RESEARCH ARTICLE OPEN ACCESS

A Multi-Layered Collaborative Marine Governance Model: Evaluating Change and Innovation of Marine Governance Arrangements

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ABSTRACT

Marine ecosystems are facing substantial stress due to global challenges that have escalated in magnitude and impact. The European Green Deal (EGD) can act as a driver of change and innovation in marine governance. There are multiple enabling and constraining conditions to orchestrate change and innovation, as it requires coordination of multiple governance levels and across different economic sectors. Drawing on established theory and concepts, this paper introduces a Multi-layered Collaborative Marine Governance (MLCMG) Model to evaluate change and innovation of marine governance arrangements. The MLCMG model integrates multiple components: (1) marine governance arrangements (comprising actors/coalitions, rules of the game, resources, and discourses); (2) the institutional setting and structural conditions affecting collaborative processes; (3) collaborative dynamics (comprising principled engagement, shared motivation, and capacity for joint action); (4) governance capabilities of state and non-state actors to attain societal goals; and it considers the role of e-governance to lever institutional arrangements, collaborative dynamics, and governance capabilities. Process performance refers to the ways that change and innovation came about, centering the decision-making abilities and social learning potential of the public and private actors active in marine governance arrangements. Productivity performance focuses on the cumulative results of change and innovation, namely outputs, outcomes, and impacts. Using the EGD vision as a normative reference point against which governance performance can be assessed, the model offers a framework that supports studies of governance change, innovation, and performance.

1 | Introduction

Marine ecosystems are facing substantial stress due to global challenges that have escalated in magnitude and impact. These challenges include climate change, which is leading to an increase in sea temperatures and sea-level rise; biodiversity loss, leading to weakened, less-resilient marine ecosystems; and pollution, particularly from plastics, which is causing pervasive

harm not only to marine species and habitats but also to human activities such as fishing and tourism. The individual and cumulative effects of these pressures illustrate the triple planetary crisis that impacts marine and coastal environments, potentially irreversibly damaging the ecological balance of the planet and undermining livelihoods, particularly for communities that most rely on marine resources (IPBES 2019; UNEP 2022). The global scale of this challenge requires a transformative approach across governance levels, national boundaries, and policy domains (Brodie Rudolph et al. 2020; Van Leeuwen et al. 2025).

The European Union established the European Green Deal (EGD) in 2019 as a strategic vision and overarching framework that aims to foster sustainable practices and drive a transition towards a climate-neutral and sustainable economy. It encompasses a range of objectives, including cutting emissions, investing in renewable energy, supporting biodiversity, and reducing pollution on land and at sea (Fetting 2020). A new but central component of the EGD's approach to governance is the incorporation of e-governance and digital strategies. This includes the development of digital twins, which are virtual representations of marine environments that can be used for monitoring, simulation, planning and decision-making. These technological innovations offer the opportunity to enhance the governance capabilities of actors by providing real-time data and predictive analytics, thus allowing for more informed and agile policy responses (Tzachor et al. 2023). At the same time, e-governance also comes with risks such as excluding some actors or issues that cannot be captured by these systems.

The EGD drives change and innovation within marine governance by setting ambitious policy goals and targets that will not be met within prevailing governance frameworks. Governance arrangements change when their capacity is insufficient to meet established goals, or when societal goals shift. For instance, the governance arrangement in place to address marine biodiversity degradation may be insufficient when biodiversity levels continue to decline or when new ambitions for biodiversity protection are put forth. Innovation is defined as an original, disruptive, and fundamental transformation of an organization's core tasks (Lynn 1997, 154). Governance innovations can be changes in processes, rules, and/or normative standards but exclude incremental improvements (Moore and Hartley 2008), unless these incremental improvements reach a tipping point and become disruptive over time (Van Leeuwen et al. 2025).

Several challenges restrain a green transition in marine domains, including barriers that limit the adaptiveness of institutions, such as a lack of meaningful stakeholder engagement (Weiand et al. 2021), and limited capabilities of states to participate in deliberative processes (Toonen and van Tatenhove 2020). The fragmented nature of governance, where different actors pursue varying goals and operate through multiple regulations (Fanning and Mahon 2020; Mahon and Fanning 2019; Raakjaer et al. 2014), is further exacerbated by inadequate collaboration among the various actors involved in marine governance. These include governmental bodies, non-governmental organizations, industry stakeholders and civil society.

Marine governance and the implementation of the EGD are characterized by their multi-layered nature (Van Leeuwen et al. 2015; van Tatenhove 2022). The process of implementation does not only require the translation of EU directives into national laws and regulations across multiple sectors and coherence between nations, but also local implementation activities, such as the designation and management of marine protected areas and offshore wind energy parks. Progress towards achieving the goals of the EGD requires that the EU and its Member States, including national and local authorities, find ways to collaborate effectively to implement EU regulations within and across borders.

In addition, the EGD requires coherent policy integration and coordination across all scales, particularly in the marine domain, which is managed by various governance structures responsible for different sectors (Fanning and Mahon 2020; Mahon and Fanning 2019). Maritime transport, marine energy, marine plastics, fisheries, and ocean conservation, are examples of sectors each governed by their own specialized structures, often referred to as "regime complexes." Each regime complex presents its own set of institutional barriers and policy challenges (Raustiala and Victor 2004). These barriers include, for example, bureaucratic challenges, conflicting policies between different governance levels, and challenges in stakeholder engagement.

Building on collaborative governance theory (Emerson et al. 2012), collaboration is deemed key to the success of the EGD as well, because implementation of the EGD goals requires "processes and structures of public policy decision-making and management that engage people across the boundaries of public agencies, levels of government and/or the public, private and civic spheres in order to carry out a public purpose that could not otherwise be accomplished" (Emerson et al. 2012, 2). This notion of collaborative governance on the one hand pays attention to processes and structures in which change and innovation came about—referred here as process performance; on the other hand, it refers to the cumulative results of change and innovation, namely outputs, outcomes, and impacts benefiting society—understood as productivity performance.

This paper introduces a model that supports analysis of how marine governance arrangements (MGAs) change and innovate over time in response to an orchestrating policy initiative such as the EGD. A governance arrangement refers to the way a policy domain is temporarily shaped in terms of substance and organization (van Tatenhove 2013). The Multi-layered Collaborative Marine Governance model (MLCMG model) aims to offer a more holistic analysis by drawing on and integrating the following existing models, concepts, and frameworks to evaluate marine issues: marine governance arrangements (van Tatenhove 2013; Liefferink 2006), institutional barriers (Oberlack 2017), and collaborative governance (Emerson et al. 2012). Moreover, the MLCMG model includes both E-governance (Bannister and Connolly 2012) and governance capabilities (Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Candel et al. 2016) as additional components that are underrepresented or missing in existing models. In integrating established governance models, a framework for institutional barriers, and the governance capability concept, we explore the multi-faceted nature of change, innovation, and performance in marine governance. Also, we highlight the emerging role of digital tools (e.g., e-governance) and the

agency of actors active within governance arrangements (e.g., governance capabilities) to attain societal goals. Taken together, we argue that the five model components address key factors that influence the governance of the transition to a sustainable green economy.

The structure of the paper is as follows. We first present an overview of relevant literature regarding change, innovation, and performance of marine governance, showing the need for an integrated approach, and providing the rationale for the development of the MLCMG model. We then briefly explain the methodology used to co-develop the MLCMG model. The paper subsequently introduces the model, providing details for each of its components (including the addition of governance capabilities and e-governance). We then provide guidance on how to use the model and provide a case study to illustrate the explanatory value of the MLCMG model. In the conclusion, we reiterate the purpose of the MLCMG model regarding the implementation of the EGD and identify directions for future research.

2 | Change, Innovation, and Performance of Marine Governance

To explore change, innovation, and performance of MGAs, we have reviewed key literature regarding marine governance, institutional change, and collaborative governance. The first type of scholarship ventures into marine-specific processes and structures. The second explores the processes and factors that lead to institutional change. In the third, collaborative governance speaks to the demand for collaboration, co-creation, and co-production of knowledge and solutions. Moreover, to explore the agency of actors and the emerging role of e-governance, we consider two additional components: governance actors' abilities to observe complex problems and develop and employ strategies to deal with them, and innovations in digital processes or technologies.

In our review, we noticed a lack of focus on the EGD in marine governance literature and insufficient understanding about the link of marine governance arrangements with drivers of institutional change. Further attention needs to be paid to how multi-level governance actors perform in collaborative settings. In addressing these gaps, we need to take stock of how smart e-gov applications change and innovate marine governance, and how governance capabilities of actors structure agency in marine governance arrangements. In addition, there is a lack of attention to synergies between the issues that these literatures focus on and how this relates to governance performance. Taken together, this motivated the development of the integrated MLCMG model (see Section 3).

2.1 | Marine Governance

Marine governance spanning across borders is required to address species conservation (Miller et al. 2019), environmental degradation (Weiand et al. 2021), transboundary pollution, and biodiversity degradation (Sykora-Bodie and Morrison 2019). Fragmented governance systems are ill-suited for complex

interrelationships in ecosystems and between humans (Kelly et al. 2018). However, available marine governance models do not appear suitable for addressing orchestrated and broad-spectrum governance changes resulting from a strategic policy initiative such as the EGD. Rather, many scholars use generic governance theories to evaluate sector-specific marine issues.

Some scholars combine governance approaches with marine-specific planning processes, for instance, in the case of collaborative governance theory and transboundary marine spatial planning (Li and Jay 2023). Kossmann et al. (2016) explain how governance challenges in marine conservation should be addressed with an understanding of collaborative setups. A focus on stakeholder dynamics brings to the fore value conflicts in governance systems which will appear when multiple stakeholders must make a joint decision (Page et al. 2018). Others explore marine threatened species protection through the perspective of adaptive and collaborative governance frameworks (Miller et al. 2019).

While marine governance is usually conducted on a national scale, current climate threats require transboundary governance arrangements (Li and Jay 2023). Simultaneously, integrating local-level interests is key in implementing policies, as the hierarchical structure between stakeholders might affect the interaction in decision-making. Power dynamics on different jurisdictional levels influence the outcome of decisions, and how stakeholders are affected by them. A multilayered governance framework should then integrate and include viewpoints stemming from diverging ambitions from a multitude of stakeholders across institutional levels (Xu 2021). Nonetheless, uncertainties regarding actors' varied roles and responsibilities can negatively affect the outcome of actor participation in governance processes (Greenhill et al. 2020).

The literature review shows that governance concepts are multi-faceted and can be applied to a wide variety of marine issues. In this way, a governance concept might not be exclusively marine focused but can be used to investigate marine issues. This opens up opportunities for developing a more comprehensive MLCMG model that builds upon various key factors that shape innovation and change, while taking into account the marine context. For example, marine governance literature considers several characteristics around governing the use and protection of the marine environment (Van Leeuwen et al. 2025; van Tatenhove 2022; Tafon et al. 2022), including the focus on localized and fair collaboration in decision-making processes, and the recognition that marine issues span across national borders and always involve multiple institutions.

2.2 | Institutional Change

Institutions are understood as "the cluster of rights, rules, and decision-making procedures that give rise to social practices, assign roles to participants in the practice, and guide interactions among occupants of these roles" (Young 2008, xxii). Despite the relative stability of institutions, they change over time due to the interplay between actors and institutional structures. New rules can come into place through

institutional work, which are the "actions through which actors create, maintain, or disrupt institutional structures" (Beunen and Patterson 2019, 12). According to Mahoney and Thelen (2010, 8), institutional change occurs "when problems of rule interpretation and enforcement open up space for actors to implement existing rules in a new way." They see ambiguity as a permanent feature of rule interpretation. More radical changes may be needed when gradual improvement of the institutional structures is not anymore considered adequate for addressing the problems at hand. For example, the Punctuated Equilibrium Theory views the evolution of public policies as processes characterized by long stable periods punctuated by short periods of radical change (Baumgartner and Jones 2010). Radical change implies discontinuity with the past and the introduction of innovations in the governance system (Osborne and Brown 2005; Moore and Hartley 2010). Thus, change and innovation are overlapping phenomena, but whereas change represents continuity, innovation represents a break with the past (Osborne and Brown 2005). There are different drivers of institutional change, including (conflicting) ideas and discourse, elite activity, trust, and power dynamics (Béland 2007; Beunen and Patterson 2019). Conflicting values, interests, and rules can be a catalyst for change by providing opportunities to challenge the existing institutional arrangements (Tafon et al. 2022).

There is a conceptual relationship between governance arrangements and drivers of institutional change. Actors in governance arrangements are bound by the rules of the game, are partly enabled and constrained by the institutional structure, and partly contribute to their production and reproduction. In this way, actors respectively contribute to institutional stability, maintenance, and change (Hacker et al. 2015; Mahoney and Thelen 2010; van Tatenhove 2022). How institutional barriers relate to the interaction between and collaborative capacity of actors in the context of the implementation of the EGD is not well addressed in the literature, and this is considered in the proposed model.

2.3 | Collaborative Governance

As per the EGD, the development and strengthening of collaboration between actors across various institutional levels and sectors is imperative. Collaborative interaction between governments and industry has become increasingly relevant in advancing a sustainable economy (Österblom et al. 2020; Bellanger et al. 2020). By addressing the EU's focus on collective efforts and cooperation, collaborative governance is considered a suitable approach to decision-making and problem-solving. Collaborative governance is based on sharing information and resources and engaging in joint activities. Thus, it enables achieving outcomes that are not possible with other approaches (Avoyan 2022a, 2022b).

Batory and Svensson (2019) reviewed 700 articles and identified five key dimensions crucial for understanding the collaborative efforts between public and private actors: (1) Collaboration between governmental and non-governmental actors. (2) Public actors initiating or overseeing collaborative processes. (3) Collaborative governance conceptualized as multi-organizational, or a broad public involvement of citizens. (4) Scope of collaboration: durability within the policy process. (5) Open objective versus public purpose objective in the collaboration. Their review overlooks specific factors such as the external conditions that incentivize or influence these dynamics and the governance capabilities of non-state actors. We argue that these factors influence the performance of collaborative governance.

There are several studies that interrogate the performance of collaborative governance (Avoyan 2022a, 2022b; Emerson and Nabatchi 2015). Avoyan et al. (2017) distinguish between process and productivity performance. Gerlak et al. (2012, 414) draw attention to the lack of (or insufficient) data and evidence on the outcomes of Collaborative Governance Regimes (CGRs). Also, there is limited empirical research on cross-boundary performance (Emerson and Nabatchi 2015). Finally, existing models of multi-layered collaborative governance do not focus on e-governance or governance capabilities as levers to change and innovation (Sani et al. 2019).

2.4 | The Need for a More Holistic Model

While the three strands of the literature—marine governance, institutional change, and collaborative governance—help to understand part of the puzzle of marine governance performance in a multilayered context such as the EU, there is a need to integrate these literatures in a model. This will generate a more holistic approach to the enabling and constraining factors to implement the EGD vision in marine regime complexes. In turn, such a model will solve the lack of focus on the EGD in marine governance literature, interrelate marine governance arrangements with drivers of institutional change, and offer insights into the performance of multi-level and multi-actor governance in collaborative settings.

Moreover, such a model would not just need to go beyond the current state-of-the-art by integrating insights from the three bodies of literature, but it also needs to take in two additional components: governance capabilities and e-governance developments. Governance capabilities are needed as a concept to better capture the agency of governing actors in marine governance arrangements. While the three discussed strands of literature do not exclude actions and interactions, these are often studied empirically, or actions and interactions are described and analyzed from actors' roles, responsibilities, and interests. By considering governance capabilities as a separate dimension, the emphasis goes to what actors *do* and *can do*, highlighting their actual and aspired contribution to the performance of governance arrangements (cf. Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Candel et al. 2016). Another component that needs to be foregrounded as a separate dimension is e-governance. E-governance is highlighted by the EU in the EGD, presented as an opportunity to arrive at more informed and agile policy responses (Tzachor et al. 2023). Also, bringing in e-governance concurs with the emerging trend in social science research to scrutinize how Information and Communication Technologies (ICT) are leveraged to enhance communication and political participation (Bekkers 2004; Best and Krueger 2005; Curwell et al. 2005; Sæbø et al. 2008).
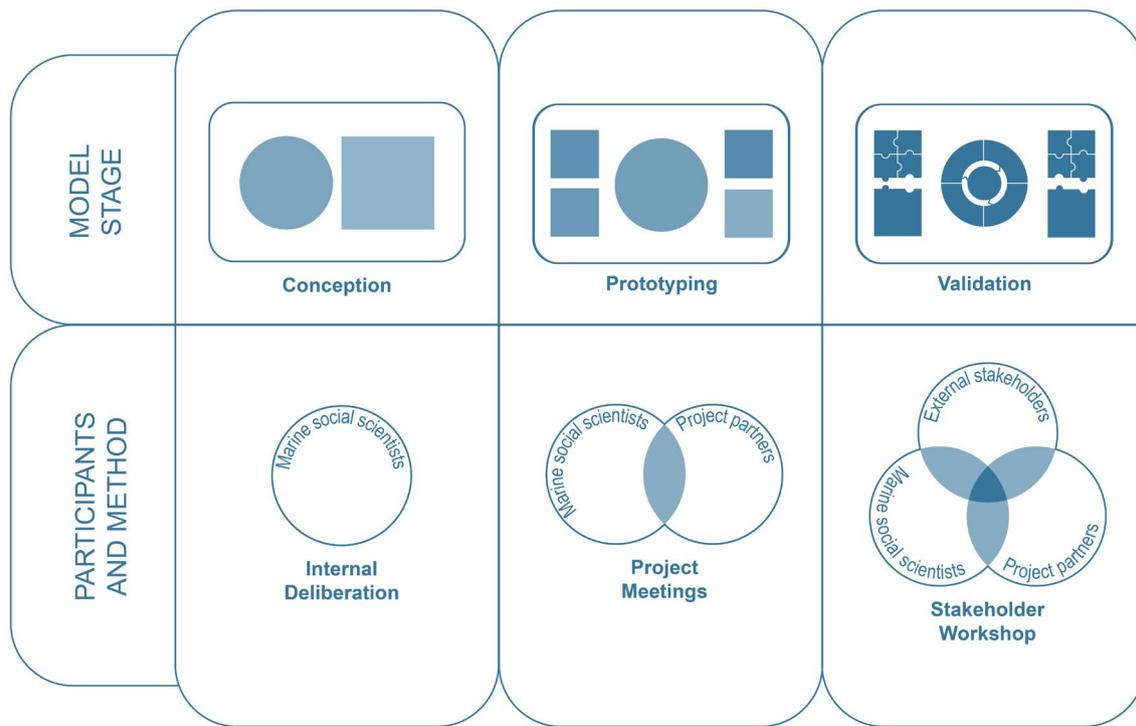
FIGURE 1 | Co-design process.

2.5 | Summary

This section presented a brief review of marine governance, institutional barriers and opportunities, collaborative governance, e-governance, and actor's capabilities. Each of these bodies of literature helps understand part of the puzzle of marine governance performance in a multilayered context such as the EU. Integrating these literatures into a model will generate a more holistic approach to the enabling and constraining factors to implement the EGD vision in marine regime complexes.

3 | Methodology: Co-Developing the MLCMG Model

The MLCMG model is developed by a team of social scientists working on a range of marine governance issues. The MLCMG model is an output of PERMAGOV, which is a collaborative research project that sets out to improve marine governance in the EU so that it can better meet the goals and objectives established in the EGD. The model contributes to a core objective of the PERMAGOV project, which is to co-develop and apply a Marine Governance Performance Assessment Framework to assess how institutional barriers, collaborations, and e-governance tools enable and constrain the capability of actors to implement EU marine policies within the regime complexes of Marine Energy, Maritime Transport, Marine Life, and Marine Litter. The model will be used to analyze the nine PERMAGOV case studies within the four regime complexes.

The MLCMG model was developed by a team of social scientists of the PERMAGOV project based on existing literature, including state-of-the-art definitions and models of collaborative

governance, governance arrangements, institutional barriers, e-governance, and capabilities research. Inspired by principles of design research (Chilvers and Kearnes 2015), we used a step-change co-creation approach to developing the model together with the end-user partners of the project and a wider set of stakeholders (see Figure 1).

Design research encourages iterative experimentation and prototyping, allowing for continuous refinement and improvement of a governance model (Chilvers and Kearnes 2015). The scientific team (i.e., marine social scientists) started with initial conversations about building blocks to explain the change and innovation of marine governance arrangements and captured ideas through visual tools (e.g., Miro Board). During various iterations and regular engagement with the project partners, including the end-users (i.e., individuals representing organizations primarily involved in policy implementation), the scientific team developed a prototype of the model. End-users involved in the project are 2 policy making institutions, 3 industry associations and 2 eNGOs, representing the four marine regime complexes (e.g., Marine Life, Maritime Transport, Marine Energy, and Marine Plastics).

The team subsequently tested and further refined this prototype through a 1-day workshop with external stakeholders (Brussels, Belgium, 15-02-2024). The workshop had the goal of fostering collaboration, creativity, and adaptability. By embracing principles of human-centered design, multidisciplinary collaboration, and continuous experimentation, the research team engaged stakeholders to reflect on the complexity of EGD implementation and to provide insights into the enablers and barriers to change and innovation. Representatives from four regime complexes (Marine Life, Maritime Transport, Marine Energy, and Marine Plastics) as
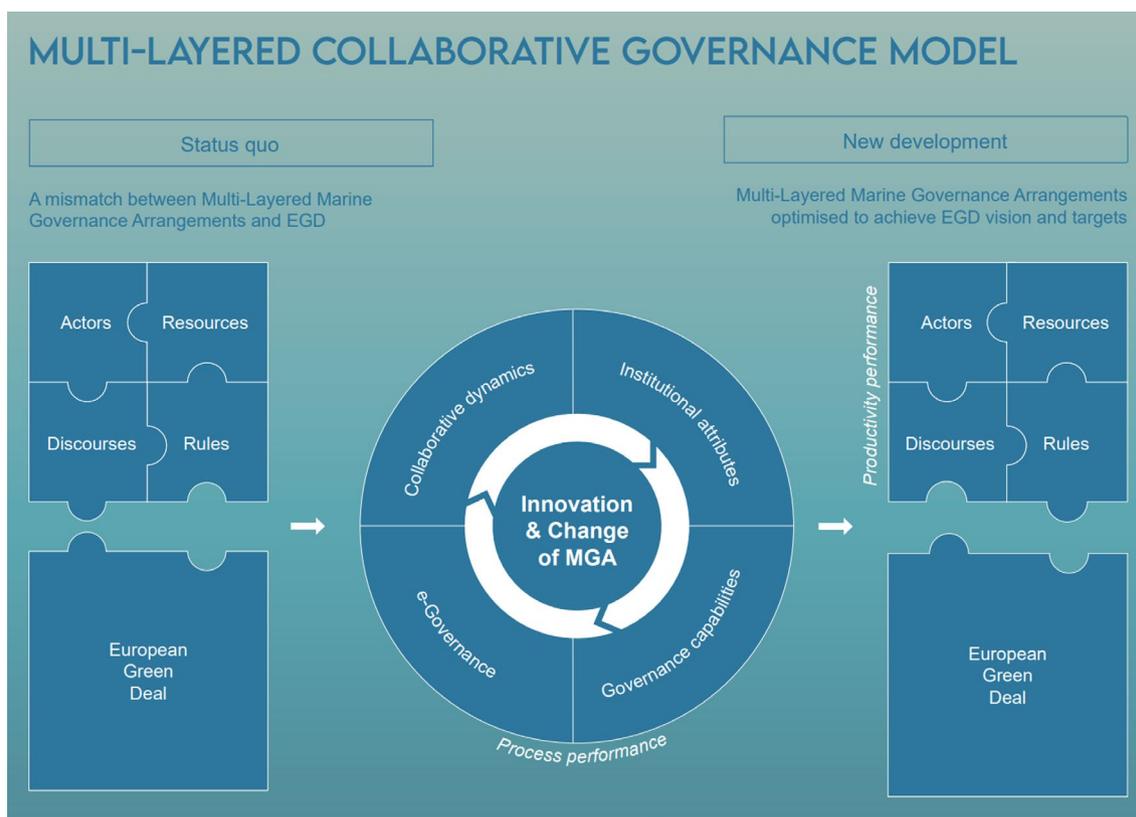
FIGURE 2 | MLCMG model.

well as governmental actors from different institutional layers from the EU, Norway, and the United Kingdom participated in the workshop, provided feedback on the initial model draft and its respective components. The workshop brought together around 50 key individuals from research, policy-making, industry and civil society as well as partners from the PERMAGOV project. With the model consolidating other research project tasks of PERMAGOV (focusing on specific components of the model), the day was designed to first discuss the building blocks of the model while the final session of the day focused on discussing the interrelationships between the building blocks. Based on the stakeholder workshop, the scientific team finalized the MLCMG model.

A particular challenge in this participatory design process was the highly theoretical and abstract nature of the model's building blocks. Input from end-users and external stakeholders focused on applying the model to concrete examples (as part of the nine PERMAGOV project's case studies) which required translating the theoretical building blocks and concepts proposed by the scientific team into more specific terms. This in turn created two opportunities. First, applying and working through the model with stakeholders allowed for a better understanding of the linkages between the building blocks of the model. Second, the opportunity for end-users and project partners to understand the focus and terminology used in marine governance research in general and in the PERMAGOV project specifically, created a common understanding for partners, benefiting the implementation of the second half of the research project.

4 | Multi-Layered Collaborative Marine Governance Model

4.1 | Introduction to the Model

The MLCMG model (Figure 2) brings together different components to study the enabling and constraining conditions of MGAs to support progress towards the EGD vision:

- marine governance arrangements (comprising actors/coalitions, rules of the game, resources, and discourses) which are multi-layered;

- the structural conditions affecting collaborative processes, notably the institutional context;

- the characteristics of the collaborative process in which governmental actors (public agencies) in deliberation with non-state actors (e.g., representatives of maritime sectors, non-governmental organizations) are engaged in decision-making of marine policies;

- the governance capabilities of state and non-state actors to attain societal goals; and

- the role of e-governance to enable the effective implementation of the EGD.

In practical terms for implementing the EGD, the MLCMG model offers a simplified representation of how marine governance arrangements change and innovate over time. We conceive marine decision-making and the implementation of marine policies as

a collaborative process structured by institutions, constrained by institutional barriers, enabled by the governance capabilities of actors, and facilitated by e-governance. The problem that the MLCMG model addresses is multifaceted: it involves navigating the complexity and fragmentation of marine governance, implementing the EGD's ambitious objectives in a sector-specific and context-sensitive manner, and overcoming institutional barriers within diverse marine regime complexes. Moreover, it considers the EGD as both a driver of change and an overarching vision to achieve.

4.2 | Description Components

When reading the MLCMG model from left to right, the first component in the MLCMG model is the multi-layered marine governance arrangement that exists of actors, resources, discourses, and rules. The puzzle pieces illustrate that the current arrangement—the "status quo"—of these four dimensions do not match the EGD targets. Through a dynamic process of innovation and change (visualized in the middle part of the figure), MGAs are ideally optimized to achieve the EGD vision and targets. Evaluation of this "new development" is studied in the right part of the model. The optimization or improved performance of MGAs is visualized with matching puzzle pieces. Noticeably, the transition towards better performance of MGAs is not a given.

Next, we provide a detailed overview of the components and sub-components integrated into the MLCMG model. See

Table 1 below for an outline of these, as well as referenced key literature.

4.2.1 | Multi-Layered Marine Governance Arrangements

The concept of multi-level governance captures the distribution of decision-making power from member states to the European Union and sub-national actors (Marks 1996; Marks and Hooghe 2003). In general, multi-level governance is primarily concerned with decision-making competencies of actors on different levels or layers of government and the increased interdependence of public actors operating at different levels (vertical). However, at the same time, the concept of governance also refers to the growing interdependence between public and private actors at various levels (horizontal) (see also Bache and Flinders 2004; Hooghe and Gary 2003). This means that coalitions of governmental and non-governmental actors of different governance levels (subnational, national, supranational, and international) try to influence activities and developments within a specific regime complex. In general, multi-level governance is defined as the sharing of policy-making competencies in a system of negotiation between nested governments at several layers (supranational, national, regional, and subnational/local) on the one hand and private actors (e.g., NGOs, market parties, and citizens) on the other hand (van Tatenhove 2003; Van Tatenhove et al. 2006; Van Leeuwen et al. 2012; van Hoof et al. 2012). Multi-layered Collaborative Marine Governance Arrangements refer to the way in which marine governance arrangements are

TABLE 1 | MLCMG model components, sub-components, and key literature.

Components	Sub-components					Key literature
Multilayered marine governance arrangements	Actors	Resources	Discourses	Rules		(van Tatenhove 2013; Liefferink 2006; Marks and Hooghe 2003)
Institutional attributes	Barriers of adaptation		Enablers of adaptation			(Oberlack 2017; Mahoney and Thelen 2010)
Collaborative dynamics	Principled engagement	Shared motivation		Capacity for joint action		(Emerson et al. 2012; Ansell and Gash 2008)
e-Governance	Seeing and knowing	Participation and engagement		Interventions and actions		(Kloppenburg et al. 2022; Davret et al. 2024)
Governance capabilities	Reflexivity	Resilience	Revitalization	Rescaling	Responsiveness	(Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Candel et al. 2016; Sen 1999; Robeyns 2017)
Change, innovation and performance	Change is the gradual formation of the rules, resources, and discourses	Innovation is disruptive transformations that are non-incremental	Process performance comprises social, system and technological performance	Productivity performance comprises outputs, outcomes, and impacts		(van Tatenhove 2022; Avoyan et al. 2017; Helm and Sprinz 2000; Young 2001)

essentially shaped by actors operating on multiple institutional levels and across multiple sectors. Multi-layered governance is the combination of both multi-level and multi-actor governance.

A governance arrangement is a temporary stabilization of the substance and organization of a policy domain, which can be analyzed along four dimensions: actors and their coalitions, discourses, resources, and rules of the game (Liefferink 2006; van Tatenhove et al. 2000). In a governance arrangement, different (and more or less stable) coalitions of public and private actors try to influence the activities and developments, and design legitimate initiatives, based on shared discourses, managing resources, and defining rules of the game (on different levels). These governance arrangements evolve because of the interplay between processes of political modernization and interactions between interdependent actors in policy practices (Arts et al. 2006; Van Tatenhove et al. 2006). Political modernization refers to the "structural processes of social change and their impact on the political domain" (Arts et al. 2006, 97). In this paper, we focus on MGAs that are engaged in addressing the EGD vision and targets that relate to the marine environment.

Next, we discuss the dynamic components in the middle part of the MLCMG model: institutional attributes, collaborative dynamics, governance capabilities, and e-governance. These components enable and constrain the change and innovation of MGAs.

4.2.2 | Institutional Attributes: Barriers and Enablers of Adaptation

The first component in the dynamic middle section of the MLCMG model is institutional attributes. Institutions may both constrain and enable the performance and adaptation of governance arrangements. Institutions enable change processes by establishing shared expectations about interactions. Without this, it would be difficult for actors to cooperate to identify the need for change and initiate adaptations. However, institutions are rather stable entities, and institutional change tends to be incremental, which also limits the scope for innovation. We particularly look at institutions through the perspective of governance arrangements, meaning institutions that influence the interaction between actors and their coalitions, discourse, and resources.

Following Oberlack (2017), institutional attributes that provide for adaptation can be termed "institutional enablers," while institutional attributes that limit the scope for adaptation are termed "institutional barriers." According to a systematic scoping review of institutional barriers to marine policy performance, frequent institutional attributes that inhibit policy implementation are the scale of institutions, the development and use of knowledge, and actor control (Nielsen et al. 2023).

Mahoney and Thelen (2010, 15–18) distinguish four forms of institutional changes that influence the performance of governance arrangements: displacement (removal of existing rules and the introduction of new ones), layering (introduction of new rules on top of or alongside existing ones), drift (the changes impact of existing rules due to shifts in the environment), and conversion (the changed enactment of existing rules due to their strategic redeployment). The recognition of an institutional barrier may motivate actors to invest in institutional adaptation or innovation design to improve the performance of governance arrangements. However, certain types of institutional barriers limit the potential for adaptation, at least in the short term. Such types of barriers include path dependence (Liebowitz and Margolis 1995; Rixen and Viola 2015), institutional arthritis (Young 2010), and bounded rationality (Kyriazis and Metaxas 2010).

Institutional change does not always lead to improvements in performance. Furthermore, an institutional change may improve governance performance in one respect, while reducing another aspect of performance. For instance, broad participatory processes may enhance governance legitimacy and acceptance; while at the same time, it may reduce or slow down governance processes. Institutional change can be incremental but may also be radical, disruptive, or transformative, which in turn produces innovation (e.g., innovations in the system, actor networks, governance and management, initiatives or niches, and cultures) (Kelly et al. 2018).

In sum, institutions can either catalyze or impede change and are thus important to consider in processes of changing governance arrangements. When identifying and addressing institutional barriers, it is important to understand the governance features that propagated them. For example, path dependency may arise from institutional rigidity, or it may be due to the intransigence of powerful stakeholders.

4.2.3 | Collaborative Dynamics

Next in the MLCMG model is the component of collaborative dynamics, which refers to the dynamic interactions of actors in collaborative governance regimes. Actors mobilize resources (e.g., financial, human) and use discourses and rules to have power over (e.g., influence, resist) the process and content of decision-making when creating collective responses (e.g., policy design and implementation) to marine issues such as plastic pollution, loss of biodiversity, or expanding renewable energy capacity. Actors engage in collaborative governance because they anticipate benefits from working together.

The framework of Emerson et al. (2012) identifies multiple dimensions of collaborative governance, including the collaborative dynamics between actors. Collaborative dynamics consist of three components: principled engagement, shared motivation, and capacity for joint action (Emerson et al. 2012). These components allow us to characterize how actors in governance arrangements jointly discuss problems and opportunities and come to an agreement on joint action. These components also shed light on the conditions (e.g., trust, mutual understanding) and resources that enable effective relationships (e.g., leadership and knowledge). Through principled engagement, actors work across boundaries to solve problems by adhering to fair and open communication about all relevant interests and being informed by the viewpoints and knowledge of all participants. Principled engagement includes four iterative process elements (discovery, definition, deliberation, and determination) that produce social learning and facilitate the agreement of shared aims

or a purpose and a shared theory of action for achieving the aims or the purpose. Shared motivation refers to a self-reinforcing cycle that consists of four inter-personal or relational elements (trust, mutual understanding, internal legitimacy, and commitment) contributing to social capital. Capacity for joint action is the pool of functional elements (procedural and institutional arrangements, leadership, knowledge, and resources) that creates the potential for taking collective actions. Actions can be undertaken by all participants in concert, by individual partners, or by external entities, and they can lead to both internal (within the collaborative regime) and external outcomes. The functional elements represent together the actor/group's problem-solving capacity.

Process benefits of collaborative governance include social learning, the creation of trust, and the development of public values. In terms of outcomes, this could include formal decisions, concrete plans, or established measures. Impact involves an alteration to conditions in the system context, for example, when there is a more coherent and effective approach to implementing EGD objectives. Nevertheless, interactions between actors and coalitions in collaborative dynamics are influenced by asymmetries in power, knowledge, and resources (Ansell and Gash 2008). A potential issue that may arise from collaborative governance is the co-option of weaker participants. Stakeholder engagement can be improved by ensuring the principles of inclusivity, justice and equity, and co-production (Dobbin et al. 2023). The productiveness of collaborative dynamics (process) fluctuates over time. Depending on the context, actors can increase their participation and integration in a collaborative governance regime over time, take breaks from the interaction, reorganize themselves and restart, or withdraw from the collaboration (Avoyan 2022a, 2022b; Heikkila and Gerlak 2016; Imperial et al. 2016; Ulibarri et al. 2020; Scott et al. 2020). Governance capabilities of actors influence individual organizations' ability to participate in governance arrangements (see next section).

4.2.4 | Governance Capabilities

Governance capabilities are another important component in the middle part of the MLCMG model. Governance capabilities refer to abilities of governing actors to observe complex problems and develop and employ strategies to deal with them (Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Candel et al. 2016). The capability concept foregrounds the agency of actors active within governance arrangements. Actions and interactions are often only studied empirically, or explained in terms of roles, responsibilities, and interests that actors have, based on their background, ambitions, and context-specific position in a governance arrangement. However, actors enact, through their abilities, also a certain degree of freedom to choose strategies (Toonen et al. 2021) following (Sen 2005; Robeyns 2005). Focus on what actors *do* and *can do*, means highlighting both their actual and aspired achievements, which allows for a better understanding of whether (to what extent) specific opportunities an actor has or develops (capabilities) are indicative of a changing performance in a MGA.

In our understanding of capabilities, we combine the capability approach, embedded in development sociology and economics (Sen 1999; Robeyns 2017) with work within public administration scholarship (Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Candel et al. 2016). The capabilities approach builds upon two key concepts: capability (the effective freedom or real opportunities one has) and functioning (the actual achievement—being or doing—one has reason to value) (Sen 1999; Robeyns 2017). In the capabilities approach, emphasis is on the micro level, what individuals do and can do (to achieve what they have reason to value), while governance and public administration scholars take the meso-level as the unit of analysis, defining actors as public or private organizations which have a capacity to perform, beyond the individual actions of the people who represent them, and goals that surpass individual needs, ambitions, or interests.

Termeer et al. developed the concept of governance capabilities, to capture the abilities of organizations to achieve their specific societal and political goals, breaking the concept down into five abilities. Governing actors need to be (1) reflexive, meaning they need to have and develop the ability to deal with multiple discourses that exist and emerge in society and policy. An actor also needs to be or become (2) resilient (or agile), referring to flexible adaptation to frequently occurring and uncertain changes. Another capability is (3) revitalization (or innovation drive), that is, the ability of the actor to unblock deadlocks and stagnations in policy processes, to develop new ideas and to create solutions. Given the complexity of many of the challenges governing actors face, they also need the ability to (4) rescale, which means they need to address mismatches between the scale of a problem and the scale at which it is governed. Also, governing actors need to be (5) responsive, referring to their ability to communicate, so they respond wisely to changing agendas and public demand (Termeer et al. 2015, 2016; Termeer and Dewulf 2014; Toonen et al. 2021).

While governance capabilities are defined at a meso-level, these five abilities are often shown at the micro-level. Actors are not faceless organizations but are represented by individuals. These individuals (are able to) act in terms of skills, repertoires, capacities, commitments, and readiness (Willems and Baumert 2003; Robeyns 2017; Termeer et al. 2015), performing within their function/job and thus within an organization. How (and the extent to which) governance capabilities affect the change and innovation of a governance arrangement depends on the interplay between micro- and meso-level (Trang et al. 2023). At the same time, an actor's ability is closely connected to the macro level, because of the institutional capacity held by networks of organizations that collectively work towards a common goal, so a meso- and macro-level interplay.

4.2.5 | E-Governance

E-governance is the fifth model component in the MLCMG model. Concepts like e-participation, e-inclusion, and e-government refer to the use of ICT to enhance and broaden political involvement and have supported the maturing of the concept of e-governance (Saebo et al. 2008). The concept of e-governance emerges as an element in newer governance models (Charalabidis and Koussouris 2012), referring to the use of ICT tools in ways that change the underlying mode of governance

(Bannister and Connolly 2012). Combined with collaborative governance, some studies explore the performance of collaborative e-governance (Pandey 2023). Whether e-governance can facilitate collaboration is uncertain. Nevertheless, given the potential of e-governance tools to support collaboration in marine spaces, we need to pay attention to e-governance as a component in the change and innovation of MGAs.

We conceptualize e-governance to refer to the development and application of digital processes or technologies aimed at improving the governance and/or management of marine activities and resources, including within and across sectors and governance levels (Kogut et al. 2024). E-governance tools and processes may support the implementation of the EGD in multiple ways. Digital tools can potentially help actors overcome institutional barriers and strengthen collaborations by communicating interests, values, and concerns, and building up relationships with organizations across different institutional levels and economic sectors.

Following Kloppenburg et al. (2022), the implications of digital tools on governance can be reflected on in terms of how they lead to changes along three dimensions of governance: (1) seeing and knowing; (2) participation and engagement; and (3) interventions and actions.

By supporting actors in their "seeing and knowing," e-governance solutions have the potential to make visible, often in real-time, resource use and user location, rule infractions, and environmental health monitoring data, and the connections between these components. This may potentially reveal new insights, including hitherto unseen trends and can help build future use scenarios. These technologies may also enhance trust and transparency by making the data underpinning governance actions more accessible and transparent. They may also bring new actors into governance arrangements by making them and their data more visible. Conversely, seeing and knowing types of e-governance solutions may negatively impact collaborative arrangements by narrowly defining governance problems as what is knowable through these digital technologies (Kloppenburg et al. 2022), creating inclusion barriers for actors whose interests cannot be easily captured within visual data (e.g., intangible cultural heritage), or those without the resources or incentive to digitize their data.

The potential of digital tools to enhance "engagement and participation" refers to strengthening the capacity of a wide range of actors to participate in and contribute to decision-making. According to Kloppenburg et al. (2022, 235), "One of the promises of digitalized environmental governance is that it opens up new possibilities for participation in governance practices and processes across all these levels, with an assumption that this in turn would enhance the democratic character of governance." Using app solutions also tends to support two-way communication, for example when citizens report on pollution or disturbance from mills via an app and receive feedback on whether others also filed a complaint, and how the complaints were handled (Solman et al. 2023). However, since technology companies and digital conglomerates often act as "novel intermediaries and brokers" (Bernards et al. 2020, 528), the power balance does not automatically play out in favor of social groups whose participation should be enhanced.

Next to seeing and knowing, and engaging and participating, Kloppenburg et al. (2022) recognize the potential to "intervene and act." Accordingly, "a key promise of digital technologies is that they collect and process data to automate and optimize decision-making processes and interventions. This includes new possibilities for automating compliance and for reorienting the decision-making of actors (from individuals to governments) toward improving sustainability" (Kloppenburg et al. 2022, 237). The European Digital Twin Ocean reflects the EU's ambition to move towards an innovative, integrated set of tools that makes knowledge available, facilitates exchange and discussion, but also uses input into and feedback to the system to calculate and detect patterns, and to simulate and test solutions. Automated systems have huge benefits in terms of optimization and efficiency due to the scale and speed at which they operate. However, Kloppenburg et al. (2022, 238) warn that digital technologies have specific built-in properties and are designed with specific questions or goals in mind, meaning that "the anticipation (or glimpse of an alternative reality or world) offered by a digital twin is thus fundamentally dependent on certain normative choices and knowledge paradigms that gear it toward certain goals and interests". It is expected that different digital tools, developed for and used in the diverse MGAs, will show different impacts, positively or negatively (Davret et al. 2024).

4.3 | Change, Innovation, and Performance

Having explained each of the components of the MLCMG model, we explicate in this section our understanding of change, innovation, and performance of MGAs. The model assumes that actors in MGAs change and innovate when their capacity to meet the established goals is recognized to be insufficient and/or when societal goals are shifting. Change and innovation are considered processes of structuration and stabilization of MGAs (van Tatenhove 2022) to adapt to environmental problems and societal goals. Structuration is the gradual formation of the rules, resources, and discourses in interaction between actors, and the disruptive transformations that are non-incremental, and represent innovation (Sandfort and Moulton 2020). The actors apply their governance capabilities to navigate and overcome institutional barriers, collaborate to generate change and innovation, and use e-governance tools to facilitate communication and access to knowledge, and to comply with regulations. Thereby, they reform the rules of the game, redistribute resources, and adopt new discourses. The content and organization of an MGA temporarily stabilize forming institutionalized arrangements, which tend to constrain the agency of actors by presenting different types of barriers while the actors also defend the existing MGA (van Tatenhove 2022; Arts and Van Tatenhove 2006). Thus, the new MGA is an outcome of the interplay between structuration and stabilization. Noticeably, change and innovation is an ongoing process, which implies that MGAs are always in flux.

Performance indicates the actual capacity of MGAs to solve societal problems and create societal opportunities. Process performance refers to the ways that change and innovation came about. Productivity performance refers to the cumulative results of change and innovation, namely outputs, outcomes, and impacts benefiting society.

Process performance describes the competence of governance actors for decision-making and social learning (Avoyan et al. 2017). We propose two perspectives to study process performance: social performance and technological performance. Social performance is based on the capability of actors to collaborate, which is indicated by their ability to successfully communicate their perspectives, agree on problems and solutions, build relationships, jointly commit to change and innovation, and respond to social problems. Technological performance denotes effective use of e-governance tools for different purposes (e.g., rule compliance, communication, relationship building, observing complex problems, and developing and employing strategies to deal with problems) to overcome institutional barriers and enhance collaboration.

Productivity performance can be identified in terms of outputs, outcomes, and impacts (Helm and Sprinz 2000; Young 2001, 14). Outputs are developed and delivered by MGAs and are expected to contribute to outcomes. Examples are new policies, regulations, strategies, monitoring, and enforcement mechanisms. Outcomes refer to positive changes in terms of new or improved policies, plans, and practices that contribute to longer-term impacts. Examples include behavioral changes within marine governance arrangements, changes in the regulatory environment, the establishment of joint working groups or other new measures for collaboration, and improved communication platforms. Impacts refer to an improvement in the social, environmental, and economic state of society and is broader in scope than outcomes. In the context of the marine domain, impact generally relates to environmental protection in the form of reduced emissions and plastic pollution or increased biological diversity and improved ecosystems. Also, impact is when MGAs achieve social and/or biophysical progress by solving societal problems and creating societal opportunities (e.g., actual progress on carbon capture through CO_2 reduction).

4.4 | Guidance on How to Use the MLCMG Model

The MLCMG model can be used to evaluate the performance of an MGA in terms of achieving the objectives of the EGD and to consider the possibilities to induce and support change and innovation for governance to better match the EGD requirements. In practice, the model is a framework that researchers can use to study how institutional attributes enable or constrain the pursuit of EGD, whether collaborative dynamics need to be enhanced, the extent that governing actors have abilities to observe, develop and employ strategies to deal with complex problems, and the role of e-governance to facilitate the implementation of the EGD. The MLCMG model provides a framework to understand the extent that MGAs are changing and innovating. What this means is that it provides a snapshot of the actors, processes, and structures in the specific MGAs in relation to their ability and actions to progress towards the EGD vision. The linkages between the components of the MLCMG model depend on the context of a specific MGA. The relationships between institutional attributes, collaborative dynamics, e-governance, and governance capabilities can be enabling/supporting innovation and change, but also restraining/conflicting, or neutral (see also Lombard

et al. 2023). This means that the relevance of each of the components and sub-components depends on the regime complex and case study area.

To aid empirical analysis, we have developed a list of questions to structure MLCMG model-informed case study analyses (see the Supporting Information S1). With marine governance being in constant flux (van Tatenhove 2013), successive studies over a period are recommended. This means that the evaluation of the "status quo" and the "new development" will be different depending on the timing of the case study analysis.

5 | Application of the MLCMG Model: Regional-Level Governance of Seabed Integrity in the Baltic Sea

To illustrate the explanatory value of the MLCMG model to assess change, innovation, and performance, we present a case study on seabed integrity in the Baltic Sea. The *multi-layered marine governance arrangement* in this case is as follows. In terms of *rules and actors*, the protection of benthic habitats from human pressures in the Baltic Sea is guided by the EU's Marine Strategy Framework Directive (MSFD) and implemented by its member states. A prevailing *discourse* suggests that benthic habitats play a key role in the health of marine ecosystems, but they are increasingly threatened by multiple cumulative human pressures. At the regional level, the intergovernmental Baltic Marine Environment Protection Commission (HELCOM) supports its contracting parties—most of which are also EU member states—in seabed protection, specifically through its strategic program, the Baltic Sea Action Plan (BSAP). In practice, seabed integrity in HELCOM is addressed by several working groups and expert groups that involve contracting parties, scientific experts, and observers. The knowledge base provided by the groups is a key *resource* for governance.

Innovation and change of the MGA are underperforming due to several constraining *institutional attributes*. The implementation of seabed-related aspects of the MSFD is poorly coordinated both vertically and horizontally, demonstrating limitations in terms of *scale of institutions*. The non-binding nature of HELCOM policies and the limited legal weight of the MSFD reflect weaknesses in the *formality of institutions*. These constraints pose risks to seabed integrity and the Baltic Sea ecosystem. To strengthen the implementation of the MSFD, the EU introduced quantified threshold values for the loss and disturbance of seabed habitats in 2023. HELCOM parties, for their part, have agreed to develop a common approach to enhance the coherence of seabed governance across the region. These new but different strategies are changing and innovating the MGA in the Baltic Sea to facilitate the implementation of the MSFD in the Baltic Sea region.

Another *institutional attribute* that impacts process performance is *knowledge gaps* regarding the locations of degraded benthic habitats, the impacts of human activities, and the recovery potential of habitats. Further development and harmonization of data collection and assessments, both among Baltic Sea countries and between HELCOM and the EU, would support more targeted and effective measures.

HELCOM possesses relatively strong potential in its *governance capabilities* to improve seabed management. As a regional sea organization, it is designed to enable *rescaling*, facilitate coordination between countries, and mediate between the EU and its Baltic Sea member states. Its decisions address ecological boundaries and cross-border scales. The *rescaling* capability of HELCOM is effective for the governance of many marine environmental issues, but, as pointed out above, it has not yet been fully realized for seabed management. The assessment procedures of HELCOM support *reflexivity* through continuous updating of knowledge. Decision-making and collaboration practices within HELCOM also enable a relatively high level of *agility*. A strong scientific and collaborative foundation supports the development of new solutions to *revitalize* the HELCOM approaches. *Responsiveness* to shifting political agendas is embedded in the system through the generation of new initiatives. HELCOM's various groups foster *collaboration dynamics*. Such arrangements support *principled engagement* as well *capacity for joint action*.

However, HELCOM also has limitations. Its intergovernmental nature restricts its influence on contracting parties, and reaching consensus is not always straightforward. Social and economic perspectives are not sufficiently included in the assessments, limiting *reflexivity*. A strong environmental bias, slow decision-making processes, and bounded creativity limit the organization's *agility*. The system is primarily open to observer organizations demonstrating *responsiveness*, but participation requires the resources, capabilities, and skills to operate at the international level. Decision-making in HELCOM is limited to formal representatives, and its outreach tends to resonate most with environmentally oriented and knowledgeable stakeholders, which constrains *responsiveness*. The analysis suggests that interest and capacity of industries to collaborate are not always high due to scarce resources and issues of trust. Some groups prioritize other collaboration platforms than HELCOM, which suggests insufficient *shared motivation* if a common purpose and objectives for collaboration are not recognized.

The last component of the MLCMG model, *e-governance*, has the potential to facilitate seabed governance. In the MGA, *digital tools* are primarily used for data-sharing and reporting. At the national level, digital platforms are being developed to manage data from monitoring through to assessments and reporting. Reporting to both HELCOM and the EU is largely digitalized. In some countries, digital systems are used for permitting activities such as dredging. However, the application of digital tools for reporting from MS to the EU, for sharing data between HELCOM and the EU, and at the regional sea level still requires further development to enhance seabed governance.

The MLCMG-based analysis of seabed governance in the Baltic Sea suggests that to ensure the effectiveness of HELCOM's common approach in enhancing seabed governance, its development should build on the strengths of the working groups focused on the seabed, while addressing the identified weaknesses. Digital tools could play an important role in filling gaps in HELCOM's work.

The application of the MLCMG model allowed us to highlight a broad range of governance-related topics that help to explore innovation and change in the seabed integrity case study (institutional attributes, collaboration dynamics, e-governance, and governance capabilities). The model does not place greater emphasis on any of these topics relative to the others at the outset. Instead, it requires the analyst to study all components, with the empirical analysis revealing which components and subcomponents are more important in a specific case study. The model also facilitates the study of relationships between the components. For instance, in the seabed case we could analyze how the EU threshold values for seabed integrity—as a form of "governance through metrics" (Loconto et al. 2024)—and the HELCOM's common approach—as a collaborative approach to ecosystem-based management (Söderström and Kern 2017) can contribute to improved governance, especially if successfully combined.

6 | Conclusion

Developed based on various social scientific theories, the MLCMG model offers a framework to analyze the complexities of marine governance, including institutional attributes, collaborative dynamics, and governance capabilities of state and non-state actors. Moreover, the MLCMG model also highlights the growing importance of e-governance in enhancing governance capabilities. The model was co-developed and tested with a group of stakeholders, helping to ensure that it has value in understanding real-world challenges of marine governance and assessing their capacity to achieve agreed-upon societal goals as established in the EGD (i.e., performance).

The MLCMG model provides a significant advancement in understanding and implementing the EGD's objectives in marine governance. The MLCMG model can be used to assess the current state of MGAs progress towards the EGD, and as a springboard for the creation of new governance strategies to orchestrate change and innovation. It can also provide a useful framework for researchers to engage with marine stakeholders and practitioners to discuss and reflect on the governance challenges they face or opportunities they may have when engaging in EU policy. The MLCMG model would benefit from future studies which apply the model to practical examples or case studies to collect empirical evidence about its application within such settings as well as how the different model components and sub-components interlink and enable or impede governance innovation, change, and performance.

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data sharing not applicable to this article as no datasets were generated or analyzed during the current study.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.