Journal of *Marine Science and Engineering*

MDPI

Article

The Role of the Fishing Sector in the Blue Economy: Prioritization, Environmental Challenges, and Sustainable Strategies in Europe, with a Focus on Spain

Nicoletta González-Cancelas, Javier Vaca-Cabrero * and Alberto Camarero-Orive

Department of Transport, Territorial and Urban Planning Engineering, Universidad Politécnica de Madrid, 28040 Madrid, Spain; nicoleta.gcancelas@upm.es (N.G.-C.); alberto.camarero@upm.es (A.C.-O.)
* Correspondence: j.vaca@upm.es

Abstract: The fishing sector is a key component of the European Blue Economy, contributing to economic growth, food security, and employment. However, it faces sustainability challenges, including overfishing, biodiversity loss, and climate change impacts. This study uses decision tree modeling to assess the sector's prioritization within the Blue Economy, comparing its economic and environmental footprint to other maritime industries. Using EU Fleet Register data, findings reveal disparities in fleet modernization and efficiency, with industrialized fleets in Spain, France, and Italy exhibiting higher tonnage and power, while artisanal fisheries in Greece and Portugal remain more vulnerable to economic and environmental shifts. The study highlights the sector's economic relevance but also its exposure to regulatory constraints, emphasizing the need for modernization and stricter sustainability policies. The paper proposes technological innovation, enhanced regulations, and conservation-based management to align fisheries with Sustainable Development Goal 14, the EU Common Fisheries Policy, and the European Green Deal. These insights provide data-driven strategies for policymakers and industry stakeholders to ensure a more sustainable and resilient fishing sector.

Keywords: biodiversity conservation; overfishing; blue growth; marine resource governance; fleet modernization

Academic Editor: Juan José Alava

Received: 23 February 2025
Revised: 17 March 2025
Accepted: 19 March 2025
Published: 20 March 2025

Citation: González-Cancelas, N.; Vaca-Cabrero, J.; Camarero-Orive, A. The Role of the Fishing Sector in the Blue Economy: Prioritization, Environmental Challenges, and Sustainable Strategies in Europe, with a Focus on Spain. *J. Mar. Sci. Eng.* **2025**, *13*, 621. https://doi.org/10.3390/jmse13030621

1. Introduction

The fishing sector is a key pillar of the European Blue Economy, supporting food security, employment, and regional economies [1]. As one of the oldest marine industries, it remains essential for coastal communities and international seafood markets, particularly in Spain, France, Portugal, and Greece [2].

The Blue Economy (BE) presents significant challenges at economic, social, and environmental levels, necessitating a balance between growth and the protection of ocean resources to achieve sustainable development goals (SDGs) [1].

The fishing sector faces critical sustainability challenges, including overfishing, habitat degradation, and biodiversity loss, exacerbated by climate change and ineffective resource management [3].

Rising ocean temperatures and shifting fish migration patterns are increasing pressures on fish stocks, requiring adaptive and science-based regulatory strategies [4]. Degradation of habitat, extinction of species, and ecological disturbances are being brought on by rising temperatures, ocean acidification, and changed hydrological cycles. Climate change

demands flexible and adaptive management approaches that have the potential to mitigate future impacts through enhancing ecosystem resilience.

In response to these growing concerns, regulatory frameworks such as the European Union's Common Fisheries Policy (CFP) have been implemented to promote sustainable fishing practices through catch limits, quotas, and ecosystem-based management approaches [5].

Additionally, the United Nations Sustainable Development Goal 14 (SDG 14: Life Below Water) emphasizes the need for responsible fisheries management to protect marine ecosystems while ensuring food security [6]. Despite these efforts, balancing economic viability with environmental conservation remains a complex challenge for policymakers, industry stakeholders, and marine scientists.

Despite the growing emphasis on the Blue Economy as a framework for sustainable maritime development, the role of the fishing sector within this framework remains underexplored in the current literature. While previous studies have analyzed fisheries in terms of economic impact, sustainability challenges, and policy regulation, there is a lack of structured classification approaches that compare fisheries to other key maritime industries within the Blue Economy.

This study addresses this gap by applying decision tree modeling to assess the hierarchical position of fisheries within the European Blue Economy, integrating economic, structural, and environmental indicators. Unlike prior research that primarily examines fisheries in isolation, this study offers a comparative perspective, evaluating how fisheries perform relative to sectors such as maritime transport, coastal tourism, and aquaculture. Additionally, by incorporating fleet structure analysis and sustainability risk assessment, this research provides a data-driven foundation for fisheries policy development, offering new insights into fleet modernization needs and environmental impact mitigation strategies.

The findings of this study contribute to the existing literature by bridging the gap between fisheries sector analysis and broader Blue Economy classification methodologies. This research not only enhances the understanding of sectoral interactions within the maritime economy but also provides practical recommendations for policymakers, ensuring that fisheries are integrated into sustainable maritime development strategies.

This study aims to analyze the prioritization of the fishing sector within the Blue Economy in Europe by evaluating its economic, environmental, and regulatory significance in comparison to other marine-based industries such as maritime transport, coastal tourism, and aquaculture. Specifically, the study seeks to conduct the following:

- Assess the position of the fishing sector within the Blue Economy using decision tree modeling to establish its relative importance compared to other maritime industries.
- Analyze the structural characteristics of the European fishing fleet, including vessel distribution, gross tonnage, and engine power, using data from the EU Fleet Register.
- Evaluate the environmental impact of the fishing sector, focusing on overfishing, bycatch, and marine biodiversity conservation.
- Propose sustainable fisheries management strategies, integrating regulatory frameworks, technological innovations, and conservation initiatives to align the industry with SDG 14 and EU sustainability policies.

By providing a data-driven approach to fisheries sustainability, this study contributes to the discourse on how the fishing sector can evolve within the Blue Economy framework while addressing critical environmental and regulatory concerns. The findings aim to inform policymakers, industry stakeholders, and marine scientists on the need for adaptive strategies that ensure a balance between economic growth and marine ecosystem conservation.

2. State of the Art

2.1. The Role of the Fishing Sector in the Blue Economy

The Blue Economy encompasses a wide range of marine-related economic activities, integrating sustainability principles to balance economic growth with environmental conservation [7]. As a core component of this framework, the fishing sector plays a vital role in food security, employment generation, and the economic stability of coastal regions [8]. The findings indicate that fishery production significantly improves sustainable food security in the EU27 countries, particularly in developing nations, highlighting the importance of the fishery sector in achieving long-term food security.

Implementation of proven effective management practices, policies to improve accessibility and consumption patterns, and the prioritization of small-scale wild-caught fisheries are needed to ensure the food security of billions of people in coastal communities [9]. The Blue Economy presents significant challenges at an economic, social, and environmental level, which is why the Blue Grow strategy is presented as the key piece of the puzzle to guarantee environmental sustainability and efficient management of the seas and oceans' resources. In this context, the SDGs imply that economic development is both inclusive and respectful of the environment, and it is necessary to find a balance between economic, social, and environmental spaces. Therefore, it is urgent to set goals with objectives and indicators that demand productive, healthy, and resilient oceans.

According to the EU Blue Economy report (2024) [10], the fisheries and aquaculture sectors contribute significantly to the European maritime economy, yet their sustainability remains a critical concern due to environmental pressures such as overfishing, habitat degradation, and climate change [11].

Globally, the fishing industry has faced significant transformations in the past decades due to technological advancements, regulatory changes, and evolving market dynamics [12]. The introduction of sustainable fishing policies and ecosystem-based management approaches has aimed to mitigate the sector's impact on marine biodiversity. However, challenges persist in implementing effective monitoring, enforcing regulations, and integrating fisheries into a broader sustainable Blue Economy strategy [13].

The future of the fishing sector within the Blue Economy lies in the integration of technological advancements, policy adaptation, and sustainability-driven innovations. Key areas for development include the following:

- Smart fisheries and digital monitoring: the use of AI, remote sensing, and blockchain technologies for real-time stock assessment and traceability [14].
- Alternative and low-impact fishing techniques: innovations in selective fishing gear to reduce bycatch and minimize habitat destruction [15].
- Decarbonization of the fishing fleet: adoption of renewable energy sources and electrification in vessel operations [16].

By embracing sustainability-focused policies and technological solutions, the European fishing industry can transition toward a more resilient and adaptive role within the Blue Economy, ensuring long-term economic stability while minimizing environmental impact [1].

2.2. The Fishing Industry in Spain and Europe

Europe has one of the most developed and regulated fishing industries worldwide, with Spain, France, Portugal, and Greece being major players in the sector [17]. Spain, in particular, has historically maintained a leading position in the EU's fishing fleet, with a significant number of vessels, high gross tonnage, and strong international seafood trade relationships [18]. According to data from the EU fleet register, Spain ranks among the top countries in fleet capacity, alongside Italy and Greece.

Despite its economic importance, the fishing sector in Spain and Europe faces multiple sustainability challenges:

- Stock depletion and overfishing: the decline of key fish stocks in European waters has led to stricter total allowable catches (TACs) and fishing quotas [19].
- Impact of climate change: rising ocean temperatures and shifting fish distribution patterns have disrupted traditional fishing grounds [20].
- Regulatory constraints: the Common Fisheries Policy (CFP) sets strict sustainability rules that influence fleet capacity, fishing rights, and conservation efforts [21].

In response, Spain has diversified its fishing activities by strengthening its aquaculture sector and investing in sustainable fisheries management programs, including bycatch reduction initiatives, marine protected areas, and alternative energy sources for fishing fleets [22].

Spain's prominence in the European fishing sector is reinforced by the strategic importance of its ports, which serve as major hubs for both national and international fisheries. Among them, the Port of Vigo stands out as the largest fishing port in Europe and one of the most significant in the world in terms of seafood landings and trade volume [23]. Vigo plays a crucial role in the global seafood supply chain, handling large quantities of fresh and frozen fish, and hosting an extensive fish processing and distribution network. The city is also home to the International Fishing Fleet, which operates in waters across the North Atlantic, South Atlantic, and Indian Oceans, reinforcing Spain's position as a global fisheries leader [24].

In addition to its economic significance, the Port of Vigo is at the forefront of sustainability and innovation in the fishing industry. It has implemented environmental and technological initiatives aimed at reducing the ecological footprint of fishing activities. This includes bycatch reduction programs, energy efficiency measures for vessels, and efforts to decarbonize port operations [23]. Furthermore, Vigo has become a key player in the European fight against illegal, unreported, and unregulated (IUU) fishing, hosting international summits and collaborating with organizations such as the Food and Agriculture Organization (FAO) and the European Commission to enforce traceability and transparency in seafood supply chains [25]. These measures underscore Spain's leadership in ensuring the long-term sustainability of the fishing industry while maintaining its competitive edge in the European and global markets.

2.3. Environmental and Policy Challenges in Fisheries Management

The European fishing industry operates within a complex regulatory framework aimed at ensuring sustainability while maintaining economic viability [26].

The European Green Deal and the EU's Blue Economy strategy emphasize the importance of reducing the environmental footprint of fisheries through decarbonization and the adoption of alternative energy sources. Additionally, they highlight the need to enhance stock management by implementing quota allocations, advancing technological monitoring systems, and promoting data-driven decision-making to ensure sustainable resource use. Furthermore, these strategies reinforce the commitment to strengthening marine conservation efforts through initiatives such as the marine strategy framework directive and Natura 2000, which aim to protect marine ecosystems and biodiversity while supporting the long-term viability of the fishing industry [27].

Moreover, illegal, unreported, and unregulated (IUU) fishing remains a persistent issue, threatening the effectiveness of regulatory frameworks and undermining sustainability efforts [28]. Addressing these challenges requires a multi-stakeholder approach, integrating policymakers, researchers, and industry representatives to develop innovative and adaptive fisheries management strategies.

2.4. Research Gap

Despite the growing body of research on the Blue Economy and the management of marine resources, significant gaps remain in the prioritization and sustainability assessment of the fishing sector within this framework. Existing studies on the Blue Economy often focus on broader economic indicators or on emerging maritime sectors such as offshore renewable energy and marine biotechnology [29]. However, comprehensive analyses specifically address the role of fisheries in the Blue Economy, their ranking among other maritime industries, and their sustainability challenges remain limited.

One of the key research gaps is the lack of decision-making tools that integrate economic, structural, and environmental dimensions to assess the fishing sector's role in the Blue Economy. While previous research has evaluated fisheries from an economic or ecological standpoint separately [30], studies incorporating a data-driven, hierarchical approach to classify fisheries within the broader Blue Economy landscape are scarce. This gap limits policymakers' and industry stakeholders' ability to allocate resources effectively and implement targeted sustainability measures.

Furthermore, existing analyses often focus on macro-level trends in European fisheries management, emphasizing total allowable catches (TACs) and quota allocations under the Common Fisheries Policy (CFP) [31]. However, there is a lack of detailed assessments of fleet structure by country and its direct implications for sustainability and economic performance. This study aims to address this shortcoming by analyzing fishing fleet data at a granular level, considering vessel distribution, gross tonnage, and engine power across European nations.

Another significant research gap is the limited integration of environmental sustainability indicators in fisheries prioritization models. While the environmental impact of fisheries (such as overfishing, bycatch, and habitat degradation) is well documented [32,33], few studies incorporate these factors into sectoral ranking frameworks. Addressing this gap is crucial for aligning fisheries with Sustainable Development Goal 14 (SDG 14: Life Below Water) and ensuring that sustainability considerations are at the core of fisheries management policies.

This study seeks to bridge these research gaps by applying decision tree modeling to classify the fishing sector within the Blue Economy, integrating economic, structural, and environmental indicators. By providing a quantitative and hierarchical approach, the research will contribute to a more comprehensive understanding of fisheries within the broader maritime economy, offering valuable insights for policy development and industry adaptation.

3. Methodology

This study employs a quantitative approach based on decision tree analysis to prioritize the fishing sector within the Blue Economy in Europe. Additionally, a detailed analysis of the fishing fleet structure is conducted using data from the EU Fleet Register, aiming to assess the operational capacity and distribution of fishing resources across different countries. Finally, an environmental impact assessment is carried out, considering sustainability metrics, bycatch levels, and effects on marine ecosystems (Figure 1).

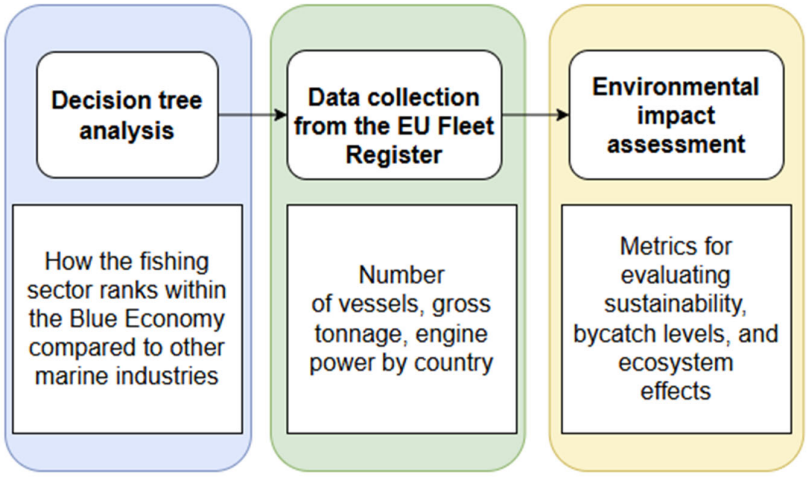

Figure 1. Research flow chart. Source: own elaboration.

3.1. Decision Tree Analysis

To determine the relative position of the fishing sector within the Blue Economy in Europe, a decision tree model was applied using the Classification and Regression Tree (CART) method. This technique enables the hierarchical classification of maritime economic sectors based on key variables such as their contribution to GDP, employment generation, and environmental impact.

The process of constructing the decision tree began with the selection of maritime sectors included in the study, such as maritime transport, coastal tourism, shipbuilding, and fisheries. Official economic and environmental data were then collected and preprocessed to ensure consistency and comparability. The model was trained using a dataset split into training and validation sets, applying cross-validation techniques to minimize overfitting and enhance model robustness.

The decision tree analysis provided insights into the ranking of the fishing sector within the Blue Economy, highlighting key influencing variables. Furthermore, a comparative analysis between Spain and the broader European context was conducted to identify sector-specific patterns and economic or environmental differentiators.

Spain was selected for a detailed classification within the European Blue Economy framework due to its historical and economic significance in the fisheries sector. As the country with the largest fishing fleet in the EU in terms of gross tonnage and one of the most influential seafood trade hubs in Europe (Vigo), Spain represents a highly relevant case for understanding industrialized fisheries' sustainability challenges and modernization needs.

The methodological approach in this study was structured in several distinct phases, beginning with an exhaustive literature review and data collection from official European sources. The analysis incorporates two key datasets: the European Union's Blue Economy Observatory (2008), which provides historical economic trends, and the EU Fleet Register (latest available year from the report), which offers up-to-date fleet composition and operational capacity data.

The variables selected for the analysis include economic indicators such as turnover, value added, gross operating surplus, personnel costs, and number of employees, which provide insights into the financial relevance and workforce distribution of the fishing sector. Additionally, fleet-specific data such as gross tonnage, engine power, and vessel numbers were analyzed to assess the technological modernization and efficiency levels across different European countries. The datasets were obtained in CSV format and via open data APIs, ensuring consistency and reliability for subsequent analysis.

The combination of these datasets enables a comprehensive evaluation of the fishing sector, balancing historical economic performance with current fleet capacity, allowing for a rigorous assessment of the industry's position within the Blue Economy.

3.2. Data Collection and Analysis of the European Fishing Fleet

The analysis of the fishing fleet structure is based on data extracted from the EU Fleet Register, an official database of the European Union that provides detailed information on fleet composition by country. For this study, three key variables were selected: total number of vessels, gross tonnage (as an indicator of carrying capacity), and engine power (kW) (as a measure of the fleet's operational capacity).

These variables were chosen as they provide a comprehensive assessment of fleet characteristics, offering insights into both operational efficiency and economic scale. The total number of vessels reflects the size and distribution of fleets across different nations, allowing for comparisons between industrial and small-scale fisheries. Gross tonnage is a widely used indicator of fishing capacity as it represents the potential volume of catch a fleet can handle, influencing stock sustainability and regulatory management. Engine power (kW), on the other hand, serves as a measure of technological advancement, affecting fuel consumption, carbon emissions, and the fleet's ability to operate in diverse maritime environments.

These parameters align with those used in EU fisheries assessments and sustainability reports, making them essential for evaluating trends in fleet modernization, economic contribution, and environmental impact. Their inclusion in this study allows for a structured analysis of the fishing industry within the Blue Economy, offering a data-driven perspective on sectoral disparities across Europe.

Data collection was conducted using the latest available records from the EU Fleet Register, ensuring that the study reflects the most current structural conditions of the fishing sector. A data cleaning and normalization process was applied to remove inconsistencies and standardize the dataset for analysis.

An exploratory analysis of the dataset was performed to identify patterns in fleet distribution, highlighting differences in operational capacity and the dominance of either industrial or artisanal fisheries across European countries. Additionally, historical fleet evolution trends were examined to contextualize current sustainability challenges and regulatory adaptations in the EU fishing sector.

3.3. Environmental Impact Assessment of the Fishing Sector

To evaluate the sustainability of the fishing sector, several key environmental metrics were considered, focusing on marine ecosystem conservation. One of the primary indicators was bycatch levels, a phenomenon that significantly affects biodiversity and threatens the viability of numerous marine species. Data from official reports on bycatch levels in various European fisheries were analyzed, differentiating between fishing techniques and specific regional contexts.

Another critical factor assessed was the impact of fishing activities on marine ecosystems, particularly the degradation of habitats due to intensive fishing practices such as bottom trawling. Previous studies and environmental databases were reviewed to establish correlations between fishing intensity and ecosystem health in high-activity fishing zones.

Furthermore, sustainability indicators related to fisheries resource management were incorporated, evaluating the implementation of regulatory measures such as the total allowable catches (TACs) under the Common Fisheries Policy (CFP) and the adoption of sustainable fishing certifications. The combination of these data sources provided a

comprehensive perspective on the environmental impacts of the fishing sector and its alignment with the Blue Economy principles.

The methodological design of this study allows for a multidimensional assessment of the fishing sector, integrating economic, structural, and environmental perspectives. Decision tree modeling provides a visual and analytical tool for understanding the sector's prioritization within the Blue Economy, while the analysis of fishing fleet data contextualizes operational capacity across Europe. Additionally, the environmental impact assessment delivers valuable insights for policymakers and industry stakeholders to formulate sustainability strategies in fisheries management.

4. Results and Discussion

4.1. Prioritization of the Fishing Sector in the Blue Economy

Based on the decision tree classifications for Spain and Europe, we can now conduct a rigorous analysis of the fishing sector and its role within this framework. Below is a detailed breakdown of the sector's classification, relevance, and implications for policy and sustainability.

4.1.1. Hierarchical Classification in Europe

The decision tree analysis for Europe's Blue Economy (Figure 2) provides a structured classification of maritime industries based on key factors such as economic contribution, structural complexity, and sustainability constraints. Among the sectors analyzed, the fishing industry (categorized under living resources) appears at an upper level, highlighting its fundamental role in the maritime economy. However, compared to other sectors such as maritime transport, port activities, and coastal tourism, the fishing industry exhibits a lower level of segmentation, suggesting a more homogeneous structure across European nations.

One of the most notable aspects of the classification is that maritime transport and port activities are positioned as highly diversified sectors, reflecting their complex supply chains, multiple sub-industries, and extensive economic reach. In contrast, the fishing sector is relatively uniform in structure, with fewer sub-sectors and a more direct economic cycle that revolves around resource extraction, processing, and trade. This homogeneity is both an advantage and a limitation—while it ensures a clear economic role within the Blue Economy, it also makes the sector highly susceptible to external pressures, such as regulatory changes, climate variability, and ecosystem degradation (Figure 3).

The classification also underscores the strong economic and employment base of the fishing sector, particularly in coastal regions of Spain, France, Portugal, and Greece, where fisheries represent a significant share of local GDP and labor markets. However, this economic strength is counterbalanced by persistent sustainability challenges, including overfishing, bycatch, and stock depletion. The presence of these issues at an early stage in the decision tree suggests that environmental constraints are deeply embedded in the sector's classification, making it one of the most vulnerable industries in terms of long-term sustainability. This contrasts with sectors such as port logistics or maritime transport, where economic activity can be decoupled from direct environmental dependencies.

Moreover, the decision tree results reveal that the fishing sector does not exhibit the same level of diversification or technological adaptation as other maritime industries. While sectors like offshore energy and maritime logistics have rapidly integrated digitalization, automation, and sustainability innovations, fisheries continue to rely on traditional extraction-based models, with slow adoption of alternative production methods such as aquaculture. This lack of diversification reinforces the sector's exposure to economic and ecological shocks, indicating a pressing need for policy interventions aimed at modernization, sustainability integration, and economic resilience.

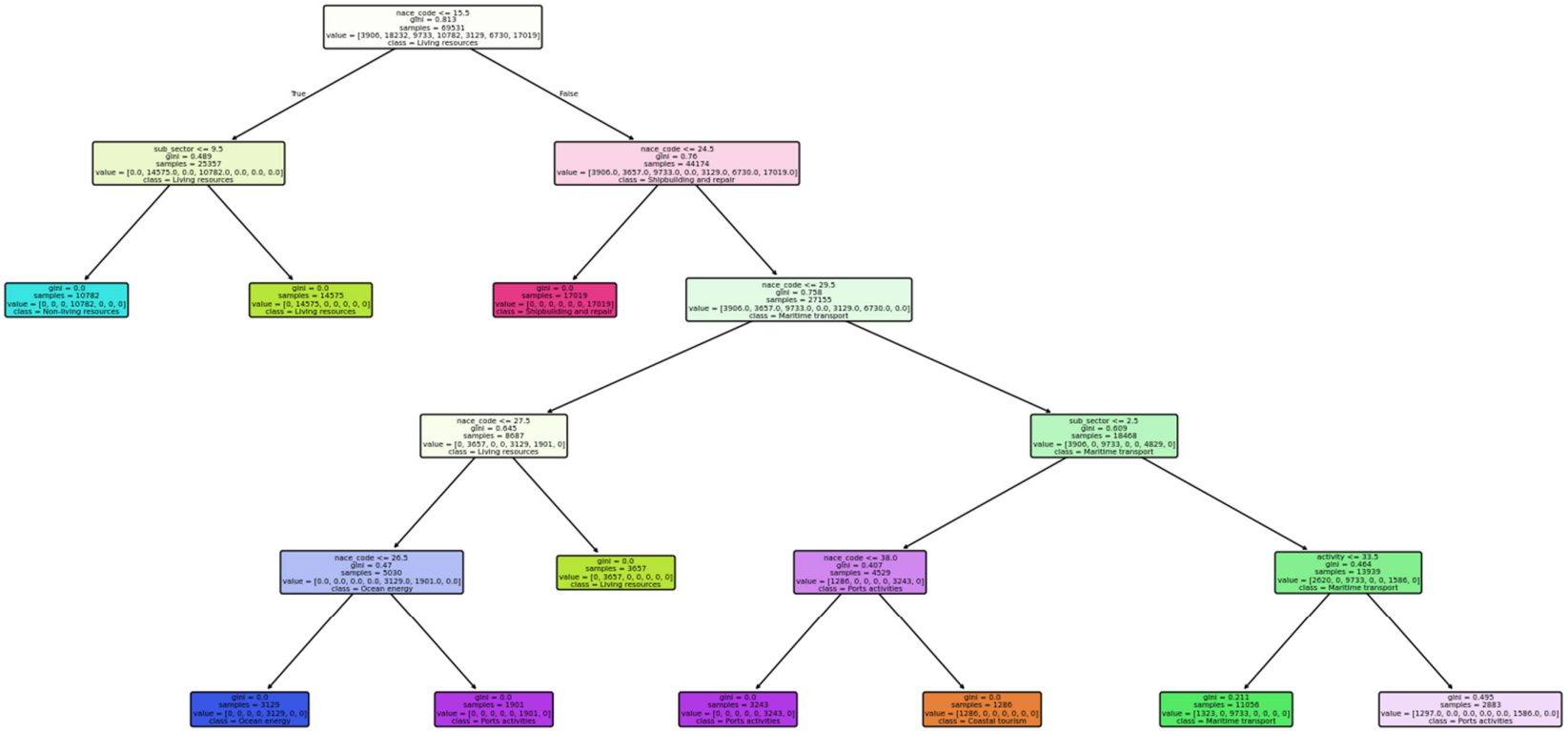

Figure 2. The decision tree analysis for Europe's Blue Economy. Source: own elaboration.

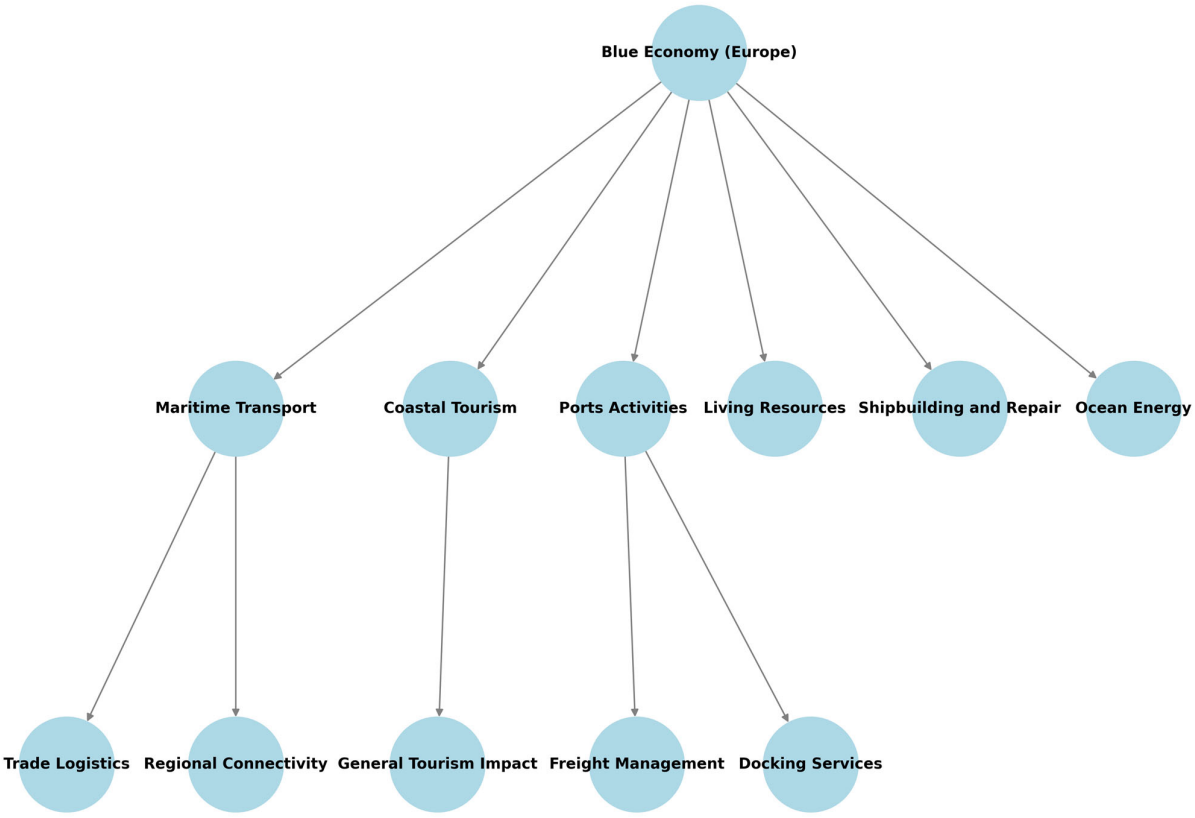

Figure 3. Europe: hierarchy of the Blue Economy sectors.

Although this study focuses on capture fisheries, aquaculture plays an increasingly important role in the European Blue Economy. The sector has grown as a means to reduce pressure on wild fish stocks, yet it presents different sustainability challenges, such as disease management, feed sustainability, and habitat transformation. Future research could explore how fisheries and aquaculture interact, assessing their complementary roles in sustainable seafood production and their integration into Blue Economy strategies.

The hierarchical classification of the fishing industry within the Blue Economy suggests that while it remains a cornerstone of Europe's maritime activities, it is increasingly being surpassed by more technologically advanced and less resource-dependent industries. The sector's continued relevance will depend on its ability to balance economic demands with ecological responsibility, ensuring long-term viability amid shifting regulatory and environmental conditions. The next step in addressing these challenges involves aligning fisheries with sustainability-focused policies, including marine protected areas (MPAs), quota management, and technological innovation, to enhance their resilience within the evolving Blue Economy framework.

Figure 4 illustrates the economic contribution and sustainability risk levels of various sectors within the Blue Economy in Europe. While maritime transport, port activities, and coastal tourism exhibit the highest economic contributions, they also demonstrate a lower relative sustainability risk. In contrast, the fishing industry, despite its crucial role in food security and employment, faces one of the highest environmental risks, primarily due to overfishing, bycatch, and stock depletion. This visualization underscores the need for stronger regulatory frameworks and technological innovations to mitigate the environmental challenges associated with fisheries while maintaining their economic viability.

Figure 5 illustrates the Sustainability Risk Index for key sectors within the Blue Economy, calculated based on multiple environmental impact factors. The fishing industry exhibits one of the highest sustainability risks due to overfishing, bycatch, and ecosystem

degradation, despite its crucial economic role. In contrast, maritime transport and port activities, while contributing significantly to carbon emissions, benefit from strong regulatory frameworks and technological advancements, which help mitigate their overall sustainability risk. The results highlight the need for stronger environmental policies and technological innovations in fisheries to align them with the broader sustainability goals of the European Green Deal and SDG 14 (Life Below Water).

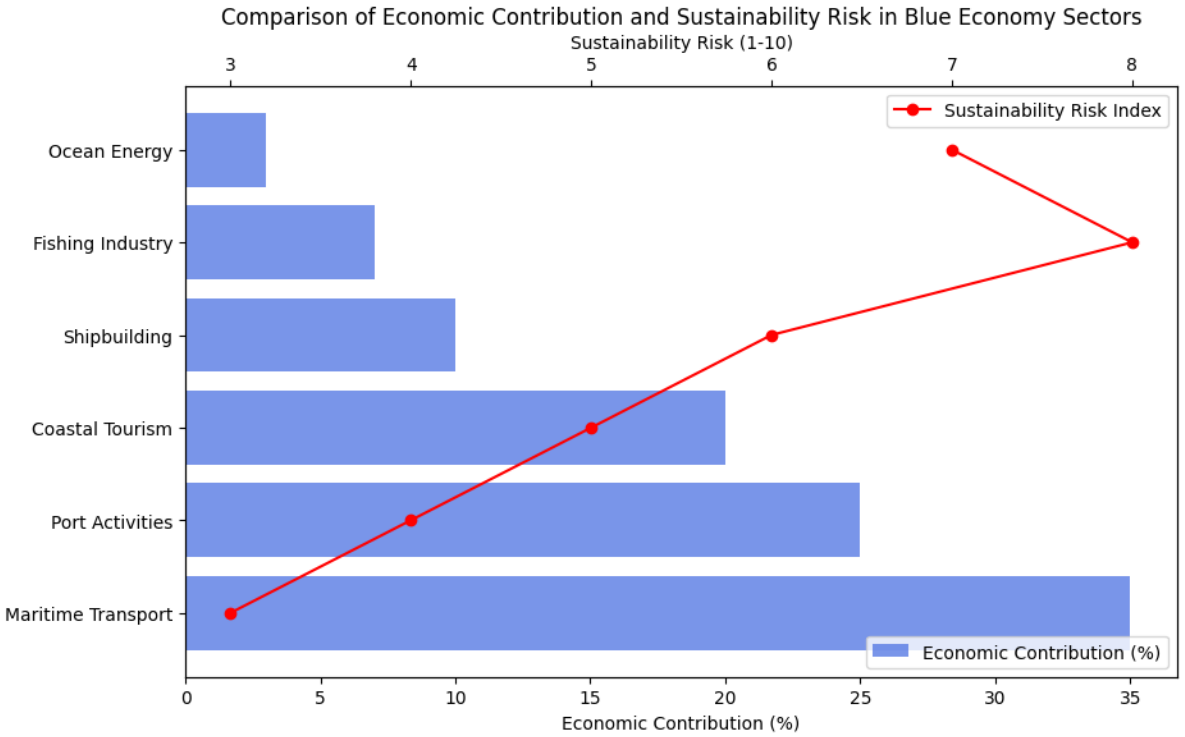

Figure 4. Comparison of economic contribution and sustainability risk in Blue Economy sectors in EU. Source: own elaboration.

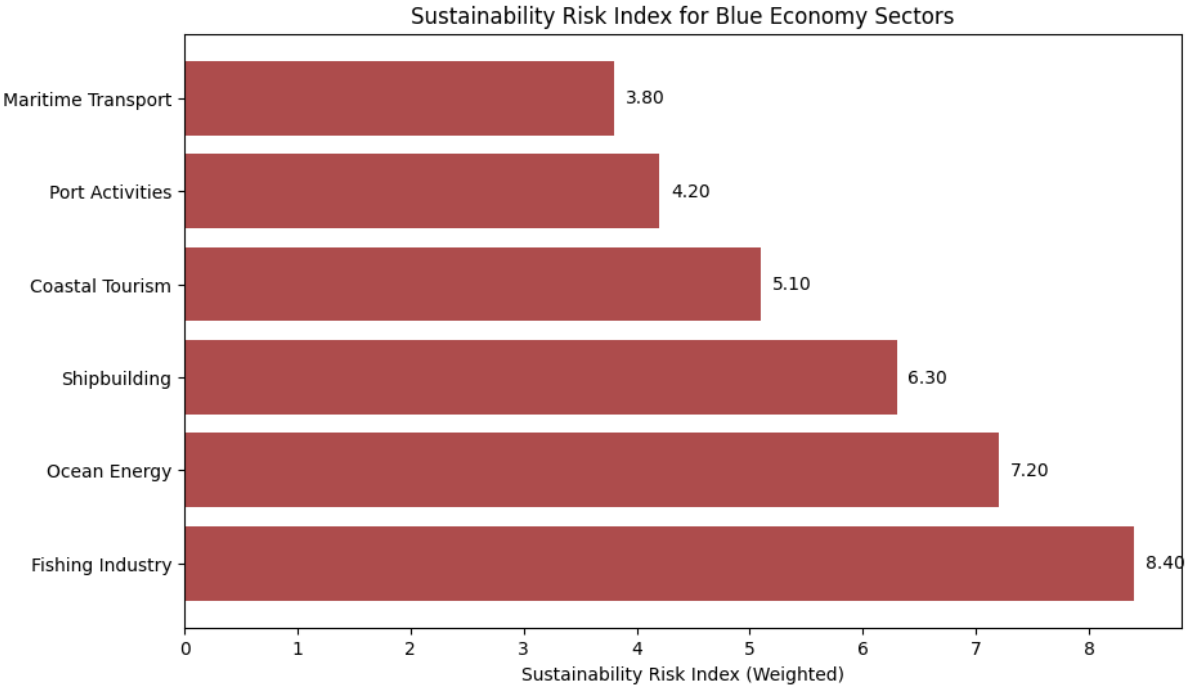

Figure 5. Sustainability risk in Blue Economy sectors in EU. Source: own elaboration.

4.1.2. Hierarchical Classification in Spain

The decision tree analysis for Spain's Blue Economy (Figure 6) provides a structured classification of maritime industries, considering key factors such as economic contribution, regional specialization, and exposure to external risks. Among the sectors analyzed, the fishing industry is classified as a priority area, yet it exhibits distinct characteristics compared to other high-ranking sectors such as maritime transport and coastal tourism.

One of the key insights from the classification is that the fishing sector appears at a shallower depth within the decision tree compared to transport and tourism, indicating a more homogeneous economic structure (Figure 7). Unlike sectors with complex supply chains and multiple sub-industries, fisheries are primarily focused on resource extraction, processing, and trade, making them less diversified within the Blue Economy framework. While this ensures a well-defined economic function, it also increases the sector's vulnerability to regulatory, climatic, and ecological disruptions.

The classification also underscores the regional specialization of the fishing industry, particularly in coastal communities such as Galicia and Andalusia, where the sector plays a vital role in employment and local GDP. Spain's fisheries maintain a strong industrial fleet, with Vigo serving as a central hub for both national and international seafood trade. However, the reliance on specific regional economies means that any fluctuation in fish stock availability, policy regulations, or market conditions can have disproportionate effects on local communities.

Furthermore, the decision tree results indicate that Spain's fishing sector lacks the level of diversification observed in other European nations. While some countries are rapidly integrating aquaculture and digital monitoring technologies into their maritime sectors, Spanish fisheries remain heavily dependent on traditional extraction-based models. This limited diversification amplifies the sector's exposure to global economic and environmental shifts, reinforcing the urgent need for targeted modernization strategies. By aligning fisheries with technological advancements, sustainability-driven policies, and ecosystem-based management, Spain can enhance the long-term resilience of its fishing industry within the evolving Blue Economy framework.

A key factor reinforcing the strategic importance of Spain's fishing industry is the role of the Port of Vigo, which serves as the largest fishing port in Europe and one of the most significant globally in terms of seafood landings and processing capacity. Vigo functions as a critical hub for the Spanish and international fishing fleet, facilitating the distribution of fresh and frozen seafood across European and global markets. Additionally, the port plays a central role in Spain's fisheries value chain, integrating industrial-scale fishing, seafood processing, and export logistics. However, its reliance on wild-catch fisheries also makes it highly exposed to regulatory shifts, sustainability constraints, and stock variability, emphasizing the need for enhanced resource management and technological innovation to maintain the sector's long-term resilience within the Blue Economy.

Figure 8 illustrates the economic contribution of key sectors within Spain's Blue Economy, highlighting the predominance of maritime transport, port activities, and coastal tourism. Maritime transport emerges as the most significant sector, accounting for nearly 38% of the total economic output, followed by port activities (28%) and coastal tourism (18%). These three sectors collectively represent the core of Spain's maritime economy, benefiting from well-developed infrastructure, trade connectivity, and increasing tourism demand.

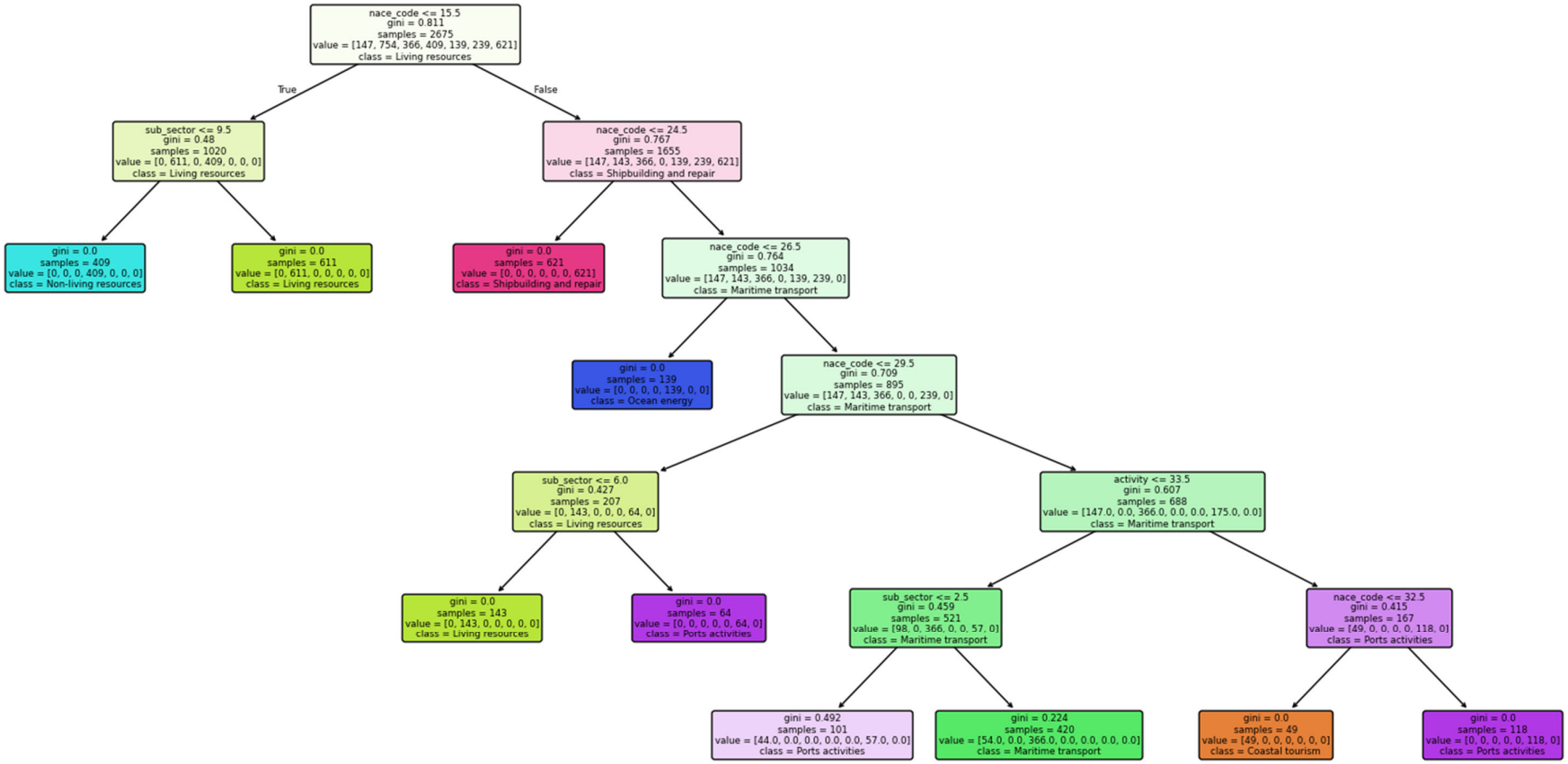

Figure 6. The decision tree analysis for Spain's Blue Economy. Source: own elaboration.

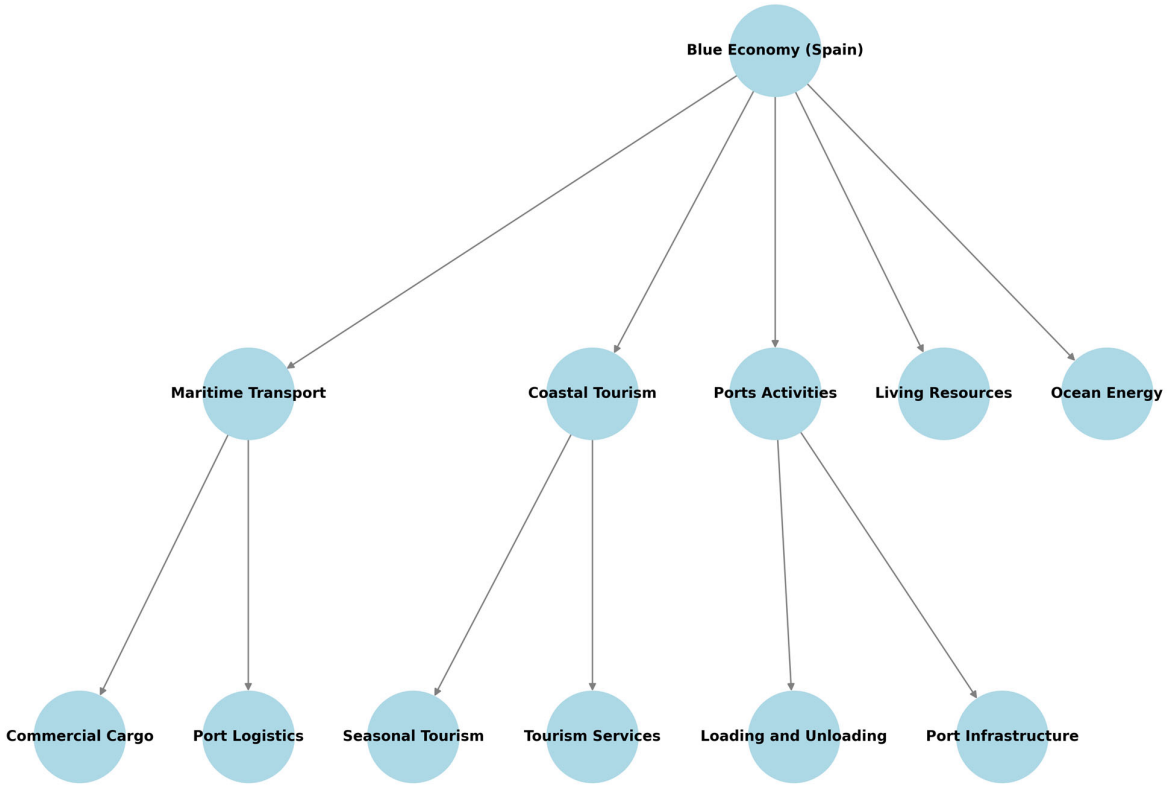

Figure 7. Spain: hierarchy of the Blue Economy sectors.

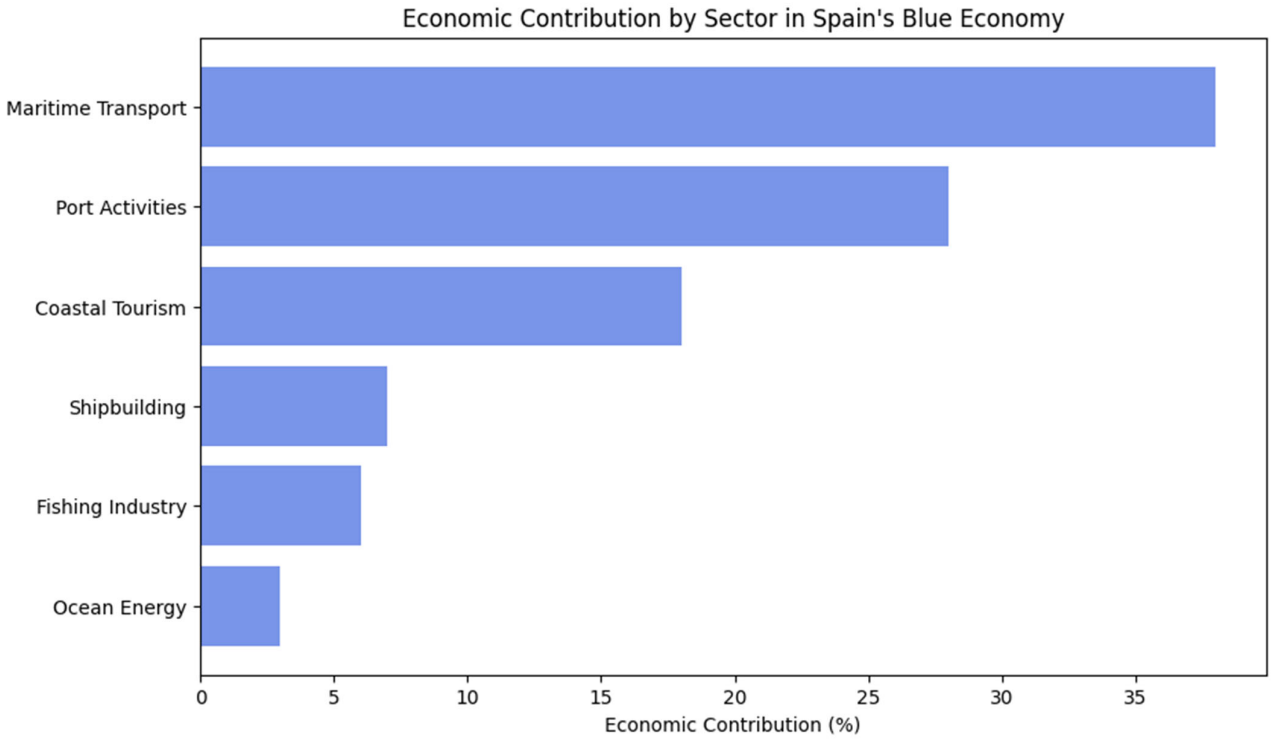

Figure 8. Economic contribution in Blue Economy sectors in Spain. Source: own elaboration.

In contrast, the fishing industry, shipbuilding, and ocean energy sectors contribute a smaller share, with fisheries accounting for only 6% of the total Blue Economy despite its critical role in food security and employment. The relatively lower contribution of these sectors underscores the structural challenges faced by Spain's fishing industry, including sustainability constraints, regulatory pressures, and resource depletion concerns.

Understanding the economic positioning of fisheries within the broader Blue Economy framework is essential for policy development, targeted investment, and long-term sustainability strategies to enhance the sector's resilience while maintaining ecological balance.

Figure 9 presents the Sustainability Risk Index for key sectors within Spain's Blue Economy, highlighting the varying degrees of environmental impact and regulatory challenges across industries. The fishing industry exhibits the highest sustainability risk, with a score of 9 on a scale of 1 to 10, reflecting the sector's vulnerability to overfishing, stock depletion, habitat degradation, and high carbon emissions from outdated fleets. Ocean energy and shipbuilding also demonstrate elevated sustainability risks, primarily due to the environmental footprint associated with offshore infrastructure development and industrial pollution.

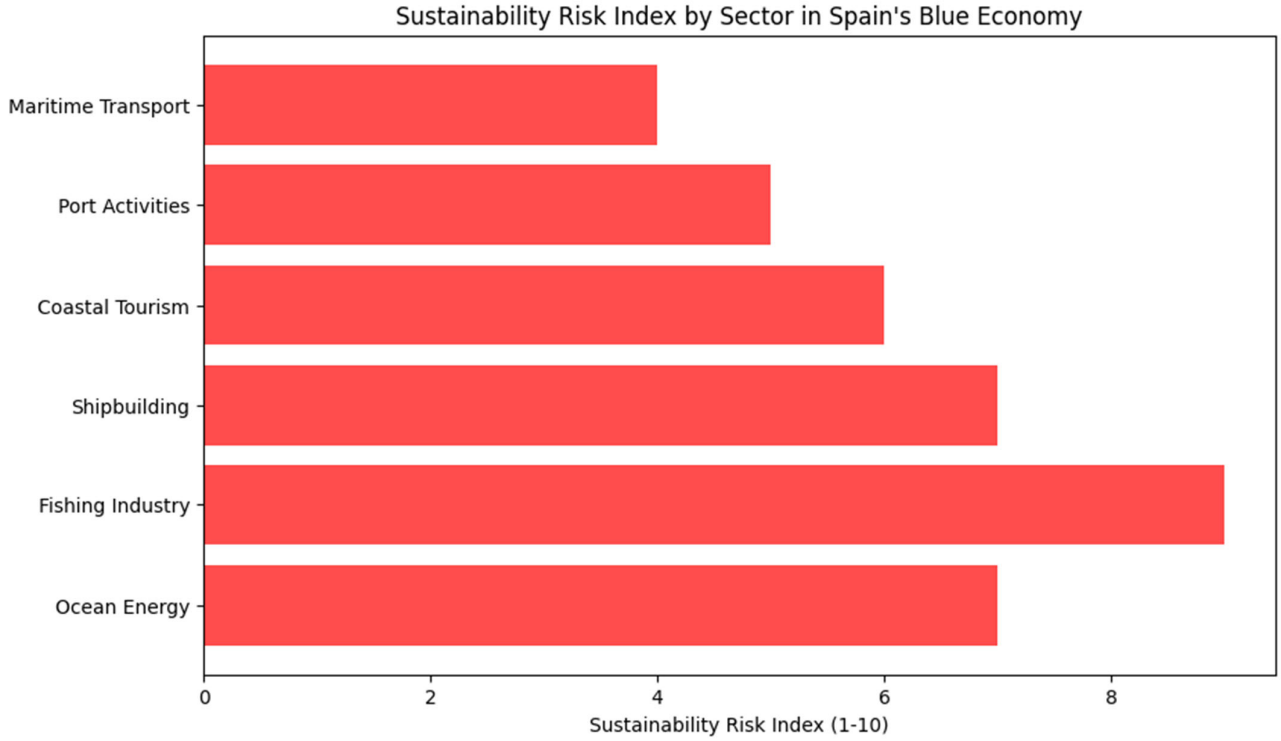

Figure 9. Sustainability risk in Blue Economy sectors in Spain. Source: own elaboration.

In contrast, maritime transport and port activities display lower sustainability risk levels, benefiting from advancements in emission reduction technologies, regulatory compliance, and infrastructure modernization. Coastal tourism, while contributing significantly to Spain's economy, also shows a moderate sustainability risk, largely influenced by coastal ecosystem pressures, waste generation, and seasonal environmental disturbances.

The results emphasize the urgent need for targeted sustainability strategies in high-risk sectors, particularly fisheries, which require enhanced regulatory enforcement, technological innovation, and integration with marine conservation initiatives to balance economic contributions with long-term ecological resilience.

The decision tree analysis for Europe and Spain highlights notable differences in the hierarchical classification of the fishing sector within the Blue Economy. At the European level, fisheries are classified as a key maritime industry, but they appear at a lower segmentation depth compared to more diversified sectors such as maritime transport and port activities. This suggests that, across Europe, the fishing industry is relatively homogeneous in its structure, primarily focused on resource extraction and trade, with fewer sub-sectors contributing to economic diversification. The European decision tree also underscores the strong influence of sustainability constraints, positioning fisheries as a

sector that is economically significant but highly vulnerable to environmental risks and regulatory pressures.

In contrast, the decision tree for Spain places the fishing sector with greater priority, reflecting the country's historical and economic reliance on fisheries, particularly in regions like Galicia, Andalusia, and the Canary Islands. However, the Spanish model shows less depth compared to transport or tourism, indicating that while fishing remains a core industry, it lacks the same level of economic segmentation and diversification as other maritime sectors. This highlights Spain's dependence on wild-capture fisheries, making the sector more sensitive to external shocks such as climate variability, stock fluctuations, and evolving EU regulatory frameworks. Additionally, the strong regional specialization observed in Spain, particularly in major fishing hubs like Vigo, reinforces the need for localized policy adaptations to enhance sustainability and sectoral resilience.

While this study focuses on Spain due to its leading position in EU fisheries, the methodology applied here could be extended to other key fishing nations such as France and Italy, which also maintain large and diversified fleets. Future research could apply a similar hierarchical classification approach to assess fleet structures, sustainability risks, and regulatory impacts across different European maritime economies.

While the fishing industry remains a cornerstone of the Blue Economy, aquaculture has emerged as a complementary and increasingly essential sector in marine resource management. As traditional fisheries face growing sustainability constraints due to overfishing, climate change, and regulatory limits, aquaculture has experienced steady growth, providing an alternative means to meet global seafood demand while reducing pressure on wild fish stocks.

In recent years, aquaculture has shown a notable expansion across Europe, with leading producers such as Spain, France, and Italy investing heavily in marine farming. This shift is reflected in the increasing economic contribution of aquaculture, which has begun to rival traditional fishing in terms of production volume and market value. Figure 10 illustrates the growth trajectory of aquaculture in Europe, highlighting its steady increase over the past two decades.

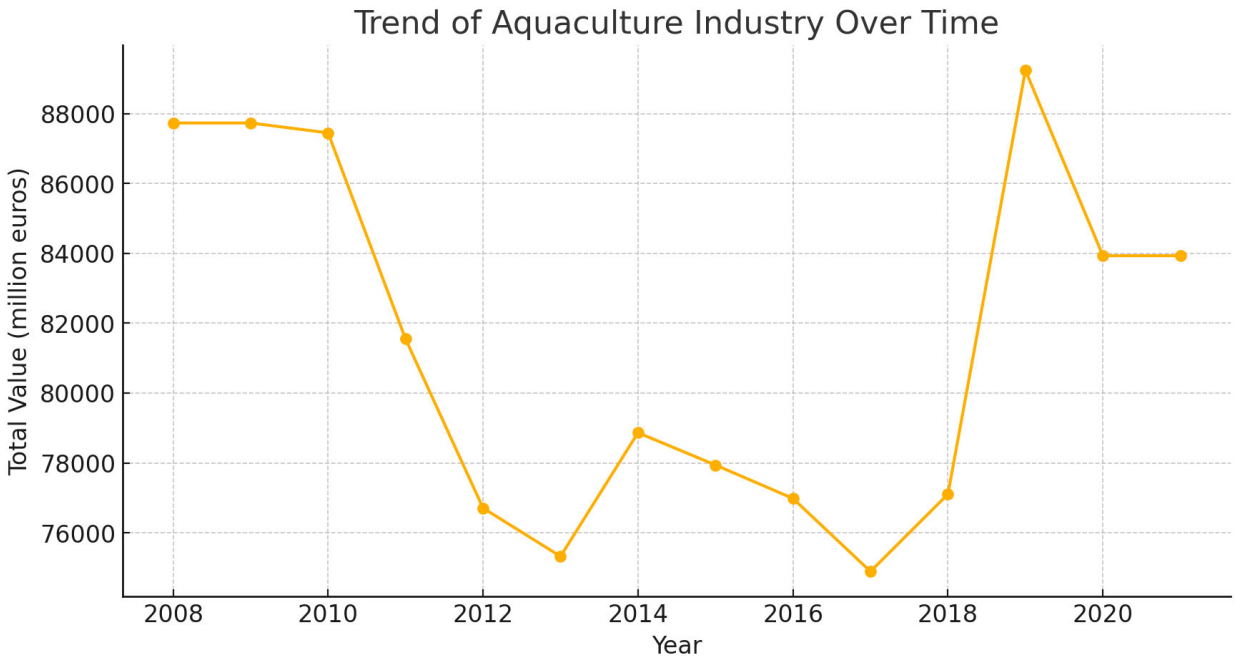

Figure 10. Growth trajectory of aquaculture in Europe. Source: own elaboration.

Despite its economic potential, aquaculture is not without challenges. Environmental concerns, including habitat alteration, water pollution, and competition for marine space, remain key issues that must be addressed to ensure long-term sustainability. Regulatory frameworks such as the EU's Blue Economy Strategy emphasize the need for responsible aquaculture practices that minimize ecological impact while enhancing production efficiency.

When comparing the economic impact of fisheries and aquaculture, notable differences emerge in terms of employment, productivity, and sustainability. While the fishing sector continues to provide significant employment, particularly in coastal communities, aquaculture has demonstrated higher economic resilience and growth potential. The controlled nature of aquaculture allows for more predictable output, reducing the volatility associated with wild fisheries.

However, aquaculture's sustainability benefits depend on production methods. Traditional open-water systems, particularly intensive fish farming, can generate environmental externalities such as nutrient discharge and habitat degradation. Conversely, innovative approaches like recirculating aquaculture systems (RASs) and integrated multi-trophic aquaculture (IMTA) offer promising solutions to mitigate these impacts while enhancing resource efficiency.

Figure 11 presents a comparative analysis of the sustainability risks associated with fisheries and aquaculture, showcasing the distinct environmental pressures each sector faces. While overfishing and bycatch are critical concerns in traditional fisheries, aquaculture's primary challenges lie in habitat impact and resource utilization. Future policy directions should focus on integrating sustainable aquaculture with responsible fisheries management to ensure a balanced and resilient Blue Economy.

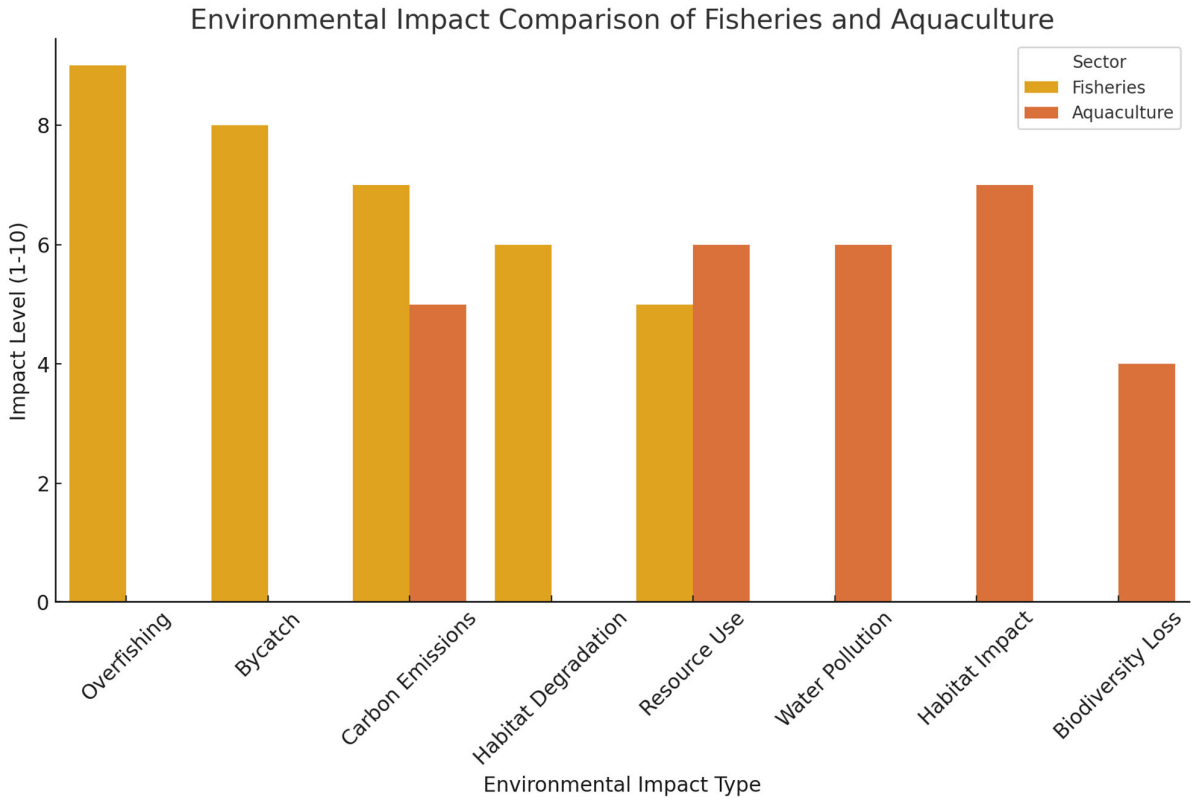

Figure 11. Sustainability risks associated with fisheries and aquaculture. Source: own elaboration.

4.2. Structural Characteristics of the EU Fishing Fleet

The structure of the EU fishing fleet varies significantly across member states, reflecting differences in fleet size, specialization, technological capacity, and sustainability practices.

The analysis of data from the EU Fleet Register highlights disparities in the number of vessels, gross tonnage, and engine power, providing insight into how different nations approach fisheries management.

The selection of parameters used in this study was based on official data provided by the European Maritime Transport Report (2025), ensuring consistency, accuracy, and comparability across EU member states. The dataset includes key economic, structural, and environmental indicators, which were chosen due to their relevance in assessing the role of fisheries within the Blue Economy. The primary economic indicators—turnover, value added, gross operating surplus, personnel costs, and number of employees—reflect the financial significance and labor intensity of each sector. Structural variables such as fleet size, gross tonnage, and engine power were incorporated to analyze the operational scale and modernization level of the fishing industry. Environmental parameters, including overfishing pressure, CO_2 emissions from fishing vessels, and biodiversity impact assessments, were selected to evaluate the sustainability challenges faced by the sector. These indicators were used in the decision tree model to classify and compare fisheries with other maritime industries, providing a data-driven approach to sectoral prioritization within the Blue Economy framework.

4.2.1. Distribution of Fishing Vessels Across EU Countries

Figure 12 illustrates the distribution of vessels among EU member states. Greece, Italy, and Spain account for the largest share of vessels, indicating the prominence of the fishing sector in their economies. Spain, despite its extensive fleet, shows a lower number of vessels compared to Greece, suggesting a higher proportion of large-scale industrial fishing vessels rather than small-scale artisanal operations.

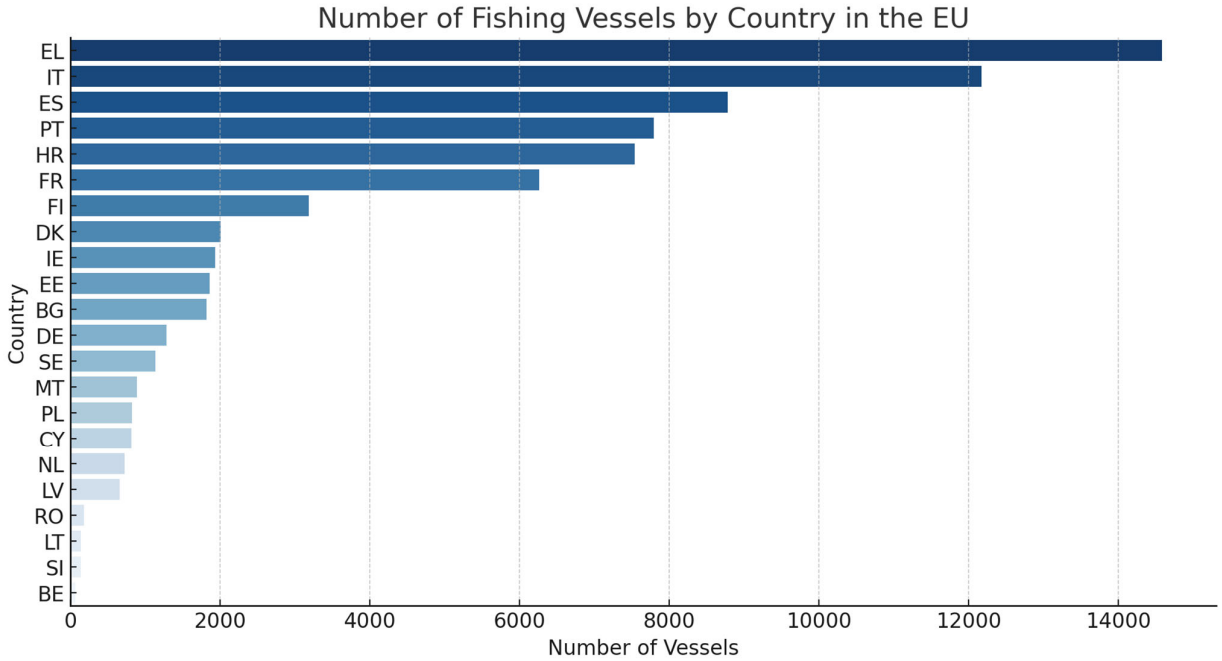

Figure 12. Number of fishing vessels by country in the EU. Source: own elaboration. The country codes in the figure correspond to the following nations: EL (Greece), IT (Italy), ES (Spain), PT (Portugal), HR (Croatia), FR (France), FI (Finland), DK (Denmark), IE (Ireland), EE (Estonia), BG (Bulgaria), DE (Germany), SE (Sweden), MT (Malta), PL (Poland), CY (Cyprus), NL (Netherlands), LV (Latvia), RO (Romania), LT (Lithuania), SI (Slovenia), and BE (Belgium). The notation 1e6 in the figure represents 1×10^6, equivalent to one million.

Portugal, Croatia, and France also maintain significant fleets, but their structures appear more balanced between industrial and artisanal fisheries. In contrast, countries

such as Germany, Sweden, and Poland have relatively small fishing fleets, reflecting either a greater reliance on other maritime sectors or a focus on more technologically advanced and capital-intensive fishing methods.

This distribution suggests strong regional dependencies on fisheries for employment and economic stability, particularly in Southern European nations. The higher number of vessels in Greece may indicate a greater reliance on small-scale coastal fishing, whereas Spain and Italy, despite fewer vessels, likely maintain a higher operational capacity per vessel, as confirmed in the tonnage and engine power analysis.

4.2.2. Gross Tonnage and Engine Power Across the EU Fishing Fleet

Figure 13 provides a deeper insight into the operational capacity of the European fishing sector. While the previous graph focused on vessel quantity, this figure examines fleet power and carrying capacity, two key indicators of efficiency and sustainability.

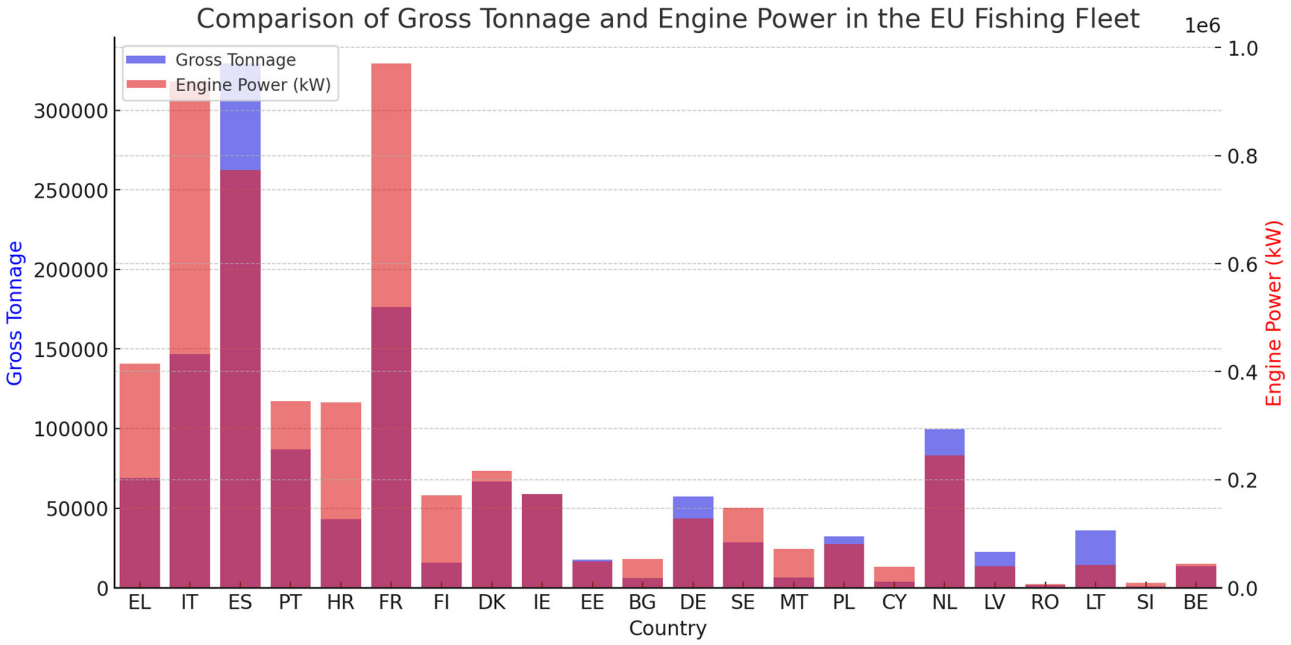

Figure 13. Comparison of gross tonnage and engine power in the EU fishing fleet. Source: own elaboration. The country codes in the figure correspond to the following nations: EL (Greece), IT (Italy), ES (Spain), PT (Portugal), HR (Croatia), FR (France), FI (Finland), DK (Denmark), IE (Ireland), EE (Estonia), BG (Bulgaria), DE (Germany), SE (Sweden), MT (Malta), PL (Poland), CY (Cyprus), NL (Netherlands), LV (Latvia), RO (Romania), LT (Lithuania), SI (Slovenia), and BE (Belgium). The notation 1e6 in the figure represents 1×10^6, equivalent to one million.

Spain, France, and Italy lead in total gross tonnage, indicating a highly industrialized fleet with significant deep-sea fishing operations. Spain, in particular, ranks among the top nations in terms of fishing capacity, reinforcing its role as a European leader in seafood production and international trade. Greece, despite having the highest number of vessels, displays a lower gross tonnage, confirming its fleet's focus on small-scale fishing with lower carrying capacity per vessel.

Engine power follows a similar trend, with Spain, France, and Italy possessing the highest levels of operational capacity. These countries operate high-powered fishing vessels, allowing them to access distant waters and conduct large-scale fishing operations. However, this also implies a higher carbon footprint, making fleet modernization a crucial element for achieving sustainability goals.

In contrast, nations like Germany, the Netherlands, and Denmark exhibit disproportionately high engine power compared to gross tonnage, suggesting a greater reliance

on technologically advanced, fuel-efficient vessels. This trend indicates a move toward sustainability through modernization, as higher engine efficiency typically correlates with reduced fuel consumption and lower emissions per unit of fish caught.

4.2.3. Implications for Sustainability and Policy Development Regulatory Frameworks

The structural disparities in the EU fishing fleet highlight several key sustainability and economic challenges that must be addressed to ensure the long-term viability of the sector. Fleet efficiency and modernization are critical factors, as countries with older fleets and lower engine power often face higher operational costs and reduced fuel efficiency, leading to increased regulatory pressure and competitiveness issues. In contrast, nations investing in fleet renewal programs and low-carbon technologies are likely to enhance both economic resilience and environmental sustainability, positioning themselves as leaders in sustainable fisheries management.

Another significant challenge is the balance between industrial and artisanal fishing. The dominance of industrial fishing in Spain, France, and Italy raises concerns about stock depletion and ecological footprint, necessitating stricter quotas and resource management strategies to prevent long-term resource degradation. Meanwhile, countries with strong artisanal fleets, such as Greece and Portugal, may benefit from targeted policies that support small-scale fishers through incentives for sustainable practices, improved market access, and fair competition within the broader EU fisheries framework.

At the regulatory level, the European Green Deal and the Common Fisheries Policy (CFP) will play a fundamental role in guiding the transition toward more sustainable fishing fleets. Policies aimed at reducing emissions, improving selectivity in fishing practices, and encouraging the adoption of alternative energy sources must be prioritized to achieve the EU's sustainability targets and ensure the long-term stability of marine ecosystems. The effectiveness of these interventions will largely depend on their implementation at the national level, requiring a coordinated approach between policymakers, industry stakeholders, and environmental organizations to foster a resilient and sustainable future for European fisheries.

The sustainability of the EU fishing sector depends on the effectiveness of regulatory frameworks, technological advancements, and its integration with broader marine conservation efforts. Ensuring that fisheries contribute to economic stability while minimizing environmental impact requires a combination of governance, innovation, and ecological responsibility.

The EU Common Fisheries Policy (CFP) is the cornerstone of fisheries management in Europe, aiming to ensure that fishing practices are economically viable, socially equitable, and environmentally sustainable. Through a system of total allowable catches (TACs), fishing quotas, and fleet capacity regulations, the CFP seeks to prevent overfishing and maintain healthy fish stocks. However, enforcement remains a challenge, particularly in areas where illegal, unreported, and unregulated (IUU) fishing persists.

Additionally, the United Nations Sustainable Development Goal 14 (SDG 14: Life Below Water) provides an international framework for the conservation and sustainable use of marine resources. Its objectives align with the EU's efforts to reduce harmful subsidies, promote small-scale fisheries, and strengthen marine protected areas (MPAs). Despite these frameworks, the balance between economic interests and conservation measures remains a challenge, requiring ongoing collaboration between governments, industry stakeholders, and environmental organizations to ensure long-term compliance and effectiveness.

In Spain, where fisheries play a critical economic and social role, national policies often complement EU regulations with additional sustainability incentives, such as bycatch reduction programs and investment in fuel-efficient fleets. The Port of Vigo, as one of the

leading fishing hubs, is an example of how local governance can drive sustainable practices, integrating traceability systems, eco-certifications, and digital monitoring technologies to ensure compliance with sustainability targets.

Although this study provides a comprehensive classification of the fishing sector based on recent data, it is important to acknowledge that fisheries are highly dynamic and affected by long-term environmental and regulatory changes. Climate change, ocean acidification, and pollution levels may alter fleet efficiency, stock availability, and policy constraints over time. Future research should incorporate longitudinal datasets to assess how these evolving conditions impact fisheries management and sustainability strategies.

The findings indicate that the fishing sector holds a critical but structurally constrained position within the Blue Economy compared to other maritime industries such as maritime transport, port activities, and coastal tourism. Unlike maritime transport, which benefits from a highly diversified and technologically advanced infrastructure, the fishing sector remains heavily dependent on natural resource availability and faces substantial regulatory constraints. Previous studies have emphasized that while industrial fisheries in countries like Spain, France, and Italy contribute significantly to national economies, they also pose severe sustainability risks due to overfishing and habitat degradation. In contrast, the port and shipping industries have managed to decouple economic growth from direct environmental depletion through efficiency improvements and regulatory compliance mechanisms such as the International Maritime Organization (IMO) decarbonization targets. The results align with the existing literature on fisheries sustainability, reinforcing the need for targeted interventions to modernize fleets and improve resource management strategies.

The hierarchical classification of the fishing industry within the Blue Economy underscores the necessity of integrating sustainability policies into the sector's governance framework. The European Common Fisheries Policy (CFP) has already imposed strict quotas and conservation measures to mitigate stock depletion; however, the results suggest that further adjustments are needed to ensure fleet modernization and promote selective fishing practices. Similar concerns have been raised in studies assessing the effectiveness of EU-wide regulatory efforts in balancing economic viability with environmental sustainability. The European Green Deal and SDG 14 (Life Below Water) provide overarching frameworks to transition fisheries toward a more sustainable model, yet their success depends on robust enforcement mechanisms and financial incentives to support the adoption of eco-friendly technologies. Strengthening fisheries management through real-time monitoring and adaptive quota systems could further enhance sustainability outcomes, particularly in regions where overfishing remains a persistent challenge.

As the fishing sector faces increasing pressures from climate change, resource depletion, and shifting consumer demand, its long-term resilience will depend on a combination of technological innovation, regulatory adaptation, and economic diversification. Future research should focus on assessing the effectiveness of hybrid and low-emission propulsion systems in fishing fleets to align with EU decarbonization goals. Additionally, further studies could explore the socioeconomic impacts of stricter fisheries regulations on coastal communities, particularly in countries where small-scale fisheries are predominant. Emerging technologies such as blockchain-based seafood traceability and AI-driven stock assessment models have the potential to revolutionize fisheries management, improving transparency and decision-making efficiency. By leveraging these advancements and fostering stronger public–private partnerships, the fishing industry can transition toward a model that ensures both economic competitiveness and ecological responsibility in the evolving Blue Economy landscape.

5. Conclusions

This study provides a comprehensive assessment of the fishing sector within the EU Blue Economy, highlighting its economic significance, structural disparities, and sustainability challenges. The decision tree analysis confirms that fisheries remain a key maritime industry, particularly in Spain, Italy, and Greece, but face pressing environmental and regulatory pressures, including overfishing, stock depletion, and carbon emissions from outdated fleets. The analysis of fleet structures reveals disparities in modernization and efficiency, with industrialized fleets in Spain, France, and Italy exhibiting higher operational capacity, while small-scale fisheries in Greece and Portugal remain more vulnerable to policy shifts and stock variability.

To ensure a sustainable future for EU fisheries, this study emphasizes the need for three key strategies:

1. Fleet modernization and low-carbon technologies—Investing in energy-efficient vessels, hybrid propulsion systems, and selective fishing gear is crucial to reducing emissions and habitat destruction.
2. Stronger fisheries governance and compliance—Strengthening monitoring, control, and surveillance mechanisms, alongside the enforcement of adaptive quota systems and policies to combat IUU fishing, is essential for long-term sustainability.
3. Integration with marine conservation efforts—Expanding marine protected areas (MPAs) and adopting ecosystem-based fisheries management approaches will enhance resource sustainability while maintaining industry profitability.

Future research should focus on the economic and environmental impacts of fleet modernization, the socioeconomic consequences of stricter fisheries regulations, and the integration of fisheries into the EU's broader decarbonization agenda. Additionally, understanding consumer-driven sustainability initiatives and the role of blockchain-based traceability systems could further contribute to enhancing transparency and market incentives for sustainable fisheries.

Given these limitations, future research should explore the long-term impacts of fleet modernization on both economic performance and environmental sustainability. Additionally, further studies should examine the social and economic implications of stricter fisheries regulations, particularly in small-scale fisheries that are more vulnerable to policy changes.

By providing data-driven insights for policymakers, fisheries managers, and sustainability researchers, this study contributes to marine sustainability science, responsible fisheries governance, and climate adaptation strategies. Ensuring that fisheries remain economically viable while safeguarding marine ecosystems requires coordinated policy action, technological advancements, and collaborative conservation efforts.

Ensuring a sustainable future for EU fisheries requires coordinated action in three main areas. First, investment in fleet modernization is critical, with the adoption of energy-efficient vessels, hybrid propulsion systems, and selective fishing gear to reduce carbon emissions and habitat destruction. Second, fisheries governance must be strengthened by enforcing adaptive quota systems, improving monitoring and control mechanisms, and combating illegal, unreported, and unregulated (IUU) fishing. Third, integrating fisheries management with marine conservation efforts, such as expanding marine protected areas (MPAs) and adopting ecosystem-based management approaches, will enhance sustainability while maintaining industry profitability.

Author Contributions: Conceptualization, N.G.-C.; Methodology, J.V.-C.; Formal analysis, N.G.-C.; Investigation, N.G.-C., J.V.-C. and A.C.-O.; Writing—original draft, N.G.-C.; Writing—review & editing, N.G.-C., J.V.-C. and A.C.-O.; Supervision, N.G.-C. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data used in this study were obtained from the EU Fleet Register and other relevant maritime databases, ensuring a comprehensive and up-to-date analysis of the European fishing sector within the Blue Economy framework.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Martínez-Vázquez, R.M.; Milán-García, J.; De Pablo Valenciano, J. Challenges of the Blue Economy: Evidence and research trends. *Environ. Sci. Eur.* **2021**, *33*, 61. [CrossRef]
2. Raimundo, A.; Stavridis, S.; Tsardanidis, C. The Eurozone crisis' impact: A de-Europeanization of Greek and Portuguese foreign policies? *J. Eur. Integr.* **2021**, *43*, 535–550. [CrossRef]
3. Pham, C.-V.; Wang, H.-C.; Chen, S.-H.; Lee, J.-M. The Threshold Effect of Overfishing on Global Fishery Outputs: International Evidence from a Sustainable Fishery Perspective. *Fishes* **2023**, *8*, 71. [CrossRef]
4. Nimma, D.; Devi, O.R.; Laishram, B.; Ramesh, J.V.N.; Boddupalli, S.; Ayyasamy, R.; Tirth, V.; Arabil, A. Implications of climate change on freshwater ecosystems and their biodiversity. *Desalin. Water Treat.* **2025**, *321*, 100889. [CrossRef]
5. Piet, G.J.; Brunel, T.P.A.; Kraan, M.L.; van Oostenbrugge, J.A.E.; Hamon, K.G.; van der Valk, O.M.C.; van Overzee, H.M.J. *The Implementation of Ecosystem-Based Approaches Applied to Fisheries Management Under the CFP: Final Report: EASME/EMFF/2018/011 Specific Contract Lot 1 No. 1 EASME/EMFF/2018/011 Specific Contract Lot 2 No. 3*; Publications Office of the European Union: Brussels, Belgium, 2022; ISBN 978-92-95225-57-2.
6. Andriamahefazafy, M.; Touron-Gardic, G.; March, A.; Hosch, G.; Palomares, M.L.D.; Failler, P. Sustainable development goal 14: To what degree have we achieved the 2020 targets for our oceans? *Ocean Coast. Manag.* **2022**, *227*, 106273. [CrossRef]
7. Directorate-General for Maritime Affairs and Fisheries (European Commission); Joint Research Centre (European Commission); Addamo, A.M.; Calvo Santos, A.; Carvalho, N.; Guillén, J.; Magagna, D.; Neehus, S.; Peralta Baptista, A.; Quatrini, S.; et al. *The EU Blue Economy Report 2021*; Publications Office of the European Union: Brussels, Belgium, 2021; ISBN 978-92-76-37879-2. Available online: https://data.europa.eu/doi/10.2771/8217 (accessed on 22 January 2025).
8. Alsaleh, M. The role of the fishery industry in the shift towards sustainable food security: A critical study of blue food. *Environ. Sci. Pollut. Res.* **2023**, *30*, 105575–105594. [CrossRef]
9. March, A.; Failler, P. Small-scale fisheries development in Africa: Lessons learned and best practices for enhancing food security and livelihoods. *Mar. Policy* **2022**, *136*, 104925. [CrossRef]
10. Centro Común de Investigación (Comisión Europea); Dirección General de Asuntos Marítimos y Pesca (Comisión Europea); Borriello, A.; Calvo Santos, A.; Codina López, L.; Feyen, L.; Gaborieau, N.; Garaffa, R.; Ghiani, M.; Guillén, J.; et al. *The EU Blue Economy Report 2024*; Publications Office of the European Union: Brussels, Belgium, 2024; ISBN 978-92-68-16024-4. Available online: https://data.europa.eu/doi/10.2771/186064 (accessed on 11 November 2024).
11. Bădîrcea, R.M.; Manta, A.G.; Florea, N.M.; Puiu, S.; Manta, L.F.; Doran, M.D. Connecting Blue Economy and Economic Growth to Climate Change: Evidence from European Union Countries. *Energies* **2021**, *14*, 4600. [CrossRef]
12. Garcia, S.M.; Rosenberg, A.A. Food security and marine capture fisheries: Characteristics, trends, drivers and future perspectives. *Philos. Trans. R. Soc. B* **2010**, *365*, 2869–2880. [CrossRef]
13. Lindley, J.; Techera, E.J. Overcoming complexity in illegal, unregulated and unreported fishing to achieve effective regulatory pluralism. *Mar. Policy* **2017**, *81*, 71–79. [CrossRef]
14. Probst, W.N. How emerging data technologies can increase trust and transparency in fisheries. *ICES J. Mar. Sci.* **2020**, *77*, 1286–1294. [CrossRef]
15. Suuronen, P.; Chopin, F.; Glass, C.; Løkkeborg, S.; Matsushita, Y.; Queirolo, D.; Rihan, D. Low impact and fuel efficient fishing—Looking beyond the horizon. *Fish. Res.* **2012**, *119*, 135–146. [CrossRef]
16. Koričan, M.; Herc, L.; Pfeifer, A.; Vladimir, N.; Duić, N. Long-term influence of the gradual naval fleets decarbonization on the flexibility of an integrated energy system. *Sustain. Energy Technol. Assess.* **2024**, *72*, 104041. [CrossRef]
17. Guyader, O.; Berthou, P.; Koutsikopoulos, C.; Alban, F.; Demaneche, S.; Gaspar, M.B.; Eschbaum, R.; Fahy, E.; Tully, O.; Reynal, L. Small scale fisheries in Europe: A comparative analysis based on a selection of case studies. *Fish. Res.* **2013**, *140*, 1–13. [CrossRef]
18. Ortega, M.; Lloret-Lloret, E.; Coll, M. Diversity, competition and collaboration in the Catalan Mediterranean coastal fisheries. *Ocean Coast. Manag.* **2024**, *255*, 107257. [CrossRef]
19. Murawski, S.A. Rebuilding depleted fish stocks: The good, the bad, and, mostly, the ugly. *ICES J. Mar. Sci.* **2010**, *67*, 1830–1840. [CrossRef]
20. Perry, A.L.; Low, P.J.; Ellis, J.R.; Reynolds, J.D. Climate Change and Distribution Shifts in Marine Fishes. *Science* **2005**, *308*, 1912–1915. [CrossRef]
21. Symes, D. Regionalising the Common Fisheries Policy: Context, content and controversy. *Marit. Stud.* **2012**, *11*, 6. [CrossRef]

22. Miret-Pastor, L.; Molina-García, A.; García-Aranda, C.; Herrera-Racionero, P. Analysis of the fisheries diversification funds in Spain during the period 2007–2014. *Mar. Policy* **2018**, *93*, 150–158. [CrossRef]
23. Ramos Velasco, E.; González-Cancelas, N.; Camarero Orive, A.; Díaz-Gutiérrez, D. Green Ports Analysis Using an End-to-End Tool Application in the Fishing Port of Vigo. *J. Mar. Sci. Eng.* **2022**, *10*, 1959. [CrossRef]
24. Sultan, F.A.; Routroy, S.; Thakur, M. Evaluating sustainability of the surimi supply chain in India: A life cycle assessment approach. *Int. J. Life Cycle Assess.* **2021**, *26*, 1319–1337. [CrossRef]
25. Mwikya, S.M. *Fisheries Access Agreements: Trade and Development Issues*; International Centre for Trade and Sustainable Development (ICTSD): Geneva, Switzerland, 2006. Available online: https://www.researchgate.net/profile/Stephen-Mbithi-Mwikya/publication/242268677_Fisheries_Access_Agreements_Trade_and_Development_Issues/links/54c679990cf2911c7a58e577/Fisheries-Access-Agreements-Trade-and-Development-Issues.pdf (accessed on 20 February 2025).
26. Arlinghaus, R.; Mehner, T.; Cowx, I.G. Reconciling traditional inland fisheries management and sustainability in industrialized countries, with emphasis on Europe. *Fish Fish.* **2002**, *3*, 261–316. [CrossRef]
27. Kyvelou, S.S.; Ierapetritis, D.G.; Chiotinis, M. The Future of Fisheries Co-Management in the Context of the Sustainable Blue Economy and the Green Deal: There Is No Green without Blue. *Sustainability* **2023**, *15*, 7784. [CrossRef]
28. Li, Q. From Ecology to Humanities: A Review, Insights, and Recommendations on National Marine Parks. *Sustainability* **2024**, *16*, 9734. [CrossRef]
29. Vaca Cabrero, J.; Gómez Garach, C.P.; Camarero Orive, A.; González-Cancelas, N. Evaluation of the Implementation of the Dimensions of the Blue Economy in Spanish Ports. *J. Mar. Sci. Eng.* **2024**, *12*, 222. [CrossRef]
30. García-Lorenzo, I.; Amigo-Dobaño, L.; Garza-Gil, M.D.; Varela-Lafuente, M. Perceptions in small-scale fisheries regarding institutional, economic, technological and environmental factors. Case study in North-Western Spain. *Mar. Policy* **2023**, *150*, 105530. [CrossRef]
31. Sulanke, E.; Rybicki, S. Community development quotas and support of small-scale fisheries as two key concepts for blue growth in fisheries. *Front. Mar. Sci.* **2021**, *8*, 752764. [CrossRef]
32. Perry, H.M.; Anderson, J.; Collins, L. Status and Management of the Blue Crab Fishery in the Gulf of Mexico. *N. Am. J. Fish. Manag.* **2022**, *42*, 164–179. [CrossRef]
33. Fatema, U.K.; Faruque, H.; Salam, M.A.; Matsuda, H. Vulnerability assessment of target shrimps and bycatch species from industrial shrimp trawl fishery in the Bay of Bengal, Bangladesh. *Sustainability* **2022**, *14*, 1691. [CrossRef]