BLUNEW

Report on Innovation in the Blue Economy

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1. About this report

1.1 Scope and objectives of this report

The Blue Economy represents a transformative shift in the sustainable utilization of marine resources, integrating technological innovation, environmental conservation, and economic development. This report explores key trends, challenges, and solutions within the Adriatic-Ionian Region, emphasizing innovation in the main sectors of the Blue Economy. The primary focus of the report is on state of the art and further advancements that can support sustainable fisheries, pollution control, climate resilience, and other challenges.

The EU policy framework is examined, with emphasis on the strategies and directives promulgated by the EU. The second part of the report explores regional applications of the Blue Economy principles within the Adriatic-Ionian countries, showcasing local best practices, case studies, and policy innovations.

1.2 Methodology

This report has been developed through the collection of data from institutions, research papers, and the general knowledge of all parties involved. The first part presents a review of the main aspects, challenges and drivers of innovation of the Blue Economy, relying primarily on documents from the UE and other institutions. The second section was created through contributions from each country represented in BLUNEW Consortium. Their material was further selected and reorganized to provide a comprehensive overview of the main challenges and proposed solutions across different countries within the Adriatic-Ionian region, with a final emphasis on future trends.

2. Introduction: What is the Blue Economy?

The Blue Economy is a relatively new concept and an evolving policy framework vision integrated in the management and governance of water bodies to enhance their sustainable management, while taking into consideration protection of aquatic ecosystems and promotion of non-harmful water-based economic activities. Sustainability in this context is intended to balance economic growth, mutual understanding, transnational cooperation, while generating tangible direct and indirect new jobs and unlocking opportunities for livelihoods[1]. However, the Blue Economy is an ongoing development of efforts to create a viable framework in achieving a sustainable future of water bodies and addressing socio-economic challenges. Across different multilateral frameworks and international organizations, the Blue Economy is interchangeably contextualized depending on the operational areas and mandate.

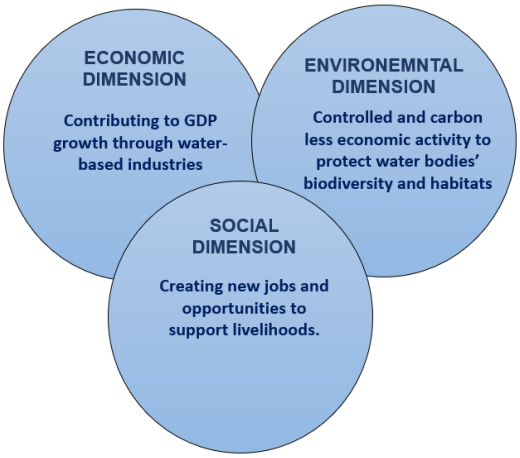
Below is a scheme of the common definitions that are largely applied:

ORGANISATION	DEFINITION	FOCUS
United Nations	Blue Economy comprises a range of economic sectors and related policies that together determine whether the use of ocean resources is sustainable.	*More regulatory and compliant approach to implementing Blue Economy.*
OECD	Blue Economy entails all industries with a direct or indirect connection to the ocean, such as marine energy, ports, shipping, coastal protection, and seafood production.	*More economy and industry focus.*
World Bank	Blue Economy covers the sustainable use of ocean resources for economic growth, improved livelihoods, and jobs while preserving the health of ocean ecosystems.	*More comprehensive and inclusive perspective.*

Table 1: Definitions of Blue Economy by UN, OECD and WB.

The range of water bodies where policies and management practices of the Blue Economy are implemented involves sea, rivers and lakes. Adequate definitions of Blue Economy are country or territorial-specific, based on types of water bodies, water-based flagship industrial sectors, conservation status of water bodies and state of

Figure 1: Three main dimensions of Blue Economy. Source: adapted by the author.



innovation. In this context, the legal recognition and adoption of a Blue Economy definition, which reflects territorial challenges and potentials, represents a significant step in designing and implementing a roadmap for the sustainable use and management of water bodies. On the other hand, aligning the national perspective of Blue Economy with international and multi-lateral commitments is essential to ensure that the Blue Economy global agenda is trackable and unified, as water bodies do not recognize political borders.

The array of economic activities and sectors covered and supported by Blue Economy is very broad, dynamic, and expanding day by day as innovation introduces new potential aspects. In the European Union, key and leading economic sectors under the Blue Economy framework that constitutes significant part of the EU overall GDP are coastal tourism, maritime transport, marine renewable energy and marine living resources[2].

The integration and enforcement of Blue Economy policy frameworks in different regions and countries has proven to have a multi-dimensional impact. Initially, the notion of Blue Economy was largely focused on the economic exploitation and profitability of marine-based industry. The advancement of sustainable development in the global agenda has added and increased the meaning of the social and environmental dimensions.

Co-benefits related to different dimensions that can result from the development of the Blue Economy:

- Protection of marine and water ecosystems from harmful human activities.

- Transboundary cooperation and cross-border coordinated actions for sustainable management of joint water resources.
- Exploration of innovation pathways for sustainable water-based technologies integrated with the ecosystems.
- Social and economic empowerment of communities connected to water sites where Blue Economy is well-managed.
- Gender inclusivity in water-based economic activities.
- Contribution to Sustainable Development Goals related to marine ecosystems, climate action, gender and social empowerment.
- Responding to global challenges related to climate-induced flooding events, poverty and food crisis.

2.1 The Blue Economy in the European Union

In the European Union, the Blue Economy has been significantly evolving throughout the years in terms of policies, economic performance and accumulation of technical expertise. The European Commission issues a report on Blue Economy on an annual basis to provide an overview of its key sectors and identify new trends in terms of employment or investment.

According to these reports, it is estimated that all economic activities relating to the Ocean and other water bodies directly employ over 4.5 million people[3] across the EU and account for 1.5 % of EU GDP. The annual revenue generated by key Blue Economy sectors is estimated to be over 750 billion EUR[4].

Looking at single sectors, the fisheries industry and aquaculture is valued 6.3 EUR billion. EU Maritime transport is essential at a global level, as it accounts for 41% of the world's shipping fleet by tonnage[5]. On the other hand, coastal and maritime tourism is another key economic pillar, as it represents over 45% of all tourism taking place in the EU, providing over 2.5 million jobs[6]. Emerging sectors are increasing their economic performance and getting higher ranking in the EU Commission's reports every year: Offshore renewable energy represents the sector with the highest growth; the EU commitment under EU Green Deal for energy transition has significantly developed offshore renewable-based energy technologies. At this moment, the EU is regarded as a global leader as 80% of the overall installed offshore wind energy is placed in EU waters[7].

Other emerging sectors with high prospects are blue biotechnology and deep-sea mining. Blue biotechnology mostly deals with marine organisms to discover different innovative solutions for pharmaceutical industry, biofuels, cosmetics, etc.[8], while deep-sea mining exploits the seabed to extract important minerals and metals.

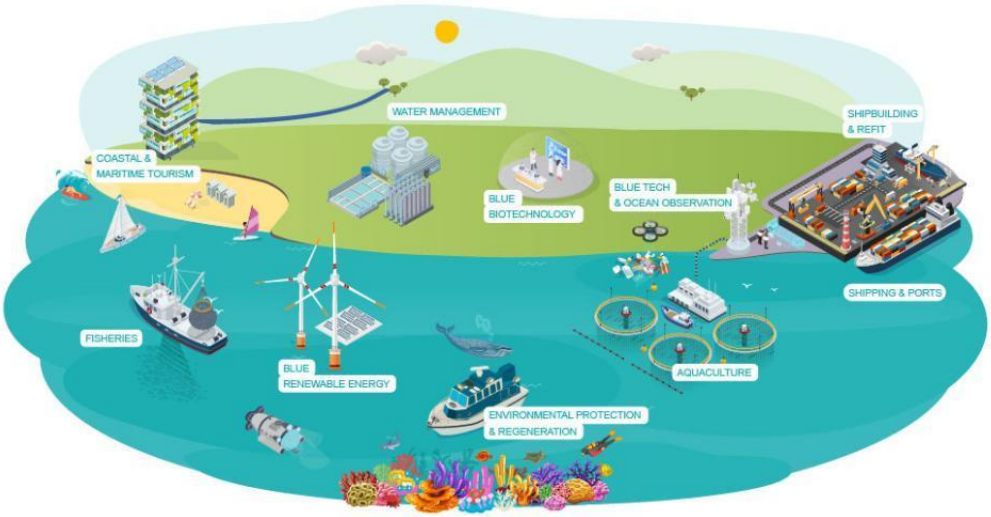


Figure 2: Key economic sectors of EU Blue Economy, source: BlueInvest report, 2023

2.2 The role of innovation in the Blue Economy: state of art and challenges

The initial focus of the Blue Economy has been the utilization of ocean and marine resources. Over the years, the notion of Blue Economy has developed in terms of dimensions and diversity of activities. **Global political commitments on sustainability goals and the economic demand have driven the innovation** of Blue Economy to respond to the evolving market needs for new products, services and goods.

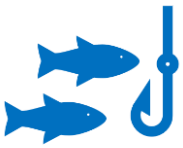
The Blue Economy report by the European Commission gives an overview of the state of innovation by confirming a list of existing established and new emerging sectors (*Table 2*), on an annual basis.

Key sectors	Sub-sectors
Marine living resources	*Primary production*
	Processing of fish products
	Distribution of fish products
Marine non-living resources	*Oil and gas*
	Other minerals
	Support activities
Marine renewable energy Port activities	*Offshore wind energy*
	Cargo and warehousing
	Port and water projects
Maritime transport	*Passenger transport*
	Freight transport
	Services for transport
Coastal tourism	*Accommodation*
	Transport
	Other expenditure

Table 2: Sectors of Blue Economy in the EU. Source: European Commission, EU Blue Economy 2024.

In recent years, innovation has achieved significant success in key areas such as marine renewable energy, aquaculture, marine biotechnology, and shipping. This is influenced by different events across the world.

Marine renewable energy arises as a solution to produce clean and affordable energy by reducing dependence on fossil fuels and decreasing the overall global GHG emissions. By 2050, IRENA forecast up to 2000 GW offshore wind energy installed[9]. This will fulfill the energy needs of 4.38 billion people for an entire year based on average energy consumption per person. However, innovation and commercialization are still at their initial phase due to high costs and limited infrastructure[10].



Aquaculture supplies over 50% of the total fish consumed by humans[11]. Innovative technologies and techniques, such as smart feeding systems or underwater monitoring, have enhanced efficiency by reducing carbon footprint. Also, alternative protein sources extracted by different types of algae and lab-grown seafood provide a suitable solution to meet rising global needs for proteins. This market is forecast to reach 6.4 million dollars by 2028[12].

Marine biotechnology is gaining the spotlight of science-based projects mainly for finding alternative solutions to plastics, employing algae. Pharmaceutical products based on marine organisms and ingredients are introducing a new market, that is expected to be worth 7.4 million dollars by 2026[13].

Shipping industry is responsible for 2.9% of global CO_2 emissions (2020). Innovative solutions like ammonia and hydrogen-powered vessels and electrification of ports are being developed to meet the IMO's 2050 zero-emission targets[14].

The main challenges hampering the advancement of innovation are closely connected with the availability of financial means and scalability. In the case of energy-based projects, the upfront costs for building up renewable-based energy technologies, e.g. offshore wind turbines or wave energy converters, remain high. Also, the ongoing operational and maintenance costs of offshore wind turbines and wave energy converters is expensive compared with the revenue gained from the generated energy. Small and medium enterprises, which play a multiple role in replicating good practices

in the Blue Economy, are not capable of accessing grants or loans due to the high uncertainty of innovative projects based on water bodies.

In this perspective, the risk exists that innovation in the Blue Economy could be solely a privilege of developed economies and countries. For instance, only **6 countries globally have operational tidal energy plants**[15]. On the other hand, innovative implementations like offshore wind farms and aquaculture face challenges related to **ecosystem disruption** and local **community opposition**.

3. Innovation trends in the Blue Economy

3.1 Marine Renewable Energy

This field is based on harnessing power from the natural movement of water, including waves, tides, and river or ocean currents. Another source of marine-based energy derives from the underwater temperature spread.

Tidal and Wave Energy is produced by the surge of ocean waters during the rise and fall of tides. All methods use special generators to convert tidal energy into electricity[16]. Over the past ten years, tidal stream and wave devices - on different scales - have been tested in European waters. However, only a few examples can be found today in operation. Considerable progress is needed - in research, development, demonstration and validation of technology - for this sector to realize its potential contribution to energy supply, industrial leadership, economic growth and mitigation of climate change.

Progress is needed in the design and validation of ocean energy devices, balance of plant (supporting components and auxiliary systems), logistics and marine operations, integration in the energy system, and modelling tools. Knowledge about the potential impacts of devices on the environment also needs to improve[17].

Offshore wind energy is a renewable energy source generated by harnessing wind power from turbines located in bodies of water, typically seas or oceans, to produce electricity.
The EU has helped develop wind power thanks to its ambitious policies and investments. Currently, the EU is a global leader in the manufacturing of key wind turbine components, as well as in the foundations and cables industry: almost half of the active companies in the wind sector (onshore and offshore) are headquartered in the EU. Progress towards green electricity is the most effective way to ensure energy affordability, with home-grown renewable power expected help to lower energy bills in the long term[18].

To access offshore sites farther out to sea with stronger and more consistent winds, several European developers are working on floating offshore wind turbines. Multiple pilot projects are already up and running, with deployment expected to accelerate towards the end of this decade. The EU is supporting further development of such technology, including via calls for demonstration projects under Horizon Europe and by approving targeted state aid measures. Looking overseas,

as of June 2024 China is the country with the largest number of offshore wind farms, followed by the UK, Germany and Vietnam.

Ocean Thermal Energy Conversion (OTEC) power generation uses temperature differences between upper surface layer and deeper layers (800 –1000 m) of the sea, generally operating with temperature differences of around 20°C or more. The advantages of OTEC allow the provision of electricity on a continuous basis, while also providing cooling without electricity consumption. The technological challenge is that small temperature difference requires very large volumes of water at minimum pressure losses. This requires large seawater pumps, large piping systems, and large cold-water pipes operating almost continuously in a hostile and corrosive environment. OTEC seems especially suitable and economically viable for remote islands in tropical seas where generation can be combined with other functions e.g., air-conditioning and freshwater production.

Recent studies suggest that total worldwide power generation capacity could be supplied by OTEC, and that this wouldn't impact the ocean's temperature profiles.

3.2 Sustainable Fisheries and Aquaculture

Sustainable fisheries and aquaculture are vital components of the Blue Economy. Sustainable fisheries ensure that marine species are harvested at levels that maintain ecosystems' balance, while aquaculture provides a controlled method of producing seafood without overexploiting natural fish stocks. Together, they support food security, create jobs, and promote economic development, while aligning with conservation goals and reducing environmental degradation in coastal and marine environments.

Aquaculture involves the farming and husbandry of fish and other marine organisms, as well as the growth and harvesting of aquatic plants like seaweed. The technology used to do this includes systems for water quality management, automated feeding, disease control and breeding, as well as advancements like recirculating aquaculture systems (RAS), integrated multi-trophic aquaculture (IMTA), and genetic improvements. These technologies aim to increase production

efficiency, sustainability, and the health of the farmed species while minimizing the environmental impact[19].

Sustainable fishing practices are integral to advancing the Blue Economy, aiming to balance economic growth with marine ecosystem health. In the European Union, trends include adopting ecosystem-based fisheries management, stricter quotas, and real-time data monitoring. For instance, the EU's Common Fisheries Policy (CFP) promotes Maximum Sustainable Yield (MSY) to ensure fish stocks are maintained at levels that allow for regeneration[20]. Technological innovations, such as vessel monitoring systems (VMS) and bycatch-reduction devices, are also being implemented to minimize environmental impact while improving compliance and efficiency.

Several EU nations exemplify leadership in sustainable practices. Denmark has embraced selective fishing gear and seasonal closures to protect vulnerable species, while Spain has developed co-managed marine protected areas that allow controlled fishing while safeguarding biodiversity. Additionally, Ireland's focus on traceability through blockchain technology ensures transparency in seafood supply chains, benefiting both consumers and ecosystems. These initiatives highlight how sustainable fishing practices are supporting economic development, food security, and ocean conservation in line with Blue Economy principles.

2.3 Blue Tech

Blue Biotechnology is defined as the "application of science and technology to living organisms from marine resources, as well as parts, products and models thereof, to alter living or non-living materials for the production of knowledge, goods and services". Marine organisms that are covered include, amongst others, microbes, microalgae, cyanobacteria, seaweed, invertebrates, and discards of fish and other marine organisms that show potential for the development of innovative and high value products as well as valorization of co-products[21].

Algae are an incredibly versatile material, with potential new applications in various sectors of the economy. They are being used to develop new pharmaceuticals (e.g. to treat viral infections or heal wounds), bring healthy food to the market or substitute fish oil in animal feed. Adding algae to cattle diets can help reduce the methane

emissions from bovines. Seaweed aquaculture, especially if combined with shellfish aquaculture, will not only provide healthy food but also contribute to ecosystem services: carbon sequestration, removal of nutrients and CO2, ecosystem support, ocean habitat restoration, coastal ecosystem resilience.

Algae also have potential to be used for cosmetics (anti-aging moisturizers, toothpaste), crop nutrition/bio-fertilizers, bio-packaging (packaging, coatings and plastic films for food containers), energy (biofuel) etc. Beyond these examples, seaweed has many more innovative applications which are still being developed or scaled, including textile fibers, laundry detergents, construction materials, and biochar for soil improvement.

2.4 Protection of aquatic ecosystems through remote sensing and monitoring technologies

Artificial Intelligence (AI) plays a transformative role in advancing the Blue Economy by enhancing the sustainability and efficiency of ocean-based industries. AI applications include predictive analytics for marine resource management, real-time monitoring of ocean conditions, and optimizing maritime operations. For example, AI-driven satellite imagery and machine learning algorithms are used to monitor illegal fishing activities, detect changes in marine biodiversity, and assess ocean pollution. These technologies enable policymakers to make data-informed decisions, balancing economic growth with environmental protection[22].

In the European Union, AI is increasingly integrated into Blue Economy strategies. Portugal, for instance, employs AI-powered systems to optimize aquaculture practices by monitoring water quality and predicting fish behavior, thereby improving yield and reducing waste. Similarly, the Netherlands leverages AI to model sustainable shipping routes, minimizing fuel consumption and greenhouse gas emissions. These innovations illustrate how AI not only supports economic productivity in marine industries but also ensures alignment with sustainability goals, fostering a resilient and inclusive Blue Economy.

Remote sensing technologies are increasingly vital for monitoring aquatic ecosystems, enabling more accurate and efficient management of marine and freshwater environments. These technologies, which include satellite imagery, drones, and aerial sensors, provide real-time data on water quality, biodiversity, and habitat changes. For example, remote sensing can detect pollution levels, algal blooms, and changes in temperature or salinity, which are essential for understanding the health of aquatic ecosystems. By using these technologies, researchers and policymakers can track environmental shifts, identify areas in need

of conservation, and support sustainable practices in industries like fisheries and aquaculture[23].

In the European Union, several countries are employing remote sensing technologies to monitor aquatic ecosystems. In the Netherlands, for example, remote sensing is used to monitor water quality and map habitats in the North Sea[24], aiding in the management of marine protected areas. France utilizes satellite data to monitor coastal erosion and the impact of climate change on aquatic habitats. Additionally, Greece has implemented drones and aerial imagery for tracking biodiversity in the Mediterranean, ensuring the protection of key marine species. These innovations showcase how remote sensing is transforming aquatic ecosystem management, offering real-time insights for better decision-making.

2.5 Sustainable and Community-based Tourism

Mitigating the negative externalities of tourism and supporting local communities are key pillars of sustainable tourism, which aligns with the Blue Economy by promoting economic development while protecting ecosystems. Tourism often generates negative impacts such as environmental degradation, overcrowding, and pressure on local resources. Strategies to mitigate these externalities include implementing sustainable tourism practices, promoting eco-tourism, and regulating visitor numbers in sensitive areas. These actions help reduce environmental footprints and preserve cultural heritage while benefiting local communities economically by providing employment opportunities and encouraging the development of sustainable enterprises.

In the European Union, several initiatives have been established to mitigate the externalities of tourism and support local communities. For example, in Spain, the Balearic Islands introduced a "tourism tax" to fund environmental conservation and offset the impacts of mass tourism. Similarly, Italy's sustainable tourism strategy promotes community-based tourism and supports small-scale businesses that prioritize local culture and environmental protection[25]. In Greece, the government has implemented programs to diversify tourism, reducing dependence on coastal regions by promoting rural tourism, which provides economic opportunities for local farmers and artisans while spreading the benefits of tourism more evenly across the country[26]. These initiatives demonstrate how managing tourism's externalities and investing in local communities can create a more balanced and sustainable tourism model.

4.The EU framework

The concept of Blue Economy gained prominence during the 2012 United Nations Conference on Sustainable Development. As discussed in the first chapter, the EU adopted a broad definition of the Blue Economy, fostering greater interconnection between policies and strategies across various sectors. Since then, a range of policies and strategies have been implemented (*Figure 1*).

4.1 Key EU strategies and directives for Blue Economy

4.1.1 EU strategies

The first steppingstone in policy level for Blue Economy in the EU was marked with the adoption of **Integrated Maritime Policy (IMP),** introduced in 2007. This policy framework aims to establish a coordinated inter-sectorial approach across maritime sectors. The primary focus of IMP highlights the interconnectivity of maritime activities and their dependence on protected and healthy marine ecosystems. The IMP provided a framework for integrated maritime governance and decision-making that takes into consideration three main dimensions of Blue Economy – *social, environmental and economic dimensions* (*Figure 2*).

Key components of IMP entail:

- **Maritime Spatial Planning (MSP) –** ensures efficient and sustainable use of marine resources and reduces conflicts between sectors.
- **Marine Data Collection and Sharing –** facilitates access to reliable marine data through initiatives like EMODnet, aiding sustainable development and innovation.
- **Sea Basin Strategies –** focuses on regional cooperation tailored to specific challenges and opportunities in areas such as the Baltic Sea, Mediterranean, and Atlantic Ocean.
- **Sustainable Development –** promotes environmentally conscious growth across maritime sectors, integrating the goals of the Marine Strategy Framework Directive.
- **Maritime Surveillance –** enhances safety, security, and environmental monitoring through shared systems like the Common Information Sharing Environment (CISE).

In the light of IMP, the EU designed and adopted a broader strategy on Blue Economy in 2012, the **Blue Growth Strategy (BSG).** This strategy serves as the EU's flagship policy for supporting and increasing the visibility of sustainable economic growth in maritime sectors. BSG recognizes water bodies as fundamental drivers of the EU economy, which creates jobs and influence innovation.

This strategy's key enablers are built upon the following pillars:

1. **Maritime Spatial Planning (MSP) – essential** for coordinating the use of marine space among competing sectors and ensuring sustainable growth.
2. **Research and Innovation –** drives technological advancements and solutions tailored to maritime challenges, supported by EU research programs like Horizon 2020.
3. **Marine Data Collection –** initiatives such as the European Marine Observation and Data Network (EMODnet) provide critical data for informed decision-making.
4. **Skill Development –** addresses workforce needs by improving training, education, and career opportunities in Blue Economy sectors.
5. **Funding Mechanisms –** European Maritime and Fisheries Fund (EMFF) and other programs provide financial support for blue growth projects.

Synergy and regional collaboration are vital for the management of Blue Economy. The BDG framework particularly envisages the increase of cross-border actions and decisions for transboundary water bodies. The **Blue Economy partnership** consisting of key institutions in Europe's emerged to address the regional cooperation and enhance cross-border action for Blue Economy. This partnership represents a collaborative effort among 74 partner institutions from 30 countries and the European Commission to pool resources and expertise. It aims to promote innovation, research, and entrepreneurship in the Blue Economy, fostering sustainable growth and job creation. Blue Economy partnership, through coordinated action and synergy among concerned institutions, work together to support key EU policy objectives of green transition, digital transformation and recovery and ultimately contribute to the Sustainable Development Goals. The Partnership is coordinated by Italy (Ministry of Universities and Research), with Norway as co-coordinator[27].

4.1.2. EU directives

A set of EU directives are part of EU Blue Economy framework which covers different areas and sectors, which constitute the source of horizontal legislation for Blue Economy in EU member states. These directives pertain to sustainable use of marine resources, environmental protection, economic growth in maritime sectors. These directives collectively contribute to the EU's Blue Economy by ensuring that economic activities related to oceans, seas, and coasts are environmentally sustainable, economically viable, and socially equitable.

Marine Strategy Framework Directive (MSFD) (Directive 2008/56/EC)

This is considered as a fundamental directive of the EU Blue Economy framework. It aims to introduce an environmentally friendly approach in the management of maritime economic activities, the so-called “Good Environmental Status” (GES). This directive contributes directly to:

- **Protection of Marime ecosystems** by addressing key environmental pressures (pollution, overfishing, biodiversity loss, etc.).
- Promoting **sustainable practices** by developing marine strategies (EU member states) based on environmental-friendly principles.
- Establishing **Marine Protected Areas** (MPAs) as part of efforts to achieve GES and enhance socio-economic benefits, fish stocks and sustainable tourism.
- Integrate and coordinate the link with other directives:
    - Water Framework Directive
    - Habitats Directive
    - Birds Directive

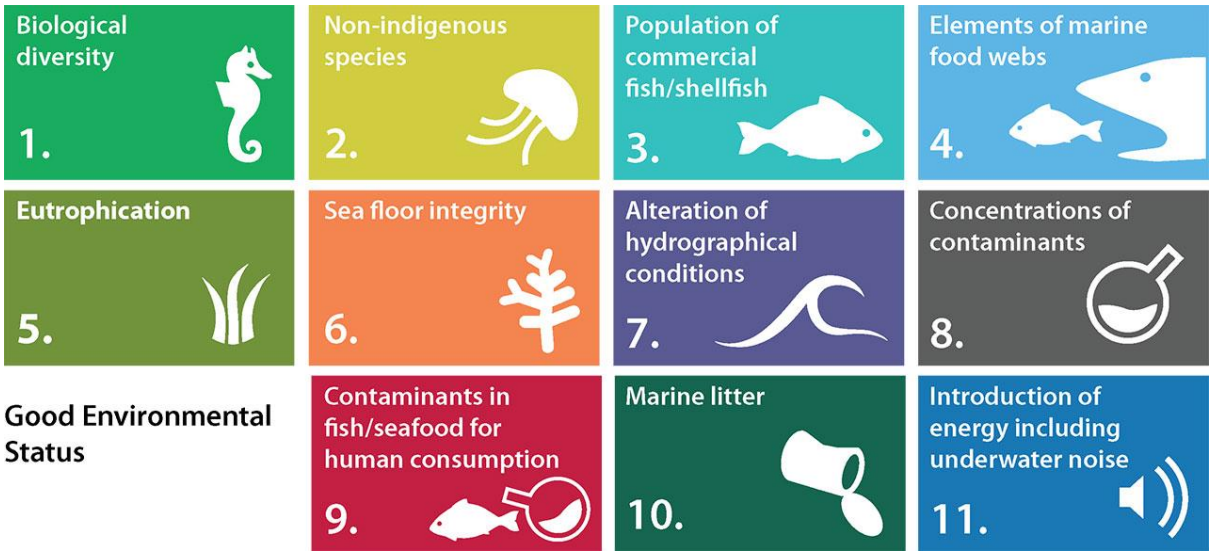


Figure 3: Scheme displaying the 11 indicators to assess GES

The Birds Directive (Directive 2009/147/EC)

This directive contributes significantly to the Blue Economy by safeguarding the biodiversity based on marine ecosystems, where most marine and costal activities are supported. Bird Directive foreseen the following actions in relation to Blue Economy:

- **Protection of habitats critical to economic activities –** designation of Special Protected Areas.
- **Sustainable tourism –** by protecting habitats for bird species and supporting eco-tourism and bird-watching activities.
- **Marine and Coastal Ecosystem Health –** the directive indirectly protects marine ecosystems by safeguarding species reliant on coastal and marine habitats.
- **Support the development of maritime renewable energy –** by avoiding harmful activities and infrastructure in areas with high ecological importance, by considering bird populations and conservation status during planning.

Environmental Impact Assessment (EIA) Directive (Directive 2011/92/EU)

This directive ensures that environmental considerations are integrated in planning and approval of projects affecting directly and in-directly marine and other water bodies

MedBlue Economy Platform. For example, in case of port expansions EIAs ensure that the project incorporates measures to minimize dredging impacts, protect marine biodiversity, and maintain water quality, supporting sustainable maritime transport and fisheries. Key pillars of this directive supporting Blue Economy include:

- **Sustainable project development** – the EIA Directive mandates that all projects that are likely to have significant effects on the environment undergo a rigorous assessment process.
- **Support for renewable energy projects –** the EIA Directive facilitates the development of offshore wind farms and other marine renewable energy projects by ensuring that environmental concerns, including impacts on seabirds, marine mammals, and benthic habitats, are addressed during planning stages (Annex IV).
- **Community engagement and transparency** – the directive requires public participation and consultation during the assessment process (Article 6).
- **Mitigation of negative impacts** – EIA reports, as required by Annex IV, detail mitigation measures to minimize or offset the environmental impacts of proposed projects.
- **Cross-Sectoral Planning** – the EIA Directive complements other EU legislation, such as the Marine Strategy Framework Directive (2008/56/EC) and the Habitats Directive (92/43/EEC), by ensuring that Blue Economy projects align with broader goals for marine conservation and sustainable development.

Energy Efficiency Directive (Directive 2012/27/EU)

This directive establishes measures to promote energy efficiency within the EU. Improving energy efficiency in maritime industries reduces operational costs and environmental impact, contributing to the sustainability of the Blue Economy[28].

Water Framework Directive (Directive 2000/60/EC)

The Water Framework Directive (WFD) was designed to protect and improve water quality in rivers, lakes, groundwater, and coastal waters. Its goal is to make all European waters clean and healthy by reducing pollution, protecting ecosystems, and ensuring a good balance between human activities and nature. It follows a "one out, all out" rule, meaning that if even one quality standard isn’t met, the whole water body

is considered not in good status. The WFD promotes cooperation and long-term actions to secure clean water for people and wildlife.

4.2 The EU Green Deal

Launched in 2019, the European Green Deal consists of a package of policy initiatives, which set the EU on the path to a green transition, with the ultimate goal of reaching climate neutrality by 2050[29]. The adoption of EU Green Deal re-shaped the EU framework on Blue Economy by shifting the current strategies and policies into a more decentralized approach. Blue Economy principles were integrated and mainstreamed across key pillars of the EU Green Deal. This further increased the importance of Blue Economy and its inter-sectorial approach that was first introduced in the IMP policy. The EU Green Deal tackles the Blue Economy by ensuring the integration of three main pillars (environmental, social and economic) into maritime sectors in the context of climate neutrality goal by 2050. The integration of Blue Economy into the EU Green Deal has produced the following policy milestones, largely in strategies and policies such as *EU Circular Economy Action Plan, EU biodiversity Strategy, Energy Transition, Farm to Fork, Zero Pollution.*

Its principles involve:

- **Increased protection of maritime biodiversity and ecosystem restoration**

  In alignment with the EU Biodiversity Strategy for 2030, 30% of EU seas will be designated as Marine Protected Areas (MPAs). Degraded ecosystems will be restored, such as coral reefs and seagrass beds, which are vital for biodiversity and carbon sequestration. Pollution will be reduced by combating marine litter and preventing water pollution by plastic waste leakage and nutrients from agriculture.

- **Expansion of marine renewable energy**

  In alignment with energy transition's goals under EU Green Deal, the EU seeks to boost the production of clean, renewable energy by increasing the installation of offshore wind farms and supporting innovation in marine energy technologies. This will further increase funding opportunities and inter-sectorial cooperation between energy and the Blue Economy.

- **Circular economy in the Blue Economy**

  In alignment with the EU Circular Economy Action Plan, which promotes the transition to circular economy, the Green Deal will envisage measures and actions directly and indirectly supporting Blue Economy. This will mainly contribute to the environmental dimension of Blue Economy. Through this plan, the EU will support the development of biodegradable materials for use in maritime industries, such as fishing gear and packaging, thus decreasing the level of plastic pollution and harmful leakage into waters. Also, this plan will encourage industries in Blue Economy to adopt circular practices and approaches, such as using marine biomass for sustainable products or converting ocean waste into reusable materials.

- **Sustainable fisheries and Aquaculture**

  The adoption of the EU Green Deal created necessity for the revision of EU's Common Fisheries Policy (CFP) in alignment with targets and overarching targets of EU Green Deal. The revised CFP ensures that fish stocks are managed sustainably by setting catch limits based on scientific estimations to avoid the depletion of fish populations. Also, CFP foresees measures to reduce illegal, unreported and unregulated (IUU) fishing through strict enforcement and coordinated monitoring systems.

- **Protection of coastal areas and blue-friendly infrastructure**

  The EU Green Deal contributes to sustainable coastal development by combating coastal erosion and protecting marine habitats through nature-based solutions. Coastal zones are critical for Blue Economy sectors since they host shipping, fisheries and tourism. Therefore, the EU Green Deal set strict rules and procedures for the infrastructure in these areas. Innovative and eco-friendly infrastructures that respond to environmental limits are highly encouraged and financially supported.

- **Advancement of innovation and technological support for Blue Economy**

  The EU Green Deal is a transformative reform for systematic transition of certain economic areas enabled by innovative and carbon-less technologies. Thus, the EU Green Deal drives innovation in the Blue Economy by funding research and

technological development in marine-related industries, such as **smart shipping, marine biotechnology, ocean monitoring,** and **sustainable coastal development.**

4.2.1 Institutional framework and financial support

The EU institutional framework for the Blue Economy involves a range of institutions operating at central, regional, and local levels. This multi-level governance approach ensures a balance between centralized EU policy-making and local adaptability based on financial capacity, technical expertise and tailored solutions. These institutions work collaboratively to develop, implement, and monitor policies supporting sustainable growth in maritime sectors. Here's a ranking from central to local, with their key roles (*Figure 3)*.

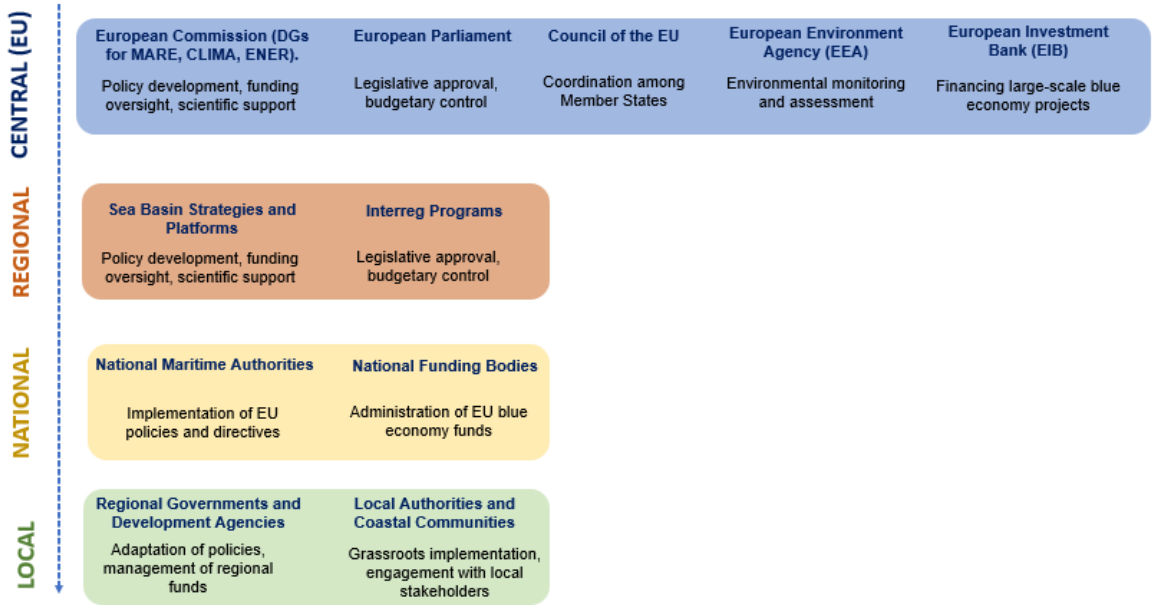


Figure 3: EU institutional framework dealing with Blue Economy, source: adapted by the author.

The EU budget contribution for the development of Blue Economy's actions is significant for creating pilot models and supporting innovation. EU funds target various areas and activities, mostly tackling fisheries, aquaculture, maritime renewable energy, and coastal tourism, aligning with sustainable development goals and the key reforms of EU Green Deal. Key EU funding mechanisms (*Table 3*):

European Maritime and Fisheries Fund (EMFF)	The primary funding sources for maritime and fisheries activities in the EU. Throughout the period 2014-2020, its budget was 6.4 billion. This fund also supports innovation and advancing of sustainable practices of fishing techniques and aquaculture. For 2021-2027 this fund has been replaced by the European Maritime Fisheries and Aquaculture fund (EMFAF), with a similar purpose but with an extended framework and scope.
Horizon 2020 and Horizon Europe	Horizon 2020 (2014–2020) allocated €338 million for marine and Blue Economy research through initiatives like Blue Growth calls. This legacy continues with Horizon Europe (2021-2027), funding projects that drive innovation in sectors such as renewable energy, marine biodiversity conservation, and sustainable aquaculture.
European Regional Development Fund (ERDF)	ERDF supports regional development and it has specific budget lines for Blue Economy projects, providing investments in coastal infrastructure, maritime transport, and tourism initiatives.
Connecting Europe Facility (CEF)	It focuses on enhancing connectivity across Europe, including investments in maritime infrastructure such as ports and shipping.
LIFE Programme	LIFE provides funding for environmental and climate action projects. Moreover, it supports initiatives aimed at marine conservation, reducing pollution, and protecting ecosystems critical for Blue Economy activities.

European Investment Bank (EIB)	The EIB finances large-scale Blue Economy projects, including offshore wind farms, port infrastructures, and ocean energy initiatives, through mechanisms like the European Fund for Strategic Investments (EFSI). It offers blended finance options to reduce risks and attract private investment in innovative Blue Economy ventures.
Regional and Local Initiatives	Interreg Programs promote cross-border and interregional cooperation for Blue Economy projects, such as marine conservation, coastal tourism, and renewable energy development. Also, another funding opportunity enables community empowerment for Blue Economy's actions: Community-Led Local Development (CLLD). It is facilitated through the EMFF, empowering coastal communities to lead small-scale, innovative projects tailored to local needs.

Table 3: EU financial support earmarked for Blue Economy, source: adapted by the author

4.3 The EU Blue Economy future challenges and trends

The stability of the Blue Economy in the EU is undermined by several challenges and emerging trends. These challenges and trends are connected to climate change, environmental pollution, technological advancements, availability of financial support, economic demand, and policy priorities.

The impact of climate change on marine and freshwater ecosystems is evolving and will be the greatest challenge. Warming oceans, rising sea levels and acidification will disrupt marine life, fisheries, and coastal economies. EU will need to adopt measures to protect the established sectors of Blue Economy, while mitigating environmental damage.

The illegal and harmful activities are also a threat to the ecological status of marine ecosystems and coastal areas. Overfishing, habitat destruction and pollution are contributing to the overall biodiversity loss. **Illegal, unreported, and unregulated**

(IUU) fishing continues to be a threat, requiring more effective monitoring, surveillance, and international cooperation. The EU needs to ensure that fish stocks are sustainably managed to prevent depletion, which will require more stringent regulations and enforcement. This will require coordinated actions and adequate enforcement of strict environmental regulations.

The level of pollution from plastic waste and agriculture nutrients remains an ongoing challenge. The EU circular economy plan should support the introduction of marine-friendly materials and cycles for packages. Additionally, the chemical pollution and nutrient overloads from agriculture are poorly controlled and monitored; their pollution is invisible, and in most cases, it leads to eutrophication and the creation of dead zones in marine ecosystems. The EU Biodiversity strategy, in synergy with the EU Agriculture strategy, has foreseen measures but the enforcement is rather at the early stage after the adoption of the EU Green Deal.

Maritime transport is the largest emitter of GHGs, with a significant percentage in the global level. While there are ongoing efforts for the decarbonization of maritime transport, such as sustainable fuels and low-emission shipping technologies, the state of implementation remains limited. Also, this transition requires investment and additional regulatory support.

Many coastal communities rely heavily on Blue Economy sectors like fishing, tourism, and maritime industries. As the EU transitions to more sustainable practices, there may be short-term economic disruptions. Ensuring that the social and economic well-being of these communities is protected will be an important challenge.

Cross-border governance of marine and coastal resources is complex, especially in EU where multiple nations and international stakeholders are involved. This is important for the coordination of actions and the evaluation of investments and policies. Data collection is a challenging task in this political set-up. Therefore, compliance with environmental regulations and other directives through unified systems is important for the enforcement of laws and EU strategies.

In this context, considering the challenges the EU is expected to face in the coming years, the future of the Blue Economy will focus on:

- Expansion of marine renewable energy as a response to energy transition and crisis.
- Transition to circular economy to reduce pollution of plastic waste and increase the use of biodegradable materials.
- Investments in technological innovation and smart shipping for climate-friendly maritime transport.
- Promotion of sustainable coastal and marine tourism in order to avoid environmental pollution and degradation.
- Investments in sustainable blue projects, backed by public and private funding.
- Ensuring adequate marine spatial planning based on data and scientific monitoring, taking into consideration the environmental status and climate change’s impacts.

5. Innovation in the Blue Economy in the Adriatic-Ionian region

5.1 Albania

5.1.1 National policies for Blue Economy sector

Although the country has not yet established a dedicated strategy for the Blue Economy, several national policies address aspects related to it. For example, the National Strategy for Development and Integration (NSDI) for the period 2021-2030 focuses on sustainable economic growth and improved management of natural resources, including marine and coastal areas. Additionally, the National Water Management Strategy (2018-2030) promotes the sustainable management of water resources, including rivers, lakes, and coastal ecosystems, by implementing measures to reduce marine and coastal pollution, monitor water quality, and educate local communities on the importance of protecting aquatic ecosystems. Furthermore, the Strategy for Fisheries and Aquaculture Development (2021-2027) provides financial support for activities that adopt sustainable practices. The challenges of plastic pollution and tourism-related impacts are addressed through the Plastic Recycling and Reduction Programs (2020-ongoing) and the Sustainable Tourism Strategy (2019-2025), respectively. Finally, Albania is part of the EU Strategy for the Adriatic-Ionian Region (EUSAIR), which aims to foster regional cooperation for sustainable economic development and marine ecosystem protection.

5.1.2 Main challenges and threats

The limited marine and port infrastructure restricts the development of key sectors such as fishing, aquaculture, and tourism; therefore, investments are necessary, along with international cooperation to share expertise and technologies. Additionally, establishing training and education programs for professionals in fishing, tourism, and aquaculture is essential to address the lack of skills and expertise in the Blue Economy sector.

5.1.3 Overview of the national innovation ecosystem

Universities and research centers play a leading role in advancing marine technologies. Programs like IPA-ADRION and EUSAIR support innovation in the country by promoting research, sustainability, and regional cooperation. Albania is experiencing an increased use of digital technologies for monitoring and managing aquatic resources, along with pilot projects focused on sustainable aquaculture and eco-friendly fishing practices. In marine waste management, various projects are being implemented to promote recycling and reduce plastic pollution along the coastline. The tourism sector is also evolving, with emerging services designed to highlight marine biodiversity and preserve coastal cultural heritage. Additionally, renewable energy sources such as wind and wave power are being explored to support marine-related activities. Collaboration with international partners further strengthens Albania's capacity by fostering knowledge exchange and the adoption of best practices across the Adriatic-Ionian region. Despite progress, the innovation ecosystem faces obstacles such as lack of funding for research and innovative projects, limited collaboration between universities and the private sector, and the need for more supportive policies for startups and new businesses.

5.1.4 Case studies description

The Karavasta Lagoon is one of Albania's most important biodiversity hotspots, hosting various aquaculture activities. Sustainable farms have been established, supported by advanced water quality monitoring systems. As a result, fish production has increased, leading to higher exports to European markets while minimizing negative impacts on the local ecosystem.

Another example of sustainable project is the "Clean Adriatic" project, that was developed in collaboration with local communities to address plastic pollution along the Vlora coast. New recycling technologies have been introduced, along with educational initiatives to raise awareness about waste sorting and recycling. These efforts have led to a reduction of plastic waste in the coastal area and improved awareness among residents and local businesses.

Moreover, in Saranda, Blue Tourism Centers have been created to promote ecological diving and tourism focused on marine biodiversity. Sustainable tourism practices have been developed to minimize visitor impact on marine ecosystems, with international

partnerships supporting the promotion of protected areas. This initiative has attracted more tourists interested in ecological tourism and strengthened the local economy through small business development.

5.1.5 Future national trends and challenges

Pollution remains a serious issue, particularly in coastal areas like Durrës and Vlora. Climate change is negatively affecting Albanian ecosystems and economic sectors like aquaculture and tourism. Therefore, future efforts need to be focused on overcoming environmental problems by choosing strategies that could promote sharing of resources with neighboring countries. A serious challenge that needs to be addressed is represented by the previously discussed notable limitations in skills and technology to support innovation; it needs to be tackled by following the example of many developed countries, which are investing in education and technology to improve skills and expertise in Blue Economy sectors.

5.2 Bosnia and Herzegovina

5.2.1 National policies for Blue Economy sector

Concerning the Republic of Srpska (RS), the responsible public body is Ministry of Agriculture, Forestry and Water Management. Legal framework includes the Law on water, while ministry activities are related to water management in general[30]. This law focuses on characterization of water, territorial water management, water use by abstraction, and protection of water from pollution. It prescribes the adoption of 24 by-laws or acts by the Government of the Republic of Srpska or the relevant Ministry. Integrated Water Management Strategy of the Republic of Srpska 2015-2024 has set the main objective to achieve unique, managed and fully coordinated water regime in the territory of the Republic of Srpska, in each of its two regional river basins (Danube and Adriatic Sea)[31].

The Federal Ministry of Agriculture, Water Management, and Forestry performs administrative and professional tasks as mandated by law within the Federation of Bosnia and Herzegovina (FBiH). The Water Law governs water management across the Federation's territory, addressing aspects such as water protection and utilization, flood defense, and the regulation of watercourses. Specifically, the law defines public and private water resources, outlines water infrastructure requirements, and

designates the roles of legal entities and relevant institutions in water management. Additionally, it covers the establishment and enforcement of sanitary protection zones for groundwater sources, ensuring compliance with existing regulations[32].

5.2.2 Main challenges and threats

Decrease in water quality represents the main challenge to address in Bosnia and Herzegovina (BiH): surface and underground waters are at risk of further degradation, and in some watercourses the water quality has already been significantly impaired. One of the main challenges in preserving water quality is the drainage and purification of wastewater, whether it comes from active industrial and other economic pollutants, municipal wastewater, or leachate from landfills. Also, agricultural activities in the country put significant pressure on water quality. The most serious situation is happening in the Bosna River basin, where the quality of surface water is terribly low. Since it is a highly inhabited area it suffers the greatest load in the country from municipal wastewater. Also, here is the largest concentration of industrial plants, which are both large consumers and polluters of water. According to the current legislation, all industrial producers are obliged to build their own devices for the pretreatment of industrial wastewater before discharging it into the public sewage system or to purify their wastewater before directly discharging it into a natural recipient. However, this is not applied to a significant number of industries in BiH. A significant problem is also posed by the hydro morphological changes in water bodies of surface waters caused by the construction of dams, hydroelectric power plants, embankments and other facilities. This results in the failure to maintain an environmentally acceptable flow in certain watercourses, further exacerbated by the lack of enforcement of regulations on sanitary protection zones for groundwater sources. There are also shortcomings in the establishment of systematic monitoring, especially of groundwater, and in adequate control and supervision of the monitoring system[33].

5.2.3 Overview of the national innovation ecosystem

Cooperation between different parties is the major driver of innovation in Bosnia and Herzegovina. The recently signed Memorandum on Cooperation between VTK BiH (Foreign Trade Chamber of BiH), OACM (Ocean Alliance Conservation Member), and the International Chamber of Blue Economy Commerce (ICBEC - International Chamber of Blue Economy Commerce) provides the basis for the coordination of the

project for systematic cleaning and maintenance of Bosnian water resources. Representatives of the Ministry of Foreign Affairs of BiH, the Ministry of Tourism and the Environment of FBiH, the Chamber of Foreign Trade of BiH, and companies from Bosnia and Herzegovina held meeting on presenting cooperation with the organization OACM, a global conglomerate for the conservation and cleaning of water surfaces. Additionally, a Republic Water Information System (RWIS) has been established to promote quality monitoring based on geographic information systems (GIS) technology[34]. This system enables storage and processing of data, contributing to planning and operational tasks of importance for water management.

5.2.4 Case studies description

Water quality has been described as the major concern to BiH's waters. To provide an innovative solution, a water disinfection device was installed at the Slapnica pumping station, from where citizens of Velika Kladuša are supplied with drinking water. The device represents a new technology that works on the principle of producing liquid chlorine through electrolysis from salt, without harmful effects on the environment. In the coming period this device is planned to be installed at the remaining four pumping stations in Velika Kladuša in order to provide all users with better quality and healthy drinking water[35].

5.2.5 Future national trends and challenges

There is a lack of integration of climate change adaptation measures in strategic planning documents in the water sector at levels of entities, cantons, and local municipalities. Therefore, the withdrawal of funding from international funds is essential to cope with this issue. There is also a gap in programs and project documentation that outline measures for adapting to climate change and protecting against floods and droughts. Efforts must be directed towards addressing this lack, in addition to increasing funding. RS and FBiH have developed forecast models for the Una, Vrbas, Bosna, Ukrina, Drina River basins, and The ISRBC (International Sava River Basin Commission) has established a forecast platform for the Sava River Basin. A project is currently being prepared to develop a forecast platform for the Trbišnjica RB in RS and the Adriatic Sea in FBiH. To promote models' efficiency, improvement and further development of the network of hydrological and precipitation stations on watercourses.[36]

Other issues, such as water sanitization and flood risk management, are being addressed through various projects. The WATSAN project's aim is to reconstruct and build new water supply networks, sewage systems and wastewater treatment plants, while a flood risk management project, funded by the EU, aims to reconstruct flood protection structures to ensure better water management in the country. During the roundtable, stakeholders highlighted that wastewater treatment represents a major challenge in the country. The lack of sufficient funding, high operational costs, and a large workforce contribute to the shifting of this sector towards unsustainable practices, being the construction of new facilities more cost-effective than rehabilitating and modernizing existing structures. Therefore, with EU financial support, it is essential to implement sustainable practices in the future.

5.3 Croatia

5.3.1 National policies for Blue Economy sector

Croatia's water management is governed by national laws aligned with the European Union Water Framework Directive (WFD). Key legislative and institutional developments include National Water Management Plans, which outline strategies for sustainable water use, pollution control, and climate change adaptation; monitoring systems, that are extensive networks with the aim of monitoring water quality and quantity; transboundary cooperation, consisting of international water agreements, particularly within the Danube River Basin framework. In addition, the implementation of Integrated River Basin Management Plans (IRBMPs) in Croatia is in accordance with directives issued by the European Union to protect hydrological quality and biodiversity.

5.3.2 Main challenges and threats

Biodiversity loss represents a multifaced problem that both affects the environment and the economy. A direct consequence of human exploitation of natural resources is represented by the decline in fisheries: according to the Croatian Bureau of Statistics, the number of fish caught from the sea declined by approximately 5,870 tonnes in 2021, which represents a 6.5% decrease compared to the previous year. The freshwater sector is facing the same issue, witnessed by a decrease of 11.4% between 2018 and 2024.
Additionally, issues related to the sectors of infrastructure and innovation particularly

hinder the development of the Blue Economy in this country. This problem is particularly evident in the inland waterways, where insufficient funding leads to a lack in operations, maintenance, and modernization. In Croatia and across Europe, taxpayers bear most of the operational costs, while private barge operators contribute minimally through lockage fees[37]. Compounding the issue of funding is the ageing infrastructure of locks, dams, and ports. Many of these structures are decades old and prone to breakdowns, leading to shipping delays and increased operational costs for users[38]. The deterioration of navigational channels and hydraulic structures impacts trade efficiency, discouraging industries from relying on inland water transport as a viable alternative to road and rail networks. Another critical obstacle is the lack of research and development focused on inland waterway innovation. Unlike rail or road transport, which benefit from continuous advancements in technology and automation, inland waterways receive limited research funding[39].

5.3.3 Overview of the national innovation ecosystem

Croatia is driving innovation in several fields of the Blue Economy, to become a leader of sustainability in the Adriatic zone. Companies like Indra Water are developing systems that recycle up to 95% of wastewater for reuse, significantly reducing contamination and improving water quality in inland systems[40]. Meanwhile, advances in sensor technology and AI enable real-time monitoring of water quality and quantity. The advancements in technologies are accompanied by solutions based on the conservation of natural heritage, such as wetland restoration. To increase more innovation and development in the sustainability field, The Croatian government has taken a significant step in this direction by launching the INpuls 2025 initiative, which is a national awards program that promotes sustainable urban practices. As concerns energy production, Hydropower contributes significantly to Croatia's energy matrix, with plants located on major rivers such as the Drava. However, balancing hydropower with ecological and recreational needs remains challenging[41].

5.3.4 Case studies description

According to the Food and Agriculture Organization (FAO) of the United Nations, fishing nets can persist in marine ecosystems for hundreds of years, depending on their material composition, size, and environmental conditions. The natural decomposition of plastic fishing nets takes an estimated 600 to 800 years, which is 200

years longer than the decomposition of plastic bags[42]. One of the most effective approaches to clean the marine environment has been the implementation of innovative techniques to recover abandoned fishing nets and plastic debris. Divers involved in these initiatives use floating balloon systems to safely lift heavy and extensive fishing nets from the seabed to the surface. During a single day of operations, the diving teams can successfully remove 200 kilograms of fishing nets. This represents a concrete effort put by Croatia to address a major threat in marine ecosystems' health.

5.3.5 Future national trends and challenges

Tourism is one of the sectors where the economy of the country lies more. To promote sustainable development, Croatia's Sustainable Tourism Development Strategy until 2030 includes a range of specific initiatives aimed at promoting sustainable practices across the tourism sector. The strategy emphasizes the need to reduce the seasonality of tourism, which is particularly pronounced in the country. Initiatives under this goal include promoting off-peak travel and encouraging tourists to explore less visited regions throughout the year. This approach aims to balance tourist flows and alleviate pressure on popular destinations during peak seasons, thereby enhancing the overall tourist experience while benefiting local economies[43]. Also, a significant focus of the strategy is on environmental preservation. This includes implementing measures to minimize waste generation, reduce plastic usage, and promote energy efficiency within tourism operations. The strategy also advocates for the adoption of renewable energy sources in tourism facilities, aiming to decrease the carbon footprint associated with tourism activities[44].

In order to achieve a balance between development and conservation, Croatia ought to implement ICZM frameworks. This includes more stringent laws for zoning and practices that promote sustainable tourism[45].

The future Croatian objectives include enhancing collaboration within the Adriatic-Ionian Initiative and adhering to the goals of the European Union, and actions to support wildlife and ecosystems health.

Concerning trends in energy production, the potential for harnessing wave energy along the Croatian coastline is significant. Current assessments suggest an average energy density of approximately 2.5 kilowatts per meter, with theoretical annual

potential reaching up to 128 Terawatt hours[46]. This suggests that this sector will be one of the most growing in the next years.

5.4 Greece

5.4.1 National policies for Blue Economy sector

The Greek Blue Economy is supported by several EU policies and frameworks, such as the Integrated Maritime Policy (IMP), the Marine Strategy Framework Directive (MSFD), and Maritime Spatial Planning (MSP). Furthermore, Greece is conducting Special Environmental Studies for all Natura 2000 sites, essential for protecting biodiversity and managing marine protected areas effectively, while European Maritime and Fisheries Fund (EMFF) and European Maritime, Fisheries and Aquaculture Fund (EMFAF) are supporting Greece's fisheries, aquaculture, and coastal community development; the total financial allocation for the 2021-2027 Greek program is €519.6 million over the next six years, of which the EU contribution accounts for €363.7 million[47].

Concerning Greece-specific legislation, Greece's National Smart Specialisation Strategy (ESEE) for 2021-2027[48] identifies eight priority areas, including Environment and Circular Economy, which are pertinent to the Blue Economy. Governance of the ESEE involves multiple levels, ensuring coordinated implementation across national and regional authorities. This structure supports the integration of Blue Economy initiatives within broader economic development plans, promoting regional strengths and addressing specific maritime challenges. Greece's Smart Specialization Strategy provides a framework regarding the Blue Economy that aligns with EU policies and global trends. By focusing on sustainable development and stakeholder engagement, this strategy aims to enhance Greece's maritime sectors, contributing to economic growth and environmental stewardship.

5.4.2 Main challenges and threats

Based on the findings of the Union of Mediterranean Symposia and recent announcements by the Greek Government, the most pressing challenges primarily revolve around the region's environmental status. These challenges inevitably give rise to conflicts over resource use, particularly due to the growing demand for water across key sectors such as agriculture, industry, and tourism. Additionally, overfishing continues to pose a significant threat to fish stocks, endangering both marine

biodiversity and a vital sector of the Greek economy. As maritime activities expand, ensuring the safety and security of these operations becomes increasingly complex. This includes addressing risks associated with maritime transport, infrastructure, and the sustainable management of marine resources.

5.4.3 Overview of the national innovation ecosystem

Greece's national innovation ecosystem has undergone significant transformation in recent years, driven by strategic policies and alignment with European Union directives. Through the Entrepreneurial Discovery Process (EDP), the ESEE engages stakeholders from industry, academia, and civil society to identify and capitalize on competitive advantages. In aquaculture and fisheries, investments in smart aquaculture systems integrating IoT and real-time monitoring are prominent, aiming to increase productivity while minimizing environmental impacts.
Renewable marine energy is another key area, with offshore wind farms and tidal energy projects being explored to diversify Greece's energy mix and support its green energy targets. Coastal and marine tourism is also evolving, with the development of sustainable tourism through digitalization. In the field of marine biotechnology, research on marine-derived pharmaceuticals and bio-based materials is emerging as a potential area of economic growth. The digitalization of ports and smart logistics is bringing significant innovation, with the incorporation of blockchain for supply chain transparency and AI for predictive maintenance. Additionally, waste management and the circular economy in marine environments are receiving increased attention, with projects focusing on marine litter reduction and waste-to-energy technologies as critical contributions to sustainable practices.
Greece has witnessed rapid growth in its startup ecosystem; startups are increasingly exploring areas like yachting, berth allocation, and eco-friendly tourism, helped by the implementation of innovative technologies and supported by government initiatives such as the EquiFund program and accelerator programs like Envolve Entrepreneurship. Moreover, regional authorities play a crucial role in implementing innovation policies, particularly through the deployment of Regional Operational Programs (ROPs) under the EU’s Cohesion Policy. Regional innovation hubs, particularly in maritime regions like Crete and the Aegean Islands, foster localized innovation in the Blue Economy.
Despite significant progress, Greece’s innovation ecosystem faces challenges such as

limited private sector R&D investment, fragmentation among research institutions, and the need for enhanced technology transfer mechanisms.

5.4.4 Case studies description

Successful case studies include efforts from local fishing cooperatives in areas like Cyclades that have adopted sustainable fishing practices, including selective fishing techniques and marine protected areas (MPAs) to ensure long-term viability of fish stocks. Additionally, the adoption of multi-trophic aquaculture combines species like mussels and seaweed to reduce waste and enhance production efficiency. Another case is represented by the Zakynthos National Marine Park, that integrates ecotourism with conservation, providing guidelines for responsible tourism while protecting species such as the loggerhead sea turtle (*Caretta caretta*).

5.4.5 Future national trends and challenges

Greece's national trends in innovation and development are shaped by its strategic priorities, aligning with EU policies. One key aspect is digital transformation and smart technologies, where digital innovation is expected to play a critical role in Greece's development. Smart ports will emerge through the adoption of digital logistics systems, AI-powered analytics, and IoT solutions to enhance efficiency and reduce emissions. Major ports like Piraeus and Thessaloniki have already adopted these smart technologies to improve logistics and reduce emissions.
The use of satellite technologies and AI will serve for improvements in maritime spatial planning, biodiversity monitoring, and illegal fishing detection. Additionally, blockchain in fisheries will ensure supply chain transparency and traceability in fisheries and aquaculture. Greece is also ready to advance its role in renewable energy and decarbonization through multiple initiatives. Expanding marine renewable energy projects will involve investments in offshore wind farms and wave energy technologies to align with EU Green Deal targets. Island decarbonization efforts will establish Greece's islands as pilot zones for renewable energy integration, reducing dependency on fossil fuels. Furthermore, zero-emission shipping will be promoted through the adoption of low-carbon and hydrogen-based fuels, backed by international collaborations and EU funding, supporting a sector in which Greece is a global leader[49]. Sustainable tourism and coastal resilience will remain a focal area, with initiatives aimed at eco-friendly tourism infrastructure, including the development of

green marinas and low-impact cruise terminals. Climate change adaptation measures will be implemented through policies to protect coastal areas from rising sea levels, erosion, and habitat loss, using nature-based solutions. Meanwhile, blue biotechnology and innovation in marine sciences are expected to grow, driven by research into marine-based pharmaceuticals and developing desalination plants. Education and capacity building will also play a crucial role in preparing a skilled workforce to meet the demands of emerging industries.

5.5 Italy

5.5.1 National policies for Blue Economy sector

The Italian legislation regarding the protection and regulation of water bodies presents a rather fragmented framework. To repair this gap, a management plan for the seas, called *Piano di Gestione dello Spazio Marittim*o, was officially adopted in 2022. The document was prepared by the Interministerial Committee for Maritime Policies (CIPOM), with the participation of eleven ministers, and focuses on sixteen main points, referred to as "guidelines": maritime spaces, commercial routes, ports, energy derived from the sea, the ecological transition of the maritime industry, fishing and aquaculture, shipbuilding, the shipping industry, maritime labor, ecosystems and marine protected areas, the underwater dimension and geological resources of the seabed, the systems of smaller islands, maritime tourism, climate change, European and international cooperation and security. Additionally, a national document to consider is the *Piano per la Transizione Ecologica*, approved on March 8, 2022, by the Interministerial Committee for Ecological Transition (CITE). This plan outlines goals for the 2021-2050 period, including decarbonization, restoration, and protection of the sea.

5.5.2 Main challenges and threats

The Italian Blue Economy faces significant threats, primarily driven by environmental impacts that, in turn, affect economic stability. Pollution and urban sprawl continue to undermine the tourism sector, while overfishing depletes fish stocks, jeopardizing the livelihoods of those dependent on the fishing industry. Equally critical is the situation concerning the maritime transport sector, particularly because of the increasing presence of large vessels such as cruise ships. Cruise traffic in Italy experienced remarkable growth in the years leading up to the pandemic, with Italian ports recording

12.8 million passengers in 2023 alone[50]. These vessels not only cause severe damage to the seabed but also exacerbate overtourism in destinations along their routes. The pressure on coastal cities has highlighted the urgent need for comprehensive regulatory measures to manage passenger influx, particularly in ports capable of accommodating these massive ships. Without such intervention, many cities may struggle to cope with the growing challenges.

5.5.3 Overview of the national innovation ecosystem

According to the XII *Rapporto sull'Economia del Mare* 2024, in 2023 Italy counted 227,974 companies operating in this sector. However, there is still work to be done regarding youth entrepreneurship, as the report indicates that only 9% of the enterprises are youth-led. Encouraging data regarding Gross Value Added (GVA) comes from the EU Blue Economy Observatory - *Italy* section. According to this source, Italy ranks third in Europe for GVA in coastal tourism and shipbuilding and repair, and sixth in employment in port activities. Furthermore, the XII *Rapporto sull'Economia del Mare* 2024 highlights a 15.1% increase in GVA from 2021 to 2022 (representing 3.7% of the national economy). There was also a 6.6% increase in employment in the Blue Economy sector during the same period, accounting for 4.1% of national employment.

5.5.4 Case studies description

The Lagoon of Venice is a unique environment that hosts a wide range of species. The presence of aquatic plants, macroalgae, and phytoplankton plays a key role in absorbing CO2 from the atmosphere. Therefore, the protection of these habitats is essential for mitigating the impacts of climate change and limiting the concentration of greenhouse gases in the air. Several organizations are dedicated to preserving this habitat, and restoration projects are actively working towards this goal.

One example of restoration initiative is the SeResto project, funded by the European Union under LIFE Programme, that facilitated the recolonization of the northernmost part of the lagoon. This was achieved through extensive manual transplantation of lagoon plants, with support from local stakeholders[51]. Another interesting project is REST-COAST, funded by Horizon 2020, aimed to develop the river-coast connectivity and increase the nearshore accommodation space for the resilient delivery of coastal ecosystem services (ESS). A specific pilot regards Venice. AcquaGuard is another EU-

funded project (Interreg Italy-Croatia Programme), where Nature-Based Solutions (NBS) are explored as solutions for reducing climate-related risks and hazards, increasing authorities' ability to prevent floods.
These are just a few examples of interesting EU-funded projects where Italian Partners and stakeholders have been involved in these years.

5.5.5 Future national trends and challenges

In terms of future plans, Italy commits to following the guidelines set forth in the *Piano di Gestione dello Spazio Marittimo* (Piano del Mare) for the 2023-2025 period. Italy aims to align with the goals outlined in the European Green Deal, which establishes three fundamental objectives: halting greenhouse gas emissions by 2050, ensuring economic growth is decoupled from the use and exploitation of resources, and leaving no person or territory behind. In the shorter term, the European Green Deal also aims to reduce greenhouse gas emissions by at least 55% by 2030.

5.6 Montenegro

5.6.1 National policies for Blue Economy sector

Key legal frameworks include the Nature Protection Law, which contains provisions for the conservation of marine ecosystems and the coastline, the Maritime Transport Law, which ensures the sustainable development of maritime transport while minimizing environmental impact, and the Water Law, which regulates the use of water resources, including underwater heritage and ecosystems, and establishes measures for preventing marine pollution. In the National Strategy for Sustainable Development until 2030[52], one of the strategic goals is defined as the sustainable management of coastal area resources and the promotion of the Blue Economy. This strategy provides the basis for Montenegro's long-term development, and significant emphasis is placed on preserving biodiversity of marine and coastal areas. The strategy also focuses on integrating sustainable practices into sectors such as tourism, fisheries, maritime transport, and energy, while promoting innovations within the framework of the circular economy.
Montenegro Regional Development Strategy 2023-2027[53] aims for balanced development between inland and coastal areas. Key points include development of infrastructure projects in coastal regions, such as ports, marinas, and energy facilities; promotion of sustainable tourism, based on the preservation of the natural

environment, with the development of eco-tourism and blue sectors such as sailing and water sports. The goal is to achieve balanced development through ecological preservation while creating new opportunities for the economy along the coast.

5.6.2 Main challenges and threats

Regulation and governance challenges hinder the effective implementation of Montenegro's strategies for sustainable Blue Economy development, with obstacles including weak inspection controls as well as insufficient measures to preserve marine biodiversity. Weak coordination between Blue Economy's sectors leads to conflicts of interest, while local communities are not sufficiently involved in decision-making regarding coastal and marine resource management. Economic factors also play a role, as Montenegro's Blue Economy heavily relies on seasonal tourism, making it vulnerable to global crises such as pandemics and recessions. Moreover, mass tourism negatively impacts the environment, resources, and the quality of life for local communities. Additionally, limited public awareness of the Blue Economy hinders the path towards a more responsible citizenship.

5.6.3 Overview of the national innovation ecosystem

The Montenegrin government plays a central role in shaping the innovation ecosystem by implementing policies and strategies to support sustainable marine development. The Smart Specialisation Strategy (S3 Montenegro)[54] is an instrument that links sectoral policies and defines priority technological domains in which new added value can be created, recognizing the Blue Economy as a priority for innovation. Trough Proposal for a National Circular Transition Strategy until 2030[55], circular economy is increasingly recognized as a key tool for reducing the ecological footprint and for better management of resources, including marine ones. Therefore, this field is currently under innovation and represents a promising future trend for investment. Academic Institutions contribute to policy recommendations for sustainable aquatic ecosystem management and collaborate with EU-funded research projects and regional initiatives to advance marine innovation.
Montenegro's Blue Economy is witnessing a dynamic evolution, with the private sector and startups playing pivotal roles in driving innovation and sustainable growth. These entities are actively contributing to sectors such as sustainable tourism, maritime transport, and aquaculture, aligning with national strategies and benefiting from

regional collaborations. Innovative ventures are emerging, particularly in areas such as sustainable aquaculture, eco-friendly maritime solutions, and marine biotechnology. The Chamber of Economy of Montenegro56 serves as a central hub, representing the entire private sector and facilitating solutions to various challenges. Montenegro participates in several EU and international programs that support innovation in the Blue Economy, such as Horizon Europe and BlueMed Initiative. These partnerships help transfer knowledge, build capacity, and attract foreign investments in marine innovation.

5.6.4 Case studies description

Montenegro's Boka Bay is home to one of an example of sustainable aquaculture project, where traditional mussel and oyster farming has been enhanced through AI-powered monitoring systems that track water quality, optimize feeding schedules, and prevent disease outbreaks. Innovations include IoT sensors to monitor environmental and pollution levels in real time, blockchain implementation, and a zero-waste approach using Integrated Multi-Trophic Aquaculture (IMTA) with seaweed cultivation to absorb excess nutrients. The impact includes a 20% increase in production efficiency, reduced environmental impact by filtering excess nutrients naturally, and higher export value.

The Port of Bar, Montenegro's largest commercial port, is undergoing digitalization and decarbonization in partnership with the Government of Montenegro, the European Maritime Safety Agency (EMSA), and private sector stakeholders. Innovations include a Smart Port Management System using AI and big data to optimize cargo handling, Onshore Power Supply (OPS) allowing ships to plug into the electrical grid instead of burning fossil fuels, and a hydrogen and LNG pilot program testing alternative fuels to reduce GHG emissions. The impact includes a 15% reduction in port emissions and improved cargo handling efficiency.

5.6.5 Future national trends and challenges

Montenegro is actively advancing its Blue Economy through strategic initiatives and international collaborations aimed at sustainably harnessing marine resources, promoting economic growth, and aligning with global environmental standards. Looking ahead, the country's Blue Economy is set to benefit from several emerging trends, including offshore renewable energy exploration, such as wind and wave

energy, which offer opportunities for diversifying Montenegro's energy portfolio while promoting sustainability. Investments in marine biotechnology are expected to foster innovations in pharmaceuticals, cosmetics, and the food industry by leveraging the unique marine biodiversity of the Adriatic Sea. Eco-friendly maritime tourism is also a priority, with efforts focused on developing sustainable tourism models that minimize environmental impact while maximizing economic benefits, including the promotion of eco-tourism and environmentally responsible coastal infrastructure. The adoption of digitalization and smart technologies in maritime operations, such as smart port solutions and autonomous vessels, will improve efficiency and reduce environmental footprints. By embracing these trends and fostering collaboration among government entities, research institutions, and the private sector, Montenegro aims to build a resilient and sustainable Blue Economy that contributes to both national prosperity and environmental stewardship.

5.7 North Macedonia

5.7.1 National policies for Blue Economy sector

North Macedonia does not have a direct maritime Blue Economy due to its landlocked status, so national policies focus on the sustainable management of freshwater resources. These policies include aligning national laws with the EU Water Framework Directive to ensure sustainable water use, pollution control, and ecosystem preservation in the country’s lakes and rivers. They prioritize the protection of freshwater habitats, the reduction of pollution from agriculture and wastewater, and the maintenance of biodiversity in Lakes Ohrid, Prespa, and Dojran. Policies also support eco-tourism and integrated rural development around these freshwater ecosystems, promoting sustainable fisheries, recreation, and cultural heritage protection. In addition, North Macedonia is working towards aligning its environmental governance with EU standards, improving infrastructure for wastewater treatment and monitoring systems as part of the ongoing EU accession process.

5.7.2 Main challenges and threats

Environmental challenges, inadequate infrastructure, gaps in wastewater treatment facilities, and limited research and monitoring capacity, along with enforcement difficulties, impede effective management. Additionally, managing shared water

bodies, such as Lake Ohrid and Lake Prespa, requires strong transboundary coordination and cooperation with neighboring countries.

5.7.3 Overview of the national innovation ecosystem

The Fund for Innovation and Technological Development (FITD) and various incubators and accelerators provide support for startups, although few are specifically focused on freshwater-related solutions. Academic and research institutions, such as Ss. Cyril and Methodius University, are actively involved in environmental research, water quality monitoring, and assessing ecosystem health. International projects and donors, including EU-funded initiatives and support from organizations like UNDP, GIZ, and USAID, help foster innovation in sustainable resource management, data-driven decision-making, and community-based solutions. Additionally, emerging digital solutions present opportunities to apply tools such as remote sensing and IoT-based water sensors to improve resource monitoring and enhance eco-tourism services. Within the field of freshwater management, tools such as water quality sensors, advanced wastewater treatment technologies, and precision irrigation systems, are being implemented.

5.7.4 Case studies description

Among the examples of sustainable management, Lake Ohrid conservation projects, supported by UNESCO and international donors, focus on reducing pollution, restoring habitats, and improving wastewater infrastructure. Another example is Prespa Lake restoration, which involves transboundary collaborations with Albania and Greece, aiming to reduce nutrient loading in the basin and return the lake to pristine state.

5.7.5 Future national trends and challenges

As North Macedonia progresses towards EU integration, stronger policy alignment with EU standards is expected, particularly in areas such as water quality, environmental protection, and resource efficiency. Tourism around Lakes Ohrid, Prespa, and Dojran is anticipated to grow, with a focus on ecotourism and sustainable business models that prioritize environmental stewardship and the protection of cultural heritage. The uptake of green and digital innovations is expected to rise, including the use of monitoring technologies, precision agriculture to reduce runoff, and renewable energy solutions for water systems. Additionally, enhanced stakeholder participation is likely

to play a key role, with greater involvement of local communities, NGOs, and the private sector in decision-making and the co-management of aquatic resources.

5.8 Serbia

5.8.1 National policies for Blue Economy sector

The current Water Law was adopted in 2010[57] and is supplemented by a series of by-laws, including regulations, decrees, and acts that govern specific areas and activities related to water management. The Water Law is based on the EU Water Framework Directive and promotes an integrated approach to water management.
The Water Management Strategy of the Republic of Serbia includes the Danube River Basin Management Plan and water management plans for different water areas. Additionally, there are plans for protection against the harmful effects of water, such as the Flood Risk Management Plan and the General and Operational Plan for Flood Protection.

This strategy serves as a planning document that outlines long-term water management guidelines aimed at implementing reforms in the water sector. It seeks to achieve necessary standards in water management through organizational adjustments and the systematic strengthening of professional and institutional capacities at the national, regional, and local levels.
Plans developed for major rivers, such as the Danube, Sava, and Tisza, include measures to protect aquatic ecosystems and achieve a good ecological status of water bodies. These plans also focus on water resource management and the prevention of flood and drought risks.
Furthermore, Serbia actively participates in regional and international initiatives for the protection of transboundary water bodies, collaborating with neighboring countries to ensure the sustainable management of shared water resources and the protection of aquatic ecosystems. Serbia is also a party to several international conventions related to water protection, including the Convention on the Protection and Use of Transboundary Watercourses and International Lakes (Helsinki Convention) and the Convention for the Protection of the Danube River.

5.8.2 Main challenges and threats

The Serbian Blue Economy faces several challenges, primarily related to deficiencies in engineered infrastructure, regulatory and institutional shortcomings, management inadequacies, and a scarcity of well-trained environmental professionals. To address these challenges and sustainably drive socio-economic progress, the Serbian government needs to conduct an in-depth analysis to identify both existing and future needs, develop an educational platform to train environmental professionals, and implement a new integrated water management system[58]. Additionally, another issue that threatens Serbian Blue Economy is the reluctance of stakeholders to prioritize the fishery sector when deciding how to manage water resources[59]. According to official data, the annual fish catch in Serbia ranges between 2,000 and 3,000 tons. However, considering unreported and illegal catches, this figure is likely between 5,000 and 10,000 tons[60]. In addition to environmental degradation, this poses significant economic challenges, including reduced revenue from legal fisheries, loss of employment opportunities in the sector, and weakened sustainability of aquatic resources, ultimately impacting the long-term economic stability of the country.

5.8.3 Overview of the national innovation ecosystem

One of the major drivers of innovation in Serbia is represented by the Water Management Strategy of the Republic of Serbia, which contains projections of the necessary means for functioning and development. The projected development and efficient management of the water sector require funds of about 21.7 billion EUR over the next twenty years. A particularly rapidly growing sector within this framework is aquaculture: fish farming in Serbia has been steadily expanding in recent years, yet it currently satisfies only a third of domestic demand. Imports, amounting to approximately 34000 tons[61], far exceed exports, which remain at just a few hundred tons, with sea fish dominating the imported supply. Notably, the areas designated for fishponds, particularly for carp, utilize only a tenth of the available potential, with most of these fish farms concentrated in Vojvodina[62]. Beyond aquaculture, water resources also play a crucial role in Serbia's tourism sector. The Tourism Development Strategy of the Republic of Serbia 2016-2025 identifies water-based tourism as a significant opportunity, leveraging the country's extensive water resources, including major rivers such as the Danube, Sava, and Tisa, as well as lakes and thermal springs. While these resources remain underutilized, they hold great potential for activities such as river cruises, fishing, water sports, and wellness tourism. The strategy envisions sustainable

development by enhancing infrastructure, promoting eco-friendly practices, and integrating water-based attractions with Serbia's cultural and natural heritage. A key focus is put on the tourism development of the Danube River, through improved port facilities, expanded cruise tourism, and the creation of cycling and hiking trails along its banks. Additionally, adventure tourism is gaining momentum, particularly on rivers like the Drina and Tara.

5.8.4 Case studies description

Serbia's approach to groundwater quality monitoring provides an example of systematic effort in assessing and improving water conditions. The monitoring network operates at 60-70 locations in the alluvial soil of larger rivers, combining the efforts of the Republic Hydrometeorological Service of Serbia and Serbian Environmental Protection Agency (SEPA). Other areas fall under the jurisdiction of regional Public Health Institutes, which conduct groundwater analyses upon request from individuals, organizations, or companies, as well as in emergencies. Between 2005 and 2013, four key chemical indicators of organic pollution were monitored: nitrates, chlorides, ammonium ions, and nitrites. Findings showed that nitrate levels gradually decreased, with fewer samples exceeding the acceptable limits. The most concerning issue was nitrite contamination, where 60% of analyzed samples surpassed the limit value of 0.03 mg/L in the later years of the study. Microbiological analyses further revealed significant regional disparities in groundwater quality. The most affected areas were in the north, particularly Vojvodina, Rasina, and Moravica Districts, where contamination with Escherichia coli, fecal Streptococcus, and coliform bacteria was common. In the Central Banat District of Vojvodina, all samples also showed excessive levels of iron, manganese, and arsenic. On the other hand, groundwater quality was significantly better in the basin of the river Nišava and the western parts of the country, where contamination levels remained low. This case illustrates both the strengths and gaps in groundwater monitoring efforts. While long-term data collection has provided insights into pollution trends and improvements in certain areas, regional disparities and the limitations of non-continuous sampling indicate the need for more comprehensive monitoring to ensure sustainable water quality management.

5.8.5 Future national trends and challenges

In order to tackle water pollution, the Serbian National Environmental Strategy aims to enhance existing infrastructure, expand sewage networks, and construct wastewater treatment plants in the major hotspot locations. The Serbian government has also announced plans to provide 70 municipalities with access to water purification plants and sewage systems. Additionally, Belgrade city authorities have secured agreements with the international community to build wastewater treatment facilities. To develop water-based tourism, the Water Management Strategy emphasizes the need for stronger public-private partnerships, increased infrastructure investment, and better coordination among stakeholders[63].

5.9 Slovenia

5.9.1 National policies for Blue Economy sector

Slovenia participates in several European projects and policies to promote sustainability in the country. For example, it adopts Maritime Spatial Planning (MSP) and adheres to Integrated Coastal Zone Management (ICZM). Additionally, the country has its own plans to foster the Blue Economy sector. Firstly, the Slovenian Development Strategy emphasizes the importance of sustainable use of its coastal and marine resources; it addresses the need for balanced growth in sectors such as fisheries, tourism and maritime transport, while ensuring the protection of the marine and coastal environment. The Slovenian fisheries policy aligns with the EU Common Fisheries Policy (CFP) and ensures the sustainable management of fish stocks and aquaculture. The protection of biodiversity in marine and coastal areas is a key objective in Slovenia’s Blue Economy policy framework. The Biodiversity Conservation Strategy of Slovenia includes action plans for safeguarding marine habitats, conserving endangered species and ensuring that marine development activities do not harm the environment[64].

5.9.2 Main challenges and threats

Slovenia has relatively limited capacity in marine research compared to other EU countries with larger coastlines, such as Italy or France. The country faces challenges in developing innovative marine technologies, particularly in sectors such as renewable energy and aquaculture. Insufficient investment in research and development hampers Slovenia's ability to fully capitalize on opportunities for innovation in the Blue Economy, which could otherwise drive growth and sustainability. While Slovenia’s coastline is

small, it lies along a key shipping route in the Adriatic Sea and maritime traffic has been growing. A Traffic Separation System (TSS), Areas to Be Avoided (ATBA), existing navigation corridors, and port areas, including berths, are maintained and further developed while being coordinated with other uses based on their potential. Aquaculture in Slovenia faces sustainability challenges related to water quality management, disease control and environmental impact.

5.9.3 Overview of the national innovation ecosystem

The Smart Specialisation Strategy (S5) is a national framework, aligned with EU innovation goals, focuses on strengthening Slovenia's competitive advantages in areas such as sustainable industry, green technologies and digital transformation[65]. Universities, such as the University of Ljubljana and the National Institute of Biology (NIB), are key poles to foster innovation in the Blue Economy. The private sector plays a significant role in driving innovation in Slovenia. Maritime Transport companies in Slovenia are increasingly adopting innovative solutions to improve the sustainability of maritime transport, including digitalization, energy-efficient ships and environmentally friendly port operations. Slovenia's government supports collaboration between research institutions, startups and established companies to drive innovation in marine industries. Public-private partnerships are crucial for advancing cutting-edge technologies, scaling sustainable solutions and developing new industries within the Blue Economy.

5.9.4 Case studies description

From 1980, the local authority began to implement a spatial plan that provided for the complete filling of the Škocjan Bay, placed on the southwestern zone of the country. As a result of backfilling and drying, the Škocjan Bay lagoon has shrunk from the former 230 to a modest 80 hectares, reducing the biodiversity within it. Despite this, complete filling did not happen and the bay survived thanks to the aware representatives of civil society, led by the members of the Society for the Observation and Study of Birds of Slovenia (DOPPS), who proved to the Slovenian public that the destruction of an area with such a large and varied natural inheritance is inadmissible. In 1998 the Škocjan Bay was finally secured, and one year later DOPPS became the manager of the reserve[66].

The largest and most important role in the regeneration of the bay from a degraded area was the process of restoration and landscaping, which took place in 2006 and 2007 as part of the LIFE-Nature project "Restoration and preservation of habitats and birds in the nature reserve Škocjan Bay". Meanwhile, the first set of arrangements for visitors was also completed in the bay: a circular learning trail around the freshwater marsh with four observation points. In 2015, a visitor center and a 12-meter-high central observatory were built.

5.9.5 Future national trends and challenges

One of the key trends for Slovenia’s Blue Economy is the growth of marine renewable energy. As part of the European Union’s commitment to achieving carbon neutrality by 2050, Slovenia is expected to increase its investments in tidal energy. Additionally, the trend of digitalization and the integration of smart technologies into the Blue Economy will continue to transform Slovenia’s marine industries. From smart shipping to data-driven marine conservation, digital tools will improve efficiency, sustainability, and decision-making processes. Protection of the naturally preserved coastline is a priority and represents a sector where future investments need to be made. This includes three long sections: the first is placed between the Sv. Jernej Bay or the border with the Republic of Italy and Valdoltra, the second spans between the Simon and Strunjan bays and the third is located between the Strunjan Bay and Piran. Here, Access by tourist vessels and anchoring are limited or regulated to prevent negative impacts. Furthermore, Slovenia’s maritime sector will likely adopt more sustainable practices in

ship recycling, including the reuse of materials from decommissioned ships and reducing ship emissions, and is also striving towards the reduction of plastic pollution in the seas. Finally, Slovenia's participation in EU projects and regional initiatives like the Adriatic-Ionian Initiative will strengthen cross-border efforts to protect the Adriatic Sea and promote sustainable economic activities across the region.

6. Conclusions

The report reveals a clear similarity in the challenges shared by the countries of the Adriatic-Ionian region. These are mainly caused by the negative effects of human activities on the environment, along with the need for technological development in various sectors, and underscore the need for an integrated and sustainable approach to marine and water resource management. Innovation is a key element in addressing these issues, offering advanced technological solutions that are progressively being developed and integrated in many sectors. Participation in European projects and cross-border collaboration initiatives further strengthen countries' commitment to common sustainability goals.

However, significant challenges remain, including limited financial resources, infrastructure development, and the need for communication and cooperation within and among countries. Overcoming these challenges requires joint efforts from institutions, businesses, and local communities, along with an efficient regulatory framework. Although several issues are connected to the social and governance aspects of sustainability, the environmental ecosystem health is the main driver of the Blue Economy, being ecosystems providers of invaluable services and goods to humanity. Protecting biodiversity and habitats, reducing pollution, combating global climate change and adopting sustainable practices are paramount to ensuring a positive future for the region. An approach that focuses on the environment, economy, and society can preserve and enhance the natural heritage of the Adriatic-Ionian region while also promoting social development.

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