that formalise voluntary cross-sector collaboration by clarifying shared objectives, responsibilities, and resource-sharing arrangements; NbS financing bundles that combine revolving funds, targeted fiscal or insurance incentives, and cross-sectoral performance criteria aligned with the IUCN Global Standard for NbS; and cross-sectoral coastal adaptation roadmaps that coordinate the timing, location, and responsibilities of retreat, restoration, and sector-specific adaptation measures across sectors and governance levels.

To initiate CST processes, researchers, particularly those working in interdisciplinary settings, are uniquely positioned themselves to take on such boundary roles. With their understanding of sectoral realities and access to interdisciplinary knowledge, they can articulate cross-sector value propositions to organisations — including those in the private sector — that cannot be framed within any single sector. For these value propositions to be compelling, they should be presented as potential benefits to sectors rather than processes that will lead to benefits. Therefore, it is useful to align them with urgent, timely, sector-specific issues. Effective entry points can include regulatory or market triggers, such as changes in permits, insurance requirements or certifications. For example, businesses are more likely to engage when an issue they already have to deal with is on the table.

The four directions in this article are themselves areas for interdisciplinary collaboration. We have developed them based on a dialogue across different disciplines, research fields and European countries. The purpose of this dialogue is to establish more systematic research collaborations that will foster cross-sectoral transformation for coastal climate adaptation. Importantly, this dialogue is open. With this perspective, we want to invite and encourage other researchers, including those from other relevant disciplines such as economics, organizational behaviour and public policy, to collaborate with us and other researchers in and outside Europe. This will help us to foster the transformation of coastal communities and sectors in response to changing climate and environmental conditions.

CRediT authorship contribution statement

Kristof Tomej: Conceptualization, Methodology, Writing – original draft, Writing – review & editing, Visualization, Project administration. **Carla Garcia-Lozano**: Writing – original draft, Writing – review & editing. **Josep Vila-Subiros**: Conceptualization, Writing – original draft, Writing – review & editing. **Alberto Innocenti**: Conceptualization, Writing – original draft, Writing – review & editing, Visualization. **Emil Juvan**: Conceptualization, Writing – original draft, Writing – review & editing. **Olivier Le Pape**: Conceptualization, Writing – original draft, Writing – review & editing. **Niels Tobias Arnoldussen**: Conceptualization, Writing – original draft, Writing – review & editing. **Jonathan Verschuuren**: Conceptualization, Writing – original draft, Writing – review & editing. **Tim Taylor**: Writing – review & editing. **Gesche Huebner**: Writing – review & editing. **Nicola Tollin**: Conceptualization, Writing – original draft. **Sebastian Mernild**: Conceptualization, Writing – review & editing, Supervision.

Funding sources

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Generative AI and AI-assisted technologies in the writing process

During the preparation of this work the authors used Deepl Write AI-powered tool for the linguistic editing and improving readability of parts of the manuscript text. After using this tool/service, the authors reviewed and edited the content as needed and take full responsibility for the content of the published article.

Declaration of Competing Interest

There are no relevant financial or non-financial competing interests to report.

Data availability

No data was used for the research described in the article.

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