An Integrated Systems View of Sustainable Blue Economy Governance

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Contents

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Abstract

Despite the widely accepted view of blue economy as an integrating policy framework for the sustainable development of the ocean—requiring a systems approach to governance—achieving the integration of the economic, social, and environmental dimensions of sustainability remains challenging. Various critical issues and obstacles complicate the alignment of these different goals, primarily due to the diversity of interests and the intrinsic complexity of sustainability itself. Additionally, the dynamic and evolving nature of blue economy governance necessitates an ongoing adaptation process. This requires defining the essential components of sustainable ocean development and optimizing governance frameworks to strengthen the blue economy and broader global sustainability initiatives.

Given this context, this chapter adopts a managerial perspective based on Triple Helix approaches, which emphasize collaboration among academia, industry, and government, to propose a reference framework that facilitates an integrated sustainability approach to blue economy governance. Illustrating the connections between blue economy and other sustainable economy frameworks from the green economy, bioeconomy, and circular economy, this chapter presents an interpretative pathway that proposes the Triple Helix of Sustainability as a unifying framework, offering insights and guidelines from a systems perspective. This chapter further emphasizes that a cultural shift in the harvesting, production, and use of natural resources is essential for the sustainable viability of the blue economy and its contribution to global sustainability.

Keywords

Blue economy · Governance · Sustainability · Sustainable development · Sustainable development goals · Systems approach · Green economy · Bioeconomy · Circular economy · Triple Helix of Sustainability

Introduction: Toward an Integrated Sustainable Blue Economy Governance

The blue economy is generally acknowledged as a policy framework for the ocean's sustainable development that calls for a comprehensive approach to governance. However, there is still a need to revitalize the concept (Leal Filho et al. 2018) and find ways to integrate economic, social, and environmental aspects of sustainability (Benzaken et al. 2022). Due to the inherent complexity of sustainability and the wide range of interests, several criticalities and challenges prevent the various goals from being combined (Barile and Saviano 2018). Beginning with this assumption and

moving toward the managerial viewpoint (Vito et al. 2018), this chapter aims to provide the groundwork for a blue economy governance framework that supports an integrated sustainability approach.

During the 2012 Rio+20 United Conference on Sustainable Development (Choudhary et al. 2021), the blue economy emerged as a powerful idea, changing how coastal and marine areas contribute to sustainable development. As a result, worries about marine pollution, climate change, and the rising demands placed on the ocean's renewable and nonrenewable resources have come to the forefront (Benzaken et al. 2022). The necessity of the marine environment as an essential part of the much-needed paradigm changes in the bioeconomy, referred to as the blue economy, was highlighted in a 2012 synthesis report by the United Nations Environmental Program (UNEP) titled Green Economy in the Blue World (Choudhary et al. 2021). Greening the global economy has been a growing movement, and Small Island Developing States (SIDS) have been at the forefront of this movement, with many advocating for what is known as a blue economy (Voyer et al. 2018). Research and innovation are prioritized in the Blue Economy Strategy of the European Commission. Funding is allocated to three areas of intervention: (1) reaching climate neutrality, (2) restoring and preserving marine and coastal ecosystems, and (3) supporting innovations in ocean sustainability (Pace et al. 2023). An economy that leads to increased human well-being and social fairness while considerably lowering environmental dangers and ecological scarcities was identified as the green economy, which supported the blue economy as its marine component (Barroso et al. 2022).

The UN's Sustainable Development Goals (SDGs) emphasize the importance of balancing sustainable development's economic, social, and environmental aspects concerning the oceans. Consistent with the United Nations' Sustainable Development Goal 14 and the European Commission's Green Deal and Blue Economy Strategy, maintaining ocean activities that produce economic prosperity is critical to bolstering the expansion of the blue economy (Pace et al. 2023). The blue economy is a newly developed system of governance that defines the right way to utilize and manage the seas, and it forms a new kind of discourse that impacts international negotiations and mediates between different players (Voyer et al. 2018). Society can benefit from the seas and coastal regions through a sustainable blue economy. To ensure the oceans' long-term capacity and the sustainability of such operations, it is necessary to extract them in a circular manner (Barroso et al. 2022). A sustainable blue economy must respect environmental integrity, and creating a circular economy is the only surefire to achieve long-term prosperity (Simpson 2021). It is essential to establish a sustainable bioeconomy to address climate change and meet the growing need for food, feed, energy, materials, and goods (Gottinger et al. 2020). The circular economy model, often aligned with the bioeconomy, promotes sustainable practices like reusing and recycling resources to minimize waste and support environmental integrity (Simpson 2021).

In order to contextualize the blue economy within the broader frameworks of ocean governance, it is essential to conceptualize it as an integrative policy approach for the sustainable development of the ocean (Benzaken et al. 2022). As Wuwung

et al. (2022: 2) state: "Governance is widely recognized as a critical component of sustainable development, and in some instances is nominated as a fourth pillar of sustainability. While governance encapsulates a broad diversity of formal and informal mechanisms aimed at enabling, supporting, or leading sustainability outcomes, in practice, it remains a complex concept." Establishing governance mechanisms to support a blue economy is a well-acknowledged initial stage in its development and implementation (Voyer et al. 2018). Nevertheless, for a blue economy to be operational, it is crucial to define it and its sectors in detail and integrate a blue economy strategy into current governance frameworks (Wuwung et al. 2022).

As part of the paradigm change required to achieve sustainability, for which is widely recognized the need for a systems approach (Clayton and Radcliffe 2018) and framed as an integrative policy approach for the sustainable development of the ocean, a sustainable blue economy governance requires a systems thinking view as well (Wu and Khaskheli 2024). A systems approach is necessary to break down old barriers and consider the interconnectedness of ocean ecosystems, human demands, and regulatory frameworks. Many ecological, social, and economic factors must be considered to fully understand any real-world occurrence pertinent to sustainable development and sustainability objectives (Barile et al. 2018b). Systems thinking emphasizes the basis of feedback loops, where activity results are continuously monitored, and changes made in the light of such assessments. This becomes necessary since the blue economy involves dynamic marine ecosystems that may change with certain human activities. Feedback loops enable adaptive management whereby policymakers can adapt politics to real-time data and changing conditions (Auad and Fath 2022). The systems paradigm is also imperative in enhancing resilience in the blue economy frameworks through enabling integrated solutions to both ecological and socioeconomic impacts of environmental issues (Garmestani and Benson 2013).

In the blue economy, with various sectors competing for resources and space, systems thinking provides a framework through which decision-makers consider trade-offs and synergistic outcomes across industries (Bache and Reynolds 2022). For instance, marine tourism may benefit from conserving coral reefs, which are principal attractions. On the other hand, healthy ecosystems also provide fishery resources and other ecosystem services critical for coastal protection. Integrating economic and environmental objectives through system thinking enhances these cobenefits and fosters long-term sustainability (Cisneros-Montemayor et al. 2021).

A fundamental aspect of the systems paradigm is its emphasis on collaborative governance. Robust blue economy frameworks require the engagement and collaboration of many stakeholders, including governments, enterprises, local communities, and environmental NGOs (Silver et al. 2015). Systems thinking plays a crucial role in this context, facilitating the comprehension of interdependencies among various players, thereby enhancing collaborative efficacy. In coastal zone management, for instance, systems thinking can unite stakeholders from tourism, fishing, conservation, and infrastructure development to identify solutions that reconcile

economic demands with environmental preservation. This interdisciplinary collaboration is crucial for the long-term sustainability of the blue economy (Kelly 2023).

To frame collaboration among many different actors adopting a systems approach to sustainable development governance, a fundamental reference is offered by the Triple Helix of Sustainability (THS) (Farioli et al. 2018; Saviano et al. 2019). Built by integrating the Triple Helix set out to support universities' "third mission" in guiding social and economic innovation by Etzkowitz and Leydesdorff (2000) within the well-known framework of the Triple Bottom Line by Elkington (1994), the THS provides a novel representation that gives an account of the systemic functioning of the helix and its impact on the dynamics of the three spheres of sustainability (Saviano et al. 2019). In an integrated framework for sustainability, the model emphasizes the responsibilities and interactions of science, policy, and industry in achieving sustainable development as a common goal (Scalia et al. 2018; Saviano et al. 2019). Through the THS, systems thinking supports the holistic view necessary to implement the integrative governance of the blue economy framework. The blue economy framework highlights sustainable development goals (Auad and Fath 2022), whereas the THS actualizes these objectives by fostering innovation through collaboration among principal players). Simultaneously, systems thinking guarantees that this innovation is implemented within a comprehensive socio-ecological and socioeconomic framework (Saviano et al. 2019), considering marine ecosystems' complex and interrelated characteristics (Stead 2019). The blue economy framework builds a foundation for an equilibrium between economic advantages, environmental preservation, and social equity. This framework necessitates technologically innovative solutions, collaborative efforts among various stakeholders, and strategic long-term planning (Cisneros-Montemayor et al. 2021).

Collaboration among government, industry, and academia, the core of the triple helix concept, is crucial for establishing a resilient blue economy (Garmestani and Benson 2013). The framework promotes an ongoing transfer of knowledge, wherein the government establishes the requisite legal frameworks to guarantee that social and economic activities are consistent with the environmental requirements, science envisions scenarios and conceives new sustainable solutions, and industry cocreates, develops, and implements these advancements (Farioli et al. 2018; Saviano et al. 2019. In this interaction context, systems thinking enhances the efficacy of triple helix collaboration. It allows policy, science, and industry leaders to comprehend the effects of their actions on the wider ecosystem, assisting them in formulating long-term sustainable initiatives (Auad and Fath 2022). This comprehensive perspective guarantees that the blue economy framework is propelled by innovation (via the triple helix) while recognizing the complexity of marine ecosystems (Kontovas et al. 2022). This approach is endorsed by international organizations and frameworks, like the UN Agenda 2030 (Sustainable Development Goals) and the UNEP Sustainable Blue Economy Initiative, which advocate for systems-based governance and innovation to attain enduring sustainability in the blue economy (Bache and Reynolds 2022).

This chapter develops a conceptual pathway to frame the governance of a sustainable blue economy based on a systems view, using the Triple Helix of

Sustainability. The chapter is built on a comprehensive and thorough review of existing academic literature on established theories and governance frameworks related to the sustainable blue economy. Data collection for this study involves analyzing significant international contributions, including reports from the United Nations and discussions from the Rio+20 United Nations Conference on Sustainable Development. The analysis follows recognized methodologies like the Etzkowitz's Triple Helix Model and the Viable Systems Approach (VSA). These frameworks provide a dynamic and systemic lens to examine the interactions between the economic, environmental, and social dimensions of sustainability (Etzkowitz 2003). This approach is critical for capturing the complex, interrelated factors that inform the governance of the sustainable blue economy within and linked to other frameworks and action areas, such as green economy, bioeconomy, and circular economy. A shader governance approach can enable economic development while safeguarding environmental integrity and promoting social inclusion.

Perspectives: Blue Economy Within Broader Sustainable Economy Frameworks

The Evolving Definition of Blue Economy

Currently, functional definitions can help create and execute a blue economy. "The sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of the ocean" is the blue economy definition provided by the World Bank (2017). The economic activities of ocean-based enterprises, coupled with the marine environment's assets, products, and services, make up what the OECD calls the ocean economy (Benzaken et al. 2022). Most definitions aim to balance economic, social, and environmental objectives with the Sustainable Development Goals (SDGs) (Benzaken and Hoareau 2021). This concept includes promoting economically viable endeavors that ensure equitable opportunity, social stability, and inclusive growth, preserving and protecting marine environments and biodiversity (Benzaken et al. 2022). Despite efforts at defining a blue economy, it remains a contested and evolving concept as evidenced by ongoing debates among scholars and policymakers around issues of governance, sustainability, equity, and ocean privatization, a reflection of the broad range of blue economy actors, their values, and objectives (Jouffray et al. 2020). While a more integrated approach to sectoral management could be the key to the blue economy's success in practice, there is less proof that it would effectively drive the integration of social, economic, and environmental goals and even less evidence that it would engage with equity goals in many countries. Moreover, the blue economy is still far from reaching its full potential in promoting an integrated policy framework (Benzaken et al. 2022).

A paradigm shift in sustainability science occurred when the focus shifted from humans to ecosystems, from an anthropocentric (human-centered) view of natural resources to an ecocentric (ecosystem-centered) one. This change accelerated the move toward strong sustainability, with Earth protection as the primary goal (Iandolo

et al. 2018). Compared to the geological processes that have formed and transformed the Earth throughout its lengthy history, the current era—Anthropocentrism—is defined by intense human pressure on natural systems. On the other hand, ecocentrism is a response to the environmental crisis that focuses on the ecological dimension and the equilibria of the Earth system and finds inherent worth in all forms of life and ecosystems. The idea of planetary boundaries was crucial in this shift because it focused on the link between human pressure and environmental protection, which helped to overcome the knowledge gap that had previously plagued the early stages of sustainable development (Scalia et al. 2016). In 2015, the United Nations endorsed the 2030 Agenda for Sustainable Development, which included 17 Sustainable Development Goals (SDGs). In light of the increasing importance of coastal and marine areas to sustainable development, the blue economy has become a focal point, particularly concerning SDG14 (Conserve and sustainably use the oceans, seas, and marine resources for sustainable development) and SDG15 (Protect, restore and promote sustainable use of terrestrial ecosystems, sustainably manage forests, and halt biodiversity loss); these issues are specifically addressed, including maintaining healthy seas and fisheries, as well as restoring and conserving biodiversity and ecosystem services (Leal Filho et al. 2018).

Enabling variables, such as socioeconomic and governance characteristics, not just resource availability, determine whether a nation can transition to a blue economy that is both sustainable and equitable and use its ocean resources to produce products and services (Cisneros-Montemayor et al. 2021). There is no agreed-upon definition of governance despite its importance in facilitating the shift toward a more inclusive and environmentally friendly blue economy. Concepts, behaviors, and institutions that control social evolution are encompassed in this broad understanding (Brodie Rudolph et al. 2020). A society's economic, political, and social affairs are managed through interactions among the state, civil society, and the private sector; this process is known as governance (Benzaken et al. 2022). Each of the many theories and governance models has strengths and weaknesses when explaining and describing the structural configurations of decision-making processes and the outcomes required, such as conservation, livelihoods, or sustainable development (Brodie Rudolph et al. 2020). Good governance as a model emerged in development research as a reaction to the gap between support and sustainable development and corruption-related issues. It is based on the idea that strong institutions are necessary for effective governance. The model is also based on concepts relevant to government functions, such as legitimacy, accountability, performance fairness, and direction (Benzaken et al. 2022).

Each primary component of the blue economy has its own set of ideals and objectives. In addition to being a source of oxygen, water on Earth plays a crucial role in regulating the Earth's climate by absorbing excess heat and greenhouse gases. In addition to facilitating the cheap transportation of a vast array of goods and commodities, it supplies food and energy (Veríssimo et al. 2021). Thus, protecting marine life and keeping the ocean in good shape is critical to human existence and has economic implications. Although most global transportation now occurs at sea, there is a growing need for more efficient and environmentally friendly marine

shipping technologies and routes (Silver et al. 2015). It will be crucial to optimize the sustainability and efficiency of the production chains in fisheries and aquaculture simultaneously as our population continues to rise and the seas continue to suffer from climate change and pollution (Voyer et al. 2018). In order to alleviate the strain on marine ecosystems and prevent pollution, it is imperative to limit seafood waste. Therefore, valorization may turn garbage into cash and new jobs (Hoegh-Guldberg and Bruno 2010). Coastal towns may turn to the oceans for a sustainable energy source—the waves and wind—to help them become energy-independent. While careless tourists can devastate ecosystems, eco-friendly beachgoers and mariners can help restore and protect iconic sites (Veríssimo et al. 2021). Even though protecting marine life should be a top priority, it is equally important to honor the cultural practices of coastal communities by learning about and developing ways to protect the environment without compromising on long-held customs and practices (Dornan et al. 2018; Saviano et al. 2018).

The following subsections illustrate the differences, and, above all, the convergences between the blue economy and the other frameworks.

Sustainable Economy Frameworks

Many frameworks and related streams have been developed over time to address the challenges of sustainability and sustainable development (Saviano et al. 2017). Although characterized by different scopes and interests, these frameworks all underline the need for a systems approach. Making explicit not only the differences but especially the interdependencies between these frameworks can favor sharing a common systems view, hence, shared governance, overcoming fragmentations of both the view and the practice of sustainability.

Table 1 lists the principles of the green, bio, circular, and blue economies to provide an overview of the main aspects to consider in an integrated governance effort which will be illustrated in the subsequent sections.

Table 1 offers an overview of the sustainable economy's frameworks, emphasizing the fundamental principles that regulate them and their correspondence with the Agenda 2030's SDGs. Sustainable economies seek to tackle diverse difficulties across sectors by advocating principles based on environmental preservation, resource efficiency, and social equality. The green economy prioritizes sustainable resource utilization, diminishes greenhouse gas emissions, preserves biodiversity, and advances green technology, all while guaranteeing inclusive governance and ecological integration in policy formulation (D'amato and Korhonen 2021). The bioeconomy promotes the sustainable utilization of biological resources, emphasizes recycling, fosters economic diversification, and aids rural and Indigenous communities, promoting social fairness and well-being via collaborative stakeholder engagement (D'Amico et al. 2022). The circular economy is founded on essential ideas that promote sustainability and efficiency. It emphasizes eradicating waste and pollution, preserving product value through reusable and durable designs, and restoring ecosystems (Simpson 2021). The circular economy fosters a

Table 1 The principles of the green, bio, circular, and blue economies

Sustainable economies	Principles	Main SDGs
Green Economy (Sources: Kahle and Gurel-Atay 2013; Dornan et al. 2018; D'amato and Korhonen 2021)	Utilizing natural assets without jeopardizing future generations' capability to satisfy themselves by sustainable resource consumption/ management Decreasing greenhouse gas emissions to slow down global warming and move to more sustainable energy sources Keeping the environment intact and maintaining it to sustain biodiversity and continue to offer essential services Creating a sustainable economy that is resilient to environmental, societal, and economic challenges Promoting green technologies can improve resource productivity and lessen adverse environmental effects Ensuring efficient, accessible, and inclusive governance procedures incorporating all relevant parties concerning economic and environmental policy Adopting ecological issues into financial planning and policymaking	(SDG 12) (SDG 13, SDG 7) (SDG 15) (SDG 8, SDG 11) (SDG 9) (SDG 16) (SDG 17)
Bioeconomy (Sources: Gottinger et al. 2020; D'amato and Korhonen 2021; D'Amico et al. 2022)	Advocating for regenerative methods that maximize the use of biological resources while reducing their environmental impact Finding new and creative ways to use by-products and recycle them back into the manufacturing cycle Presenting opportunities for competitive economic diversification by generating new sectors and employment in coastal and rural regions Well-organized production, management, and utilization of biological resources Benefiting all segments of society, mainly rural and native populations Guarantying that social equality will not be sacrificed in pursuit of economic progress Providing health and well-being by providing cleaner energy, bio-based goods, and sustainable food systems Effective governance and cooperation among stakeholders, such as governments, corporations, researchers, and society	(SDG 12, SDG 15) (SDG 9, SDG 12) (SDG 8, SDG 14) (SDG 15, SDG 12) (SDG 1, SDG 10) (SDG 5, SDG 10) (SDG 3, SDG 7) (SDG 17)

(continued)

Table 1 (continued)

Sustainable economies	Principles	Main SDGs
Circular economy (Sources: D'Amato et al. 2017; Simpson 2021; Tan and Lamers 2021; Barroso et al. 2022)	Eliminating waste and pollution from the design process by reevaluating product design, production, and consumption behaviors about resource use Maintaining the value of products and resources through durable, reusable, and recyclable designs Improving ecosystems and restoring natural systems Using digital technology to facilitate circular activities, such as monitoring and enhancing resource consumption Prioritizing renewable resources by making use of renewable energy and materials Emphasizing an integrated approach to problems, focusing on the system as a whole rather than its parts	(SDG 12, SDG 9) (SDG 11. SDG 12) (SDG 14, SDG 15) (SDG 9) (SDG 7, SDG 12) (SDG 17)
Blue economy (Sources: Choudhary et al. 2021; Veríssimo et al. 2021; Benzaken et al. 2022; Voyer et al. 2022; Wuwung et al. 2022)	Using ocean and freshwater resources in a way that does not harm their regeneration capacity or reduce their biodiversity Ocean preservation and rehabilitation to keep marine and freshwater ecosystems healthy Integrating policies and plans for marine and land management to realize the interdependence of inland, coastal, and marine environments Addressing climate change by utilizing ocean-based solutions, such as renewable marine energy and coastal infrastructure Developing innovative, ecologically sound, and long-term solutions for managing oceans' limited resources International collaboration and affiliations to solve global ocean issues like overfishing, pollution, and acidification Limiting land-based activities contributing to marine pollution and enhancing waste management procedures to keep toxic chemicals and materials out of the water	(SDG 14, SDG 15) (SDG 6, SDG 14) (SDG 13, SDG 14) (SDG 7, SDG 13) (SDG 9, SDG 14) (SDG 14, SDG 17) (SDG 6, SDG 12)

Source: Authors' elaboration

comprehensive, integrated strategy for addressing environmental issues by utilizing digital technology for resource efficiency and emphasizing renewable resources (Barroso et al. 2022). The blue economy emphasizes the integration of marine and land management to enhance ocean protection and address climate change (Wuwung et al. 2022).

Blue Economy and Green Economy

A blue economy is oriented toward the conservation of marine ecosystems and their constituent life forms. In contrast, a green economy covers a broader range of terrestrial and atmospheric resources and sectors striving to optimize the utilization of terrestrial natural resources to satisfy human necessities (Dornan et al. 2018). The objective of both blue and green economies is to establish a more just and sustainable world for all living organisms; however, they differ in their scope and the types of resources they focus on.

This sectoral perspective on the unitary ecosystem functioning of life on the planet does not favor good governance. The 2012 United Nations Conference on Sustainable Development (Rio+20) significantly contributed to overcoming the sectoral and territorial distinction between the green and blue economy. The United Nations Environment Programme (UNEP) offers the most popular and widely used definition of a green economy. According to them, a green economy improves human well-being and social equity while reducing ecological scarcity and risks. In its most basic definition, a green economy promotes social inclusion, resource efficiency, and minimal carbon emissions (Simpson 2021). This view is based on the International Chamber of Commerce, which states that a green economy is one in which these three factors reinforce one another (D'amato and Korhonen 2021).

According to the UN Environment Program, the green economy is a "low-carbon, resource-efficient, and socially inclusive" economy. Its stated goals are the protection of ecosystems and biodiversity, the enhancement of energy and resource efficiency, and the decrease of pollution and carbon emissions. Ecosystems and biodiversity should be protected, and they should work to make energy and other resources more efficiently used. Policy changes, backed by tools like new legislation, public spending, tax cuts, and other incentives, are required to speed up these investments (Kahle and Gurel-Atay 2013).

Even though there has been progress toward more sustainable production systems and economies by implementing green economy principles, our aquatic ecosystems are still under-protected. As Veríssimo et al. (2021) observed, "The blue of the oceans is not yet the new green." Despite 15% of land being designated as a conservation area, only 1% of the ocean's surface is legally protected.

Essentially, the term "blue economy," as conceived at the 2012 United Nations Conference, aimed to extend the "green economy" scope to encompass marine activities and ecosystems. The blue economy has extended to the oceans the necessity of sustainable development, social equity, and economic growth (Voyer et al. 2018). The blue economy is unable to sustain itself in competition with the

green economy. Veríssimo et al. (2021) argue that the ocean is an ecosystem that has been overlooked and is both fragile and in need of further guidance. There is explicit agreement on the guiding principles and end objectives of green and blue economies. While the green economy depends on blue economy principles to move forward with more sustainable development goals, the blue economy depends on the green economy to maintain its viability.

The two concepts are inextricably interrelated, forming a complex and interdependent system. The impact of the blue economy on coastal and marine-related activities (such as the so-called established sectors such as fishery, aquaculture, mining, renewable energy, port activities, shipbuilding and repair, maritime transport, and coastal tourism) extends beyond the territorial boundary of marine and coastal areas, reaching inland regions that also benefit from the exchange of goods and services facilitated by the sea. From this perspective, the geography of maritime Europe can be defined as a blue territorial capital driven by the interactions between maritime and land-based activities (Coronato 2018). Such land–sea interaction engenders greater economic value, yet exerts increased pressure on marine and terrestrial ecosystems. It is, therefore, essential to consider these interdependent impacts when making spatial planning governance decisions, acknowledging the complexities introduced by institutional fragmentation and divergent mandates (González-Espinosa et al. 2025), particularly in developing innovative sectors such as renewable energy and blue biotechnology based on green-oriented models. Such sectors facilitate the transition to a sustainable economic paradigm that can enhance the health of marine and coastal ecosystems while reducing environmental risks. Furthermore, this transition enhances the value of ecosystem services, which in turn improves the well-being of citizens and fosters the growth of sustainable economic activities, including the creation of new employment opportunities in green and blue sectors.

Blue Economy and Bioeconomy

While the blue economy focuses on oceans and marine resources, the bioeconomy covers a wider range of biological resources from land and water. The bioeconomy goal is to transform multiple sectors using renewable biological inputs, including plants, animals, and bacteria. The focus is on medical products, bioplastics, biofuels, and other bio-based commodities. One way to make traditional, resource-intensive industries more sustainable is to adopt the bioeconomy model (D'Amico et al. 2022).

Sustainable development, circular economy, and bioeconomy are converging concepts. Combining the best aspects of each concept may result in a holistic approach to sustainability that considers the economic, social, and environmental dimensions of sustainability regarding the whole ecosystem of life on the planet (D'Amato et al. 2017). Gottinger et al. (2020) cite the creation of a sustainable bioeconomy as an essential component of the battle against climate change and to meet the growing demands for food, feed, energy, materials, and goods. To attain more sustainable production methods, particularly concerning the UN's Sustainable

Development Goals (SDG), around 50 nations worldwide have lately embraced national bioeconomy programs (Gottinger et al. 2020). Many thinks of the bioeconomy as the circular economy, which aims to keep products, materials, and resources in circulation for as long as feasible while throwing away as little as possible. However, a solid legislative framework and supportive measures are necessary to harness the potential of a sustainable bio-based circular economy and make the transition there more manageable (D'Amato et al. 2017).

The bioeconomy is not a novel economic phenomenon or industry in and of itself (D'Amico et al. 2022); instead, it is unique in two respects: the sustainability and efficiency of renewable resources, which set it apart from more conventional uses of biomass (Gottinger et al. 2020). Concurrent with the slow reorganization of long-standing regimes, the old and new bioeconomies undergo simultaneous evolution. The continuing discussion over measuring and tracking the bioeconomy reflects the challenge of distinguishing it from the previous bioeconomy (Salvador et al. 2021). In order to map the bioeconomy, it will be necessary to develop a new set of categories that will enable the phenomenon to be narrowed down. This contrasts with other sustainability transitions, such as the renewable energy transition, where economic actions related to renewable energy sources can be discovered with traditional classification systems (Tan and Lamers 2021). Evolutions in the context of sustainable development are described as changes in sociotechnical systems that necessitate a fundamental re-orientation of societal development. These changes encompass a multitude of interconnected transformations in aspects such as markets, states, society, science, and technology, as well as their interrelationships (Saviano et al. 2019). A sustainable bioeconomy goes beyond only replacing fossil fuels with biological resources, yet there remains a risk of limiting and unsustainable growth (Giampietro 2019).

Multiple theoretical frameworks have evolved in recent years to study these sustainability transitions. This approach can provide a more nuanced understanding of the emergence of environmentally conscious manufacturing and consumption practices. Furthermore, it enables the identification of potential replacements for these practices through a detailed examination of innovative research. A shift in focus is required for sustainable development research, moving away from the gradual introduction of greener technology and instead embracing a systemic transformation in how goods and services are created and utilized (Barile and Saviano 2018).

By elevating environmental concerns to the forefront of international politics, the determined and interdependent SDGs have paved the way for coordinated international action considering the interplay between environmental, economic, social, and cultural factors in development (Barile and Saviano 2018). Gathering data on public and private goods and services interacting in the maritime space, developing, implementing, and monitoring management plans, and involving all stakeholders are all part of this comprehensive approach to the striving aim of preserving the oceans' natural capital and fostering the sustainable economic growth of the maritime sectors. Given the inherent uncertainty in measuring marine resources and services and the complex interplay between them, evaluating the competing

demands placed on the ocean and its resources calls for a knowledge- and governance-driven process that is both dynamic and adaptive (World Bank 2022).

As part of this process, ecosystem assessments are conducted, which means that the values and advantages of biodiversity for human welfare and ecosystem health, including environmental and cultural goods and services, are identified and determined. Since several social and ecological systems coexist in the same environment at various institutional settings and geographic scales, thoroughly comprehending these systems' interrelationships and processes is essential for marine strategy. This lack of continuity and coordination in designing long-term and concrete actions is mainly due to the poor networking among institutions and communities involved. Despite the recent spread of sophisticated models that attempt to quantify different uses and values associated with marine and coastal ecosystems and assess potential cause–effect relationships embedded in different timeframes, these models are not oriented to society's needs or to inter- or transdisciplinarity (Leal Filho et al. 2018).

Blue Economy and Circular Economy

The key element of the circular economy is to look at the processes of the economy in a nonlinear but systemic way, recognizing the feedback mechanisms, typical of living systems, and the existence of emerging phenomena that make them complex systems. In this sense, the circular economy represents a management philosophy whose application aims to overcome the production model based on the linearity of flows and the indiscriminate use of resources to adopt new models in which the economy intentionally "regenerates" itself in both biological and technological flows (Saviano 2018). In a broader perspective, UNEP, in the Report "Towards a Green Economy" of 2011, defines it as an economy capable of producing better quality and more equitably extended well-being, safeguarding natural capital. Since the early 2000s, many initiatives have aimed at promoting a "circular" economic model. Europe drew up, for the first time in 2014, a Circular Economy Package with the Communication "Towards a circular economy: A zero-waste program for Europe," followed, in 2015, by the Communication "Closing the loop—An EU Action Plan for the Circular Economy," in order to trace effective guidelines to address ongoing global trends and deal with the related critical issues in a broad sustainability perspective.

The "2018 Circular Economy Package," proposes actions that encourage recycling and reuse, benefiting to both the environment and the economy. The plans aim to extract the maximum value from using raw materials, products, and waste, promoting energy savings and reducing greenhouse gas emissions. The proposals cover the entire life cycle of products: from production to consumption, waste management, and the market for secondary raw materials.

Recognizing the relevance and urgency of action to tackle climate change and seeing it as an opportunity to rethink the economic model, the European Green Deal commits Member States to make the EU the first climate-neutral continent by 2050, to reduce emissions by at least 55% by 2030 compared to 1990 levels, by reviewing

existing climate laws and introducing new laws on the circular economy, building renovation, biodiversity, agriculture, and innovation.

Although the circular economy has the potential to support sustainable development by reducing waste, preventing pollution, conserving resources, and boosting the economy, problems like inadequate knowledge, out-of-date technology, and broken supply chains are impeding its widespread adoption (Tan and Lamers 2021). Goals 12 (Responsible Consumption and Production), 13 (Climate Action), 14 (Life in Water), and 15 (Life on Earth) are among the many Sustainable Development Goals that may be substantially advanced via the integration of bioeconomy and circular economy initiatives (Barroso et al. 2022).

In order to expedite the transition to a circular economy, business models must be devised that prioritize the minimization of waste and the enhancement of resource efficiency. This will necessitate the integration of sustainable price structures, product-service systems, sharing platforms, closed-loop technology, and a reevaluation of current economic paradigms. Companies should conduct lifecycle evaluations, promote transparency and accountability, build long-term partnerships, and upgrade their models often (Salvador et al. 2021). For instance, D'Amico et al. (2022) highlight the ability of circular business models (CBM) to support a sustainable bioeconomy. "Reduce, reuse, recycle" is how they characterize CBM actions, which aim to end material cycles while reducing resource usage; their novel approach to sustainability is the smart and sustainable bioeconomy platform (D'Amico et al. 2022). For a blue economy to succeed, this platform uses cutting-edge technology and partnerships to collect and analyze data in real time, track environmental impacts, facilitate the sharing of information and working together, help with decision-making, and increase openness and responsibility (Pace et al. 2023). To sum up, the circular economy will not resolve every problem in the blue economy, but it can help with resource conservation, waste reduction, ecosystem protection, innovation, and economic value creation—all of which are essential for integrated sustainable governance (Barroso et al. 2022). Nevertheless, for it to be effectively put into practice, there must be a concerted effort on all levels of government, as well as constant vigilance and adjustment in response to shifting social and economic contexts.

Approach: Blue Economy as an Integrating Policy Framework for the Sustainable Development of the Ocean

Blue Economy Governance Issues

The blue economy has emerged as a critical topic in discussions on how the world's oceans can be utilized to achieve the UN's sustainable development goals (SDGs) (Voyer et al. 2018). The Blue Economy gained significant prominence at the 2012 Rio+20 United Conference on Sustainable Development, reshaping the significance of coastal and marine areas in sustainable development. It has sparked concerns about the ocean's health due to mounting pressures on renewable and nonrenewable

ocean resources, marine contamination, and climate change (Benzaken et al. 2022). The inclusion of SDG 14, devoted to conserving and using oceans, seas, and marine resources sustainably to promote sustainable development, is an example of sustainable development in the marine environment. The Blue Economy lies at the intersection of environmental issues and liberal economic goals (Germond-Duret 2022). Blue economy definitions typically encompass social, environmental, and economic goals. The World Bank defines the Blue Economy as the sustainable utilization of ocean resources to promote economic growth, enhance livelihoods, and create jobs while safeguarding ocean health (Wuwung et al. 2022). The integrated sustainable blue economy sees the ocean as a socioecological system. It is possible to set up this system as a chaotic one with strong flows and interactions between its parts, as well as feedback loops that make it hard to figure out cause and effect due to big gaps in time and space, thresholds, and limits (Saviano et al. 2019).

Upon closer examination of regional blue economy initiatives, such as the EU's new approach to a sustainable blue economy in 2021, it becomes apparent that they all share a few commonalities. One key point is that they all recognize the ocean as an innovation and sustainable development accelerator at national and regional levels. Moreover, they all aim to promote ocean health, sustainability, equity, and resilience. Lastly, they all acknowledge that governance is critical in achieving a blue economy's goals (Benzaken et al. 2022). The blue economy must balance short-term profits and the long-term health of the ocean in a manner compatible with sustainable development and dedicated to ensuring fairness across generations (Keen et al. 2018). Specifically, SDG 14 of the SDGs acts as a framework; all maritime operations must now adhere to these standards and be directed by this overall goal, either by playing a direct role in its attainment or by ensuring it is not obstructed (Germond-Duret 2022). Economic sustainability, which involves generating income and employment opportunities for the populace; social sustainability, which ensures equal distribution of human well-being among various classes and genders; and environmental sustainability, which focuses on maintaining the quality and reproducibility of natural resources, are the three fundamental components of sustainability (Farioli et al. 2018).

Resource availability is less critical than empowering conditions like socioeconomic and governance variables regarding a country's capacity to move toward a sustainable and equitable blue economy and reap the benefits of its ocean resources (Cisneros-Montemayor et al. 2021). The best way to govern a country depends on its circumstances, and many nations are debating whether to build new institutions or enhance their current ones (Benzaken et al. 2022). For a shared approach to sustainability to fully take hold, development conditions must be livable, fair, and practical. These conditions are found where the different dimensions meet (Farioli et al. 2018). So, looking at things from a systems perspective can help us figure out how these complicated interactions and dependencies work. These rules are known as the dynamics of socioecological systems, which behave as complex adaptive systems (Farioli et al. 2018). The systems view of sustainability in the Triple Helix of Sustainability (Scalia et al. 2018) can support an integrated sustainability perspective on blue economy governance. This framework assists in capturing dynamic

processes impacting the states of the environment, economy, and society, which are difficult to capture using traditional and deterministic analytical approaches in such a complex system of interactions. This evolutionary strategy is based on the kinematic laws of mechanics. It goes like this: when one domain does not win out, the three leading players or dimensions of sustainable development—the environment, society, and economics—can dynamically approach a state of equilibrium through gradual adjustments (Farioli et al. 2018).

The governance of the blue economy presents significant sustainability challenges, compounded by a fragmented legal and institutional framework. Although the United Nations Convention on the Law of the Sea (UNCLOS) provides a global legal framework, it fails to ensure effective management of marine resources in many areas, especially those outside national jurisdictions. The sustainability of the blue economy requires harmonization between different economic activities, such as fishing, shipping, and mining, which are currently regulated by separate, often uncoordinated bodies (Fanning et al. 2007). This sectoral approach hinders integrated and sustainable management of marine resources, leading to conflicts between economic actors and undermining ecosystem protection. The transboundary nature of the oceans makes it difficult to apply regulations uniformly and distribute benefits from marine resources equitably. Problems such as illegal, unreported, and unregulated (IUU) fishing, marine pollution and biodiversity loss accentuate these difficulties and undermine efforts for sustainable governance of the blue economy (Österblom et al. 2017).

The main critical elements in the governance of a sustainable blue economy are listed in Table 2.

The Need for a Systems Approach

A new paradigm for economic growth, social equality, and environmental sustainability was established by introducing the concept of sustainable development to the international community. Since then, sustainability has become increasingly important in defining the governing processes of institutions and business organizations (Farioli et al. 2018). Consequently, it has become evident that the three traditional pillars of sustainable development—environmental preservation, economic progress, and social justice—are insufficient for achieving sustainable development. Broader cultural, technological, and institutional concerns must also be addressed (Saviano et al. 2019). The scientific community has a wide range of opinions on what constitutes sustainability and how to define it, with some seeing it as a common ethical principle (Barile et al. 2018a). An agreement on such value judgments in a shared economic context determines what can be perpetuated. Systems theory has been widely used in several fields because it provides a broad framework that may help understand the principles that govern the operation of nearly any real-world occurrence. Managers have begun to see systems thinking as essential for handling complexity and bolstering decision-making. Research has a lengthy history, which suggests that people have an innate propensity to try to make sense of the universe

Table 2 Critical elements of sustainable blue economy governance

Critical elements	Reference
Oceans' potential: Recognizes the ocean's significance in national and regional innovation and sustainable development	Benzaken et al. (2022)
Marine health and equity: Emphasizes the importance of enhancing ocean health, sustainability, accessibility, and community resilience	Benzaken et al. (2022)
Governance matters: Effective governance mechanisms are crucial to blue economy goals and sustainability	Benzaken et al. (2022)
Balancing economic goals: Emphasizes the necessity to balance short-term profits with ocean ecosystem health and sustainability	Keen et al. (2018)
SDG 14 requirements: All maritime operations must follow SDG 14 criteria to maintain marine resources	Germond-Duret (2022)
Socioeconomic empowerment: A sustainable and equitable blue economy requires governance to address socioeconomic circumstances	Cisneros-Montemayor et al. (2021)
Institutional development: Discusses how nations must create or improve institutions appropriate to their governing circumstances and difficulties	Benzaken et al. (2022)
Sustainable development requires: Establishing livable, equitable, and practical conditions promoting a collaborative sustainability approach	Farioli et al. (2018)
Complex system dynamics: Highlight the importance of comprehending intricate interactions among socioecological and sociotechnical (economic) systems and necessitating adaptive governance strategies	Farioli et al. (2018)
The integrated sustainability framework: Advocates for implementing cohesive reference frameworks to facilitate the integrated governance of environmental, social, and economic aspects of sustainable development	Scalia et al. (2018)
The adaptive equilibrium strategy: Promotes governance that balances environmental, social, and economic sustainability	Farioli et al. (2018)
Stakeholder engagement: Emphasizes the significance of including various stakeholders, such as local communities, corporations, and governmental bodies, in decision-making processes	Wuwung et al. (2022)
Promotes open and accountable governance: To hold all stakeholders accountable for their ocean resource impacts	Benzaken et al. (2022)
Capacity building: Training and tools to help local people and government authorities manage and safeguard ocean resources	Cisneros-Montemayor et al. (2021)
Policy coherence: Promotes cohesive policies across sectors (e.g., fisheries, tourism, conservation) to regulate marine resources	Germond-Duret (2022)
Science integration: Promotes scientific research and data integration into governance frameworks for sustainable decision-making	Saviano et al. (2019)
Resilience to climate change: Emphasizes the need for governance methods to strengthen marine ecosystems and coastal communities	Voyer et al. (2018)

(continued)

Table 2 (continued)

Critical elements	Reference
Cultural heritage consideration: Blue economy governance should embrace indigenous and local populations' traditional knowledge and cultural values	Farioli et al. (2018)
Monitoring and assessment: Effective monitoring and evaluation systems are recommended to examine policy and practice impacts on marine health and sustainability	Benzaken et al. (2022)

Source: Authors' elaboration

(Barile et al. 2018b). The first stage of the sustainability theory debate highlights the importance of general systems theory as a platform for various scientific fields to collaborate and share research methods, ideas, and concepts, which can lead to a fresh viewpoint that considers the whole rather than just focusing on individual components (Farioli et al. 2018). On the other hand, a system's discipline is rooted in the ever-changing landscape of several academic fields. By introducing General System Theory (GST) in 1968, von Bertallanfy explicitly pioneered chances for discourse on a systems approach (Barile and Saviano 2018).

Numerous researchers from various organizations, labs, schools of thought, and research perspectives have built up the notion of sustainability, and their contributions can be seen in qualifying the method (Scalia et al. 2018). An innovative and increasingly vital technique to handle sustainability concerns is to include a circular approach to governance, particularly within a systems view of complexity. Products and resources are encouraged to be repaired, refurbished, remanufactured, shared, and recycled as part of the circular economy model's emphasis on closed loops that form a regenerative system. As a result, less energy is lost, less trash is produced, and fewer pollutants are produced. Sustainable development, economic resilience, and environmental stewardship may all be fostered when this strategy is applied to governance (Jouffray et al. 2020). In the late 1940s, when the Macy's Foundation Conferences brought together brilliant minds, sustainability began to take shape. The goal of reassembling science around a unifying vision, was to amass multidisciplinary knowledge. By doing so, he pioneered the concept now more often called the circular economy, in which trash is recycled and used in new production cycles (Farioli et al. 2018). This approach to consumption and production aims to optimize ecological efficiency. To tackle systems' intricate and interdependent nature, one must thoroughly comprehend the underlying dynamics and the possible unforeseen effects of interventions. To effectively implement a circular governance strategy, one must involve numerous stakeholders, each with a unique set of interests and points of view (Farioli et al. 2018).

Disagreements on how various "capitals" should be defined and evaluated directly result from divergent views on sustainability. The divergences gave rise to the two primary strategies, namely, robust and fragile sustainability. Each form of capital must be protected for the benefit of subsequent generations; robust sustainability rests on the premise that some forms of natural capital provide tasks

that cannot be adequately replaced by artificial capital. A lack of sustainability indicates a worldview that considers natural and artificial capital part of total capital (Farioli et al. 2018). When it comes to government, taking a systems approach means acknowledging how all three systems—social, economic, and environmental—are interdependent. This viewpoint is essential for taking a comprehensive and coordinated approach to solving complicated problems, ensuring that decisions made in one area do not negatively influence others, and strengthening the system (Barile et al. 2018a). Based on Elkington's (1994) famous Triple Bottom Line framework, which integrates the needs of people, profit, and planet, multilateral division calls attention to the need to broaden the scope of business valuation to include social equity and environmental preservation, as the triple bottom line agenda necessitates companies to focus not simply on the economic value they add or destroy (Farioli et al. 2018). Development conditions that are livable, equitable, and feasible are determined by the intersection of the different dimensions, depending on the "areas" involved. These conditions are necessary to fully implement a shared approach to sustainability (Barile et al. 2018b). To that end, it is essential that at the micro level—in organizations and especially in the business sector—the consideration of diverse and composite viewpoints demanded of policymakers when outlining the broad trajectories of development materialize (Barile and Saviano 2018). Although literature-based sustainability interpretations have considered the interplay of the various components, most of these representations have stayed static and failed to explain how to establish a harmonious interaction. Sustainable development is more of a journey than a final goal; it requires constant reevaluation, education, and improvement. The most critical linkages are those between the economy, society, and the environment, but all interconnections must be recognized, understood, and acted upon. Achieving long-term success in any one pillar is impossible apart from achieving success in the others (Farioli et al. 2018).

Although circular principles provide a helpful foundation for creating blue bioeconomy that can withstand the test of time, it is essential to remember that emergent static models are not enough on their own. The sector's intrinsic complexity necessitates a more dynamic management style. A comprehensive and adaptive management paradigm that smoothly integrates the circular vision is the key to effectiveness (Barile and Saviano 2018). A comprehensive, integrated, and adaptable approach to governance is necessary to implement a sustainable blue economy. This approach must acknowledge the interdependence of marine ecosystems, economic activity, and human well-being. A systems approach to governance focuses on managing complexity and driving sustainable results through holistic thinking, collaborative networks, and feedback mechanisms (Barile et al. 2018a). In contrast to governance, the blue economy necessitates developing frameworks and strategies for the (bio)economic circular model to sustain marine resources and the ocean. This strategy promotes marine ecosystem regeneration, restoration, and sustainable management to maximize societal, economic, and ecological advantages (Barroso et al. 2022), paving the way for us to understand the blue bioeconomy's underlying

complexity, discover its latent interactions, and construct a system that can quickly adapt to new circumstances.

The Triple Helix of Sustainability (THS) as a Systems Governance Framework

The initial intention of the triple helix idea was to support universities' so-called "third mission" in governing socioeconomic innovation; it was developed on the territory of social and economic sciences. With the Triple Helix framework, Etzkowitz and Leydesdorff proposed a new paradigm for governance in 2000. This paradigm emphasizes cooperation between governments, industry, and academia to develop innovations.

As mentioned in the introduction, in the Triple Helix of Sustainability (THS), which integrates the Triple Helix and the Triple Bottom Line frameworks, the interplay between the three main actors, shown as a "helix," modifies the spheres' dimensions across time as they affect society, the environment, and the economy (Etzkowitz 1998). The three facets of sustainability are examined in the model through the lens of the interplay between the responsibilities and deeds of essential players. More specifically, three types of intersections exist here: those involving society and the environment, society and the economy, and the economy and the environment (Scalia et al. 2018; Saviano et al. 2019).

In this context, the helix model can be understood as a representation of the vortex effect of the ever-changing context in which environmental, social, and economic dynamics interact, generating a multitude of mechanisms that impact the same dynamic (Barile and Saviano 2013). Thus, the sustainability interpretation key is based on the helix's requirement to spin to generate a driving force; yet, to do so, it must comprehend its surrounding environment or recognize the field forces (Barile and Saviano 2018; Scalia et al. 2018). The framework's underlying premise is that the three parties involved must work together effectively to pursue and achieve sustainable innovation (Saviano et al. 2019).

Although new efforts may emerge from the traditional separation of the three spheres under consideration, THS model states that the only way to sustain the development of innovative concepts and the gathering of capital resources needed to implement them is through their functional integration and the sharing of the different players. Therefore, interaction is fundamental to the framework's beneficial operation and the transmission of information, which is the pivotal point of any creative process. The model's main contribution is that it emphasizes the importance of direct participation from the subjects concerned to promote evolutionary self-organization (Farioli et al. 2018). The framework's central suppositions are that:

1. There will be righteous cooperation between the three institutional spheres.
2. Interaction among the three actors will be a fundamental process that will trigger a virtuous cycle.

3. It may be necessary to temporarily replace roles between the three actors through so-called hybridization processes to ensure that each role is played.

Shifting the focus of our attention from the blades of the helix and onto the underlying dynamic of the framework, namely the interaction between the three parties, the framework's central and most challenging component is building a successful relationship among the actors. For sustainable decision-making to be done right, all three parties involved must work together effectively. Specifically, to establish the course of suitable policies and governance mechanisms for sustainability, the following steps should be taken (Saviano et al. 2019):

1. Policymakers should base their decision-making on scientific evidence.
2. Scientists should consider policy and industry viewpoints when imagining potential scenarios.
3. The industry should work toward practical solutions by, on the one hand, valuing and protecting resources and, on the other, enhancing market attention to sustainability.

Based on the Triple Helix logic, institutions and individuals who have always worked independently are required to work together toward a common goal while simultaneously creating positive intersections that can change how things are; if the government were to take the lead among the three actors, it would limit the quantity and quality of ideas and be unable to guarantee adequate development trajectories due to its dominant perspective (Farioli et al. 2018).

The THS framework is rooted in the management studies' stream of the Viable Systems Approach (*VSA*) (Barile 2024; Barile et al. 2014; Barile and Saviano 2018). Recognizing the inherent systemic character of all phenomena, the primary goal of *VSA* is to rediscover the shared system's foundations in all fields of study, including management, by creating a systems-based approach to organizational interpretation and governance (Barile and Saviano 2011). The *VSA* sustainability framework emphasizes the helix as an organizational framework for understanding the interplay between sustainability's ecological, social, and economic components and the interconnected responsibilities of government, academia, and business (Barile et al. 2014). The helix movement illustrates the dynamic interplay between policymakers, scientists, and businesses, all considered essential to sustainable development. As shown in Fig. 1, governments (policy) set the environmental necessities or the limits that socioeconomic activities must adhere to when utilizing the environment as a resource complex. Science (university/academia) sets the socioecological possibilities, or what can be done given the necessities, thanks to Science's knowledge advancements, by conceiving innovations to safeguard and valorize available and new resources. Lastly, the industry develops socioeconomic solutions based on the socioecological possibilities complying with the established necessities.

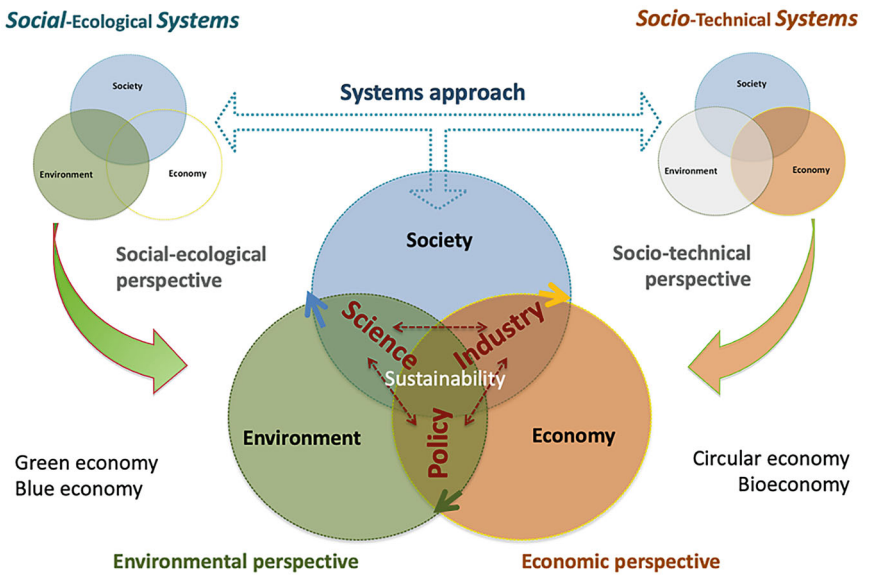

Fig. 1 Integrating the socioecological and sociotechnical systems perspectives of sustainability within the Triple Helix of Sustainability—THS. (Source: Adapted from Saviano et al. 2019: p. 1558, http://www.asvsa.org)

The Viable Systems Approach (*VSA*) provides the theoretical and conceptual basis for the systemic reading and functioning of the THS framework. The Triple Helix actors activate the interactions needed to transition between dimensions (Farioli et al. 2018). Here, the environment's structure and the resources at the actors' disposal form the basis for the regulations that governments must establish. These regulations establish a social context within which scientific institutions generate numerous ideas, which are implemented through industrial solutions and applications (Barile and Saviano 2011).

Proposal: An Integrated Systems Approach to Sustainable Blue Economy Governance

An Integrated Systems Approach to Sustainability Governance

Adopting a systems approach, which focuses on interactive and positive dynamics, requires a view that includes all the people involved in the organization's operations (Barile et al. 2018b). The systems paradigm provides valuable interpretive support for developing a comprehensive understanding of the dynamics generated by the interactions between the three dimensions of sustainability: environmental, social, and economic. Systems thinking, an approach to management and governance grounded in systems theory, has been put forward as a means to understand and

work toward the integration of sustainability's economic, social, and environmental aspects, which would help societies foster the well-being of both humans and ecosystems (Barile et al. 2018a). To better address complexity and enhance decision-making, systems thinking has gained popularity among managers.

The systems paradigm provides a solid foundation for a comprehensive view of sustainability and the interplay between its three dimensions, as it helps shed light on important issues and provides guidelines that organizations can use to guide their decisions and actions (Iandolo et al. 2018).

Systems thinking shifts the focus from the relationships and connections between the parts of an observed phenomenon to the interactions that make them work together as a single, interdependent whole rather than focusing on the parts themselves (Barile and Saviano 2011). Understanding the systemic functioning of socio-ecological and sociotechnical systems is crucial for comprehending their complexity from a sustainability perspective (Saviano et al. 2019). The triple-bottom-line model of sustainability, which combines environmental, social, and economic factors, actually relates to two common types of Complex Adaptive Systems (CAS) (Barile and Saviano 2018):

- Socioecological Systems (SESs) (Ostrom 2009) focused on humans–nature coupled systems, in which, however, the environmental perspective dominates.
- Sociotechnical Systems (STSs) (Trist 1981) focused on humans–technology coupled systems, in which, however, the economic (and engineering) perspective dominates.

The two CAS have the characteristics of being "systems" and having a social component. Using systems thinking, the social component may unite the two CASs that are economically and environmentally focused (Barile and Saviano 2018). Figure 1 shows a way forward that uses the social and systemic aspects that both the sociotechnical and socioecological systems points of view have in common (Saviano et al. 2019). All three facets of sustainability—environmental, social, and economic—can be seen as having "representative" players in the suggested integrated model. These actors include science, policy, and industry. Despite their viewpoints, they inherently reflect the prevailing ideas and plans in their contexts.

The THS framework shows how a larger relational environment can create a complex web of connections. These connections may lead to a roughly equal equilibrium where the roles of the three actors reflect the most essential values and priorities. Environmental needs, socioecological opportunities, and socioeconomic solutions should be delineated and developed as dynamically emerging at the intersection of all actors' views and perspectives to promote sustainability and sustainable development effectively. Each actor can play significant interface roles, carrying out institutional functions and promoting hybridization processes (Saviano et al. 2019). From a systems point of view, the essential part of the THS is that sustainability can only be reached when the three dimensions interact positively with each other (Scalia et al. 2018). How well these players practically work together to promote sustainability remains to be seen. As things are right now, harmonization is

still a long way off. This is a key issue in the governance of a sustainable blue economy as an integrative framework. Creating value by combining the management of a natural ecosystem with its social and economic potential is an expected outcome of good blue-growth governance (Giannoumis et al. 2021).

As emphasized by Scheel and Aguiñaga (2025) and Bartolini and Viaggi (2025), ecological functions and public value should be integrated within economic systems. The THS approach provides logic and guidelines for building an integrating policy framework for the sustainable development of the ocean. Key elements are listed in Table 3.

A THS Approach to Sustainable Blue Economy Governance

Environmental, economic, and social sustainability are the three realms of the THS, which can help to highlight the significance of these three sustainability components within the framework of blue economy governance with responsibilities to be shared among all the involved actors. The preservation and responsible utilization of coastal and marine resources are the primary concerns of environmental sustainability. Managing marine resources responsibly, regulating fishing procedures, protecting marine ecosystems, and minimizing pollution are all part of this effort to keep the environment and biodiversity intact. On the other hand, social sustainability stresses the importance of equitable accessibility to resources, equitable distribution of wealth, and equality in economic development, while economic sustainability promotes blue economy activities that offer secure incomes and job possibilities without depleting marine resources. This includes developing sustainable fisheries, aquaculture, maritime transportation, tourism, and emerging sectors like ocean energy (Benzaken et al. 2022). Governance frameworks utilizing the THS should strike a balance between environmental protection, sustainable economic activities, and equitable social accomplishments to ensure sustainability in the long run (Saviano 2018; Saviano et al. 2019). Comprehensive regulations, cross-sectoral partnerships, and stakeholder involvement are critical components of this approach for effective blue economy governance, which aims to tackle complex sustainability concerns systemically.

To better manage the blue economy, governments, businesses, and civil society organizations should work together to share policies that encourage responsible fishing, fund the development of clean marine technology, and help coastal communities adapt to the effects of climate change (Lee et al. 2020). These methods of governance can aid in preserving ocean resources in a way that is equitable for present and future generations by combining the three tenets of sustainability. Incorporating environmental preservation, economic development, and social justice into blue economy governance (Siswanto and Rosdaniah 2023) can be addressed by adopting the THS approach. Coordinated policies and actions across sectors and levels of government are necessary to implement a sustainable blue economy governance. The private sector, civil society, and local communities must actively be involved, engaged and responsible for achieving shared goals. This includes fostering cross-sectoral collaboration in the blue economy sectors (e.g., fishing,

Table 3 The THS contribution to sustainable blue economy governance

Blue economy's governance critical elements	THS's contribution	Reference
Acceptance of the seas' potential	The importance of the seas as drivers of national and regional sustainable development and innovation is recognized by THS	Pace et al. (2023)
Advancement of marine well-being and equity	When it comes to sustainable development, THS considers both the social and environmental aspects	Wuwung et al. (2022)
Critical role of governance	THS offers a comprehensive governance structure for reference	Keen et al. (2018)
The integration of economic interests	THS takes a multifaceted and dynamic approach to sustainable governance, promoting the alignment of diverse and changing interests	Barroso et al. (2022)
Adherence to SDG 14 Standards	THS adheres to all principles of Agenda 2030, indicating that each Sustainable Development Goal must be tackled in conjunction with the others	Leal Filho et al. (2018)
Socioeconomic advancement	THS assumes responsibility for all participants in the performance, highlighting the significance of the social realm as a connective element between environmental and economic viewpoints	Giannoumis et al. (2021)
Institutional development	THS follows a systemic approach to leadership	Jouffray et al. (2020)
Sustainable development conditions	THS places the blue economy in a whole perspective of sustainable development	Lees et al. (2025)
Complex system dynamics	THS offers a holistic perspective on adaptive regulation of interaction between socioecological and sociotechnical (economy) systems	Gong et al. (2025)
Sustainable growth system	THS offers a holistic governance perspective on sustainability	Espuny et al. (2025)
Adaptive equilibrium strategy	THS uses its core principles to seek balance between the three pillars of sustainability	Saviano et al. (2017) van Bueren et al. (2025)
Involvement of stakeholders	THS adopts a *VSA* suprasystems perspective on stakeholders, emphasizing the necessity of dynamically determining the most pertinent issues to address the focal concern	Barile and Saviano (2011)
Transparency and accountability	THS relies on accountability measures to foster harmony among interacting actors	Barroso et al. (2022)
Capacity building	The THS emphasizes the significance of taking action at the level of the local setting	Grossarth (2025)
Policy coherence	The core tenet of THS is that in order to achieve sustainable development, there must be a consistent convergence of the perspectives and activities of all sectors into a single objective	Saviano et al. (2019)
Integration of scientific research	In order to make sustainable decisions, THS recognizes the paramount importance of science	Lundquist and Granek (2005)

(continued)

Table 3 (continued)

Blue economy's governance critical elements	THS's contribution	Reference
Resilience to climate change	THS regards environmental imperatives as the foundational basis for formulating any governance approach	Veríssimo et al. (2021)
Taking into account cultural heritage	In the THS approach, it is important that circumstances of consonance are most favored when people's values, cultures and strong beliefs are in harmony with each other	Armeli Minicante et al. (2022)
Evaluation and MONITORING TECHNIQUES	THS perceives governance as a continuous spiral process of incremental modifications and enhancements informed by feedback systems	Brodie Rudolph et al. (2020)

Source: Authors' elaboration

tourism), investing in clean technologies, sustainable infrastructure, and community-based projects, creating integrated policies that balance social, economic, and environmental considerations all at once, and creating platforms for collaboration among businesses, NGOs, community groups, and academia to share knowledge and leverage resources for sustainable development (Wuwung et al. 2022).

The THS may be effectively employed in developing and governance the blue economy to formulate a comprehensive strategy that protects marine ecosystems for future generations while enhancing economic growth and social welfare. The academic, industrial, and governmental sectors—the three primary elements of the sustainability triple helix—must cooperate to create efficient and effective governance that fosters the green economy, encompassing the bioeconomy, circular economy, and, particularly, the blue economy. Achieving this objective requires that the system's core principle—governance—utilizes thorough consideration and action concerning the three pillars of sustainability: society, the economy, and the environment, thereby promoting the advancement of the blue economy toward sustainability. A TSH approach to the sustainable governance of the blue economy encompasses systems thinking, adaptive governance, stakeholder and community involvement, participatory procedures, and the cocreation of knowledge and value. These elements are crucial for developing a path toward a sustainable future that integrates all sustainable economies (Fig. 2).

As the above framework explains, an integrated systems approach to blue economy governance should be based on a few essential principles for sustainably managing and using marine resources. Fostering comprehensive and coordinated governance frameworks that balance economic development, environmental protection, and social equality requires these prerequisites. The blue economy frameworks should embrace the same governance concepts as the green economy, bioeconomy, and circular economy to foster cooperation and coordination among national, regional, and worldwide players (Dornan et al. 2018). Ocean management projects are made more successful and legitimate with multilevel governance frameworks that set up clear power channels and procedures for exchanging information and

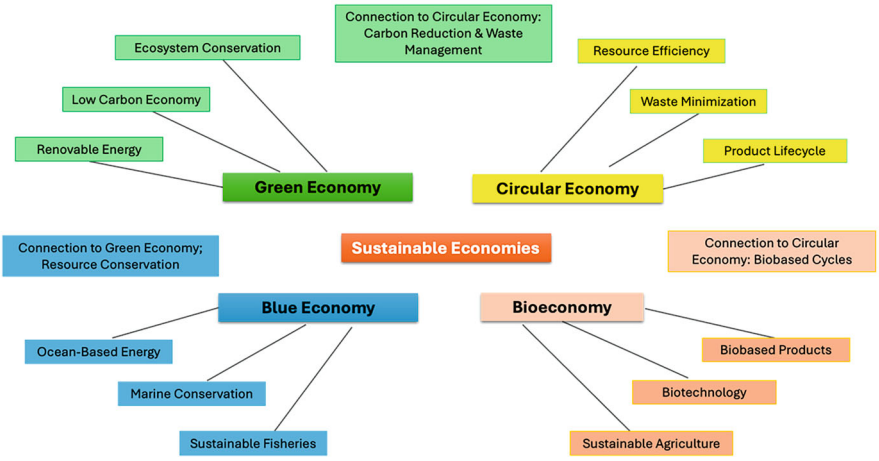

Fig. 2 An integrated view of sustainable economies. (Source: Authors' elaboration)

making decisions. In addition, an integrated systems approach to blue economy governance should prioritize ecosystem-based management concepts, and ecosystem-based management principles should be applied (Choudhary et al. 2021).

Governance structures require a comprehensive view of the blue economy grounded in the THS framework, which emphasizes the interdependence of social, economic, and ecological systems and calls for the active engagement of numerous stakeholders, including society, businesses, and universities (Saviano et al. 2019). The strategy should promote the reduction, reuse, and recycling of resources, which should incorporate the circular (bio)economy concepts. New governmental regulations and economic models must be introduced that encourage environmentally friendly consumption and manufacturing practices, minimize waste, and facilitate the recovery of ecosystems to achieve this objective (Hoegh-Guldberg and Bruno 2010). The uncertainty around climate change, human activity, and the ever-changing character of marine ecosystems necessitates governance structures that can adapt and evolve (Barroso et al. 2022). Management methods must be monitored, evaluated, and adjusted continuously to adapt to new circumstances and increase efficiency (Hoegh-Guldberg and Bruno 2010).

Given the blue economy's complexity and the possibility of unexpected outcomes, policies, and actions should be developed using systems thinking approach. This strategy aids in finding leverage indications, comprehending feedback mechanisms, and creating robust, conditionally adaptive methods (Barile and Saviano 2018). The governance network should prioritize the resilience and sustainability of maritime ecosystems and communities. Preventive steps should be put in place to save biodiversity, lessen the effects of climate change, and strengthen the ability of coastal and marine systems to adapt (Veríssimo et al. 2021). It is necessary to coordinate spatial planning efforts across diverse sectors and levels of government, such as fisheries, aquaculture, shipping, and tourism, to minimize disputes, optimize

resource usage, and conserve vulnerable maritime environments (World Bank 2022). Marine ecosystems and international trade are inherently interconnected, making successful governance dependent on international collaboration. Participating in joint conservation and research initiatives, exchanging best practices, and conforming to international agreements and norms are all part of this (Wuwung et al. 2022).

In this context, policymakers should encourage cooperation among government departments overseeing various parts of blue economy governance, including economic development, environmental protection, marine spatial planning, and fisheries management. Promoting sustainable growth and meeting new challenges requires policies that balance economic, social, and environmental concerns. Including local communities, indigenous groups, industry representatives, nongovernmental organizations (NGOs), and academia in policy development ensures that policies reflect diverse perspectives, address local needs, and enhance public trust and support; so, policymakers must engage with stakeholders actively throughout this process.

Examples of Success

Achieving sustainable development requires the combined efforts of people, technology, and government, all of which are intricately linked. Indeed, technology holds great promise for creating sustainable solutions and easing communication and cooperation among stakeholders, regardless of how much weight people give to people's knowledge, beliefs, and actions regarding the effectiveness of sustainability initiatives. However, governance is crucial since, through well-constructed rules, sustainable activities may be guided and encouraged. A dynamic and evolutionary adjustment process that requires governance to map the elements for sustainable ocean development and, if necessary, refine models to improve the blue economy and global sustainability can perfectly capture the systemic vision of THS (Farioli et al. 2018). Under this perspective, the circular economy applied to fisheries and aquaculture sectors constitutes concrete examples of how the triple helix model can trigger virtuous dynamics that require the acceleration of transformative changes in policy, management, innovation, and investment to achieve sustainability and development but also cultural change in the modes of harvest, production, and consumption of fish products (Armeli Minicante et al. 2022).

The fishing industry, particularly the large-scale fishery, is considered responsible for the depletion of many fish stocks. However, it is, in turn, highly affected by the marine environment as a consequence of climate change (e.g., the increase in extreme events such as storm surges, the intensity of wave motion, acidification of the seas), biodiversity loss, marine pollution, including marine litter, and non-indigenous species (Lundquist and Granek 2005). Aquaculture represents an essential resource for the planet's future since the demand for food from the sea is increasing to feed the planet's growing population. However, this industry is also facing enormous challenges regarding environmental impact, human health, and farmed organisms (Germond-Duret 2022). Much work has been done on developing

new sustainable and circular production models in recent years. Algae farming, for instance, ensures a definite environmental benefit because, like mollusks, it does not require human intervention to feed itself. The economic use of seaweeds (or macroalgae) represents an example of an innovative and viable solution that encompasses various blue economy sectors (i.e., aquaculture, biotechnology, and renewable energy) and has a high potential for sustainable jobs and growth, according to the concepts of the sustainable blue economy and the bio-based circular economy (Armeli Minicante et al. 2022). Following the THS, the scientific community, managers, coastal communities, and nongovernmental organizations (NGOs) represent the social area, which bridges the economic and environmental components (Scalia et al. 2018). Artificial intelligence is another example of support to circularity, which provides valuable information to farmers, such as predictions on the nutrition and oxygen to be provided to the animals. These predictive models, therefore, make it possible to guarantee the well-being of fish and produce higher-quality food for consumers by minimizing the use of antibiotics and feed. In fisheries, the management of marine protected areas is similar. These are places where fish stocks can recover and where fishermen are encouraged to work together to watch over and fix ecosystems that have been damaged, for example, by picking up trash in the ocean, which helps the circular economy (Lundquist and Granek 2005).

A conventional management tool based on no-fishing zones turned into community-based monitoring initiatives, where fishers are actively involved in the governance and protection of their fishing grounds (Perea-Munoz et al. 2022). It has been widely recognized that the effectiveness of marine protected areas (MPAs) depends in large part on the support they receive from the local community, and that support is mainly obtained through the inclusion of different actors in the process of design and management, which are expected to generate stakeholder satisfaction (Lundquist and Granek 2005). The success of these management measures depends upon their acceptance by implicated stakeholders and on integrating the stakeholder groups into their management. This integration is essential for fishermen, whose interests are the most directly affected by MPAs. Effective communication and supportive relationships among stakeholders result in positive stakeholder behaviors and more effective system management. In such a decision-making process, recent advances in data science through, for instance, the use of tags and gear sensors, hybrid location transponders, drones, and satellites for the real-time observation of species distribution, marine habitat condition, and movements of merchants and fishing ships (through Vessel Monitoring System) were crucial in advancing the knowledge of the system (Perea-Munoz et al. 2022).

The process of cocreation of a typical value concerning sustainable fish products started by the decision-making system, the EU institutions, which have increasingly promoted the development of an eco-friendly seafood market (Scalia et al. 2016) through eco-labeled products and certifications and favored sustainable fishing practices through regulations aiming to eliminate incidental capture of nontarget species (by-catch) as sea turtles or dolphins, reduce fossil fuels, and encourage the

use of fishing gear (nets, lines) made from natural materials instead of non-biodegradable, nonrecyclable plastics (Armeli Minicante et al. 2022).

This evolutive process brought a change in consumer behavior directed toward sustainable consumption, which means not only a preference for certified, eco-labeled, and organic seafood but also a higher propensity for local, less known, and less commercialized fish and fresh/wild caught over foreign, although less expensive products. Finally, the cultural change affected fishers, who offer not only a simple food with remarkable nutritional properties but, under a socio-ecological perspective, a service having connections with the broader historical, social, ecological, and institutional context in which the fishing activity is embedded. In such a new perspective of service cocreation, fishers contribute to safeguarding and passing down the local culinary traditions, preserving the local identity, and restoring the natural capital (Golinelli 2010). In Europe and South Asia, local actors have cocreated blue economy visions with improved ecological outcomes and increased policy relevance (Amarasinghe et al. 2025; Lees et al. 2025). In addition, coordination across ministries and borders is important for regions such as the Black Sea and the Mediterranean—where many actors interact across national and sectoral borders (Seyhan et al. 2025; Loizidou et al. 2025).

Furthermore, the THS model's alignment with climate adaptation and green recovery agendas presents new possibilities for systemic reform. Linking this framework with national policy development or regional cooperation efforts, particularly in socioecologically vulnerable areas, should be a priority. The SeaTecHub project in Cyprus and Croatia exemplifies how place-based, participatory governance experimentation can produce transferable innovations for broader governance redesign (Loizidou et al. 2025). These directions point toward a governance paradigm built on continuous learning, integrated thinking, and adaptive capacity as foundational traits for a sustainable blue economy.

Summary and Key Points

Context and Issues

Governance of the sustainable blue economy requires a transition from fragmented sectoral governance toward integrated, adaptive, and participatory governance that can deal with the complexities of marine and coastal systems. In this respect, the chapter puts forward an integrated systems approach based on the Triple Helix of Sustainability framework, which provides a guideline to realign science, policy, and industry toward a sustainability-driven transformation. Blue economy initiatives should deliver economic benefits while promoting ecological resilience, institutional learning, and local empowerment.

Fragmented approaches continue to hinder policy coherence, particularly where governance institutions struggle to coordinate across scales or sectors. The THS Framework advocates for transdisciplinary and cross-sectoral methodologies. The THS framework, applying a systems-thinking approach, could act as a conceptual

compass that could drive institutional innovation and adaptive governance of the system in a range of regional settings. Regionally embedded yet systemically attuned initiatives (e.g., in the Mediterranean and Baltic) show the alignment of marine conservation with regional development when participatory structures are in place.

Approach and Logics

This chapter offers a conceptual and integrative synthesis for a systems thinking approach based on sustainability science and governance literature focusing on marine and coastal resource management. The framework is based on and adapts elements from the THS, the *VSA*, and transition theories aligned with the circular and bioeconomy. At the heart of this framework lies the adaptation of the THS model, conceptually rooted in the innovation paradigm; for the field of sustainability governance moving away from this underpinning toward a value-driven and more reflexive configuration, THS has the potential to enable institutional learning through collaborative governance. By using this logic in consideration of the blue economy, the chapter supports sustainability not by optimizing the outcome of single actors but through the coordinated negotiation of interdependent sectors and actors. The underlying logic here is that the sustainability of the blue economy is achieved not by fixed plans or prescriptive rules, but in iterative, adaptive processes, configured to changing ecological conditions and stakeholder needs. This demands governance frameworks that allow for continuous learning, feedback loop incorporation and institutional flexibility. For example, communities of practice in coastal Europe cocreated blue economy visions that reflect local knowledge, identity, and ecological realities. These participatory processes improved stakeholder alignment and led to more grounded and context-sensitive governance solutions.

Blue, circular, bio, and green economies are interlinked, and governance must reflect this complexity. Valuing marine ecosystem services, for example, depends on coordinated policy frameworks that transcend traditional silos. Integrated blue–green infrastructure can support multiple benefits only when embedded in cohesive governance systems. Fostering bottom-up engagement is just as critical.

Implications and Limitations

In the application of the THS framework, it should be considered that it is a framework of general reference that implies a level of abstraction. When adopted, the framework requires, in compliance with a systems approach, to be contextualized to the specific country's conditions in which governance models may significantly vary. Accordingly, the framework needs to be tailored and localized to depict regional diversity in governance capacities and socioecological contexts accurately as well as the operational constraints—resource scarcity, historical marginalization—that may prevent a successful coproduction process.

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