THE SYSTEMS INNOVATION APPROACH FOR THE SUSTAINABLE DEVELOPMENT OF THE BLUE ECONOMY

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"The Systems Innovation approach for the sustainable development of the Blue Economy"

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Abstract

A comprehensive, innovation-driven approach that incorporates policy frameworks, stakeholder collaboration, and adaptive governance is necessary for the sustainable development of the blue economy (BE). This chapter investigates the potential of systems innovation to resolve critical issues in the maritime sector, such as sustainable fisheries, offshore renewable energy, and marine tourism. It emphasises the significance of cross-sector synergies, data-driven decision-making, and multi-stakeholder engagement in the promotion of long-term sustainability. The chapter also identifies obstacles, including financial constraints, policy misalignment, and data fragmentation, that impede the widespread implementation of sustainable solutions. The chapter offers insights into strategies for accelerating the transition to a sustainable BE and enhancing resilience by examining successful case studies and innovation ecosystems. Key future directions include developing digital platforms for real-time data exchange, improving regulatory coherence, and expanding innovation hubs that bring together policymakers, businesses, researchers, and local communities. In conclusion, the chapter promotes a comprehensive transformation model that emphasises stakeholder-driven governance and systemic innovation as critical components of the blue economy's future.

Keywords: Blue Economy, Systems Innovation, Participatory workshops, Stakeholder Engagement, Living Lab

1. Introduction

In the 2010s, the marine economy gained prominence. The sea's resources were first regarded as a driver of economic progress following the Great Recession. The 2012 Blue Growth Strategy (COM(2012)0494) sought to attain sustainable and inclusive economic development within the marine sectors of the European Union (Blue Growth Opportunities for Marine and Maritime Sustainable Growth, 2012). The term "blue growth" was not exclusively employed by the European Union. The Food and Agriculture Organization of the United Nations (FAO) initiated its own blue growth initiative in 2013 to balance economic growth, social development, food security, and sustainable utilization of aquatic resources (FAO, 2018). However, a multifaceted definition of the blue economy is needed to distinguish between ocean degradation and socio-economic development (Smith-Godfrey, 2016). Some stakeholders and researchers worry about potential misunderstandings and misguided governance outcomes due to the lack of a distinct definition of blue growth (Eikeset et al., 2018). The resources of the sea were initially prioritized as a catalyst for economic development, particularly following the Great Recession at the conclusion of the first decade of this century. The post-crisis recovery of traditional sectors, such as maritime transport and coastal tourism, and the development of new technologies, such as marine biotechnology and offshore renewable energy, were expected to provide this impetus.

However, social inequities and degradation of marine ecosystems may result from an excessive emphasis on the rapid and unregulated expansion of the blue economy (Bennett et al., 2022)The concept of blue growth has undergone a transformation over the past decade, culminating in the European Commission's announcement of a sustainable blue economy (COM(2021)0240), in part as a response to this debate and in accordance with the objectives of the European Green Deal (European Commission, 2021b). The present methodology is designed to facilitate the transformation of value chains in the blue economy by means of programs and instruments that facilitate the development. Stakeholder engagement promotes cooperation, knowledge-sharing, and co-creation, aligning divergent interests and facilitating revolutionary change. This study examines the significance of stakeholder participation in transition processes in the Blue Economy, utilising ideas from living labs, innovation projects.

2. Literature Review on Systems Innovation and Stakeholder Engagement

Systems thinking and design thinking represent two complementary yet distinct approaches for addressing complex socio-technical challenges. Systems methodologies excel at holistic diagnosis, enabling researchers to map complexity, identify interdependencies, and locate leverage points within dynamic systems (Meadows, 2008; Voulvoulis et al., 2022). However, a well-established critique—particularly from the design thinking literature—is that systems approaches often remain abstract and analytically rich but operationally distant, producing insightful depictions of problems without necessarily translating them into actionable, human-centred solutions (Bason, 2010; Kimbell, 2011; Lewis et al., 2020). Design thinking methodologies explicitly address this limitation by prioritising human- and user-centred processes, such as empathy, ideation, prototyping, and iterative testing. Combining these approaches leads to less abstract and more action-orientated results, focusing on how people experience change and how solutions can be developed, tested, and refined in practice. The process locates stakeholders at the centre, aiming to understand and learn from participants' lived experience, tacit knowledge, and behavioural realities.

Stakeholder engagement can occur under different scopes and umbrellas. Living labs (LLs) bring experimentation out of companies' R&D departments to real-life environments serving as experimental platforms where stakeholders collectively create, evaluate, and enhance ideas in real-world environments (Akinsete et al., 2025; Almirall & Wareham, 2011; Ballon & Schuurman, 2015;

Leminen et al., 2012). The LL notion initially emerged in scholarly discourse around the 1990s. The term LL was coined by Professor William Mitchell at the Massachusetts Institute of Technology in the early 2000s to characterise a user-centred research technique for sensing, prototyping, verifying, and refining intricate solutions in diverse and dynamic real-world situations (Eriksson et al., 2016; Van Geenhuizen, 2019). The literature puts forward two main paradigms, namely open innovation and user innovation (Hossain et al., 2019). Open innovation LLs aim at the development and validation of new products and services in a structured, facilitated and collaborative setting (Bergvall-Kåreborn et al., 2009). User-centered design, on the other hand, is grounded on identifying user needs either through asking, observing or tracking their behaviour during consumption process (Dell'Era & Landoni, 2014; Liedtke et al., 2012), guaranteeing that solutions are pragmatic, socially endorsed, and scalable. Living labs facilitate the development of innovative goods and services by involving people with diverse expertise, ideas, and experiences from the quadruple helix (Arnkil et al., 2010; Hielkema & Hongisto, 2012). User participation signifies a transition of innovation towards users, hence facilitating co-creation with them (Nyström et al., 2014).

In addition, systems innovation necessitates the synchronisation of technical, institutional, and behavioural transformations (Geels, 2004; Kemp & Rotmans, 2005). Stakeholders, such as legislators, corporations, researchers, and communities, serve as pivotal actors in transformation processes by providing knowledge, resources, and legitimacy (Grin et al., 2010). Strategic niche management (Kemp et al., 1998) and transition management (Loorbach, 2010) underscore the significance of stakeholder networks in facilitating sustainable transitions. Public sector innovation laboratories utilise multi-stakeholder engagement to improve policy experimentation and adaptive governance (McGann et al., 2018; Mergel, 2018). Platforms like the European EIT Climate-KIC illustrate how intermediate entities promote transformational change via stakeholder coordination (Brodnik et al., 2020). On a broader scale, systems innovation is a mechanism to support transition management or systemic changes. The multi-level perspective (MLP) views transitions as outcomes of alignments among advances at many levels (Geels & Schot, 2007). MLP has been broadened through several ideas, such as regime changes (Van Geenhuizen, 2019), technology revolutions (Perez, 2002), technological transitions (Geels, 2002), system innovation (Elzen et al., 2004; Geels, 2005) and transition management (Loorbach et al., 2007; Roorda et al., 2014).

Successful stakeholder involvement necessitates systematic analysis and collaborative techniques. Methods such as stakeholder mapping (Widya Yudha & Tjahjono, 2019) and influence matrix techniques (Cole, 2006) facilitate the identification of major actors and their functions. Stakeholder analysis is grounded on the Quadruple Helix Model (QHM), that brings together industries, universities, citizens and Government and was originally described by (Arnkil et al., 2010; Carayannis & Campbell, 2009). The QHM incorporates user-centric innovation models to leverage the cross-pollination of ideas that fosters experimentation and prototyping in practical environments (Ballon & Schuurman, 2015). Co-creation processes in living labs illustrate that inclusive stakeholder participation from an early stage improves transition methods in various settings, from co-designing nature-based solutions (Lupp et al., 2021) to contribute to achieving specific SDGs (Compagnucci et al., 2021).

3. Methodology

The System Innovation Approach (SIA) is a methodological framework that facilitates systemic change by utilising an interconnected set of innovations that influence one another. This approach allows for innovation in both the components of the system and the ways in which they are interconnected. SIA is founded on system thinking (Meadows, 2008), and its application within the research context is informed by transition management to address persistent issues and promote sustainability (Loorbach

et al., 2016; Loorbach et al., 2007). Selected stakeholders are involved in the iterative process of co-deciding priorities, mapping challenges, developing long-term visions and co-designing solutions and innovation pathways, aiming at solving problem-orientated activities from a variety of domains and scales (Geels & Schot, 2007; Loorbach, 2010; Roorda et al., 2014). However, in order to establish a sustainable future, it is imperative to envisage desirable futures (Bennett et al., 2021). Thus, they are also actively engaged in the co-identification of shared objectives in the form of a desirable future vision. The co-identification of an interconnected set of innovations to drive the desired transition is the main result of this approach in which stakeholders are actively engaged in LLs. In this context, LLs function as open innovation spaces that encourage user collaboration, with the anticipated outcome being a more effective resolution of stakeholder requirements. This process provides a sense of direction that facilitates positive transformation (Milkoreit, 2017; Riedy & Waddock, 2022). Ultimately, innovation pathways can be co-developed to guide the region towards a sustainable state.

Prior to stakeholder engagement activities, a detailed mapping of the stakeholders is conducted to identify the stakeholders who will attend the Living Lab. This is a critical process that involves the identification and analysis of individuals, groups, and organisations that have a vested interest or influence in the goals of the research activity. Stakeholder mapping assists in the development of communication strategies, the prioritisation of engagement efforts, and the fulfilment of their needs. Stakeholders are mapped from the Quadruple Helix (Industry/Business, Government/Policy Makers, Civil Society/NGOs/Associations, and Research and Academia) and analysed with the aid of an 'influence/interest' matrix (Figure 1**Error! Reference source not found.**), whereby 'influence' refers to how much power and capacity the stakeholder has to effect change, and 'interest' refers to how likely the stakeholder is to engage in activities or initiatives relevant to the case study focus; this may be due to a resultant benefit or adverse impact (Eden & Ackermann, 1998). Once the plotting is completed, the map is validated by an external expert (e.g., project advisory board members or other local experts). This matrix is used to evaluate stakeholder positions and determine the most suitable subset for participation in the workshops. The core group that is selected to participate in the workshops is those with significant influence and interest, while the lower right and upper left quadrants included those with low interest or influence. This methodology helps identify stakeholders who are most relevant to the study and are more likely to be involved in research endeavours.
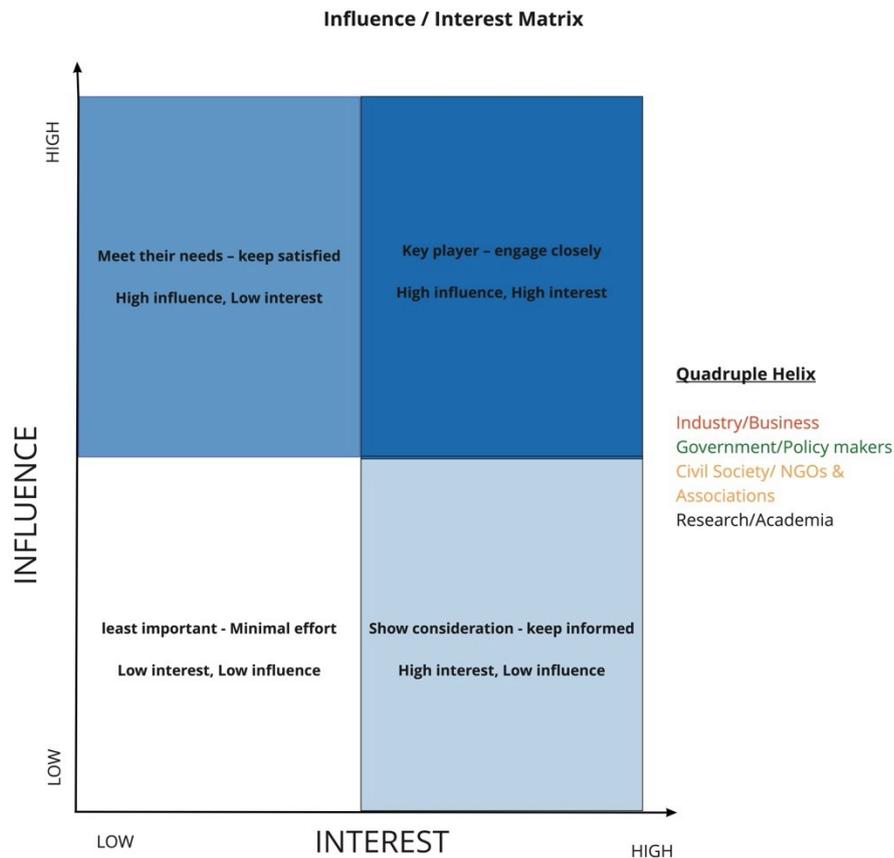
Influence / Interest Matrix

Figure 1 - Influence / Interest Matrix

4. Application / Case Study

The Black Sea, a rich socio-ecological ecosystem, is a vital part of the Blue Economy, connected to the Mediterranean Sea, Asia, and the Middle East via a strategic bridge in south-eastern Europe. Despite its economic potential, the region's Blue Economy remains underdeveloped. The Black Sea is one of the most polluted oceans globally, causing damage to fish populations, species diversity, employment, food security, tourism, and health. The EU-funded DOORS Black Sea project aims to address these issues by establishing optimal research support for the region. The project aims to unite citizens, scientists, and industry to regenerate the Black Sea and spark a new surge of potential for the 'blue economy' by developing a system of systems (SoS) to address the consequences of humans and climate change on the marine ecosystem. The success, value, and impact of DOORS depend on the level of stakeholder engagement, which involves collaboration with researchers to develop scientific and technological knowledge, making the project more meaningful on the ground.

The initial phase in the implementation of the SIA for the DOORS Black Sea project was a comprehensive stakeholder mapping. Stakeholder mapping was conducted for each Black Sea (BS) country individually, namely, Bulgaria, Georgia, Republic of Moldova, Romania, Turkey and Ukraine, by identifying stakeholders from the Quadruple Helix who operate within the 17 established and emerging industries, as defined by the (European Commission, 2021a). Using the influence-interest

matrix, a shortlist of stakeholders has been established for each BS country in collaboration with the country authorities in each country.

In this project, the SIA was implemented in two phases under a series of workshops, named Multi-Actor Forums (MAFs). The first round of workshops was designed to map the national context of the blue economy sectors and to evaluate and prioritise these requirements in the context of blue economy development in the context of the pentagonal tool. The second round was centred on the review of the working vision for the BS and preliminary innovation pathways. Additionally, milestones were established for the achievement of the vision in each relevant sector by utilising the Future Radars tool to map relevant innovations from the BGA onto each of these milestones. This process is crucial for the sustainable advancement of the blue economy, as it increases awareness and facilitates the development of SoS and capacity-building initiatives.

The primary goal of the initial round of MAFs was to designate Blue Economy sectors as national priorities (Table 1) and to utilise the PESTLE framework to identify the challenges of each priority sector (Table 2). The participants were provided with an overview of the DOORS project, which encompassed both the project's objectives and those of the MAF, during the workshop. Stakeholders in all six countries seem to believe that the Fishing, Marine and Coastal Tourism and and Marine Research and Development sectors should receive priority support. The Black Sea region comprises 37.4% of the entire FAO-designated fishery territory, with Bulgaria and Romania maintaining fishing interests. Significant value is generated in Bulgaria, Georgia, Moldova, Romania and Ukraine by marine and coastal tourism sectors. However, the tourism industry along the Black Sea is facing challenges from environmental strains to limited accessibility during high-demand periods and inadequate overall visibility. The Tourism 4.0 for the Black Sea initiative, co-financed by the European Maritime and Fisheries Fund, aims to provide information to local stakeholders to enhance their understanding of trends, visitor effects, and movement patterns. Georgia, Bulgaria, Moldova and Ukraine have designated maritime and port sectors as areas of utmost importance, with transport contributing an average of 145 million euros to their GDP over the past two decades. Marine aquaculture productivity in the region has increased steadily over the past few years, with over 700,000 tonnes of farmed seafood in 2019. Ocean Renewable Energy is recognized as an essential economic sector in Romania and Turkey, with advancements being made towards commercial viability for floating offshore wind in hazardous environments and deep waters.

Table 1 - Black Sea Blue Economy sectors prioritization (results from the 1st MAF (Bulgaria, Georgia, Romania and Turkey) and from the online Survey (Republic of Moldova and Ukraine))

Sector	Definition	Established or Emerging	MAFs in which this sector was prioritized
Capture Fisheries	The practise of obtaining naturally occurring living resources in both freshwater and marine environments in a sustainable manner.	Established	Bulgaria, Georgia, Turkey, Republic of Moldova, Romania, Ukraine
Marine & Coastal Tourism	The provision of tourism-related services in and around littoral or marine environments, which support the local community's sustainable development.	Established	Bulgaria, Georgia, Republic of Moldova, Romania, Ukraine
Marine R&D	The activities centred around the advancement of technology, knowledge, and capabilities pertaining to marine environments, encompassing oceans, seas, and other aqueous bodies.	Established	Bulgaria, Georgia, Turkey, Romania
Shipping/Ports	The operations related to maintaining a sustainable maritime transport ecosystem,	Established	Bulgaria, Georgia, Republic of Moldova, Ukraine

	encompassing terminal services and the conveyance of passengers and cargo via water.		
Marine aquaculture	The practise of aquaculture and farming with the intention of minimising any adverse effects on the purity of air, water, and soil.	Emerging	Georgia, Turkey, Romania
Ocean Renewable Energy	The production of pure and renewable energy from natural sources, such as wind, wave, tidal, and solar, at sea, offshore, on land, and in close proximity.	Emerging	Turkey, Romania
Marine Transport	The transportation of commodities, individuals, and valuable resources through waterways, encompassing lakes, rivers, oceans, and watercraft, in the company of vessels such as ferries, boats, and ships.	Established	Republic of Moldova, Ukraine
Shipbuilding	The goods and services necessary for the construction, upkeep, restoration, and repair of vessels used for ecologically conscious maritime transportation.	Established	Ukraine, Turkey
Marine Business Services	The commercial activities that rely on water and are associated with marinas and other vessel service operations.	Established	Bulgaria
Safety & Surveillance	Transportation, public spaces, and critical infrastructure are among the domains in which the application of technologies and measures designed to ensure protection, monitoring, and security is underway.	Emerging	Republic of Moldova
Offshore wind energy	The design, deployment, and management of wind turbines situated in aquatic environments with the purpose of extracting sustainable energy reserves and generating electrical power.	Emerging	Republic of Moldova
Offshore oil & gas	The extraction of gas and hydrocarbons from submerged sources.	Emerging	Turkey

Table 2 - Challenges in the Black Sea region as presented in the first round of MAFs

POLITICAL	ENVIRONMENTAL	SOCIAL
❖ Geopolitical instability ❖ Lack of collaboration between all state institutions ❖ Need for regional cooperation and intersectoral synergies ❖ Lack of international cooperation ❖ Insufficient political will ❖ Lack of vision and long-term planning ❖ Lack of a Black Sea brand at local and regional level ❖ Lack of compliance with political obligations towards the EC	❖ Pollution and environmental degradation ❖ Seawater quality ❖ Imbalance of aquaculture sustainability and overfishing ❖ Climate change's impact on biodiversity	❖ Need for training and capacity building in all Blue Economy sectors (limited human resources available) ❖ Lack of job opportunities ❖ Public awareness on aquaculture sector ❖ Need for connectivity through cultural and natural heritage, between neighbouring countries
TECHNOLOGICAL	LEGAL	ECONOMIC

❖ Need for marine research ❖ Need for initiatives, such as a beach quality award system (e.g., Blue Flag) ❖ Lack of adequate infrastructure ❖ Lack of advanced technologies (e.g. for monitoring the fishing vessel in the region) ❖ Need for digitization and creation of a unitary database. ❖ Need for use of non-polluting technologies	❖ Harmonization of national and EU legislation ❖ Specific and integrated legislations drafted clearly and concisely, with the elimination of legislative loopholes. ❖ Lack of implementation of existing regulations ❖ Lack of carrying out adequate monitoring and control ❖ High bureaucracy ❖ Corruption	❖ Need for state aid for fisheries and aquaculture sectors ❖ Need for removing the tax barriers for the maritime sector ❖ Lack of quotas in the fishing industry ❖ Financial crisis ❖ High international competition in marine products ❖ Lack of Investments

It appears that environmental degradation and contamination are the most pressing issues in each of the six Black Sea states. However, priorities differ at the national level. The most significant obstacles in Bulgaria are the absence of investments in infrastructure in coastal zones, the inadequacy of infrastructure and renewable energy, and the insufficient funding for scientific research on the Black Sea. Georgia is confronted with obstacles related to the management of marine debris and waste, the dearth of a beach quality award system, and insufficient funding for scientific research on the Black Sea. Turkey and Romania have both prioritised the surveillance and management of marine refuse and waste, with Romania placing a greater emphasis on their commitment to digitalisation. Bulgaria and Turkey also highlighted the absence of digitization and a unified database, which may hinder the effectiveness of data management and communication. This could lead to reduced efficiency and speed in operational procedures such as record-keeping, information sharing, and decision-making. Georgia, the Republic of Moldova, and Ukraine are also concerned with maritime-related incidents, such as maritime catastrophes, pollution in the seas, illicit fishing, and difficulties associated with port administration and security. These nations need to address these issues to safeguard their economic and environmental interests.

In Romania, restricted employment prospects are a significant barrier, as meaningful employment opportunities may be scarce or difficult to obtain within the country. Barriers may arise from various sources, including economic circumstances, skill inconsistencies, or systemic challenges inherent in the labor market. In Ukraine, financial assistance in the form of subsidies and investments is a matter of concern in the aftermath of the ongoing war, which has substantially impacted the economy of Ukraine, necessitating assistance from abroad to restore stability and reconstruct affected regions. Subsidies and investments may play a pivotal role in fostering economic recovery, supporting infrastructure development, and addressing urgent humanitarian needs. Another obstacle for the Republic of Moldova, Georgia, and Ukraine is the lack of a strategic vision and long-term planning, which underscores a failure to formulate all-encompassing, prospective strategies and policies that effectively steer progress and tackle critical concerns. This may lead to impromptu decision-making, temporary solutions, and overlooked prospects for sustainable development.

Policymakers must actively involve local communities, perform comprehensive evaluations of regional requirements and obstacles, and customize interventions correspondingly. International cooperation is considered of the least significance in most Black Sea (BS) countries, except for Ukraine, suggesting a potential failure to capitalize on combined knowledge, assets, and assistance required to address challenges such as economic growth, environmental protection, and maritime safety. Ukraine could

potentially place greater emphasis on global collaboration due to its strategic geographical location and continuous developments in the region.

The second round of MAFs initiated with the validation and adoption of a shared and desirable vision (Figure 2) and engaged stakeholders in downscaling the generic innovation pathways that were generated between workshops, identifying milestones for achieving the vision within each relevant sector, and mapping relevant innovations onto each of these milestones (Figure 3). In the end, 26 distinct innovation pathways were developed for each prioritised BE Sector for each BS Country. The innovative solutions identified by the Black Sea Accelerator, as well as other groundbreaking ideas, relevant to the prioritised BE sectors, were employed for this workshop. The final vision for the Black Sea is the following: *"The Black Sea region is a model of resilience, sustainability, and regional cooperation, where societies are connected through innovation, education, and shared environmental stewardship. It fosters multi-disciplinary research and cutting-edge innovation in coastal, marine, and maritime sectors while developing smart, integrated observing and monitoring systems to support sustainable resource management. Through education, citizen engagement, and transparent policy dialogue, opportunities for green jobs are unlocked, ensuring an inclusive transition towards a sustainable blue economy. The region actively mitigates and adapts to climate change, protecting marine and coastal ecosystems while advancing circular economy principles, mobilizing green energy, and implementing innovative production models suited to changing climatic conditions."*
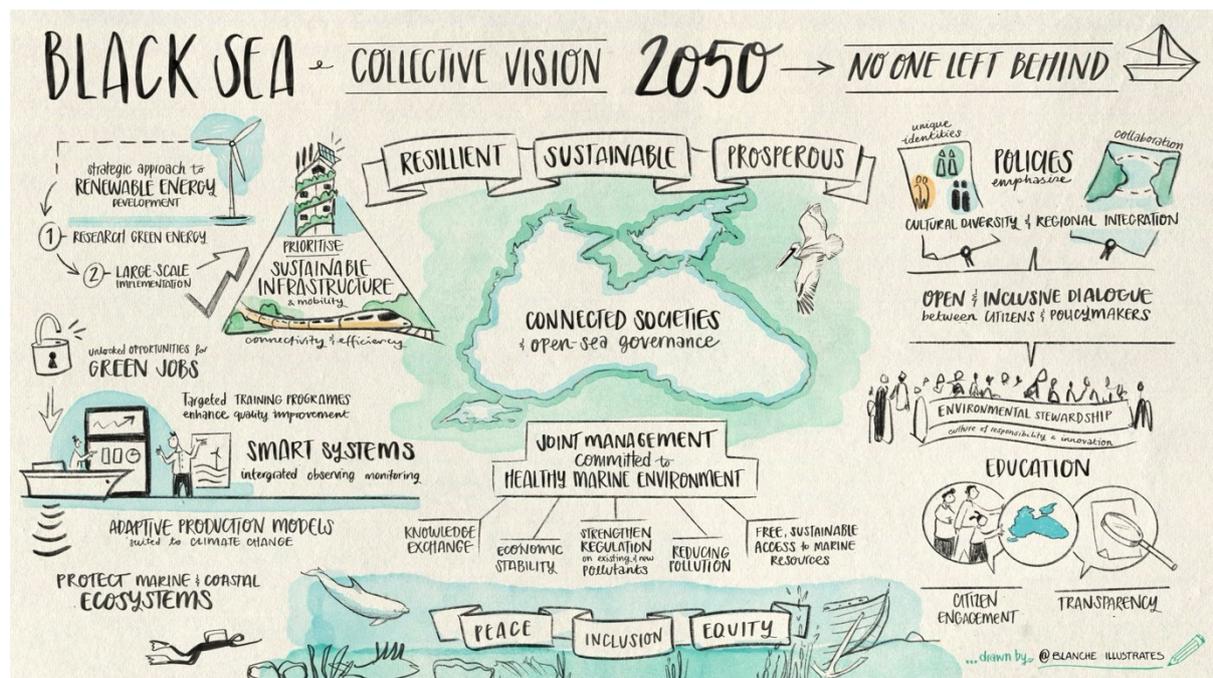

Figure 2 - Black Sea vision developed under the H2020 DOORS Black Sea project (copyright: Blanche Illustrates)

For instance, Figure 3 depicts the Marine Tourism Innovation Pathway for Georgia exemplifies a forward-thinking approach that balances tourism growth with sustainability and regional economic development by gradually integrating technology, regulation, and infrastructure. Based on the Burgas Vision and the BS SRIA (Connect Black Sea, 2023; European Commission, 2018), by 2030, the focus needs to be on the development of diving, sustainable tourism practices, seabed legislation, small cruise traffic, underwater cultural heritage tourism, and maritime safety. Electrical water vehicles and digital diving experiences are among the key innovations that can support the responsible development of tourism while also preserving marine ecosystems. Additionally, the integration of these technologies improves accessibility, enabling a broader audience to investigate marine environments without causing ecological damage. By 2050, this pathway foresees the establishment

of a Blue Tourism Innovation Hub, that will be based on the development of diversified tourism offerings and the implementation of sustainable infrastructure (by 2040), the promotion of climate-resilient tourism (by 2045), and the expansion of digital tourism platforms (by 2035). Innovative initiatives such as SEAFRONT for sustainable resource management, WINDBG for promoting blue tourism entrepreneurship, and a variety of digital innovations from Georgia demonstrate a dedication to the integration of smart, climate-adaptive solutions into the tourism industry.
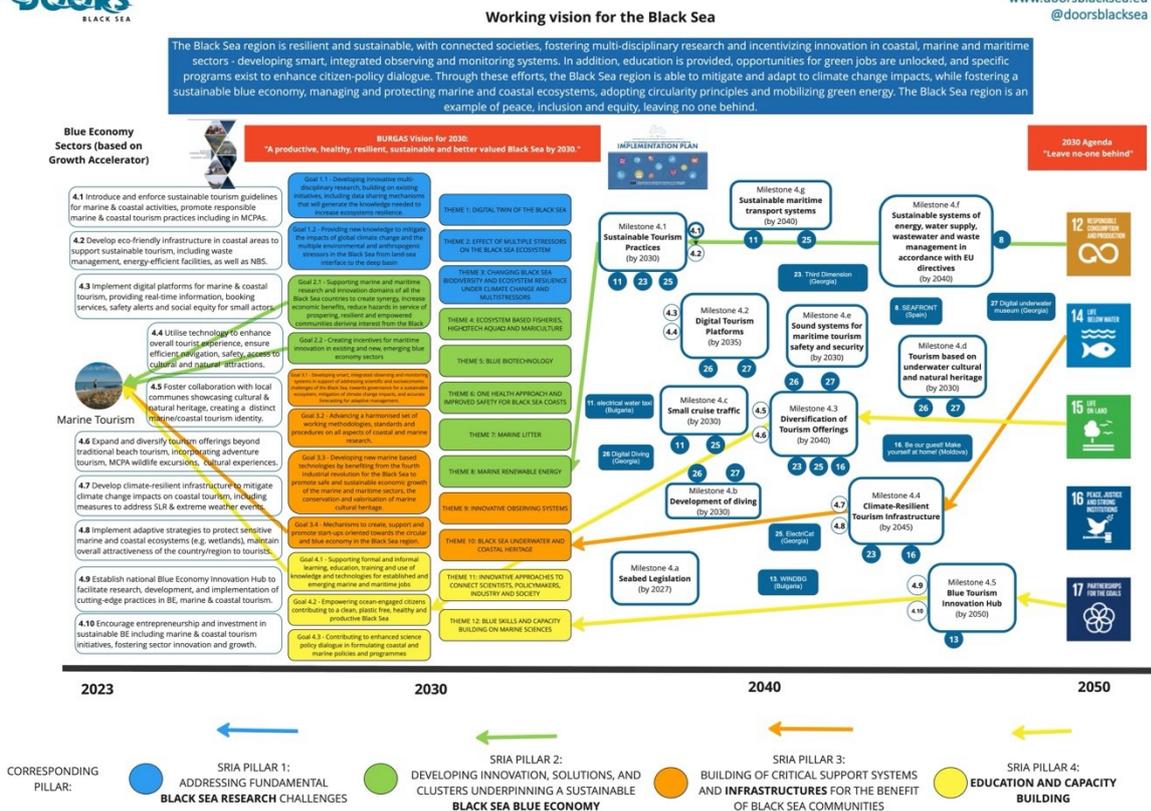
Figure 3 - Innovation Pathways for the Marine Tourism sector in Georgia

An example of the accumulation of all innovation pathways for all BS countries under one sector, can be seen in Figure 4. The Marine Tourism Pathway is a structured roadmap for the development of sustainable marine tourism in multiple Black Sea countries. It is divided into short-term (2025-2030), mid-term (2030-2040), and long-term (2040-2050) milestones and innovations. It emphasises critical areas, including sustainable tourism practices, digital tourism platforms, climate-resilient infrastructure, and blue tourism innovation hubs. The pathway also maps innovations such as sustainable energy and waste management systems, digital underwater museums, and electrical water taxis onto the identified milestones. Bulgaria and Georgia seem to prioritise technology-driven tourism solutions, while Moldova prioritises waste reduction and environmental conservation, Romania investments in maritime transport and eco-tourism, Turkey diving and recreational marine tourism, and Ukraine is working towards safe and low-carbon maritime transport. Each country has its own unique milestones and innovations.

The Innovation Gaps section pinpoints the regulatory, infrastructure, and sustainability obstacles that must be resolved in order to achieve the roadmap's objectives in their entirety. Gaps include the absence of littoral legislation, inadequate maritime safety measures, and the necessity for more robust policies regarding refuse management and overdevelopment. Furthermore, the expansion of marine protected areas, the transition to sustainable tourism models, and the education and awareness of climate impacts are among the long-term objectives. The strategic layering of the

masterplan serves as a comprehensive vision for marine tourism, ensuring a sustainable and resilient Blue Economy in the coming decades by balancing economic development, environmental responsibility, and technological advancement.
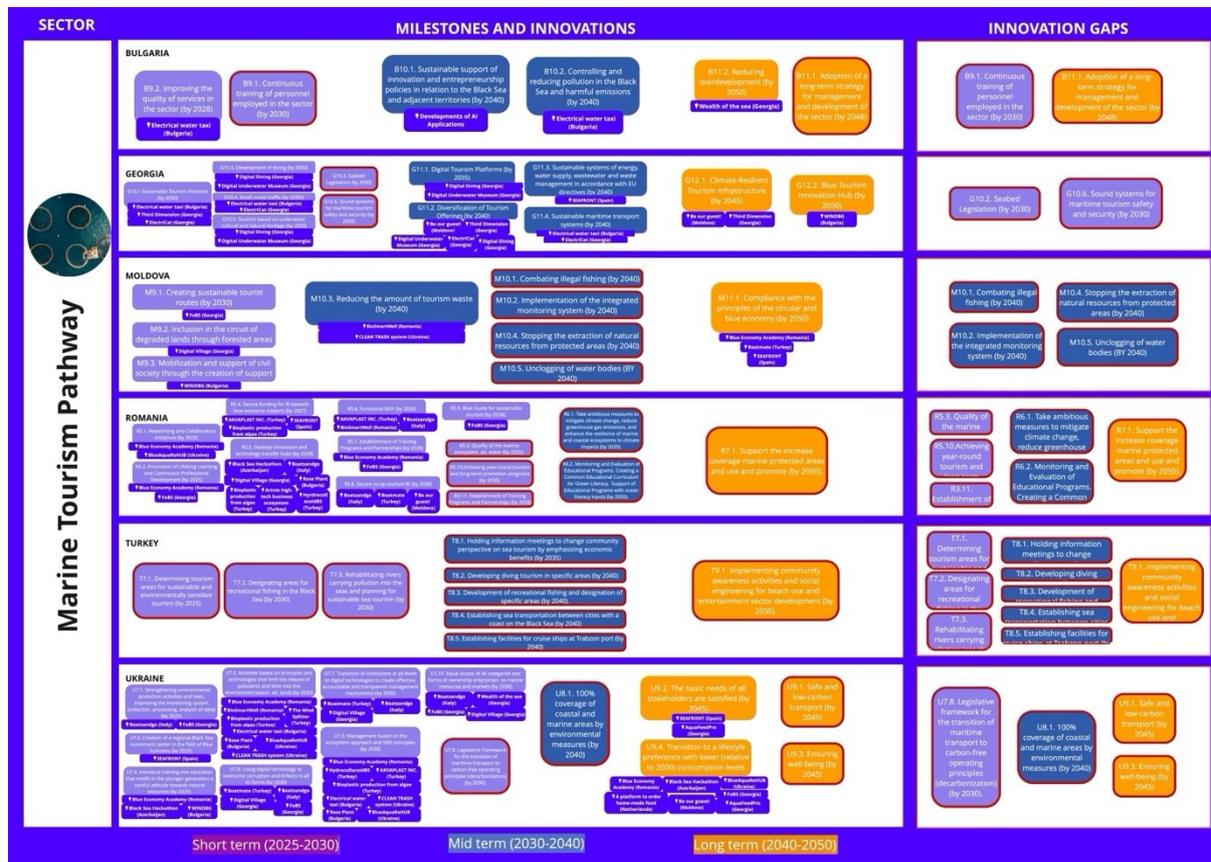

Figure 4 - Innovation Pathways for the Marine Tourism sector

5. Discussion

5.1. Benefits from Stakeholder (STKH) Engagement

Black Sea countries share multiple challenges and needs, which makes regional strategies around the blue economy, such as the Common Maritime Agenda and the Strategic Research and Innovation Agenda for the Black Sea, particularly pertinent. However, the Russo-Ukrainian war taking place for the last three years in the northwestern part of the basin added further pressure to the already long list of challenges and jeopardised regional cooperation. In this context, it is crucial to strengthen local collaborative and transboundary initiatives to foster an exchange of local knowledge, experience, mutual learning, and design common strategies and projects to attract funding. Engaging stakeholders through a system innovation approach has been demonstrated to be an effective tool for anchoring science into societal realities, harnessing valuable knowledge on local practices to better understand the drivers of change and relationships between coastal communities and the sea, and raising awareness of the human implication in the continuous degradation of the marine environment. Additionally, it serves to identify innovative solutions that can protect and preserve their well-being (Mckinley et al., 2020).

This participatory process enables the simple communication and dissemination of scientific findings to policy makers and business representatives, as well as the identification of any residual knowledge gaps. NGOs, academia representatives, and public and private actors were able to establish a common

ground and concur on a future cross-sectoral trajectory within the blue economy by utilising the systems innovation approach. The development and ownership of innovative solutions to support the adoption of sustainable practices and transformative policies are facilitated, thereby increasing the likelihood of acceptability and success during the implementation phase of those solutions (Claudet et al., 2020). In the case of the H2020 COASTAL project[1], where stakeholders were engaged to co-design strategies for land-sea synergies, the participatory approach had a positive impact on local governance arrangements, strengthening stakeholder networks but also fostering a better understanding of cross-sectoral linkages, local needs and systemic issues, and also ownership of the co-identified innovations, ensuring stronger social and sectoral acceptance as well as a higher probability of stakeholder uptake and implementation by policymakers (Guittard et al., 2024).

5.2. Challenges and Future Directions in Implementing Stakeholder Engagement activities

Notwithstanding its advantages, stakeholder involvement encounters obstacles such as power imbalances, divergent interests, and institutional inertia (Lewis et al., 2020) . Strategies like reflexive governance (Schlaile et al., 2017) and the adaptive implementation of policy combinations (Matti, 2019) assist in overcoming these obstacles and facilitating substantial involvement. Engaging stakeholders is essential for effective transitions, establishing a collaborative basis for innovation, policy formulation, and sustainable reforms. Through the use of living labs, open innovation, and strategic engagement, stakeholders may collaboratively facilitate systemic transformation towards more sustainable and resilient futures.

Living Labs encounter difficulties in attaining efficient coordination among several stakeholders, including users, researchers, and enterprises. (Leminen et al., 2017; Leminen & Westerlund, 2012) emphasise that structuring Living Labs as innovation networks necessitates reconciling the interests of many stakeholders while prioritising co-creation. Ambiguity in roles and duties frequently obstructs collaboration, rendering participatory procedures resource-intensive and time-consuming. (Liedtke et al. (2012) assert that achieving long-term sustainability in user-driven innovation environments is challenging, as initiatives frequently depend on external financing and lack scaling methods. The contextual dependencies of Living Labs also provide issues; solutions effective in one urban or regional environment may not be applicable in another owing to varying socio-economic and cultural variables (von Wirth et al., 2019; Voytenko et al., 2016).

Governance difficulties are crucial to the execution of multi-stakeholder frameworks, especially in urban and sustainability-focused Living Labs, where participatory and adaptive approaches often struggle with inclusivity, power asymmetries, and effective decision-making (Matti, 2019; Voß et al., 2006). Emerging work on commons-based innovation highlights a complementary governance logic—alongside market and hierarchical models—that has proven effective in addressing coordination failures and enabling communities to sustain and govern solutions beyond the lifespan of funded projects (Frischmann et al., 2014; Ostrom, 2010). This perspective also responds to critiques in democratic innovation research, which caution that poorly designed deliberative processes can become technocratic or exclusionary, reinforcing rather than reducing inequality (Fishkin, 2020).

Insufficient institutional support and inflexible legislative frameworks frequently constrain experimentation and innovation, as evidenced by research on sustainability transitions (Markard, 2012; Smith & Raven, 2012). Kyvelou & Ierapetritis (2019) also emphasise the necessity for more explicit policy combinations and improved cooperation channels to effectively implement blue growth initiatives, especially at local and regional levels. In the absence of these, attaining systemic change is

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[1] https://coastal-xchange.eu/

a considerable difficulty. Beyond state-based regulation and financial instruments, institutionalisation can also take the form of commons-based governance arrangements, which constitute a third mode of coordination alongside hierarchical and market-based models (Ostrom, 2010). In such arrangements, value chains are embedded not only within individual communities but also across federations of interconnected commons, enabling coordination, continuity, and self-governance that extend beyond the lifecycle of time-bound or co-funded projects (Bauwens et al., 2019; Bollier & Helfrich, 2019). Empirical and theoretical work in sustainability transitions highlights that the absence of this multi-layered institutional anchoring often limits the durability and scalability of transition initiatives, contributing to difficulties in sustaining systemic change over time (Geels, 2019; D. Loorbach et al., 2017; Schot & Steinmueller, 2018)

Methodological constraints in assessing Living Labs and sustainability transitions are another significant issue. Systems thinking methodologies can pinpoint leverage points for systemic transformation (Geels, 2004; Meadows, 2008); nevertheless, they frequently need comprehensive data and modelling instruments, which are not consistently accessible in practical contexts. Moreover, models such as Strategic Niche Management (Kemp et al., 1998) and Deep Transitions (Schot & Kanger, 2018) underscore the challenges associated with scaling niche breakthroughs to challenge entrenched socio-technical regimes. The absence of standardised measures for evaluating the impact of Living Labs or stakeholder partnerships (Mergel, 2018) complicates the capacity to formulate generalised conclusions, hence restricting the transferability of insights across different contexts. These difficulties underscore the necessity for improved methodology and governance frameworks to augment the efficacy of Living Labs and sustainability programs.

5.3. Scope and Limitations

This chapter emphasises the importance of systems innovation in the sustainable development of the blue economy (BE) from a non-technical standpoint. The discussion prioritises strategic, organisational, and policy-driven aspects of innovation and Blue Economy, rather than focussing on computer science methodologies, algorithmic minutiae, or software implementations. The analysis takes into account the systems innovation approach, a stakeholder engagement technique that employs an interconnected set of innovations that influence one another to facilitate systemic change. In order to direct the methodology, specific assumptions were made when defining the scope. Initially, it is presumed that the primary factors driving innovation in the BE are collaborative ecosystems, financial incentives, and regulatory frameworks, rather than solely technological advancements. This assumption restricts the analysis to systemic interventions rather than standalone technical solutions. Secondly, the use of participatory approaches may be subjective to the beliefs of the stakeholders who participate in a workshop. Third, innovation is examined in a local context, not taking into account, so, solutions that are developed in Asia, America or Australia. Furthermore, the changing nature of sustainability policies may necessitate ongoing updates to ensure that they are consistent with emergent regulatory trends. Lastly, the generalisability of the findings may be impacted by the limited availability of empirical data and case studies, which further restricts the analysis.

6. Conclusions

This chapter delves into the role of systems innovation in the sustainable development of the blue economy (BE), with a focus on a multi-stakeholder and holistic approach. It emphasises the potential of adaptive governance structures, cross-sector collaboration, and integrated policies to facilitate the transition to sustainability in the marine and maritime sectors. The discussion emphasises that technological advancements are not the sole factors driving innovation in the BE; rather, regulatory frameworks, economic incentives, and social acceptability are all equally important. Furthermore, the

chapter identifies obstacles to systemic transformation, including the necessity for scalable financial mechanisms, inconsistent policy implementation, and fragmented data availability. A critical lesson is that innovation is primarily fostered through stakeholder engagement, particularly in sectors such as sustainable fisheries, offshore renewable energy, and marine tourism. Diverse interests, including government institutions, private enterprises, coastal communities, and environmental groups, must be accommodated by effective governance models. Moreover, the chapter underscores the significance of digital tools, participatory decision-making, and knowledge-sharing platforms in the promotion of transparency and cooperation. The analysis also presents a successful case study in which sustainable transformations in the BE have been accelerated by systems thinking and innovation ecosystems.

Future studies could employ a more structured and data-driven approach is necessary to integrate stakeholder engagement with systems innovation in BE initiatives in the future. The development of regional and global digital platforms that enable real-time data exchange, predictive modelling, and AI-driven decision support to enhance the effectiveness of policies is a promising direction. It will also be essential to enhance regulatory harmonisation across maritime sectors and countries to guarantee a seamless transition to a sustainable BE. In addition, future research should investigate mechanisms for financing systemic innovation, such as public-private partnerships, blue bonds, and impact investment models that promote long-term sustainability commitments. The adaptability and resilience of BE initiatives will be improved by the expansion of multi-stakeholder innovation centres, which involve the collaborative creation of solutions by policymakers, businesses, scientists, and local communities. Lastly, it is imperative that capacity-building programs be implemented to provide stakeholders with the requisite knowledge and skills to effectively navigate the intricacies of systems innovation and effect meaningful change in the blue economy.

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