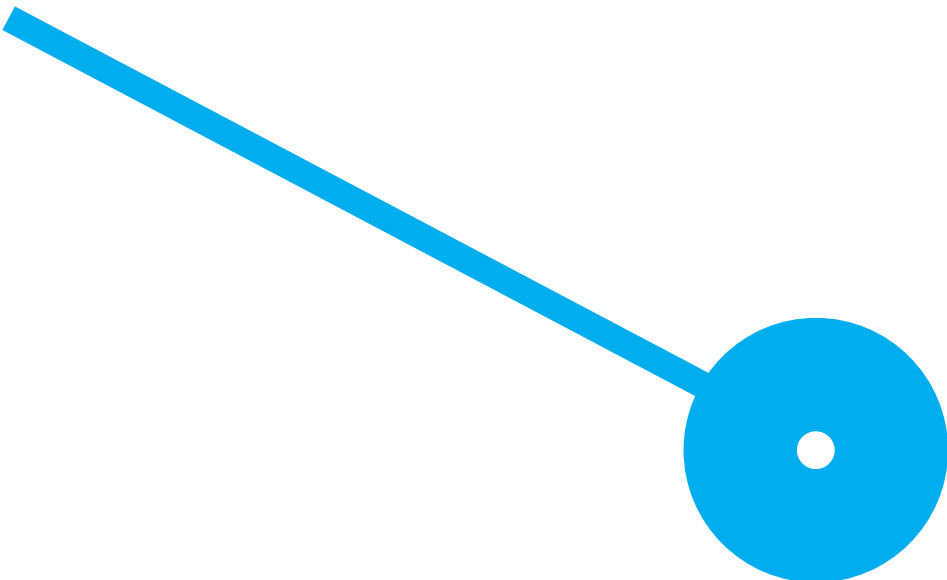
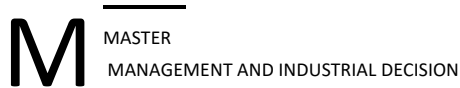


# Exploring the potential of the Blue Economy in the Iberian Peninsula: linking Sustainability and Logistics

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# How to measure the impact of Blue Economy activities in coastal zones?

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Dissertation submitted in fulfilment of the requirements for the Master's degree in Management and Industrial Decision in the School of Management and Technology of the Polytechnic of Porto.

## **Integrity Statement**

I, Inês Lima Carneiro, student nº 8190206, of the Master's Degree in Management and Industrial Decision of the School of Management and Technology of the Polytechnic of Porto, declare that I have not plagiarized or self-plagiarized, therefore the work entitled "Measuring the Implementation of the Blue Economy in the Iberian Peninsula" is original and of my own authorship, not having been used previously for any other purpose. I further declare that all sources used are cited, in the text and in the final bibliography, according to the referencing rules adopted in the institution.

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## Abstract

Over the decades the sea has always been present in economic activities, either as a food source, a means of transportation, or as a way of doing commercial trade. In more recent years, a new concept of the utilization of the oceans has emerged, namely the Blue Economy (BE) which is a concept that focuses on economic activities that depend on the sea, including tourism, maritime transport, energy, and fishing. This concept aims to promote, economic growth, social inclusion and to improve life without compromising the ocean's environmental sustainability. The scope of this study is on the utilization of living marine resources with the purpose of understanding the performance of the EU member states. In order to achieve this, a quantitative cluster analysis was conducted, and later a cluster categorization focuses on the Iberian Peninsula countries. The results obtained show how different countries implement their BE policies and contribute to its development, revealing their strengths and improvement areas.

Keywords: Blue Economy (BE); Cluster analysis; Marine Living Resources.

Index

- 1. Introduction..... 10
- 2. Literature Review..... 11
  - 2.1. BE: an overview ..... 11
  - 2.2. Linking BE and Logistics..... 14
  - 2.3. BE in the Iberian Peninsula ..... 15
  - 2.4. The role of Cluster analysis to assess BE performance ..... 16
- 3. Research Methodology ..... 18
  - 3.1. Data search and retrieval..... 19
  - 3.2. Data processing ..... 19
  - 3.3. Cluster analysis..... 21
- 4. Main findings..... 24
  - 4.1. Cluster categorization ..... 30
- 5. Conclusion..... 40
- 6. References ..... 42
- 7. Appendix..... 56

## Acronyms

BE- Blue Economy;

EEZ- Exclusive Economic Zones;

NOS 2030- National Ocean Strategy 2021-2030;

DGPM- Directorate General for Maritime Policy;

IQR- Interquartile Range Analysis;

GVA- Gross Value Added;

EU- European Union;

GMM- Gaussian Mixture Model;

BIC- Bayesian Information Criterion;

AIC- Akaike Information Criterion;

GMM- Model-Based Clustering;

GPD- Gross Domestic product;

IMP- Integrated Maritime Policy;

EIF- European Investment Fund;

EMFAF- European Maritime, Fisheries and Aquaculture Fund;

MAPA- Ministerio da Agriculture, Pesca y Alimentacion;

PLOCAN- Oceanic Platform of the Canary Islands;

SDGs- Sustainable Development Goals;

ToC- Theory of Change;

BEI- Blue Economy Index;

PNIEC- National Energy and Climate Plan;

PRTR- Recovery, Transformation and Resilience Plan;

MSP- Maritime Spatial Plans;

PSOEM- Maritime Spatial Planning Situation Plan.

## Figure Index

|                                                   |    |
|---------------------------------------------------|----|
| Figure 1- Methodology steps.....                  | 18 |
| Figure 2- Heat map.....                           | 20 |
| Figure 3- Cluster map.....                        | 25 |
| Figure 4- Cluster means plot.....                 | 28 |
| Figure 5- Cluster density plot.....               | 29 |
| Figure 6- Data score for accuracy.....            | 31 |
| Figure 7- Cluster categorization methodology..... | 31 |
| Figure 8- Scoring for CRT 1.....                  | 33 |
| Figure 9- Scoring for CRT 2.....                  | 34 |
| Figure 10- Scoring for CRT 3.....                 | 35 |

## Table Index

|                                                          |    |
|----------------------------------------------------------|----|
| Table 1- Primary results for the model analysis.....     | 24 |
| Table 2- Detailed scoring guide for assessing CRT 1..... | 56 |
| Table 3-Detailed scoring guide for assessing CRT 2.....  | 57 |
| Table 4-Detailed scoring guide for assessing CRT 3.....  | 58 |

## 1. Introduction

Over the last decades, the sea represented an infinite natural resource that the human population aimed to use indefinitely (Jobstvogt et al., 2014).

Yet, due to natural events and human actions, such as oil and gas exploitation, cable laying, pipeline construction, underwater noise, water pollution from shipping routes, waste dumping, drill cuttings from mining activities, and pollution from terrestrial sources, the sea has been exposed to numerous dangers (Jobstvogt et al., 2014).

Therefore, the BE concept appeared as a “pillar of protection” of the unsustainable use of sea resources (Nikčević & Škurić, 2021). This concept is related to an approach to encouraging economic growth through the sustainable utilization of ocean resources with technological inputs to improve livelihoods and meet the growing demands for jobs without hampering the health of the ocean ecosystem. Additionally, when used sustainably, BE supports food security, manages and protects the ocean environment, creates new jobs, and has the potential to provide new resources for energy, chemicals, food, and minerals, ultimately enhancing human welfare. Additionally, BE also fosters resilience to climate change (Sarker & Hussain, 2019).

As the ocean provides numerous alternatives to the human population, such as fishing, food, and the transportation of goods, maritime transport is of great importance to the global economy (Psaraftis, 2021).

Additionally, alongside the intensity of economic maritime activities, pollution is one of the most important factors related to these activities: it has been calling the attention of policymakers and stakeholders to develop initiatives to minimize the environmental impacts in this sector, for instance, by means of green investment in port infrastructure and ecological ships, following the current European trends and concerns (Fratila et al., 2021).

Having in mind the importance of sea activities, especially in coastal countries, this research aims to analyze the development and impact of the BE in the Iberian Peninsula, focusing on its relationship with logistics and living resources. By understanding the structure and role of BE clusters, this research provides insights into sustainable economic activities related to maritime activities.

The present study aims to fill a present gap in the literature by approaching an emerging theme (BE), establishing a link between BE and Logistics, and providing helpful insights, such as opportunities and challenges, on the implementation of BE in the Iberian Peninsula.

This study is divided into four sections, Section 1 presents the context and the main objective proposed. Section 2 presents the theoretical background that sustains the present study. Section 3 summarizes the proposed methodology and the pathway to develop the framework. In the final section of this paper, a summary of the findings and highlighted purposes for future research are presented.

## 2. Literature Review

To support the purpose of the present study, this literature review addresses key elements of the BE, approaches the utilization of maritime Living Resources, Blue sustainability, BE in the Iberian Peninsula, and Cluster analysis. The platforms consulted for the development of this study were Google Scholar, Web of Science and Elsevier. As the theme approached in this study is very recent, no filter was done when searching for articles, all the searches were conducted in English.

### 2.1. BE: an overview

As a result of increasing globalization, business leaders worldwide have highlighted the current state of the business environment, particularly the changes in the way goods are traded in a global economy. The uncertainty caused by this scenario has contributed to the worldwide market becoming more volatile, complex, and ambiguous. A constant factor is the growing demand for products of higher quality at lower costs (Nag & Tran, 2020).

In this context, life originated in the oceans, which constitute more than 95% of the biosphere. It has been responsible for providing a substantial share of the global population with food and livelihood, and serves as the means of transportation for 80% of global trade. The ocean, regardless of our actions toward its well-being, continues to support all life by generating oxygen, absorbing carbon dioxide, recycling nutrients, and regulating global climate and temperature (Bari, 2017).

The oceans can also be considered a central element in discussions about sustainability, whether the focus is on their protection or exploitation. This is true in the recent climate change discussions, which, following the major global mobilizations, have received particular attention (Ertör & Hadjimichael, 2020). This focus is justified by the increasing importance of sea activities in enabling international trade by linking sellers and buyers. For instance, the behavior patterns of these linking enablers on the oceans are gaining more attention from a regulatory and economic perspective as the relationship between land and ocean evolves in its role and significance (Smith-Godfrey, 2016).

The BE refers to a new development paradigm that advocates sustainable management, usage and conservation of ocean and ocean-related industrial activities such as fisheries, port and shipping, deep sea mining, ocean energy, coastal tourism, ecosystem services, and marine services, among others, in a manner that offers huge potential for economic expansion, wealth creation and jobs to coastal nations and marine countries (Bueger & Wivel, 2018; Findlay, 2020; Mohanty & Dash, 2020).

The approach of achieving long-term prosperity in a country or a region befitting the well-being of all citizens and mankind by preserving the environment, especially the sea, is the basis of the BE (Bari, 2017). For instance,

over the last few years, it appears that companies are in the race to create more blue ocean markets for the future, with far greater speed compared to the past. (Nag & Tran, 2020).

Understanding, utilizing, and protecting oceans are the shared goals and responsibilities of all human beings to achieve sustainable marine development in the future. Currently, BE as the new development concept, and the “blue engine,” is becoming a significant driving force for achieving global sustainable development. In this context, environmental observations play a powerful technical supporting role in realizing BE development through joint efforts, pushing forward the accord development between the BE and the global economy, society, and ecosystem in the next decade (Inbakandan, 2023).

BE activities also seek to promote economic growth, social inclusion, and the preservation and improvement of livelihoods, while at the same time ensuring the environmental sustainability of our oceans and seas (UNESCO, 2017). Yet, despite numerous efforts to define BE, ambiguities surround the term. These ambiguities are justified due to the considerable differences not only in how BE is conceptualized but also in how it is implemented and what is prioritized. Notwithstanding these differences, most BE definitions incorporate, at a minimum, a consideration of social, environmental, and economic objectives (Voyer, Quirk, McIlgorm, et al., 2018a).

In summary, BE, as a macroeconomic concept, involves every aspect of national and global governance, economic development, environmental protection, sustainability, and international communication. As such, in this research, we consider the BE as an integration of sustainable development and green growth. It highlights overall planning and coordinates development between the different activities, such as marine ecosystems and ocean and coastal zone economic systems, which are directly related to logistics activities (Hazra & Bhukta, 2022).

As humans continue to abuse and misuse natural resources, ecosystems worldwide are on the verge of collapse. The environment has already reached several tipping points, increasing the possibility that irreversible changes could occur in the future (Rockström et al., 2009).

In recent decades, there has been increasing recognition of the necessity to explore social and economic development through resource extraction and waste disposal. In the twenty-first century, one of the most challenging issues seems to be balancing economic growth among competing countries while improving the standard of living for a population projected to exceed 10 billion by mid-century (Ha, 2024).

Economic operations using the ocean have become more significant globally. The ocean economy, including fishing, marine aquaculture, tourism, transportation, logistic operations, the extraction of oil and gas, and mining, plays a vital role in economic development and climate actions (Nham & Ha, 2023).

In the global context of promoting sustainable pathways, it is crucial to explore ways to mitigate the damaging environmental effects caused by human production and consumption processes on coastal and marine ecosystems (Nham & Ha, 2023).

Today, the ocean is viewed by some as equivalent to a land-based resource system, to be managed, allocated, and developed as property and governed through market mechanisms. This interest becomes relevant when the international community confronts multiple and overlapping uses for ocean and marine environments, as opposed to separate uses, such as fishing, aquaculture, or mining (Winder & Le Heron, 2017).

As such, the term BE emphasizes the multifaceted economic and societal importance of the ocean (and, in some countries, certain inland waters), along with five key components: ecosystem resilience, economic sustainability, community engagement, institutional integration, and technical capacity (Eikeset, Mazzarella, Davíðsdóttir, Klinger, Levin, Rovenskaya, et al., 2018).

It constitutes an evolution of ideas about sustainable economies used to denote an expansion of economic wealth derived from the oceans and coasts while maintaining or even improving the natural systems upon which economic systems depend. It shares the idea that economic activities/growth are not antithetical to ecological conservation but are rather complementary or even reinforcing (Boonstra et al., 2018).

As a core component of BE, the fishing sector plays a vital role in food security, employment generation, and the economic stability of coastal regions (Alsaleh, 2023). 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 (González-Cancelas et al., 2025).

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 (Bădîrcea et al., 2021).

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 BE strategy (Lindley & Techera, 2017).

By embracing sustainability-focused policies and technological solutions, the European fishing industry can transition toward a more resilient and adaptive role within the BE, ensuring long-term economic stability while minimizing environmental impact (Martínez-Vázquez et al., 2021a).

## 2.2. Linking BE and Logistics

As one of the several logistics activities, maritime transportation can be considered the glue that links the fragmented production model of the global value chain and carries paramount importance for accelerating a country's international trade (Sheikhet al., 2023). These activities are related to the provision of sea freight services, facilitating the delivery of goods from producers to consumers regardless of distance. It also involves the transportation of goods by sea, which is particularly suitable for long-distance and heavy cargo transportation (Song & Panayides, 2021).

Due to the importance of maritime transportation as one of the most critical areas of BE, this research focuses on the importance of better discussing the area in terms of economic, environmental, and social impacts. As a complex activity, it includes the coordination and collaboration among various entities, handling, and moving cargo within seaports, as well as principles of Logistics and supply chain management (Gülmez et al., 2023a).

Maritime transportation also plays a central role in global Logistics networks, managing the flow of cargo and offering value-added services in an efficient, effective, safe, and environmentally friendly manner (Hatina, 2021).

As international trade has grown rapidly, the demand for maritime transport has also increased in several countries worldwide. This industry has experienced an increasing demand for maritime transport, which has pressed the sector to improve the conventional mode of movement of goods to a comprehensive demand for the timely, reliable, and cost-effective delivery of goods (Song & Panayides, 2021).

In this context, maritime transportation has shifted from the pure shipment of various cargoes to the effective and efficient delivery of diversified Logistics services, including warehousing, material handling, inventory management, and packaging. Due to the integration of maritime transport activities with Logistics processes, a term called maritime logistics has emerged, and it has been considered deeply involved in the overall Logistics flows within the maritime transport system (Gülmez et al., 2023b).

Yet, despite the importance of these activities, researchers focusing on evaluating the socioeconomic importance of marine and coastal activities are still scarce, which has been a challenge in attracting the attention of the international scientific and non-scientific community (Kildow & McIlgorm, 2010). This is also the case of the BE, which highlights the importance of oceans for contributing to poverty eradication by creating sustainable livelihoods and decent work, providing food and minerals, generating oxygen, absorbing greenhouse gases and mitigating the impacts of climate change, but few research focusing on the importance of linking these two areas, namely BE activities and Logistics (Chen et al., 2020).

### 2.3. BE in the Iberian Peninsula

The BE is an evolving concept; there are both established and emerging sectors (maritime transport, port activities, research and innovation, blue biotechnology, etc.) that are currently experiencing a digital revolution (Martínez-Vázquez et al., 2021a).

An example of Spain's effort to contribute for BE growth is that Spanish ports are implementing new technologies to promote sustainability, environmental quality, and logistical efficiency. This digital transformation is known as Ports 4.0 or Smart Ports, encompassing aspects such as automation, digitization, interoperability, and enhanced customer experience. The Blue Ocean concept aims to achieve effective digitalization, leading the Spanish port system towards Port 4.0 (Ortiz-Rey et al., 2020).

This energy transition is not only taking place in the economic sectors associated with ports. The concept of a "green port" is gaining increasing popularity and refers to a port that has actively committed to adopting sustainable practices and policies to minimize its environmental impact and promote social responsibility. These ports seek to integrate environmental considerations into their infrastructure and operations, focusing on energy efficiency, emission reduction, waste management, and the promotion of environmentally friendly practices (Ramos Velasco et al., 2022).

Spain, one of the world's leading tourist destinations, has a key focus on the cruise market due to its strategic geographical position in the western Mediterranean, along the Atlantic coast, and in the Canary Islands. This tourist attraction is the main engine of the Spanish economy, and for this reason, our port system is aware of and invests in the necessary infrastructures to attract cruise ships and a greater number of tourists to our territory. The impact of tourism accounted for approximately 8% of the country's gross domestic product in 2021, with a significant portion of its economy sustained by the service sector, characterized by development and excellence unparalleled among hotel and transportation offerings (de Manuel-López et al., 2024).

Regarding Portugal, with a coastline of approximately 25000 Km<sup>2</sup>, it has one of the largest Exclusive Economic Zones (EEZ) worldwide, covering over 1.7 million km<sup>2</sup>. In addition to its extensive EEZ, which includes the Azores, Madeira, and mainland Portugal, the Portuguese continental shelf is extremely important due to its delimitation beyond 200 nautical miles (Almeida et al., 2024).

Portugal developed its current National Ocean Strategy 2021-2030 (NOS2030), accompanied by an action plan for its development and implementation, and it includes programs related to the BE and sector-based domains, Directorate General for Maritime Policy (DGPM), 2023. It also sets up a financial mechanism and investment plan to support BE Economy initiatives (Almeida et al., 2024).

Therefore, Portugal has great interest, but also challenges, in the knowledge of ocean processes, the monitoring of the environmental status of the marine and coastal ecosystem, maritime spatial planning, including the creation of marine protected areas and their sustainable development, or ensuring fisheries stocks, to name a few (Almeida et al., 2024).

#### 2.4. The role of Cluster analysis to assess BE performance

In the era of big data, extracting meaningful patterns from complex datasets has become a crucial task across various scientific and industrial domains. Among the most widely used unsupervised learning techniques, cluster analysis has emerged as a fundamental tool for discovering inherent groupings in data without relying on pre-labeled outcomes (Jain, 2010).

By organizing data points into homogeneous subgroups, clustering enables researchers and practitioners to identify patterns, simplify data interpretation, and inform decision-making in various contexts, including biology, market segmentation, image processing, and urban planning (Xu & Wunsch II, 2005).

Cluster analysis is part of the broader family of exploratory data analysis techniques, which seek to reveal natural partitions in datasets based on similarity or dissimilarity measures. Unlike supervised learning methods, clustering does not rely on training labels, making it particularly useful for investigating unknown patterns or generating hypotheses in early research stages (Everitt S. et al., 2011).

Despite its broad applicability, cluster analysis presents ongoing challenges, including the selection of the appropriate algorithm, choice of distance metric, determination of the optimal number of clusters, and validation of the results. The nature of the data heavily influences the effectiveness of clustering—its scale, dimensionality, and distributional characteristics, which have motivated the development of numerous adaptations and hybrid approaches (Aggarwal et al., 2001).

Clusters can generate innovation and growth, but the adoption of one-size-fits-all policies needs to take into account local conditions and existing potential. However, the models developed are limited by their static nature, which constrains their application in practice. The focus of attention is on how clusters can be organized rather than how they emerge (Rodríguez & Comptour, 2012).

BE includes a variety of economic activities related to the oceans and coastal areas, including fisheries, maritime transport, energy production, and coastal tourism (Eikeset, Mazzarella, Davíðsdóttir, Klinger, Levin, & Sterner, 2018). As BE continues to grow, there is a need for a better understanding of regional disparities, and identifying countries with a similar blue growth profile becomes essential for adequate policy making (Voyer, Quirk, McIlgorm, et al., 2018).

In this context, cluster analysis offers a data-driven framework to propose the grouping of countries based on indicators, such as the utilization of marine resources, environmental performance, and employment (Voyer, Quirk, McIlgorm, et al., 2018).

According to (Silver et al., 2015), clustering can highlight mismatches between economic results and environmental sustainability within BE sectors, helping to identify potential blue paradoxes – defined as situations where economic growth coexists with ecological degradation.

A study from Hamdy & Bevilacqua, 2023 has sought to identify the characteristics of Blue Growth in Calabria. The results reveal the cross-sectoral linkages within the region, providing a holistic view of the current structures, which is essential for initiating an inclusive transition. It was established that there are powerful zones within Calabria that act as the dominants for Blue Growth industries. For sectors, “Engineering activities and related technical consultancy”, “Freight transport by road”, “Travel agency activities”, and “Technical testing and analysis” are the dominant ones. Crotona, Reggio Di Calabria, Cosenza, Vibo Valentia, and Lamezia Terme are the strongest Local Labor Market Areas (LMAs) in Calabria. However, Calabria is very weak compared to the rest of the country. The industries there are small, and it is not specialized in these sorts of sectors, although it is a coastal region and surrounded by water on 3 sides.

In another study, conducted by Ovchynnykova et al. 2025, a comprehensive analytical framework was applied to assess the economic characteristics and performance of the BE across EU coastal countries. Using Interquartile Range Analysis (IQR) analysis, Ward’s clustering, and z-score normalization, a subset of representative countries was identified to exemplify typical BE contributions.

In summary, countries with stable core sectors, such as the Netherlands, Finland, and Latvia, exhibit low volatility in key industries like port activities and maritime transport. This contributes to the overall stability and resilience of their BE’s. In contrast, economies with structural dependence on coastal tourism—namely Spain, Portugal, and Bulgaria—demonstrate low variability in this sector, suggesting relative stability. However, such specialization indicates limited diversification, which may heighten vulnerability to sector-specific shocks (Ovchynnykova et al., 2025).

As the interest and importance of sustainable and inclusive maritime growth continue to rise, more studies and approaches will surge, making a valuable foundation for decision-making and advancement of a more resilient BE.

### 3. Research Methodology

In this research, a systematic approach that involves planning and interventions for the discovery or interpretation of newly gained information was considered. The reliability and validity of a study depend on a well-designed study with objective, reliable, and repeatable methodology, as well as appropriate conduct, data collection, and analysis with logical interpretation (Garg, 2016).

Quantitative methodology is esteemed for producing precise, reliable, and generalizable measurements, which are critical for testing theories and making broad inferences. Statistical techniques facilitate the clear operationalization of variables, ensuring that results are not excessively influenced by researcher bias. This objective approach is highly regarded in fields that demand measurable evidence, such as economics, medicine, and the social sciences (Field, 2013).

Meanwhile, qualitative research can support research to generate hypotheses, explain underlying mechanisms, and provide contextual understanding, while quantitative methods can test hypotheses and verify the generalizability of qualitative findings (Creswell & Clark, 2017).

With the purpose of identifying patterns and group similarities among countries, a cluster analysis was conducted, based on the selected variables related to living resources within BE. By utilizing this method, it was possible to classify countries by their performance in areas like Gross Value Added (GVA), Employment, Fuel Efficiency, and environmental impact.

Furthermore, after analyzing the results provided by the cluster analysis, the categorization of clusters will be conducted using an established framework from Wuwung et al. (2022).

Figure 1 represents the steps taken in order to conduct the study:



Figure 1- Methodology steps.

### 3.1. Data search and retrieval

As shown in Figure 1, for the first step—data search and retrieval—a set of sources was consulted as the primary data source, specifically the European Union (EU) BE Observatory (European Commission, n.d.-c). After analyzing all the available data, the most relevant variables were selected, considering economic and environmental indicators associated with the maritime sector, including full-time employment in living resources; persons employed in living resources; GVA of living resources; gross profit in living resources; CO<sub>2</sub> emissions; fuel intensity; fuel use; fuel price; fuel efficiency; and energy cost.

With the aim of analyzing the performance of the selected variables, countries with available data were selected: Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, the Netherlands, Poland, Portugal, Romania, Slovenia, Spain, and Sweden. The data collected for these countries was from 2020 since it was, at the time, the most recent data available.

### 3.2. Data processing

After finalizing step one and concluding the database, the next step is to process the selected data. Data preprocessing is often necessary to ensure the validity and reliability of results from data analysis (Xiao et al., 2017). The aims of data preprocessing include removing noise from the data, organizing the data for more efficient access, and extracting specific data that is significant in a particular context (Kirchner et al., 2016).

To ensure the quality of the analysis, a correlation analysis was performed between variables, relying on the Spearman Correlation Matrix (since the variables are not normally distributed), as represented by the heat map presented in Figure 2. This process allowed the identification of strong relations between certain indicators, which suggests redundancy in the information.

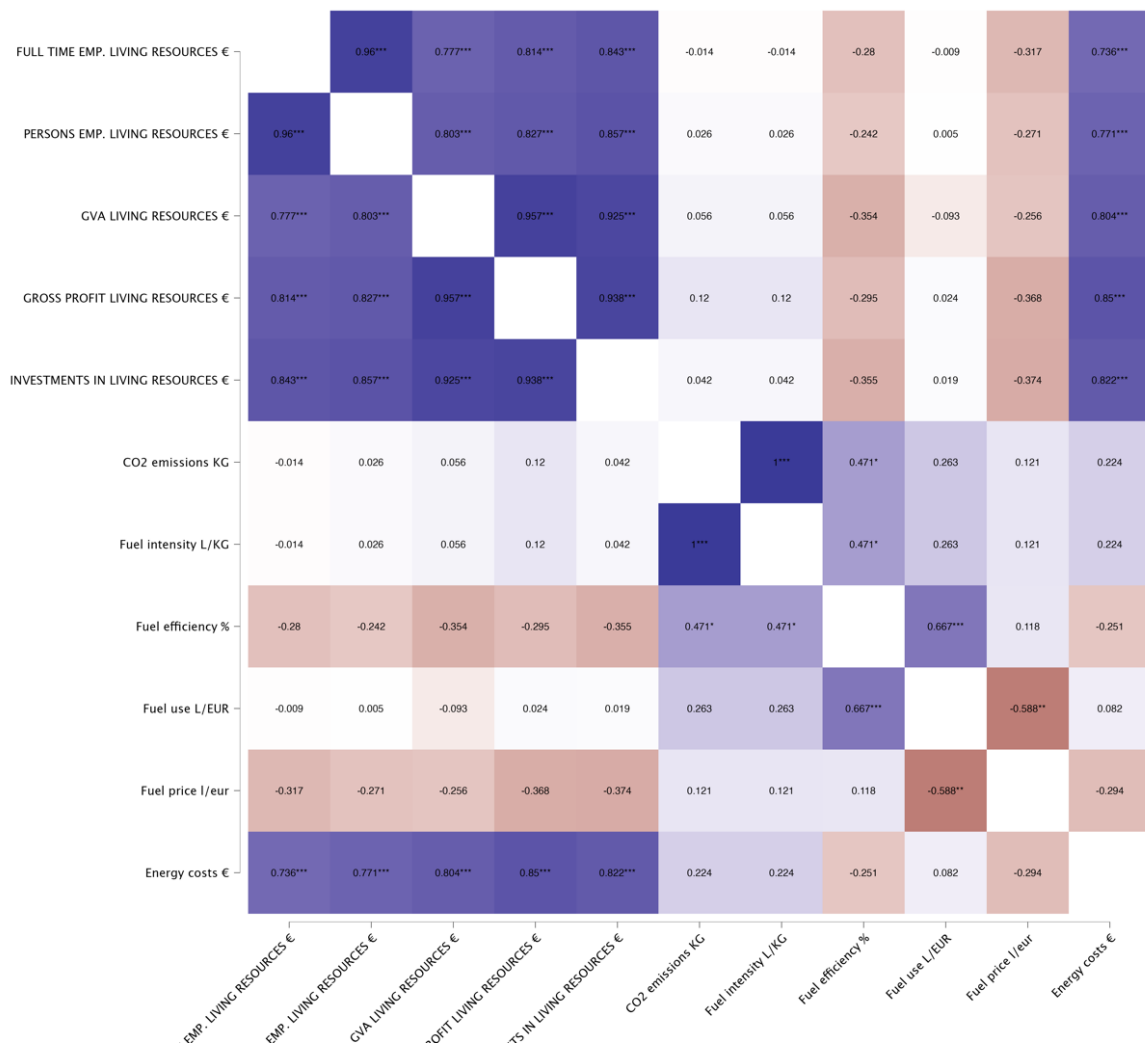


Figure 2- Heat map.

At this stage, redundant variables were identified through statistical analysis. These variables do not provide unique information because their data is already contained in other variables within the database (John Duignan, 2016). Removing them makes the model more straightforward, allowing for clearer insights into the relationship between variables (Flury, 1989).

Multicollinearity is described as the phenomenon in which two or more predictor variables in a multiple regression model are highly correlated. The presence of multicollinearity can negatively impact the analysis as a whole and severely limit the conclusions of the research study (Gregory, 2018).

Therefore, at this stage, the variables with very high correlations between indicators (greater than 0.7) were removed, retaining only one representative from each similar indicator. This process primarily reduced

multicollinearity and ensured that the clustering model identified meaningful patterns without the overwhelming effect of redundant variables.

After selecting the variables, a set of clustering methods was considered to determine which method would be most suitable for segmenting the countries.

### 3.3. Cluster analysis

The methodology adopted for this study involved the utilization of clustering techniques to identify structural patterns between the analyzed countries. A cluster analysis was chosen for this study, since clustering provides an opportunity to analyze country-level indicators collectively rather than in isolation, to determine which countries are similar and explore the relationships between variables driving cluster membership (Grein & Tatum, 2010).

The method initially applied was K-Means, which is well-known for its efficiency in clustering large datasets. The K-modes algorithm uses a simple matching dissimilarity measure to deal with categorical objects, replaces the means of clusters with modes, and uses a frequency-based method to update modes in the clustering process to minimize the clustering cost function (Huang, 1998). Even though this method is known for its simplicity and computational efficiency, it has a principle that all clusters are spherical and of similar size, which can limit its capability of capturing more complex structures in the data being studied.

The available hierarchical clustering techniques perform clustering in the original feature space of the data, which can suffer from overlap, sparseness, or other undesirable characteristics, resulting in subpar performance. However, hierarchical clustering can provide partitions of varying granularity levels according to the inherent characteristics of the given data. In this way, hierarchical clustering meets the needs of users who require data division at different resolutions (Yang & Lin, 2024). Hierarchical clustering was utilized to enhance the visualization of the cluster structure and to analyze various levels of segmentation.

However, this method proved to be less flexible for reassigning countries and exhibited some inconsistencies in the separation between larger and smaller maritime economies. Yet, when compared to traditional non-latent clustering methods (e.g., k-means clustering, hierarchical clustering), GMM (Gaussian Mixture Model) treats profile membership as an unobserved categorical variable, where its value indicates which profile an individual belongs to with a certain degree of probability (Notelaers et al., 2006).

GMM model-based methods are commonly used to generate fit statistics, enabling statistical inference. When determining the most appropriate number of clusters for a population, it's essential to consider comparisons

between clusters. Therefore, GMM is regarded as a more statistically robust clustering method, as identifying the number of latent classes is less arbitrary than with traditional clustering methods (Notelaers et al., 2006).

In this study, the model included the Bayesian Information Criterion (BIC), Akaike Information Criterion (AIC), Silhouette Score, and R-squared ( $R^2$ ):

- BIC is a model selection criterion that ensures the adequacy of the model, harmonizing the model accuracy and complexity. It can be calculated as:

$$BIC = -2 \ln(L) + k \ln(n)$$

Where:

$L$  – is the model's data likelihood function;

$k$ - is the number of the estimated parameters;

$n$ - is the number of observations.

A lower BIC value represents a model that correctly balances accuracy and complexity (Rousseeuw, 1987).

- AIC, another model criterion, that establishes the trade-off between the fit of the model with simplicity, in an empirically justifiable fashion (Moll et al., 2016). It can be calculated as:

$$AIC = -2 \ln(L) + 2k$$

$L$  – is the model's data likelihood function;

$k$ - is the number of the estimated parameters;

A lower AIC result indicates a preferable model (Forgy, 1965).

- Determining the optimal number of clusters for a data set is an important problem in certain clustering algorithms, especially the well-known k-means and similar algorithms, for this study was chosen the method of analyzing silhouettes scores (Forgy, 1965).

The silhouette coefficient is calculated by considering the mean intra-cluster distance  $a$  and the mean-cluster distance  $b$  for each data point. The interpretation of the coefficient is:

- A score with a value near + 1 means the data point is in the correct cluster;
  - A score with a value near 0 means the data point might belong in some other cluster;
  - A score with a value near -1 means, the data point is in (a) wrong cluster (Everitt et al., 2011).
- 
- As for  $R^2$ , typically, this metric can be seen in regression models, but it can be adapted to clustering. When applied to this purpose, it can indicate the proportion of total variance explained by the cluster solution, the results can be interpreted as, the higher the value the better clustering (Everitt et al., 2011).

The statistical analysis conducted in this study, for interpreting patterns in the BE for EU countries, relied on JASP software (version 0.19.3 for intel).

#### 4. Main findings

The results from GMM allowed us to identify distinct patterns between the various countries analyzed in the context of the BE. The model was optimized using the Bayesian Information Criterion (BIC), ensuring a balance between precision and complexity in segmenting the clusters.

As presented in Table 1, the value of  $R^2 = 0.627$  indicates that the model explains approximately 62.7% of the variability in the data, which is a realistic outcome for this type of analysis. The BIC was used to optimize the number of clusters, ensuring that the segmentation is efficient enough to preserve the model's quality. The Silhouette Score of 0.280 suggests that the clusters demonstrate moderate separation. At the same time, the Dunn Index shows a value of 0.317, indicating some overlap between groups without significantly compromising the interpretation of the results.

Table 1- Primary results for the model analysis.

| Clusters | N  | $R^2$ | AIC    | BIC     | Silhouette |
|----------|----|-------|--------|---------|------------|
| 4        | 22 | 0.627 | 95.010 | 121.190 | 0.280      |

Table 2 summarizes the results by highlighting the distribution of the countries within the four clusters identified by the GMM model:

Table 2- Countries distribution by clusters.

| Cluster                                          | Countries                                                                      |
|--------------------------------------------------|--------------------------------------------------------------------------------|
| Cluster 1 (C1) - "Coastal traditional economies" | Belgium, Bulgaria, Croacia, Lithuania, Malta, Portugal                         |
| Cluster 2 (C2) - "Major industrial nations"      | Cyprus, Denmark, Estonia, Finland, France, Germany, Italy, Latvia, Netherlands |
| C3 - "Emerging maritime economies"               | Greece, Ireland, Poland, Romania                                               |
| C4 - "Leaders in Blue Energy initiatives"        | Slovenia, Spain, Sweden                                                        |

The figure presented below shows the distribution of the clusters across European countries, this representation offers a more intuitive view of how the clusters are scattered.

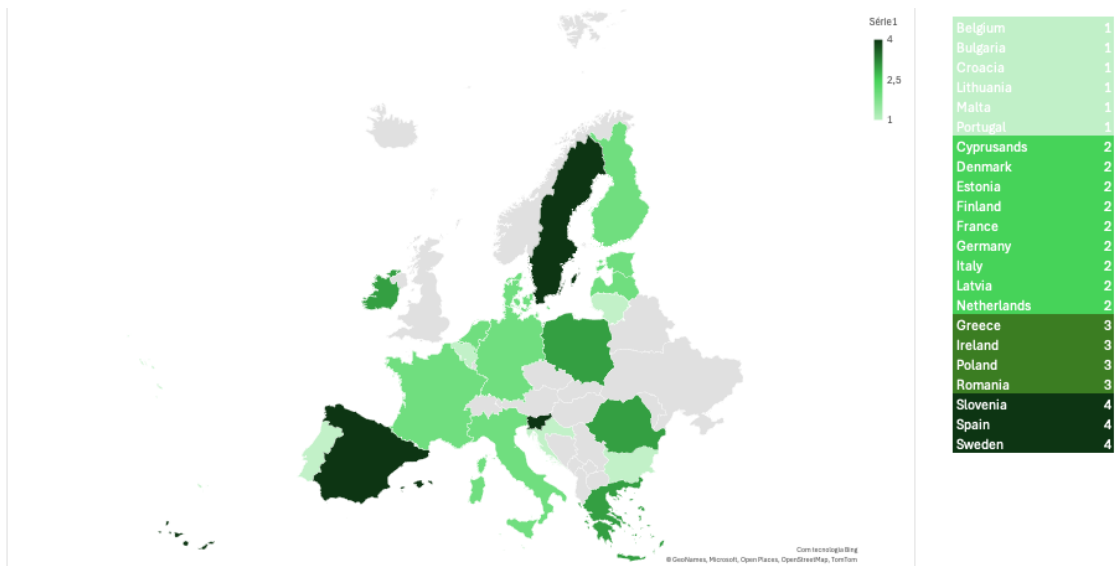


Figure 3- Cluster map.

### C1 - “Coastal traditional economies”

The countries that belong to this cluster are characterized by their low levels of employment and GVA regarding the BE, as shown by the negative values on the bars of “Full Time Employment Living Resources” and “GVA living resources €”. This suggests that the economic activities linked to the sea are reduced and depend on traditional sectors as fishing and coastal tourism.

Regarding environmental concerns, the impact of this cluster is reduced, with low  $CO_2$  emissions and with the levels of consumption of fuel being relatively balanced. However, the energy efficiency is also lower, which can indicate that there is still not much innovation in regards the transition to more sustainable technologies.

According to the maritime sector, Malta's economy is a key element, being responsible for 8% of the nation's total value added and employing over 20,000 people. Despite its importance, the industry operates within a traditional framework that, in the present day, presents challenges such as environmental impact, limited human resources, and rising operational costs (Pinczynski et al., 2024).

Thus, we can affirm that this cluster represents countries with small and traditional maritime economies that need to invest in innovation and energy efficiency in order to increase their competitiveness.

### C2 - “Maritime economies”

C2 represents countries with high GVA and a high number of full-time employment results, truly standing out, as evidenced by the significantly high blue bars on the economic indicators. These countries have advanced harbor infrastructure and more developed maritime industries, which are considered central to global maritime trade.

Even though the countries in this cluster show a medium level of CO<sub>2</sub> emissions, their fuel Consumption is relatively efficient, indicating a balance between economic production and environmental impact. The fuel price in these countries is slightly below average, which can favor the competitiveness of the maritime sector, for example, in Denmark, which belongs to cluster 2, the fuel price is 0,36€/L, meanwhile, in Croatia, which belongs to cluster 1, the fuel price is 0,45€/L.

Achieved results show that this cluster includes some of Europe's principal maritime economies, combining strong economic growth with a moderate energy transition, as seen, for example, in Germany and the Netherlands. These countries are recognized for their advancements in the maritime industry, driven by steady investments that foster more sustainable practices.

### **C3 – "Emerging Maritime Economies"**

The countries in this cluster are characterized by their high levels of CO<sub>2</sub> emissions, low energy efficiency, and high fuel consumption. This suggests that they still heavily rely on fossil fuels.

In Poland, total energy consumption in 2019 was 4,405.8 PJ. The share of hard coal amounted to 37.0%, brown coal 9.1%, crude oil 26.3%, natural gas 16.1%, renewable energy carriers 9.3%, and other carriers 2.2%. The large role of fossil fuels in Poland's energy mix translates in a high level of CO<sub>2</sub> emissions compared to the European Union. The latest data show that Poland is responsible for 11.2% of CO<sub>2</sub> emissions in the EU (Wiśniewska & Markiewicz, 2021).

In an economic level, GVA and employment in the maritime sector, they are moderately low, suggesting that these countries are still developing within the BE. Besides that, the fuel average is higher than average, which can make it harder to be more competitive in the sector.

Bank of Greece Governor Yannis Stournaras emphasized on Wednesday the significant growth prospects of Greece's BE in the coming years, contingent upon reducing its environmental and climate impact. According to 2021 data, sectors within the BE in Greece employ approximately 446,000 workers (11.4% of the national workforce) and generate about 6.5 billion euros in gross value added (4.1% of total GVA). Coastal tourism is the most significant contributor, accounting for 83% of BE jobs. The marine living resources sector employs 8% of the BE workforce, while other sectors contribute smaller shares (eKathimerini, 2024).

In this cluster, the countries represented are still growing in the maritime sector, so to face its challenges, they need to implement strategies that promote renewable energy and energy efficiency.

The government of Ireland has committed to meeting 70% of its electricity needs from renewable sources by 2030, and to achieving net-zero carbon emissions by 2050. Separately, Ireland's integrated marine plan,

Harnessing Our Ocean Wealth, sets a target to double the value of Ireland's ocean economy by 2030 (Kandrot et al., 2020).

#### **C4 – “Leaders in Blue Energy Initiatives”**

In C4, we can find the countries with the most efficient energy use, in other words, countries that use lower amounts of energy while still maintaining economic activity, which can be seen in the high blue bars in the Fuel Efficiency graphic. These countries adopt strict environmental policies and invest strongly in clean technologies, reducing the environmental impact in the maritime sector.

It is also possible to conclude that fuel consumption remains high, indicating that even though these countries are more efficient, their maritime sectors still have an energy-intensive nature. They hold an advantage since the fuel prices in these countries are lower, which can facilitate the adoption of new technologies without compromising their competitiveness.

Although the results suggest that this cluster represents countries with highly efficient and sustainable performance (those that have already transitioned to a cleaner Business Environment), they still face challenges regarding fuel consumption, as seen in the group of countries comprising Slovenia, Spain, and Sweden.

Energy efficiency first' is one of the key principles of the Energy Union, mainly due to it being the most cost-effective way to reduce emissions, improving energy security, enhancing competitiveness, and making energy consumption more affordable for all consumers (Malinauskaite et al., 2020).

For instance, Slovenia's energy policy goals also aim to ensure a reliable, safe, and competitive energy supply sustainably by ensuring the transition to a low-carbon society. The main legislative framework for the energy sector in Slovenia is postulated in the Energy Act, which transposed a number of EU directives concerning electricity and gas markets, energy efficiency, and renewable energy sources. It also contains the principles of energy policy, measures ensuring energy security, and measures regulating energy infrastructure and heat distribution. There is also a new long-term development strategy document e the Energy Concept of Slovenia (Energetski koncept Slovenije), containing the national energy program. This document, based on the country's economic, environmental, and social development projections and adopted international commitments, defines the objectives of a reliable, sustainable, and competitive energy supply for the next 20 years (and tentatively for the next 40 years) (Malinauskaite).

In 2018, domestic energy production in Slovenia was 148 299 TJ (3.542 Mtoe), with nuclear energy accounting for the largest share of 42%, followed by renewable energy sources (including hydro energy) with 32%, coal with 25%, and with less than 0.5% of energy being produced from other sources (Bozic Tomaz et al., 2019).

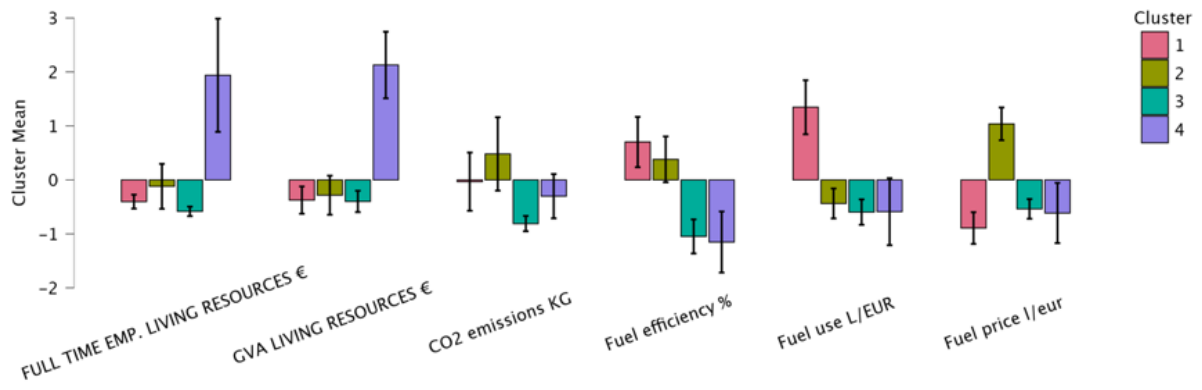


Figure 4- Cluster means plot.

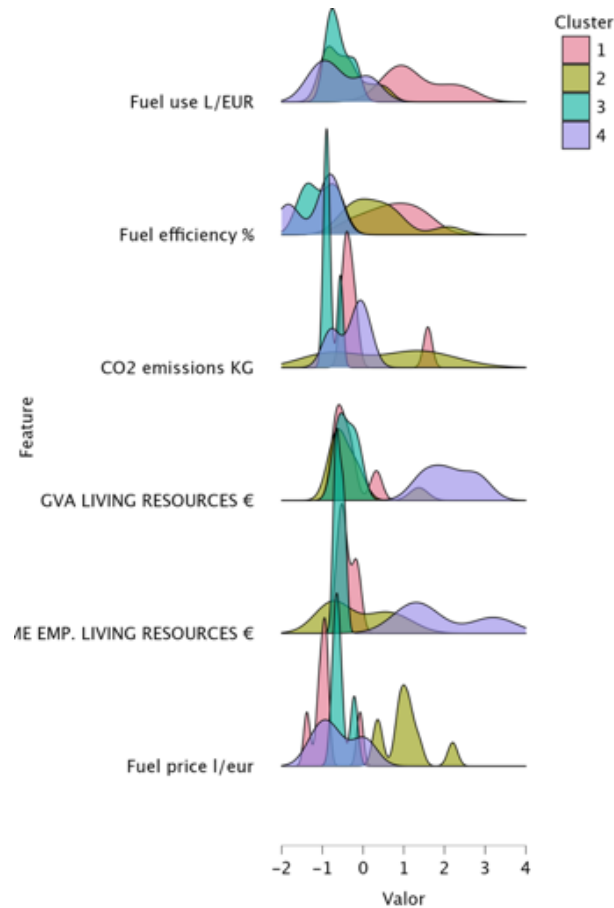


Figure 5- Cluster density plot.

As presented in Figures 4 and 5, and reinforcing the previous description of each cluster, C1 (pink) is characterized by its low/moderate full-time employment and GVA, indicating it is an active economic sector. What makes C1 stand out is the high fuel use and low fuel efficiency. CO<sub>2</sub> emissions for this Cluster are slightly above average, meaning countries belonging to this Cluster are less efficient while generating economic value.

C2 (green) presents the highest fuel process per liter when compared to the other Clusters, meaning its members support the highest fuel costs. However, regarding the other variables, this Cluster shows an average performance. The density plots reveal that most of the variables are tightly clustered around their averages. In conclusion, this Cluster is represented by a uniform group from an economic and operational point of view, regardless of the high fuel costs.

In C3 (blue), all values are mostly average or slightly below average. The density plots show that the values are closely grouped around the center, which indicates there's not much variation, no extreme highs or lows. Thus, C3 represents a group of countries characterized by a moderate performance, having as an advantage the below-average fuel price.

As for the last, C4 (purple), it stands out for the high levels of full-time employment and GVA, turning it into the strongest economic performer. It is also shown that the low levels of fuel process are lower and high levels of fuel efficiency, indicating a strong performance. CO<sub>2</sub> emissions are slightly above average, likely due to higher activity.

Table 3- Summary of clusters profiles based on the indicators.

| Cluster | GVA                    | Employment             | CO <sub>2</sub> Emissions | Fuel Efficiency        | Fuel Use               | Fuel Price    |
|---------|------------------------|------------------------|---------------------------|------------------------|------------------------|---------------|
| 1       | Low to moderate        | Low to moderate        | Slightly above average    | Low                    | High                   | Average       |
| 2       | Average                | Average                | Average                   | Average                | Average                | Highest       |
| 3       | Slightly below average | Slightly below average | Average                   | Slightly below average | Slightly below average | Below average |
| 4       | High                   | High                   | Slightly above average    | High                   | Low                    | Below average |

To summarize the results above, Table 3 was elaborated. From this table, we can see the profiles of each cluster, categorizing them by low to moderate, average, slightly below average, and high for each indicator.

#### 4.1. Cluster categorization

Considering the cluster categorization provided by Wuwung et al. (2022), this research proposes an approach to categorize the position of the Iberian Peninsula, Portugal and Spain, in the context of the BE. To begin with the cluster categorization, the work was divided into four different phases:

1. Firstly, as in the referenced study, the criteria to categorize the clusters are established: existence of a national policy or strategy related to BE, evidence of social and environmental dimensions that are linked to targets and actions in the BE, evidence of BE implementation strategies;
2. In the second phase, the process of the data collection was carried out, it was given a lot of attention to this step to ensure the data sources were reliable;
3. For the third phase, and to strengthen the model, a step was added that attributes to each data collected a score of accuracy from 1 to 5 (1- vague, 2- somewhat vague, 3- moderately clear, 4-clear, 5-very clear);
4. For the last phase, it will be attributed, based on how much information is found for each criterion, a score from 0 to 3. This process will make a clear and structured analysis that will reflect the degree of implementation of the BE for each country.






|   |                                                                                   |                                                                                                                                                                                                              |
|---|-----------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 5 |  | <b>Very clear</b><br>- Clearly cited source;<br>- Includes specific data, or real examples;<br>- Strong and fully clear, no additional clarification needed.                                                 |
| 4 |  | <b>Clear</b><br>- Source is reliable and cited;<br>- Content is objective and factual;<br>- Only minor improvements are needed.                                                                              |
| 3 |  | <b>Moderately clear</b><br>- Source is identified;<br>- General connection to the criterion is made;<br>- Lacks depth, precision, or supporting details;<br>- Missing specific examples, data, or citations; |
| 2 |  | <b>Somewhat vague</b><br>- Makes broad or general claims;<br>- Little or no sourcing;<br>- Indirect reference to the criterion;<br>- Limited detail or vague examples.                                       |
| 1 |  | <b>Vague</b><br>- No clear sources provided;<br>- Uses generic statements;<br>- Weak or no link to the criterion;<br>- Difficult to understand or interpret.                                                 |

Figure 6- Data score for accuracy.

To give a better understanding of the score of accuracy, and to establish the necessary requirements for each score, Figure 6 was elaborated. This scoring aims to ensure consistency and rigor in this assessment.

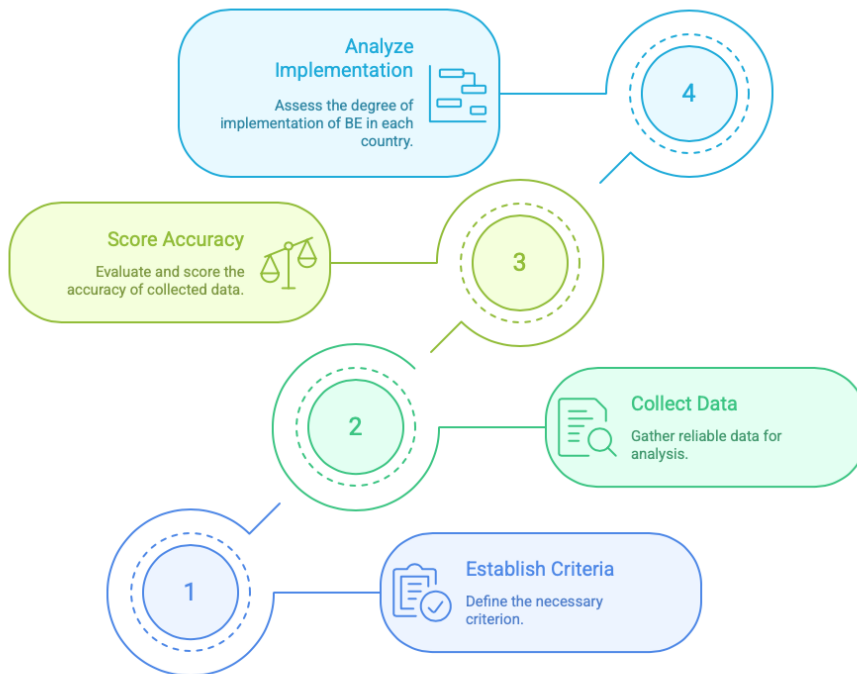


Figure 7- Cluster categorization methodology.

To simplify the understanding of the methodology described above, Figure 7 illustrates the sequential steps taken to conduct the cluster categorization.

To start with phase 1 and aiming to assess where Portugal and Spain stand when compared to other regions, the criterion to be followed is presented below:

**Criterion 1 (CRT 1): Evidence of National BE/Ocean Policy document**

This criterion aims to determine whether the country has a national-level BE (or ocean) policy document and the extent to which this document outlines a concrete action plan detailing how the country intends to manage the development of its coastal and ocean spaces. A national BE policy document will guide the development and execution of programs, serving as a reference point with shared objectives for both government and non-government stakeholders to prepare, plan, and turn the policy into operational activities (Wuwung et al., 2022).

At this stage, namely the initial assessment of the research, there is no need to differentiate between BE policies and other commonly used integrated ocean policies, such as a National Ocean Policy. The key consideration is whether the policy document establishes the capacity to govern and manage economic activities in coastal and ocean spaces based on the principle of sustainable development while incorporating social and environmental dimensions. Having a sustainable policy document that manages the coastal and ocean-based economic activities, taking into consideration environmental and social impact, at a national level, is beneficial for accountability and transparency, as it compels the country to monitor, evaluate, and report on policy implementation (Wuwung et al., 2022). The scoring guide for assessing CRT 1 is detailed in Table 5 in the appendix.

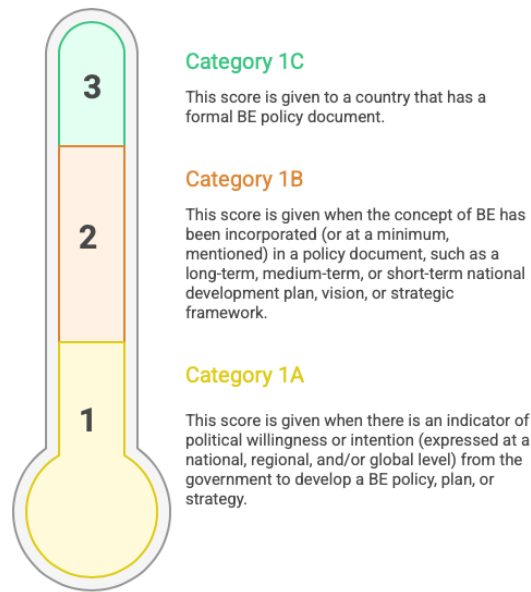


Figure 8- Scoring for CRT 1.

**Criterion 2 (CRT 2): Evidence of Social and Environmental dimensions that are linked to targets and actions in the BE**

Achieving a balance among economic development, social equity, and environmental sustainability should be regarded as a top priority, and incorporating all three dimensions into national policy is crucial for fostering a sustainable BE (Wuwung et al., 2022). This criterion aims to identify the inclusion of the three dimensions of sustainability (economic, environmental, and social) in BE policy and practice.

There is no consensus on the scale of acceptable trade-offs in sustainable development, nor any established guidelines or agreed-upon standards for measuring the optimal balance of economic, social, and environmental dimensions. In the absence of such a benchmark, minimizing potential harm to social equity and damage to environmental health would be the minimum baseline in order to ensure that social and environmental safeguards offer an appropriate check and balance mechanism to economic development (Wuwung et al., 2022). Further information on CRT 2 is provided in Table 6 in the appendix.

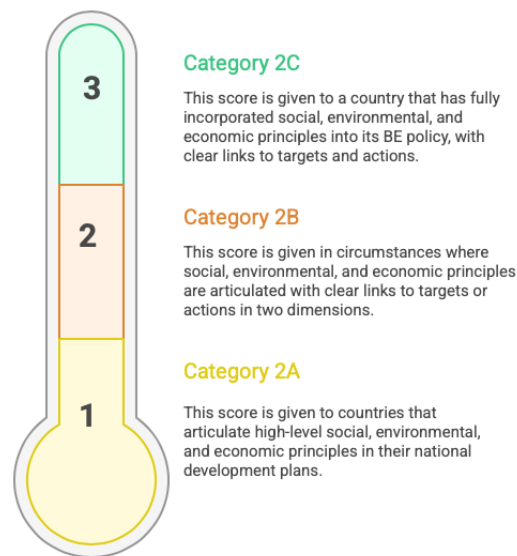


Figure 9- Scoring for CRT 2.

### **Criterion 3 (CRT 3): Evidence of BE implementation strategies**

This criterion aims to identify the practical operationalization of the BE. It primarily includes evidence of documented implementation plans or mechanisms to operationalize the BE, as well as, when applicable, other evidence demonstrating progress in BE-related activities. For instance, the BE has established sectors such as marine living resources, marine non-living resources, marine renewable energy (primarily offshore wind), port activities, shipbuilding and repair, maritime transport, and coastal tourism within EU regions (Wuwung et al., 2022).

For this criterion, six main aspects were considered to assess the level of BE implementation in each country as follows:

- 1) Evidence of operational cross-sectoral plans or action plans includes national action plans and integrated ocean management plans, such as Marine Spatial Planning (MSP) or Integrated Coastal Zone Management (ICZM), as well as other short-term, medium-term, and long-term plans;
- 2) The availability of funding mechanisms that, at a minimum, outline the source of funds, their value, and the purposes of the funding;
- 3) Dedicated whole-of-government institutional structures and or mechanisms to harmonize and coordinate the implementation of the BE;

- 4) The existence of sector-based BE projects or activities that contribute to economic, social, and environmental goals, such as job creation and added value to the national economy GVA and Gross Domestic Product (GDP);
- 5) Evidence of non-government stakeholders' engagement in developing and operationalizing BE policies or plans in ocean sector activities;
- 6) A monitoring and reporting mechanism that tracks progress and can provide inputs for future review and adaptation.

The scoring guide for the assessment of CRT 3 is presented as follows:

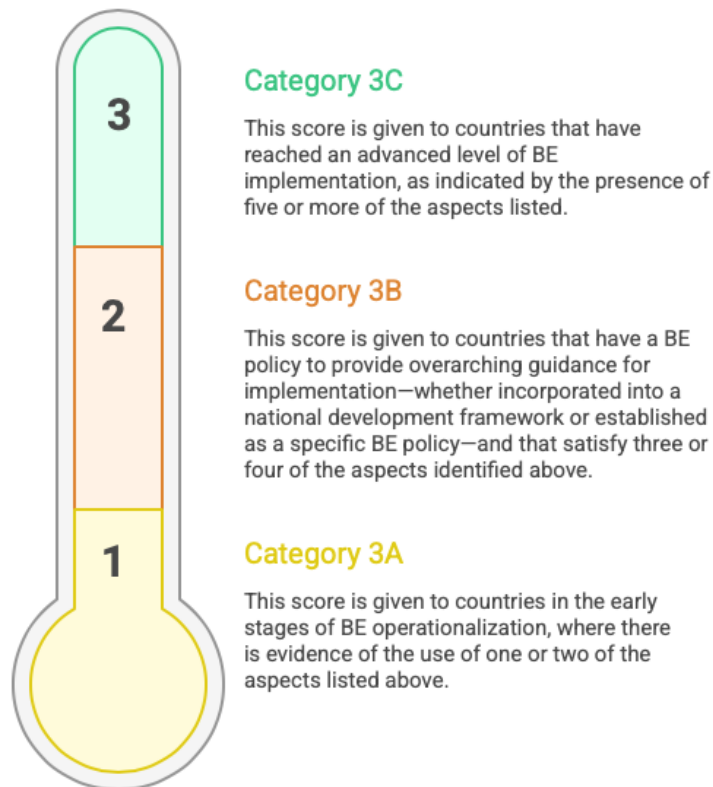


Figure 10- Scoring for CRT 3.

Details of CRT 3 can be found in Table 7 in the appendix.

Considering the importance of better understanding the performance of EU countries in terms of BE activities, and based on the results from the previous cluster analysis, this research aimed to categorize the countries belonging to the Iberian Peninsula, specifically Portugal and Spain.

For a brief analysis, Table 4 was elaborated with the main findings:

Table 4- Summary of the data collected and respective scoring of each criterion.

|          | Score<br>Criterion 1 | Evidence                                                        | Score<br>Criterion 2 | Evidence                                                         | Score<br>Criterion 3 | Evidence                                                                                                                                                                                                    |
|----------|----------------------|-----------------------------------------------------------------|----------------------|------------------------------------------------------------------|----------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Portugal | 3                    | EU Integrated Maritime Policy (Moreira & Bravo, 2022)           | 3                    | National Ocean Strategy 2021-2030 (Government of Portugal, 2021) | 3                    | Ocean strategy 2021-2030<br>Ministry of the Sea and Affairs<br>Portugal Blue Initiative (Funding program)<br>Aguçadoura Wave Farm                                                                           |
| Spain    | 3                    | Europe Strategy 2020<br>Estretgia Nacional de la Economia Azul” | 3                    | Blue Growth Knowledge Spaces                                     | 3                    | Catalonia’s Maritime Strategy 2023-2026<br>European Maritime, Fisheries and Aquaculture Fund (EMFAF)<br>Spain’s Ministerio de Agricultura, Pesca y Alimentacion (MAPA).<br>BE Barometer and BE Observatory, |

This table is only a summary of the data collected; detailed information can be found in the paragraphs below.

## Portugal

Regarding Portugal, the country belongs to the cluster “Coastal Traditional Economies.” When searching for evidence of a national BE policy document, it was concluded that as a member of the EU, Portugal has strategically aligned its national policies with regional commitments outlined in the EU Integrated Maritime Policy (IMP). This alignment is further reinforced through successive BE policy frameworks, reflecting a commitment to balancing economic growth with marine conservation (Moreira & Bravo, 2022).

Even though this data shows that Portugal is aligned with the EU BE policy, the evidence must be classified as moderately clear, as the source is identified, there is a connection to the criterion, but it lacks depth/specific details. However, as it is possible to satisfy the necessary categories, it was attributed to CRT 1 a score of 3.

Regarding CRT 2, which pertains to social, economic, and environmental dimensions, we encountered NOS 2021-2030. This document primarily aims to illustrate the sea's contribution to the nation's economy, highlighting the importance of protecting the ocean (Government of Portugal, 2021). Within this document, we find the interconnected social, economic, and environmental dimensions, reflecting a balanced approach that integrates economic growth, social equity, and environmental sustainability.

For the data collected for CRT 2, as the document NOS 2021-2030 makes a clear check for a reliable source, the content is objective and factual, the only minor improvements are needed (for example, quotes), it is attributed the score of clear. With this document, Portugal achieved a score of 3 on this criterion.

Regarding CRT 3, in an attempt to fulfill the established aspects, it was found that the National Ocean Strategy 2021-2030 includes 185 concrete measures spread across the intervention areas of the strategy, providing evidence of operationalization across the sectoral plan. It was also found that Portugal has a comprehensive government structure in place to ensure the coordination and implementation of the BE. They have the Ministry of the Sea and the Environment, with Ricardo Serrão Santos as Minister.

Regarding the funding mechanisms, the Portugal Blue Initiative was created, which was launched by the European Investment Fund (EIF) and the Instituição Financeira de Desenvolvimento (IFD). This initiative mobilizes over 75 million euros, supporting early-stage, venture, and growth capital for more than 30 start-ups, fortifying Portugal's commitment to a sustainable BE.

Utilizing tools such as the BE Barometer and BE Observatory, it is possible to track Portugal's progress in BE. By offering data in areas such as employment and marine resource utilization, among others, they support decision-making and monitor the effectiveness and implementation of BE. In order to create employment, generate GVA, and promote the development of sustainable energy, the Aguçadoura Wave Farm was created. This farm,

representing a sector-based project, is located near Póvoa de Varzim and was the world's first commercial wave farm.

The evidence collected for CRT 3 are from reliable sources, include concrete examples of initiatives and examples with no clarification needed. Having this in mind, was considered, for this data the scoring of very clear. Thus, seeing as Portugal can answer to five of the categories necessary for CRT 3, it was attributed a score of 3.

### **Spain**

Spain, classified in the cluster “Leaders of the BE sustainability”, integrates into the Europe 2020 Strategy, which promotes smart, sustainable, and inclusive economic growth while ensuring a need for a sustainable economic model. Spain's national strategy for the BE “Estrategia Nacional de la Economía Azul” that promotes the sustainable use of the maritime resources. This policy aligns with the EU IMP, as it focuses on key areas like renewable energy, sustainable fisheries, aquaculture, and tourism, which are all key elements to the BE.

To evaluate the accuracy of this data, it is established that the source is identified and a general connection to the criterion is made through the data. However, it still lacks depth/precision and is missing examples or data; having this in mind, the score is moderately clear. Having this in consideration, Spain is awarded a score of 3 for CRT 1.

Spain created the Blue Growth Knowledge Spaces with the purpose of promoting BE progress and growth. These spaces, integrated by universities and technology centers, allow the exchange of knowledge and development. The creation of these spaces shows effort in achieving a balance between social, environmental, and economic dimensions.

For the accuracy of this data, it satisfies the need of an identified source, makes a general connection to the criterion, but it is missing concrete examples and lacks depth. Having this in mind, an accuracy of moderately clear is given. However, since this data responds to all the categories needed for the CRT 2, a score of 3 is attributed.

Regarding CRT 3, to respond to the first component, Spain implemented the “Catalonia's Maritime Strategy 2023-2026” that has a focus on the environmental dimension and assuring the preservation of the marine ecosystems that are fundamental for the provision of services to society. This plan has four areas of action: a sustainable BE within the framework of an integrated maritime policy that respects all uses of the sea; healthy and resilient ecosystems; a Citizenry that loves and values the sea as a source of well-being and wealth; and innovative maritime governance in the hands of citizens (Moreira & Bravo, 2022).

For component 2, it was found that Spain is supported with the European Maritime, Fisheries and Aquaculture Fund (EMFAF). This fund allocates over 12 billion euros to support causes like sustainable fisheries, protect marine biodiversity, and promote BE across other EU member states (European Commission, n.d.).

Looking for evidence of an institutional structure or mechanism, we came across Spain's Ministerio de Agricultura, Pesca y Alimentacion (MAPA). This institution plays a fundamental role being responsible for balancing environmental preservation and economic growth in the maritime sector, in shaping and implementing BE policies and also for ensuring that Spain's and EU BE policies align.

In this search, it was also found the Oceanic Platform of the Canary Islands (PLOCAN) that is a public consortium created in 2007 between the Ministry of Education and Science, now Ministry of Economy, Industry and Competitiveness, and the Government of the Canary Islands, with the aim of building, equipping and operating a set of marine infrastructures for research in the field of marine sciences and technologies. At an economic level, this project facilitates access to marine technologies. At a social level, it leads to the training and development of skills in marine science. At an environmental level, it monitors ocean health (PLOCAN, n.d.).

Just like Portugal, Spain's data for BE is also integrated in the BE Barometer and BE Observatory, making it possible to monitor the development and growth of the BE in all the sectors included.

For this last set of data, regarding its accuracy, it can be said it fits the category of very clear. This can be justified by the multiple names of initiatives and funds, the quantitative and qualitative details, the mentioning of a real example and all of the above is justified with cited sources. Seeing as it was possible to answer 5 of the aspects established, a score of 3 was attributed.

## 5. Conclusion

In today's world, sustainability has become an important concern, particularly for companies, where the concept of sustainable development transitioned from a mere ideal to a pressing reality.

Coastal ecosystems are a valuable source of goods and services that are essential for global survival and well-being. However, as these resources are being consumed at a faster rate than they can regenerate, they are considered at risk driven by factors like rapid coastal development, pollution, and the more evident impacts of climate change.

In this study, the main purpose was to understand the role of maritime living resources in BE. This goal was achieved with a cluster analysis. Through this analysis, patterns and characteristics were identified which allowed a grouping of the countries according to their performance, development, and potential growth. Later, it was also applied a cluster categorization evaluating their performance, in this case for the Iberian Peninsula (Portugal and Spain).

Through the cluster analysis, 4 clusters were formed, the first one represents countries with small and traditional maritime economies, that need to invest in innovation and energy efficiency in order to increase their competitiveness.

C2 represents countries with high GVA and a high number of full-time employment results; these countries have advanced harbor infrastructure and more developed maritime industries, which are considered central to global maritime trade.

Regarding C3, the countries that belong to this cluster are still growing in the maritime sector, so to face their challenges, they need to implement strategies that promote renewable energy and energy efficiency.

Lastly, in C4, we can find the countries with the most efficient energy use, in other words, countries that use lower amounts of energy while still maintaining economic activity. These countries adopt strict environmental policies and invest strongly in clean technologies.

Regarding the cluster categorization for Iberian Peninsula, both Portugal and Spain show commitment to the principles of BE, achieving the maximum score across all three criteria, even though they belong to different clusters.

For future research and to improve this study, some limitations should be acknowledged. Initially, when retrieving data from the BE Observatory, data availability was not uniform across all EU member states, which constrained the scope of data, as some countries and variables were excluded due to this limitation. Secondly, the selection of variables represents a methodological limitation, as the results are influenced by the chosen variables; a

different selection could lead to different groupings and interpretations. As for the cluster categorization, to have a better understanding of the clusters' positioning, the scope should include all countries analyzed and not be restricted to the Iberian Peninsula.

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## 7. Appendix

Table 2- Detailed scoring guide for assessing CRT 1.

| SCORE 1                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                | SCORE 2                                                                                                                                                                                                                                                                     | SCORE 3                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| (Category 1A – Evidence of intent or political will at national, regional and/or global level)                                                                                                                                                                                                                                                                                                                                                                                                                                         | (Category 1B – BE incorporated (or mentioned) in a national development document)                                                                                                                                                                                           | (Category 1C- Existence of a formal BE policy document)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| This score is given when there is indication of political willingness or intention from government to develop a blue economy policy, plan, or strategy. This intention may be expressed at a national, regional, and/or global level. Examples of intent or political will include: government signatory in regional and international agreements, conventions and arrangements, government media releases, speeches or announcements endorsing the blue economy, or other evidence of government engagement such as election pledges, | Is given to a country in a circumstance where the concept of a blue economy has been incorporated (or at a minimum, mentioned) in another policy document, such as a long-term, medium-term, and/or short-term national development plan or vision, or strategic framework. | Is given to a country that has a formal blue economy policy document. Policy adoption is commonly an outcome of policy development or formulation processes and indicates a more mature state of implementation than Category 1A and 1B. Some clear indicators of this category are the existence of a strategy, roadmap, framework or other policy document, plan or legislation that has been approved by the national government, or at the ministerial or departmental levels of government. In many cases, the legislation includes designation of institutions or authorities with rights and responsibilities to plan, implement and evaluate the policy. |

|                                                                                                                                   |  |  |
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| and commissioning of academic reports or policy recommendations from educational institutions and/or non-government stakeholders. |  |  |
|-----------------------------------------------------------------------------------------------------------------------------------|--|--|

Table 3-Detailed scoring guide for assessing CRT 2.

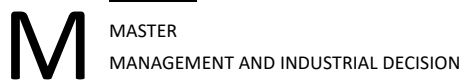
| SCORE 1<br>(Category 2A- High level social, environmental, and economic principals, goals or objectives articulated across three dimensions)                                                                                                                                                                                                                                                                                                                                                                                                                           | SCORE 2<br>(Category 2B - High level social and environmental, and economic goals, or objectives with links to targets or actions in two dimensions)                                                                                                                                                                                                                                             | SCORE 3<br>(Category 2C - High level social, environmental, and economic principles)                                                                                                           |
|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Is given to countries that articulate high level social, environmental, and economic principles, goals, or objectives in their national development plan. A national development plan is not necessarily a blue economy specific plan, but rather can be a general or sector-based plan that is aligned to the SDGs or other development objectives. Frequently, countries will achieve this minimum score, however without clear links to targets and actions that aim to fulfil all the triple bottom line objective goals, a higher score cannot be awarded. In the | Is given in a circumstance where social, environmental, and economic principles, goals or objectives are articulated with clear links to targets or actions in two dimensions. For example, if there is a clear indication of the absence of social equity or evidence of environmental compromises in the marine resource management or development plan then a country will not score above 2. | Is given to a country that has fully incorporated social, environmental, and economic principles, goals, or objectives into their blue economy policy with clear links to targets and actions. |

|                                                                                       |  |  |
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| absence of clearly articulated targets and actions, these concepts remain high level. |  |  |
|---------------------------------------------------------------------------------------|--|--|

Table 4-Detailed scoring guide for assessing CRT 3.

| SCORE 1<br>(Category 3A – Evidence of one or two implementation strategies)                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              | SCORE 2<br>(Category 3B – Evidence of three or four implementation strategies)                                                                                                                                                                                                                                                                                                                           | SCORE 3<br>(Category 2C – Evidence of 5 or more implementation strategies)                                                                                                                                                                                                                           |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Is given to countries in the early stages of blue economy operationalization and where there is evidence of the employment of one or two of the aspects listed above. Countries with no national blue economy policy in place may fulfil this category in a circumstance where they have institutional capacity to implement blue economy activities or have sectoral based blue economic activities or have sought financing for relevant blue economy activities through either national (state) budget, private sector, or international donors such as organizations under United Nations System and | Is given to countries that have evidence of a high level of blue economy operationalization by satisfying three or four aspects identified above. At this level, countries usually have a blue economy policy to provide overarching guidance for implementation, whether incorporated in a national development framework (Category 1B) or established as a specific blue economy policy (Category 1C). | Is given to countries that have reached an advanced level of blue economy implementation as indicated by the presence of five or more of the aspects listed above. At this level, countries will have a capability to operationalize cross- sectoral economic activities based on policies or plans. |

|                                         |  |  |
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| intergovernmental organisations (IGOs). |  |  |
|-----------------------------------------|--|--|



# Exploring the potential of Blue Economy in the Iberian Peninsula: A Cluster-Based Approach linking Sustainability and Logistics

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## Abstract

The sea has always been considered to play a central role in a country's economic activities, either as a food source, a route for transportation, and as a means of commercial exchange. In more recent years, with the emerging concerns about the incorrect use of the sea resources, a new concept was created, the Blue Economy (BE). This concept has a main purpose of balancing and fostering economic growth, social inclusion, and local development while considering the long-term environmental sustainability of marine ecosystems. Through this study, it is intended to compare the performance of environmental and economic indicators among the Iberian Peninsula BE countries, positioning these countries within the European Union (EU), and to analyze the different BE strategies/policies implemented in Portugal and Spain and the coherence with their performance.

Keywords: Blue Economy (BE); Composite indexes; Policies; Strategies; Theory of Change (ToC).

## Index

|      |                                                                               |     |
|------|-------------------------------------------------------------------------------|-----|
| 1.   | Introduction .....                                                            | 65  |
| 2.   | Literature Review .....                                                       | 67  |
| 2.1. | An overview of BE .....                                                       | 67  |
| 2.2. | Governance in the Blue Economy .....                                          | 68  |
| 2.3. | Indicators to evaluate Blue Economy: social and environmental indicators..... | 69  |
| 2.4. | Overview of the main projects in the Iberian Peninsula.....                   | 71  |
| 2.5. | Theory of change (TOC) .....                                                  | 73  |
| 3.   | Methodological approach .....                                                 | 76  |
| 3.1. | Correlations (economy x environment) .....                                    | 77  |
| 3.2. | Composite indexes .....                                                       | 79  |
| 3.3. | Theory of change .....                                                        | 84  |
| 3.4. | Wrap up of IB BE .....                                                        | 99  |
| 4.   | Conclusion .....                                                              | 101 |
| 5.   | Bibliography .....                                                            | 103 |
| 6.   | Appendix.....                                                                 | 118 |

## Figure Index

|                                                     |    |
|-----------------------------------------------------|----|
| Figure 1 - Methodology steps.....                   | 71 |
| Figure 2- Spearman correlation results.....         | 73 |
| Figure 3- Steps for the application of the ToC..... | 79 |

## Table Index

|                                                                             |    |
|-----------------------------------------------------------------------------|----|
| Table 1- Outputs from the economic and environmental composite indexes..... | 74 |
| Table 2- Outputs from the economic composite index.....                     | 76 |
| Table 3- Outputs from the environmental composite index.....                | 77 |
| Table 4- ToC for Portugal policies/strategies.....                          | 80 |
| Table 5- ToC for Spain policies/strategies.....                             | 84 |

## 1. Introduction

The BE concept strives to promote consumer welfare and social equality while minimizing environmental hazards and ecosystem scarcities. Realizing the BE's full potential requires the engagement and inclusion of all impacted social groups and organizations (Smith-Godfrey, 2016).

The BE is more than just a way of looking at the ocean as a source of revenue. Massive industrial states have witnessed the growth of their ocean economies via the exploitation of maritime and marine assets under the "business-as-usual approach" – for example, shipping, farming, and the oil, gas, minerals, and mining sectors - all of which operate without regard for the long-term health or efficiency of those very same resources (Mezher et al., 2011).

The BE is emerging as a new governance tool that is used to articulate appropriate use within the oceans at global, regional, and national scales. In addition to the lack of a clear definition, there is also significant ambiguity around the extent of the governance reach of a BE (Voyer, Quirk, McIlgorm, et al., 2018b).

The concepts and actions associated with the BE have been vague, leading to misunderstandings among parties, varied interpretations, and occasionally a co-opting of the term around different agendas, including oceans as natural capital (Voyer et al., 2018). There is no consensus on the key requirements for practical implementation or on how to evaluate the value or success of BE initiatives (Stephenson & Hobday, 2024).

This economically driven attention toward oceans demands improved regulations, innovative governance, an understanding of actor dynamics and relationships, and enhanced collaborations among governments, civil society, epistemic community, and private sectors, all within the broader framework of blue economy governance (hereafter BE Governance) (Hofmann, 2022).

We understand 'BE Governance' as formal, informal, political, and institutional processes that affect social-ecological outcomes relating to the ocean-based economy. Identifying the most appropriate and practical governance approach to support a sustainable BE, referring to its long-term viability and the health of marine ecosystems, in line with the Sustainable Development Goals (SDGs), is important but challenging in both national and global contexts (Das et al., 2024).

Given the importance of BE and its reflection on a country's governance, this study aims to evaluate BE performance and position Portugal and Spain within the EU countries. To achieve this, a composite index methodology will be applied, alongside the application of the ToC on the main policies/strategies these countries adopted.

Firstly, it will introduce topics necessary to get a better understanding of this study; afterwards, it will apply a composite index methodology on a set of economic and social BE indicators to position Portugal and Spain within other EU countries. To better justify this positioning, a ToC analysis will be done on a set of selected BE policies/strategies implemented in the Iberian Peninsula countries. Finally, the comparison and discussion of these results will be presented in the last chapter of this study.

## 2. Literature Review

To fully understand the purpose and the context of the present study, firstly, it is necessary to approach and acknowledge the most important concepts, such as: BE, governance in the BE, indicators to evaluate BE: social and environmental indicators, overview of the main projects in the Iberian Peninsula, and ToC.

### 2.1. An overview of BE

Oceans are vital, not only to a wide array of biodiversity and ecosystems, but also to the food chains, livelihoods, and climate regulation for a human population heading towards nine billion people. Oceans cover roughly two-thirds of our Earth's surface and contribute to poverty reduction by creating sustainable livelihoods and jobs, food, generating oxygen, absorbing greenhouse gases and mitigating the impacts of climate change, determining weather patterns, and providing international trade routes with an estimated 95 per cent of the volume of world trade carried by sea, international shipping and ports provide crucial linkages in global supply chains and are essential for the ability of all countries to gain access to global markets (Shivalingaiah, n.d.).

The traditional ocean economy did not acknowledge or honor the ocean's natural services, nor its finite capacity to take human abuse without undermining those services on which we depend. The "new blue economy" is the term of art for identifying those activities that improve the human relationship with the ocean and for aligning our systems of accounting and metrics to both define and enhance our ocean-positive economy. It also allows us to account for "ecosystem services" (provisioning, regulating, supporting, and cultural) provided by the ocean to plants and animals (including humans) (Spalding, 2016).

Blue economy offers an innovative approach to conserving the oceans, while reaping their benefits in a more equitable and sustainable way. It is increasingly obvious that without more sustainable management of the oceans, they, in turn, will be unable to sustain the population that depends on them. This is particularly true for the small island nations that are such a key part of the blue economy (Shivalingaiah, n.d.).

Fishing and aquaculture are important sources of protein and a source of income for millions of people worldwide. To guarantee long-term food security, it is essential to manage these resources sustainably. Furthermore, the ocean is an important carbon dioxide sink and a key player in controlling global climate change (Ahammed et al., 2024).

Climate change mitigation initiatives can benefit from the development of ocean-based renewable energy sources, such as wind, wave, and tidal energy. Numerous ecosystems and a wide variety of marine creatures can be found in the ocean, but many of them are under threat due to overfishing, pollution, and climate change. The conservation of biodiversity and the preservation of vital marine habitats can both be aided by the sustainable management of ocean resources (Ahammed et al., 2024).

An important challenge of the blue economy is to understand and better manage the many aspects of oceanic sustainability, ranging from sustainable fisheries and healthy ecosystems to preventing pollution (Sarangi, 2023).

The first-ever “Sustainable Blue Economy Conference,” held in Kenya in November 2018, brought together thousands of ocean experts and activists to discuss how to sustainably use our ocean. The sustainable blue economy movement is gaining momentum, including at the highest levels of decision-making (Ross & Willson, 2017).

## 2.2. Governance in the Blue Economy

Although the concept of governance is broad and variously defined, core interrelated characteristics support its contrast to government (Biermann & Pattberg, 2008). First, governance marks a shift away from state-centric, territorial-based power and “acknowledges that a plethora of forms of social organization and political decision-making exist that are neither directed toward the state nor emanate from it” (Biermann & Pattberg, 2008).

Secondly, governance foregrounds participation by nonstate actors (e.g., private companies, NGOs, civil society groups, and movements) and shifts in influence among these (Manno, 2008). Third, governance problematizes categories of public and private, as well as global, national, and local. Authority is multilayered and multiscale, and the boundaries between types of actors and the scales of interaction are porous and unfixed (Andonova & Mitchell, 2010).

Fourth, science and technology are often critical to governance, determining what and how to govern and lending legitimacy to actors seeking influence (Jasanoff, 1996). Finally, contemporary governance often emphasizes market over regulatory mechanisms; for environmental issues, this often necessitates enclosure and privatization of the commons (Büscher et al., 2012).

Increased interest in oceans is leading to new and renewed global governance efforts directed toward ocean issues in areas of food production, biodiversity conservation, industrialization, global environmental change, and pollution. Global oceans governance efforts face challenges and opportunities related to the nature of oceans and to actors involved in, the scale of, and knowledge informing their governance (Campbell et al., 2016).

While the blue economy holds potential to act as an integrating policy framework for the sustainable development of the ocean, to date, there are limited examples of implementation in practice to test the usefulness of the concept (Benzaken et al., 2022).

The ability of any country to transition to a sustainable and equitable blue economy and to benefit from goods and services from its ocean resources depends more on enabling conditions, such as socioeconomic and governance factors, than on resource availability (Cisneros-Montemayor et al., 2021a).

Although governance is seen as a key enabler to transition toward a sustainable and equitable blue economy, there is no unified definition of governance. It is broadly understood to include concepts, practices, and institutions by which societal development is overseen (Brodie Rudolph et al., 2020).

Governance is understood to be a system of values, policies, and institutions by which a society manages its economic, political, and social affairs through interactions within and among the state, civil society, and private sector (UNDP & EU, 2004).

According to Bennet & Satterfield, governance can be defined as “institutions, structures and processes that determine who makes the decisions, how and for whom the decisions are made, whether how and what actions are taken and by whom and to what effect (Bennett & Satterfield, 2018).

International events and meetings are critical to global governance. They draw together people, making time and space for negotiations, side events, and networking. Formally, they offer a sanctioned setting for the (re)configuration of social relations and structures and the (re)codification of positions and perspectives (Campbell et al., 2014).

The attention given to ocean governance and the term BE is motivated by three factors. First, the sheer extent and significance of oceans for development: oceans cover 70% of the earth’s surface; fish provide a critical source of protein for international markets and coastal communities; and new sectors like deep-sea mining and aquaculture are developing rapidly (Campbell et al., 2014). Second, most ocean space lies beyond national jurisdiction, where many resources are held in common and where UN-led governance is fragmented. Third, state and private interest in ocean conservation and development is currently high, as reflected, for example, by the recently launched World Bank Global Partnership for Oceans (Campbell et al., 2013).

### 2.3. Indicators to evaluate Blue Economy: social and environmental indicators

Although the BE was proposed as an approach focused on equitable processes and outcomes from ocean sectors, the term poses fundamental conflicts of interest regarding the goals and pathways of development, and therefore different definitions depending on the end-users. For example, some approaches lean away from a focus on equity and advocate for growth and development, emphasizing the economic opportunities by using ocean resources. In contrast, others call for prioritizing the protection of these resources to ensure long-term sustainability (Martínez-Vázquez et al., 2021b).

The difference of perspectives reflects the complex and often competing definitions of the BE, which hinders the efforts to advance equity goals among economic and environmental pressures (González-Espinosa et al., 2025). This broad scope of a Blue Economy involves evaluating a diverse range of enabling conditions and outcomes across social, environmental, economic, and governance dimensions (Cisneros-Montemayor, 2019).

For instance, to evaluate economic viability, metrics or indicators such as national stability and investments in marine infrastructure have been used. To estimate resource availability, metrics could include contributions from sectors like blue carbon, blue energy, and fisheries. Regarding social equity, indicators often encompass aspects such as coastal community well-being and the access to and equitable distribution of marine resources among different groups. To assess environmental sustainability, indicators may focus on biodiversity health (including extinction rates), marine habitat preservation, water quality, and resilience to climate change impacts (Cisneros-Montemayor et al., 2021b)

Together, these indicators might help to highlight the required/desired conditions for an equitable and sustainable BE. Identifying and understanding the relationships between diverse indicators is essential for enhancing policy development and decision-making in Blue Economy practices (González-Espinosa et al., 2025).

There are a considerable number of studies to evaluate the performance of BE, for example, a study from Ding & Tabeta introduces the Blue Economy Index (BEI), a novel framework for evaluating the sustainable blue economy, and applies it in Japan's 39 coastal prefectures. Grounded in multi-dimensional analysis, the BEI includes four sectors: Ocean Resources and Marine Industry, Environmental and Ecological Sustainability, Socio-Economic Stability, and Risk Management. Utilizing Japan's prefectural data and addressing regional disparities, the index applies four weighting scenarios—Equalitarianism, Preservationist, Sustainable Use, and Extractive Use—to reflect different developmental strategies. The result indicates a significant imbalance in blue economy development across prefectures, with leading regions like Hokkaido, Tokyo, and Okinawa vastly outpacing others such as Ibaraki and Tottori. Additionally, the development status in 39 coastal prefectures in Japan demonstrates the cluster phenomenon and exhibits a '2 high, 3 middle, 1 low' development pattern, which comprises two extraordinary clusters and four distinctive clusters (Ding & Tabeta, 2024).

Another conducted by Rickels et al, selected 18 indicators to measure progress against Sustainable Development Goal (SDG 14) as part of the 2030 Agenda, for 15 EU coastal countries in the Baltic and the North Sea and the Atlantic Ocean since 2012. In this study, the aim was to distinguish between a concept of weak and strong sustainability, assuming high and low substitution possibilities, respectively. Our results indicate that there are countries that managed to achieve sustainable development under both concepts of sustainability, but that there are also countries that failed to achieve sustainable development under both concepts (Rickels et al., 2019).

Lagoudis et al study has a main purpose of identifying the factors that add value and enhance the cluster's performance and proposes a robust framework for measuring the attractiveness of a maritime cluster with the use of a Performance Index. The proposed performance index consists of a group of performance indicators

weighted and categorized in five groups (institutional, financial, infrastructure, manpower, and governance), leading to a Performance Index similar to the World Bank's Logistics Performance Index (Lagoudis et al., 2019).

#### 2.4. Overview of the main projects in the Iberian Peninsula

Starting in Portugal, it can be said that this country has a great interest and a number of challenges regarding the knowledge of ocean processes, monitoring of their environmental status, maritime spatial planning, and their role in sustainable development and economic growth (Almeida et al., 2025).

For Portugal, the development of the sea economy is one of the fundamental parts of the economic recovery at the beginning of this decade and provides a greater resilience to face future crises. In 2018, the sea economy was responsible for 5,1% of the Gross Domestic Product (GDP) and 5% of national exports (Diário da República, 2021).

Portugal implemented the National Ocean Strategy 2021-2030 (NOS 2021-2030), which can be considered an instrument that defines the course for the public ocean policy, with the purpose of highlighting inclusive and sustainable blue growth, protection of biodiversity, while assuring the well-being and development of coastal communities. It was approved by the Ministers Council on May 6, 2021, fulfilling one of the aims of the XXII Constitutional Government Program (Direção Geral de Política do Mar, n.d.).

The NOS principles are aligned with the United Nations 2030 agenda, enhancing the contribution of the sea to the country's economy and prosperity while strengthening Portugal's position as a maritime nation. This plan involves 185 concrete actions, 30 of which are considered emblematic due to their special scope and high potential (Direção Geral de Política do Mar, n.d.).

The Recovery and Resilience Plan (PRR), in particular Component 10, has been responsible for the funds given to the Blue Hub and Blue Bioeconomy's Mobilizing and Green Agendas. The Blue Hub is a national network of infrastructures that includes Research & Development (R&D) centers, acting as accelerators, directing their knowledge to the economy. This focus allows Portugal to develop expertise in high-value niches such as marine biotechnology, sustainable biomaterials, and bioactive ingredients for the pharmaceutical and food industries (Ministério do Planeamento, 2021).

Another strategy implemented is the Maritime Spatial Planning Situation Plan (PSOEM), which integrates and organizes the various uses of the sea, such as renewable energy, aquaculture, tourism, environmental, and transport. This plan is considered the impulse for the expansion of ocean renewable energy; Portugal was actually a pioneer in Europe in implementing pilot projects such as WindFloat Atlantic (Presidência do Conselho de Ministros, 2019b).

In maritime ports and logistics, new technologies play an important role by offering solutions capable of generating gains and serving as strategic tools to support the monitoring and safety of the maritime transport of people and goods. An example of the steps being taken was the implementation of the Single Logistics Window (JUL), which has improved the work between port authorities, logistics operators, customs, and carriers by reducing waiting times, administrative costs, and consequently leading to the reduction of gas emissions (Presidência do Conselho de Ministros, 2019a).

Aquaculture is an important sector of the BE, Portugal has implemented the Strategic Plan for the Portuguese Aquaculture 2014-2020, that had established a national strategy “Increase and diversify the supply of national aquaculture products, based on principles of sustainability, quality and food safety, in order to meet consumption needs and contribute to local development and the promotion of employment”. In sum, this strategy aims to not only reduce pressure on maritime ecosystems but also to create jobs and boost coastal economies, promoting the conservation of nature and socioeconomic development (Direção-Geral de Recursos Naturais, n.d.).

In Spain, the BE is of particular importance due to its strategic geographical position, with access to the Atlantic and the Mediterranean, and its economic dependence on maritime sectors (European Commission, n.d.).

Similar to Portugal, Spain implemented the Spanish Strategy for a Sustainable Blue Economy 2022-20230 that establishes a policy framework prioritizing technological innovation, decarbonization of maritime transports and ports, sustainable aquaculture, and the protection of marine biodiversity.

This strategy is closely aligned with the Integrated National Energy and Climate Plan (PNIEC 2023-2030), with a target of achieving a 3 GW of floating offshore wind energy by 2030

The Recovery, Transformation and Resilience Plan (PRTR), approved on 13 July 2021, is helping Spain become more sustainable, resilient, and better prepared for the challenges and opportunities of the green transition and digital transition. The plan addresses bottlenecks to lasting and sustainable growth, while investments are targeted to accelerate the transition towards a more sustainable, low-carbon, and climate-resilient economy, to maximize the benefit of the digital transformation and ensure social cohesion (European Commission, n.d.-b).

Spain implemented the Maritime Spatial Plans (MSP Plans), which designate high-potential zones for the production of renewable energy while ensuring biodiversity conservation. The main objective of the MSP Plans is to foster sustainable activity and growth in the maritime sectors in a way that is compatible with respect for the values of marine spaces and with sustainable use of resources. Thus, the Spanish MSP plans are aimed at supporting a real sustainable blue growth, which promotes maritime sectors while achieving and maintaining the good environmental status of marine waters (European Commission, n.d.-d).

Regarding port decarbonization, Barcelona takes the spotlight by implementing the NEXIGEN Plan. This plan consists of an innovative shore-side electricity infrastructure that will enable ships to connect to the port's electrical grid while at berth, drastically reducing greenhouse gas emissions, noise, and air pollution. This is a critical step in aligning the port's operations with EU Green Deal targets and advancing its role as a leader in sustainable port management. Through targeted dissemination activities, the lessons learned from NEXIGEN 1+2 will contribute to the development of greener, more efficient ports, both within the Mediterranean region and beyond. The Port of Barcelona's commitment to long-term sustainability ensures that the results of this initiative will extend well past the project's duration, fostering a greener maritime future (Port de Barcelona, n.d.).

Regarding Spain's aquaculture, this country is integrated in the Strategic Guidelines for a More Sustainable and Competitive EU aquaculture 2021-2030, making a firm commitment to cooperate among the different stakeholders, as well as for the pursuit of innovative solutions to the current challenges facing aquaculture in Spain. In this strategy, steps are taken to a more sustainable supply of healthy and safe food while providing employment and economic development and opportunities (Ministerio de Agricultura, n.d.).

Spain has a state-owned port system made up of 46 ports of general interest managed by 28 port authorities, constituting an extensive network of ports that plays an essential role in international trade. The Spanish port system has undergone significant modernization in recent decades, such as the Digital Twins. In the case of ports, a digital twin is a replica of port operations, using real-time data to simulate and optimize port processes (González-Cancelas et al., 2024).

Digital twins in port are revolutionizing port management by providing real-time insight and a more accurate assessment of port activity. This allows port authorities' operations and increases their competitiveness in the maritime sector (Yao et al., 2021). For example, the port of Barcelona is using digital twins to improve cargo management and logistics to monitor activity at the port; Port of Algeciras is using this technology to improve efficiency in cargo management and logistics and to monitor activity at the port; and port of Valencia, utilizes this resource to optimize cargo management and logistics and to improve efficiency at the port (González-Cancelas et al., 2024).

It is clear by going through the data found for each country that even though each country has its policies, their policy course is very similar. Each country presents its strategies with different aspects, but both of them are trying to comply with the EU targets and worldwide pressure for a more sustainable climate transition.

## 2.5. Theory of change (TOC)

Providing a common definition of, and methodology for applying ToC is challenging as it can simultaneously be considered a way of thinking, a process and/or a product (Davies, 2018). ToC is considered a flexible and useful

approach to incorporate diverse perspectives and promote greater cooperation and learning among diverse conservation actors seeking to achieve socioecological outcomes. In doing so, ToC can promote greater understanding necessary for improved conservation policy and practice (Game et al., 2014).

Nevertheless, ToC essentially involves logically “mapping” what needs to happen in a pathway for a sequence of actions, and assumptions made, to achieve an intervention's desired result (Mayne, 2015). Furthermore, ToC can be used to account for both how change is expected to happen (i.e., planning and implementation of an intervention) and how change has happened (i.e., evaluation and adaptation of an intervention) (Douthwaite et al., 2020). In doing so, ToC can inform the actions required to bring about change by considering multiple levels of change and learning from the intervention as it evolves (Rice et al., 2020).

In other words, ToC can be seen as a planning tool, that helps organizations ask important questions about their work. It can strengthen partnerships, support organizational development, and facilitate communication. ToC originated as an evaluation tool, and as such it explains the pathways of change that lead to the long-term goal and the connections between activities, outputs and outcomes that occur at each step along the way. The clarity of purposes, results, and strategies that ToC delivers sharpens interventions and evaluation designs and strengthens the ability of practitioners to take credit for outcomes that were predicted in their theory (Taplin et al., 2013).

ToC can begin at any stage before, during, and after the lifetime of an initiative, depending on the intended use. A theory is developed at the outset is best at informing the conceptualization and planning of an initiative. As monitoring and evaluation data become available, stakeholders can periodically refine the Theory of Change based on evidence. A ToC can also be developed retrospectively by reading program documents, talking to stakeholders, and using monitoring and evaluation data. This is often done during evaluations or for a reflective process of learning about what has worked and why, in order to understand the past and to plan for the future (Taplin et al., 2013).

According to Haries et al 2014, it is recommended that all social purpose organizations—charities and funders, social enterprises and investors—build their work on a theory of change. It is at the heart of strategy. It is the foundation for the development of an impact measurement framework. It should be the cornerstone of attempts to work out whether and how well you are achieving your mission.

ToC is only as useful as its practical application, and we should not get lost in the quest for theoretical perfection. But taken at face value, as a theory to explain how your work is supposed to function, it is immensely powerful. For us in the charity sector, committed to achieving the best possible outcomes for those we aim to serve, it helps test whether our understanding of the world is backed up by what happens in reality. Theories of change,

therefore, should not be static; they evolve and improve as our understanding and knowledge are advanced by evidence and observation (Harries et al., 2014).

### 3. Methodological approach

The credibility of any empirical study relies on a comprehensible methodological framework that allows data collection, objective measurement, and a clear understanding (Hair et al., 2019). The present study applies a mixed methodology, with a quantitative and qualitative approach through the construction and analysis of a composite index, and the application of ToC for the main strategies/policies regarding the BE in the Iberian Peninsula.

The following image shows the steps taken to conduct the present study:



Figure 1 - Methodology steps.

As represented in Figure 1, the first step conducted was the elaboration of the Literature Review on the main topics approached in this study: An overview of BE; Governance in the BE; Indicators to evaluate BE: Social and Environmental indicators; Overview of the main BE projects in the Iberian Peninsula; and lastly, the ToC.

As highlighted by Pichon et al.,2021 and GÜDEMANN & MÜNNICH, 2023, composite indexes can allow comparisons between countries and give a good overview of the evolution of a situation. This comparison provides the necessary information for policymakers to design the country's governance accordingly. For more information about these authors and their work with composite indexes, please see Table 6 in the appendix.

For the second step of this study, the database considered to proceed with the composite indexes analysis is from the platform BE observatory European Commission, gathering economic indicators (full-time employment, persons employed, gross profit, gross value added and investments) and environmental indicators (fuel intensity, energy costs,  $CO_2$  emissions, fuel efficiency, fuel price l/eur, fuel use l/eur). The countries with available data were: Belgium, Bulgaria, Croatia, Cyprus, Denmark, Estonia, Finland, France, Germany, Greece, Ireland, Italy, Latvia, Lithuania, Malta, Netherlands, Poland, Portugal, Romania, Slovenia, Spain, and Sweden. The data collected for these countries were from 2020. The statistical analysis conducted in this study relied on JASP software (version 0.19.3 for Intel).

Before running the composite index analysis, a correlation analysis was done to verify the behavior between the indicators, followed by the normalization of the indicators.

The third step consists of the application of the ToC, following the methodology from Zuercher et al., 2023. This approach contributed to this study since ToC provides practitioners with a pragmatic and useful entry point for testing expectations and complicated, nonlinear causal relationships that are relevant when evaluating multi-objective and multifaceted interventions (Miyaguchi, 2022).

In step four of this study, the results obtained in each analysis are brought together in order to give a more comprehensive understanding of the results and draw broader conclusions. Lastly, in step five, the main results are presented again and confronted with the main purposes of the study to assess if they were achieved.

### 3.1. Correlations (economy x environment)

Correlation analysis is a term applied to denote the association or relationship between two (or more) quantitative variables. In other words, A correlation coefficient is a measure of the relationship between any two quantitative and categorical variables. The coefficient describes the degree of relationship between two variables (Alsaqr, 2021).

| Variable                |                | Full time employment | Fuel use | Fuel price | Energy costs | Fuel efficiency | CO2 emissions | Fuel intensity | GVA     | Investments | Gross profit | Persons employed |
|-------------------------|----------------|----------------------|----------|------------|--------------|-----------------|---------------|----------------|---------|-------------|--------------|------------------|
| 1. Full time employment | Spearman's rho | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | p-value        | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 2. Fuel use             | Spearman's rho | -0.009               | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | p-value        | 0.968                | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 3. Fuel price           | Spearman's rho | -0.317               | -0.588   | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | p-value        | 0.151                | 0.005    | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 4. Energy costs         | Spearman's rho | 0.736                | 0.082    | -0.294     | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | p-value        | < 0.001              | 0.717    | 0.183      | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 5. Fuel efficiency      | Spearman's rho | -0.280               | 0.667    | 0.118      | -0.251       | -               | -             | -              | -       | -           | -            | -                |
|                         | p-value        | 0.207                | < 0.001  | 0.600      | 0.258        | -               | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 6. CO2 emissions        | Spearman's rho | -0.014               | 0.263    | 0.121      | 0.224        | 0.471           | -             | -              | -       | -           | -            | -                |
|                         | p-value        | 0.951                | 0.237    | 0.590      | 0.317        | 0.027           | -             | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 7. Fuel intensity       | Spearman's rho | -0.014               | 0.263    | 0.121      | 0.224        | 0.471           | 1.000         | -              | -       | -           | -            | -                |
|                         | p-value        | 0.951                | 0.237    | 0.590      | 0.317        | 0.027           | < 0.001       | -              | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 8. GVA                  | Spearman's rho | 0.777                | -0.093   | -0.256     | 0.804        | -0.354          | 0.056         | 0.056          | -       | -           | -            | -                |
|                         | p-value        | < 0.001              | 0.679    | 0.249      | < 0.001      | 0.107           | 0.803         | 0.803          | -       | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 9. Investments          | Spearman's rho | 0.843                | 0.019    | -0.374     | 0.822        | -0.355          | 0.042         | 0.042          | 0.925   | -           | -            | -                |
|                         | p-value        | < 0.001              | 0.936    | 0.087      | < 0.001      | 0.105           | 0.852         | 0.852          | < 0.001 | -           | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 10- Gross profit        | Spearman's rho | 0.814                | 0.024    | -0.368     | 0.850        | -0.295          | 0.120         | 0.120          | 0.957   | 0.938       | -            | -                |
|                         | p-value        | < 0.001              | 0.916    | 0.093      | < 0.001      | 0.182           | 0.596         | 0.596          | < 0.001 | < 0.001     | -            | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
| 11- Persons employed    | Spearman's rho | 0.960                | 0.005    | -0.271     | 0.771        | 0.242           | 0.026         | 0.026          | 0.803   | 0.857       | 0.857        | -                |
|                         | p-value        | < 0.001              | 0.982    | 0.222      | < 0.001      | 0.278           | 0.908         | 0.908          | < 0.001 | < 0.001     | < 0.001      | -                |
|                         | Lower 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |
|                         | Upper 95% CI   | -                    | -        | -          | -            | -               | -             | -              | -       | -           | -            | -                |

Figure 2- Spearman correlation results.

The outputs of the Spearman correlation allow the identification of significant relations between economic and environmental indicators. To facilitate the interpretation of Spearman's rho, the following scales are necessary: if value > 0.7 – strong correlation, if value is between 0.3 and 0.7 – medium correlation, and if value < 0.3 – the correlation is weak; for the interpretation of p-value, the null hypothesis states that there is no correlation between the variables, so if the p-value < 0.05 means that the correlation is statistically significant, in other words, the relationship is unlikely due to chance.

Having this in mind and looking at the results obtained, it can be concluded that:

- There is a strong relation between full time employment and the economic indicators, such as Gross Value Added (GVA) (Spearman's rho with a score of 0.777, and also because p-value < 0.001) investments (the Spearman's rho is 0.843 and p-value < 0.001), GP (Spearman's rho = 0.814, p-value < 0.001) and persons employed (Spearman's rho = 0.960, p-value < 0.001). These results lead to believe that countries with higher levels of employment also tend to present better economic strength. Full-time employment is also positively related to energy costs (Spearman's rho = 0.736, p-value < 0.001), which indicates that countries with higher levels of full-time employment, are more likely to have bigger energy costs, because of larger production scales that require more energy resources;

- Energy costs are highly correlated with the main economic indicators, such as GVA (Spearman's  $\rho = 0.804$ ,  $p\text{-value} < 0.001$ ), investments (Spearman's  $\rho = 0.822$ ,  $p\text{-value} < 0.001$ ), GP (Spearman's  $\rho = 0.850$ ,  $p\text{-value} < 0.001$ ) and persons employed (Spearman's  $\rho = 0.960771$ ,  $p\text{-value} < 0.001$ ). By these results, it can be established that the energy costs increase at the same time as the productivity, reinforcing the importance of energy for business activities;
- Regarding fuel price, this indicator is negatively correlated with fuel use (Spearman's  $\rho = -0.588$ ,  $p\text{-value} = 0.005$ ), meaning higher fuel prices are connected to reduced consumption;
- Fuel efficiency presents a medium but positive correlation with  $CO_2$  emissions (Spearman's  $\rho = 0.471$ ,  $p\text{-value} = 0.027$ ), suggesting that countries with higher efficiency tend to attain lower emissions;
- Environmental indicators, for example,  $CO_2$  emissions and fuel intensity present weak or non-significant correlations with all the economic indicators, showing that environmental impacts are not directly impacted by the country's performance;
- Lastly, when looking into the relationship within the economic indicators (GVA, investments, GP, persons employed and full time employment), Spearman's  $\rho$  values often exceed 0.9 and  $p\text{-values} < 0.001$ , by these results, it can be established that these indicators are highly correlated, highlighting the connection between country-growth, profitability, investment and employment.

### 3.2. Composite indexes

With the rapid growth of large-scale multivariate data generation, which is both complex and expensive, extracting meaningful insights becomes a challenging task due to the voluminous data and intricate relationships among variables. Therefore, it is imperative to develop statistical methodologies for summarizing such data to uncover underlying patterns, trends, and contextual factors that facilitate informed decision-making (Singh et al., 2023).

One widely adopted approach for summarizing and comparing performance across subjects is the use of composite indicators or indexes. Composite indicators or indexes are mathematical or computational measures designed to effectively quantify multidimensional concepts that cannot be adequately captured by a single indicator alone (Singh et al., 2023).

To combine different variables in one indicator, the first step was to normalize them. In order to do that, each variable was transformed into a z-score. The more important concepts to have in mind are: positive z-scores indicate performance above the mean, while negative scores reflect performance below the mean.

Based on the z-scores, three composite indexes were elaborated: a global composite index, combining economic indicators (like employment, investment, GVA, profits) and environmental indicators (such as  $CO_2$  emissions,

energy costs, fuel use and costs); an economic composite index, only containing the economic indicators; and an environmental composite index, only with the environmental indicators.

For the variables for which higher values are better (for example, employment), the z-scores were included with a positive sign; for the variables for which lower values are better (for example, energy costs), the z-scores were included with a negative sign.

The results obtained for the global composite index were:

Table 1- Outputs from the economic and environmental composite indexes.

| <b>Counties</b> | <b>Economic and environmental composite index</b> |
|-----------------|---------------------------------------------------|
| Germany         | 1.145384294                                       |
| Spain           | 0.8464636869                                      |
| France          | 0.3650937132                                      |
| Poland          | 0.3446781184                                      |
| Italy           | 0.2699485426                                      |
| Netherlands     | 0.0760338439                                      |
| Denmark         | 0.03962961285                                     |
| Portugal        | 0.01922623462                                     |
| Finland         | -0.02727675501                                    |
| Sweden          | -0.04400718295                                    |
| Ireland         | -0.0587065521                                     |
| Croatia         | -0.06896017531                                    |
| Latvia          | -0.07378713502                                    |
| Romania         | -0.08604676137                                    |
| Bulgaria        | -0.137146792                                      |
| Lithuania       | -0.1371566218                                     |

|          |               |
|----------|---------------|
| Estonia  | -0.1322747592 |
| Greece   | -0.2779430966 |
| Belgium  | -0.2992406109 |
| Cyprus   | -0.5001833929 |
| Malta    | -0.6258439971 |
| Slovenia | -0.6378842137 |

As seen in Table 1, Portugal presents a score of 0.019, which means its position is slightly above the European average, suggesting that even though Portugal demonstrates strengths in certain dimensions of the BE, it is necessary to improve the performance of the indicators selected. Having this in consideration, it can be said that Portugal is positioned in a moderate position, with room for improvement to achieve a better balance between economic and environmental indicators.

Regarding Spain, in Table 1, this country presents an index of 0.846, indicating a performance above the average, having a position among the most competitive countries, such as Germany, France, and Poland. Spain's position shows the successful efforts in balancing economic growth and sustainability within the BE objectives.

Regarding the economic composite index, the results are presented in Table 2:

Table 2- Outputs from the economic composite index.

| <b>Counties</b> | <b>Economic composite index</b> |
|-----------------|---------------------------------|
| Spain           | 2.436580835                     |
| Germany         | 2.105136706                     |
| Italy           | 1.518522238                     |
| France          | 1.146770025                     |
| Poland          | 0.2584193468                    |
| Netherlands     | 0.1417219389                    |

|           |                |
|-----------|----------------|
| Portugal  | 0.07210082918  |
| Greece    | -0.05418249701 |
| Denmark   | -0.2516113135  |
| Ireland   | -0.3677727022  |
| Sweden    | -0.372610738   |
| Lithuania | -0.5563958505  |
| Finland   | -0.5775056531  |
| Romania   | -0.6000531567  |
| Bulgaria  | -0.6060655236  |
| Latvia    | -0.6751585584  |
| Estonia   | -0.7124962584  |
| Malta     | -0.7167349602  |
| Cyprus    | -0.736004367   |
| Slovenia  | -0.7727094116  |
| Croatia   | -0.5198919869  |
| Belgium   | -0.1600589409  |

Looking into Portugal's result, an index of 0.0721, slightly above zero, indicates a performance close to the average of the other EU countries. This positive value implies a good economic development, but shows that some aspects could be improved.

With an index of 2.4366, Spain stands out with the highest value of all the countries. This result shows an economic performance well above the average, showing a solid and competitive positioning within the European background. Spain's success should be considered as a reference for other EU countries.

Regarding the environmental performance:

Table 3- Outputs from the environmental composite index.

| Countries | Environmental index |
|-----------|---------------------|
|-----------|---------------------|

|             |                |
|-------------|----------------|
| Finland     | 0.4312473267   |
| Latvia      | 0.4273557178   |
| Poland      | 0.4165604281   |
| Estonia     | 0.3512431568   |
| Croatia     | 0.3068163344   |
| Denmark     | 0.2823303848   |
| Bulgaria    | 0.2536188177   |
| Sweden      | 0.2298291129   |
| Lithuania   | 0.2122094021   |
| Ireland     | 0.198848573    |
| Romania     | 0.3422919014   |
| Germany     | 0.3455906162   |
| Netherlands | 0.02129376477  |
| Portugal    | -0.02483592752 |
| France      | -0.286303213   |
| Cyprus      | -0.3036659144  |
| Belgium     | -0.4152253359  |
| Greece      | -0.464410263   |
| Spain       | -0.4786339362  |
| Malta       | -0.5501015278  |
| Slovenia    | -0.5255298821  |
| Italy       | -0.7705295366  |

Looking at Table 3, Portugal has an index of -0.0248, a value relatively close to zero, but still reflects a below-average performance. This means that Portugal still has to make some improvements regarding

the environment, namely within the indicators selected for this analysis. Portugal's positioning in the environmental index is the lowest ranking this country has achieved within the previous indexes.

In regard to Spain, the score presented in Table 3 was -0.4786, showcasing a below-average performance. This suggests that just like Portugal, there are improvements to be made to improve this country's position within the environmental dimension. This positioning is the lowest Spain has achieved within the three composite indexes analysis.

### 3.3. Theory of change

ToC is a theory of how and why an initiative works, which can be empirically tested by measuring indicators for every expected step on the hypothesized causal pathway to impact (Weiss, 1995).

It is developed in collaboration with stakeholders and modified throughout the intervention development and evaluation process through an 'ongoing process of reflection to explore change and how it happens (James, 2011).

In order to get a detailed look into the policies and strategies adopted by Spain and Portugal, and to construct the ToC, a table was elaborated to illustrate the relationships between inputs, activities, outputs, outcomes, impacts, assumptions, and risks. This table will provide a clear representation of the strategies/policies, allowing their critical analysis.

The methodology to construct the ToC was adapted from Zuercher et al., 2023), as presented in Figure 2:

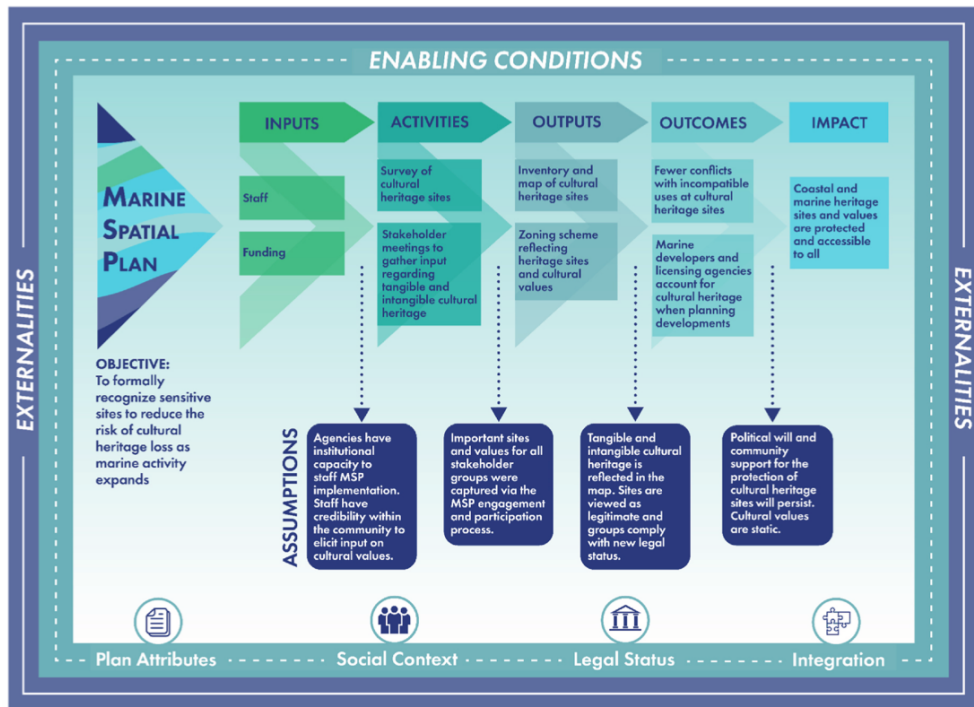


Figure 3- Steps for the application of the ToC.

As presented in Figure 3, to construct the ToC, it was necessary, for each strategy/policy, to gather essential information about the indicators:

- Inputs: monetary funding, institutional support, and a workforce dedicated to the implementation;
- Activities: Actions and measures conducted to achieve the purpose of the strategy/policy;
- Outputs: Tangible and immediate products resulting from the activities undertaken;
- Outcomes: Short/medium-term effects can be manifested in behavior or decision making.
- Impacts: Long-term transformations;
- Assumptions: Conditions required to allow change and the full implementation of the strategy/policy;
- Externalities: Factors that may influence the results of the implementation of the policies/strategies that cannot be controlled.

The strategies/policies selected for this study were discussed/presented in a prior chapter. By following these steps, resulted the following tables:

Table 4- ToC for Portugal policies/strategies.

|                                                   | Inputs                                                                                                                                                                                                                                                                                             | Activities                                                                                                                                                                                                                                                                                                                                                                               | Output                                                                                                                                                                                                            | Outcomes                                                                                                                                                                                                                                                                                                                                                                                                   | Impacts | Sources                                                                                                                                                                                         |
|---------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| National Ocean Strategy 2021-2030 (NOS 2021-2030) | <ul style="list-style-type: none"> <li>- ITI Ocean Implementation Commission;</li> <li>- European Structural and Investment Funds;</li> <li>- National funds (such as Blue Fund and Environmental Fund);</li> <li>- The Financial Mechanism of the European Economic Area (EEA Grants);</li> </ul> | <ul style="list-style-type: none"> <li>- Integrated Management: ensuring broad coordination of maritime planning and action;</li> <li>- Precaution: Anticipating risks and potential harm, without delaying effective measures;</li> <li>- Effective participation: Involving all stakeholders at central, regional, and local levels, including public and private entities.</li> </ul> | <ul style="list-style-type: none"> <li>- Implementation of a set of actions in the areas of maritime identity and international recognition, capacity building and knowledge, and maritime governance.</li> </ul> | <ul style="list-style-type: none"> <li>- Strengthen policy coherence, governance, and resource allocation;</li> <li>- Foster a resilient BE;</li> <li>- Employment and the Circular and Sustainable BE</li> <li>- Decarbonization of the economy;</li> <li>- Promotion of renewable energies, and energy autonomy;</li> <li>- Reindustrialization, productive capacity, and ocean digitization.</li> </ul> |         | <p>(Governo de Portugal, 2021)</p> <p>(Governo de Portugal – Departamento da Direcção-Geral de Política do Mar, 2021)</p> <p>(European Commission – Reform and Investment Task Force, 2022)</p> |
| Recovery                                          |                                                                                                                                                                                                                                                                                                    | <ul style="list-style-type: none"> <li>- Investment in 7 sectors;</li> <li>- Application of biomaterials;</li> </ul>                                                                                                                                                                                                                                                                     | <ul style="list-style-type: none"> <li>- 17 investment streams and 44 reforms;</li> </ul>                                                                                                                         | <ul style="list-style-type: none"> <li>- Drive the development of a cutting-edge industrial economic sector</li> </ul>                                                                                                                                                                                                                                                                                     |         | (Instituto Português do Mar e da Atmosfera, 2021)                                                                                                                                               |

|                               |                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                            |                                                                                                                                                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                                                                            |  |                                                                                        |
|-------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------------------------------------------------------------|
|                               | <ul style="list-style-type: none"> <li>- 133.084.957,80 €;</li> <li>- IPMA;</li> <li>- ENESI.</li> </ul>                                                                                                  | <ul style="list-style-type: none"> <li>- New paradigm for bivalve production; marine-based textile;</li> <li>- Sustainability in the food sector;</li> <li>- Increased algae production;</li> <li>- Circular feed solutions;</li> <li>- Bioinformatics for the fisheries sector</li> </ul> | <ul style="list-style-type: none"> <li>- 41% of the plan will support climate objectives;</li> <li>- 21% of the plan will foster the digital transition;</li> </ul>                                                                                                                                                                                                                      | <ul style="list-style-type: none"> <li>- Serve as the first major showcase of the cross-sectoral and ecological potential of marine biotechnology solutions;</li> <li>- Contribute to positioning Portugal globally as a pioneer in a sector projected to reach €200 billion worldwide by 2030;</li> </ul> |  | (European Commission, n.d.-e)                                                          |
| Single Logistics Window (JUL) | <ul style="list-style-type: none"> <li>- Co-financed by COMPETE 2020;</li> <li>- The total estimated investment amounts to €5.1 million, with an adjusted eligible investment of €4.3 million.</li> </ul> | <ul style="list-style-type: none"> <li>- Construction of a new National Reference Model;</li> <li>- Implementation of the Single Logistics Window (JUL) in each Port Authority, including the installation of the basic hardware and software required for its operation.</li> </ul>       | <ul style="list-style-type: none"> <li>- Reduced and paperless interaction with authorities;</li> <li>- Coverage of last-mile processes using simple and low-cost applications;</li> <li>- More competitive port-logistics system;</li> <li>- Optimization and synchronization of multi-modal flows;</li> <li>- Support for more agile, intelligent, and reliable operations;</li> </ul> | <ul style="list-style-type: none"> <li>- Competitive port-logistics system;</li> <li>- Optimized, synchronized, and significantly more agile logistics operations.</li> </ul>                                                                                                                              |  | (Associação dos Portos de Portugal, 2018)<br>(Associação dos Portos de Portugal, n.d.) |
| Strategic Plan                | <ul style="list-style-type: none"> <li>- EMFF funding, foreseen under</li> </ul>                                                                                                                          | <ul style="list-style-type: none"> <li>- Reduction of response times;</li> <li>- Definition of the types of procedures and minimum required information</li> </ul>                                                                                                                         | <ul style="list-style-type: none"> <li>- Facilitate administrative procedures;</li> <li>- Improve access to space and water;</li> </ul>                                                                                                                                                                                                                                                  | <ul style="list-style-type: none"> <li>- Promotion of sustainable aquaculture activities;</li> </ul>                                                                                                                                                                                                       |  | (Direção-Geral de Recursos Naturais, 2023)                                             |

|                                                  |                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                        |                                                                                                                                                                                                                                                             |                                                                                                                                                                                                                                                                                                                                                                                                                                               |  |                                                                                                                                  |
|--------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|----------------------------------------------------------------------------------------------------------------------------------|
|                                                  | <p>the MAR 2020 Program;</p> <ul style="list-style-type: none"> <li>- European Maritime, Fisheries and Aquaculture Fund (EMFAF) will continue to provide targeted financial support to EU Member States.</li> </ul> | <p>for different types of establishments;</p> <ul style="list-style-type: none"> <li>- Creation of a checklist of documentation required for licensing;</li> <li>- Creation of an electronic platform for the submission, analysis, and processing of licensing procedures;</li> </ul> | <ul style="list-style-type: none"> <li>- Strengthen the competitiveness of aquaculture;</li> <li>- Promote a level playing field for operators across the European Union, alongside increasing production capacity.</li> </ul>                              | <ul style="list-style-type: none"> <li>- Productive investments in aquaculture, including those related to energy efficiency, circular economy, digitalization, internationalization, support for aquaculture insurance premiums, and support for the creation of start-ups;</li> <li>- Management, replacement, and advisory services for aquaculture farms.</li> </ul>                                                                      |  |                                                                                                                                  |
| Maritime Spatial Planning Situation Plan (PSOEM) | NOT IDENTIFIED                                                                                                                                                                                                      | <ul style="list-style-type: none"> <li>- Identification of the spatial and temporal distribution of existing and potential uses and activities;</li> <li>- Designation of relevant areas for nature conservation;</li> </ul>                                                           | <ul style="list-style-type: none"> <li>- Compatibility between competing uses or activities;</li> <li>- Contributing to a better economic use of the marine environment and minimizing the impact of human activities on the marine environment.</li> </ul> | <ul style="list-style-type: none"> <li>- Implementation of the objectives of the National Strategy for the Sea;</li> <li>- Promote sustainable, rational and efficient economic exploitation of marine resources;</li> <li>- Prevent and minimize conflicts between competing uses and activities;</li> <li>- Ensure legal security and transparency in the allocation of the Title of Private Use of the National maritime space.</li> </ul> |  | <p>(Direcção-Geral de Recursos Naturais, n.d.)</p> <p>(Direcção-Geral de Recursos Naturais &amp; Republica Portuguesa, n.d.)</p> |

Social impact

Economic impact

Environmental impact

Technological impact

Table 5- ToC for Spain policies/strategies.

|                                                               | Inputs                                                                                                                                                                                                                               | Activities                                                                                                                                                                                                                                                                                          | Output                                                                                                                                                                                                                                                                                                                                      | Outcomes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        | Impacts | Sources                                                                             |
|---------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------|-------------------------------------------------------------------------------------|
| Integrated National Energy and Climate Plan (PNIEC 2023-2030) | <ul style="list-style-type: none"> <li>- Integrated National Energy and Climate Plan (PNIEC 2023-2030), expanding the number of planned policies and measures from 78 in the original plan to 110 in the current version.</li> </ul> | <ul style="list-style-type: none"> <li>- Planned policies and measures 107;</li> <li>- Specific actions for the railways, aviation and navigation, rural development, improved integration of renewables with the environment and territory;</li> <li>- Life cycle analysis of buildings</li> </ul> | <ul style="list-style-type: none"> <li>- Total installed capacity of 214 GW, including 160 GW from renewable energy sources;</li> <li>- Wind power capacity will reach 62 GW, including 3 GW from offshore wind farms;</li> <li>- Solar photovoltaic capacity will rise to 76 GW, including 19 GW from self-consumption systems;</li> </ul> | <ul style="list-style-type: none"> <li>- Strengthen the country's strategic autonomy by boosting energy independence by 50%;</li> <li>- Increasing the share of renewables to 48% of final energy consumption;</li> <li>- Reduction of greenhouse gas emissions by 32% by 2030;</li> <li>- Increase the role of renewable energy, which is expected to account for 48% of final energy consumption—rising to 81% for electricity;</li> <li>- Improve energy efficiency by up to 43%.</li> </ul> |         | <p>(Global Factor, 2023)</p> <p>(Cluster Energia, n.d.)</p> <p>(Djunisic, 2024)</p> |

|                                                                                                                          |                                                                                                                                                                                                                                                                                                                                                                                                      |  |                                                                                                                                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |  |                                                                          |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------|
| <p style="writing-mode: vertical-rl; transform: rotate(180deg);">Recovery, Transformation and Resilience Plan (PRTR)</p> | <ul style="list-style-type: none"> <li>- Financed by the Next Generation EU (NGEU) recovery instrument and its main spending tool;</li> <li>- The European commission will allow Spain to receive in the next three 69,500 billion;</li> <li>- The ministry of industry and tourism will manage much of the projects contained in the components 12, 13 and 14 of the Plan, which contain</li> </ul> |  | <ul style="list-style-type: none"> <li>- Modernizing, reinforcing research, and launching major projects to drive and promote innovation in the economy as a whole.</li> <li>- The fiscal system will be modernized in order to reduce the informal economy and tax fraud, guarantee sustainability of pensions and make public spending more efficient.</li> </ul> | <ul style="list-style-type: none"> <li>- Boost economic activity and job creation;</li> <li>- Support the broad structural transformation of the economy;</li> <li>- Steer the transformation towards a more sustainable and resilient growth model.</li> <li>- Improve business demographics and the business climate,</li> <li>- To support and push the productivity of the economy as a whole.</li> <li>- Adopting a climate change and energy transition law;</li> <li>- Developing a robust and flexible energy system and integrating renewable energies.</li> </ul> |  | <p>(Mileusnic, 2023)</p> <p>(Ministry of Industry and Tourism, n.d.)</p> |
|--------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------------------------------------------------|

|  |                                                                                    |  |                                                                                                                                                                                                                                                                                                                                                                     |  |  |  |
|--|------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|
|  | <p>important reforms and investments which whole amounts 12.032 million euros.</p> |  | <ul style="list-style-type: none"> <li>- New housing policy and sustainable mobility strategy are other important reforms.</li> <li>- A water law and a plan for national water treatment, sanitation, efficiency, saving and reuse;</li> <li>- Modernizing the agricultural and fisheries policy, including soil protection and efficient use of water;</li> </ul> |  |  |  |
|--|------------------------------------------------------------------------------------|--|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|--|

|                                                                |                                                                                                                                                 |                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                                                              |  |                                                                                    |
|----------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|------------------------------------------------------------------------------------|
| Maritime Spatial Plans (MSP Plans)                             | <ul style="list-style-type: none"> <li>- General State Budget;</li> <li>- Funding of European projects on maritime spatial planning.</li> </ul> | <ul style="list-style-type: none"> <li>- Establishment of priority use zones, for activities of common interest (such as the protection of biodiversity, national defense, and safety in navigation);</li> <li>- Establishment of high potential areas;</li> <li>- Give precedence to sectoral activities requiring a specific space and their potential use in the future (including port activity, marine aquaculture and offshore wind energy development).</li> </ul> | <ul style="list-style-type: none"> <li>- Promotion of the use of energy from renewable sources;</li> <li>- Conservation and sustainable exploitation of fisheries resources under the Common Fisheries Policy;</li> <li>- Conservation of wild birds;</li> <li>- Conservation of natural habitats and of wild fauna and flora.</li> </ul> | <ul style="list-style-type: none"> <li>- Promote sustainable activity and growth in the maritime sectors in a manner that is compatible with respect for the values of marine spaces,</li> <li>- The conservation of its functionality and the sustainable use of resources,</li> <li>- In addition to maintaining the good environmental status of marine waters, to contribute to achieving and maintaining a sustainable BE in Spanish waters.</li> </ul> |  | <p>(MSPglobal2030, 2025)</p> <p>(Cuatrecasas, 2023)</p> <p>(Burg et al., 2022)</p> |
| Strategic Guidelines for a More Sustainable and Competitive EU | <ul style="list-style-type: none"> <li>- Financial support of the FEMP-FEMPA</li> <li>- EU funding</li> </ul>                                   | <ul style="list-style-type: none"> <li>- Revision of national aquaculture strategies in light of the guidelines, which will also structure the use of relevant EU funding, in particular the European</li> </ul>                                                                                                                                                                                                                                                          | <ul style="list-style-type: none"> <li>- Building resilience and competitiveness,</li> <li>- Participating in the green transition,</li> <li>- Ensuring social acceptance and consumer information,</li> </ul>                                                                                                                            | <ul style="list-style-type: none"> <li>- Use of new technologies for the transmission of information (electronic delivery notes, QR codes)</li> <li>- Making the most of the opportunities offered by communication tools (social media,</li> </ul>                                                                                                                                                                                                          |  | <p>(European Commission, n.d.-b)</p> <p>(European Commission, 2021)</p>            |

|               |                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                    |                                                                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                 |  |                                |
|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--------------------------------|
|               |                                                                                                                                                                                                                                                           | <p>Maritime, Fisheries and Aquaculture Fund (2021-2027).</p> <ul style="list-style-type: none"> <li>- The EU supports research and innovation on key aspects of European aquaculture. From its interactions with the environment and health and nutrition of farmed fish, to reproduction and breeding.</li> </ul> | <ul style="list-style-type: none"> <li>- Increasing knowledge and innovation</li> </ul>                                                                                                                                                                                                                   | <p>campaigns, influencers, recognised opinion leaders)</p> <ul style="list-style-type: none"> <li>- Increased consumer awareness enables local aquaculture products to compete on the basis of quality, proximity and product safety.</li> <li>- incorporation of aquaculture into the food culture will allow the consolidation of the activity as a tool for the conservation of uses and customs.</li> </ul> |  | (European Commission, n.d.-a)  |
| Digital Twins | <ul style="list-style-type: none"> <li>- 10 million euros co-financed by the Horizon Europe program (including technology companies, solution providers, shipping companies and research organizations, including the Valenciaport Foundation)</li> </ul> | <ul style="list-style-type: none"> <li>- an open source digital platform will be developed that will use advanced artificial intelligence and machine learning to optimize maritime operations</li> </ul>                                                                                                          | <ul style="list-style-type: none"> <li>- Decision support system, enabling the shipping industry to quickly adapt to environmental regulations</li> <li>- Optimization of the use of clean and renewable fuels.</li> <li>- prioritizing both current and emerging fuels to minimize emissions.</li> </ul> | <ul style="list-style-type: none"> <li>- reduce greenhouse gas emissions from the maritime industry by 30-40% by 2030</li> <li>- reach zero emissions by 2045, all using clean technologie</li> <li>- demonstrate the feasibility of an environmental and digital transformation, driving sustainable management in shipping.</li> </ul>                                                                        |  | (Fundación Valenciaport, 2025) |
| NEXIGEN Plan  | <ul style="list-style-type: none"> <li>- Total budget €49,844,964;</li> <li>- EU Contribution 15,182,390.40 €;</li> </ul>                                                                                                                                 | <ul style="list-style-type: none"> <li>- Implementing innovative shore-side electricity (OPS) infrastructure,</li> </ul>                                                                                                                                                                                           | <ul style="list-style-type: none"> <li>- Installation of a medium voltage network with 3,000 meters of cable to the dock edge, where three connection</li> </ul>                                                                                                                                          | <ul style="list-style-type: none"> <li>- The ability to connect daily the two ships covering the Barcelona-Palma line will multiply the positive impact of the new system. Stopping the engines during their stay at the</li> </ul>                                                                                                                                                                             |  | (Port of Barcelona, n.d.)      |

|  |  |  |                                                                                                                                                                                                                                                                                                |                                                                                                                                                                                                                                                                                                            |  |  |
|--|--|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|
|  |  |  | <p>boxes specifically designed to be compatible with the terminal's operations have been installed.</p> <ul style="list-style-type: none"> <li>- These connection points, combined with the OPS's capacity to supply up to 8MW of power, allow two ships to connect simultaneously.</li> </ul> | <p>Port of Barcelona, these ships will stop emitting an average of 6.14 tons of CO2 per stop.</p> <ul style="list-style-type: none"> <li>- Elimination of 2,090 tons of CO2 annually.</li> <li>- Improving air quality in Barcelona</li> <li>- Reducing the noise generated by ship operations.</li> </ul> |  |  |
|--|--|--|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--|--|

Social impact

Economic impact

Environmental impact

Technological impact

Table 4 presents five different strategies/policies to promote the BE in Portugal: National Ocean Strategy 2021-2030, Recovery and Resilience Plan, Single Logistics Window, Strategic Plan for the Portuguese Aquaculture 2014-2020, and Maritime Spatial Planning Situation Plan (PSOEM).

Looking into the inputs, there is a common tendency of European and private funding, which suggests the alignment of Portugal's priorities with EU objectives. For example, there is a partnership between the European Investment Fund (EIF), Banco Português de Fomento, and the Portuguese Government, which is called Portugal Blue. The main purpose of this partnership is to invest in small to medium enterprises, based in Portugal and Spain, with the aim of promoting international growth of mature BE companies that focus on sustainable and climate action (Lewis, 2023).

Additionally, it shows the commitment of private investors to participate in achieving a desired outcome at the country level and the European level. Addressing the challenges required to overcome in the implementation of these strategies/policies requires interdisciplinary research and multiple stakeholder engagement from various ocean-related sectors and levels of society (Lillebø et al., 2017). Research organizations can effectively integrate knowledge and information from the interested parties through participatory processes, promote effective interactions between science and society, and open the floor for constructive, legitimate, and influential ocean solutions and issues mapping (Custodio et al., 2022). Having this in mind, being able to have these sources of funding for Portugal means increasing the probability of great outcomes of the policies/strategies and assuring their full implementation.

Regarding the activities/measures conducted to ensure the adequate implementation of the BE, there is a wide range of actions. These actions include the promotion of integrated maritime management, digitalization of administrative processes, and coordination between stakeholders.

The importance of the construction and application of an integrated maritime policy can be justified by the rapidly evolving ocean economy, driven by human needs for food, energy, transportation, and recreation. These causes led to unprecedented pressures on the ocean that are further amplified by climate change, loss of biodiversity, and pollution. The need for better governance of human activities in the ocean space has been widely recognized. This approach aims to ensure the sustainability and resilience of marine ecosystems while integrating and balancing different ocean uses to optimize the overall ocean economy (Winther et al., 2020).

The BE represents a concerted effort to establish a cohesive global framework for defining, categorizing, and optimizing economic industries and activities associated with marine ecosystems. A key driver of this transformation is digitalization, a contemporary paradigm that leverages smart technologies to enhance

operational efficiency, ensure precision in resource allocation, fortify supply chain transparency, and facilitate pre-emptive risk mitigating strategies (Sharma & Verma, 2025).

The coordination between stakeholders is also particularly important for BE, seeing as the involvement of various actors, which does not only refer to a single actor, shows that the policy process is not centralized. Stakeholder analysis is therefore necessary to gather data, particularly regarding policy players participating in the strategic process. In policy research, it is a way to understand information about behavior, interests, agendas, and influences on actors that are considered relevant to the decision-making process (Reed & Curzon, 2015).

Regarding the outputs, the results showed that there is a growing concern about maritime governance and the need to reduce administrative procedures. However, there is a lack of economic and social outputs, such as job creation, an increased number of exports, or imports. These outputs are strongly connected to the impacts that were verified. According to Volk (2024), it is assumed that outputs logically lead to certain outcomes, which in turn are expected to lead to certain impacts (Volk, 2024).

The need to improve economic and social outcomes relies on the fact that the ocean economy can become an engine of economic diversification and structural transformation. By creating and adding value across the ocean economy's production processes, countries can fully harness the potential of the ocean economy. A more resilient ocean economy can be developed by strengthening linkages between ocean-based sectors (Promoting Sustainable Ocean Economies, 2025).

Also, ocean-based economic development can generate few local economic benefits, widen existing inequalities, displace local communities and livelihoods, produce harmful pollution, threaten environmental sustainability, undermine human rights, and lead to substantial social and cultural harms (Ayilu et al., 2022). Proponents of the BE advocate for a different approach to development, one that is both environmentally sustainable and socially equitable. Yet, unless greater attention is given to advancing social sustainability and equity, future blue growth will simply perpetuate past social inequities and harms (Bennett et al., 2022).

When it comes to the outcomes, as each policy/strategy has its own objectives, and some are still in the process of implementation, it is not possible to compare their results. These differences in results don't allow the elaboration of a standard evaluation of the results obtained, but they do cover different areas. For example, the NOS 2021-2030 supports policy coherence, the decarbonization of the economy and the utilization and development of renewable energies while the RRP aims its efforts to the development of the industrial economic sector and highlights the potential of biotechnology solutions.

The assumptions that were considered necessary for the successful implementation of the strategies/policies selected were the political commitment at a national level and even at the European level, engagement of communities and stakeholders, alongside a wide range of investments, and the promotion of environmental and technological innovation.

Looking into Sapin's analysis, the strategies studied were: Transformation and Resilience Plan (PRTR); Maritime Spatial Plans (MSP Plans); Strategic Guidelines for a More Sustainable and Competitive EU aquaculture 2021-2030; Digital Twins; and NEXIGEN Plan.

The inputs gathered show consistent funding from the EU and national funding, showcasing Spain's commitment to the EU agenda. Also, its own guidelines and objectives, an example of this can be found in the PRTR, where the funding comes from the European Commission through the Next Generation EU (NGEU) and from the Ministry of Industry and Tourism.

The activities implemented to achieve the strategies/policies goals, with a focus on decarbonization, digital transformation, and sustainable use of maritime resources, highlight the commitment to economic development and environmental preservation.

Energy is an important driver of economic growth and prosperity, but transitioning to renewable energy is vital to achieving decarbonization at the global level (Bordin et al., 2025). In this area of action Spain implemented the PNIEC, this strategy stands out by the promotion of renewable energy and storage and demand management to enhance their integration, to have in 2030, 62 GW of wind power installed, 76 GW of photovoltaic power, 4.8 GW of solar thermal power, 1.4 GW of biomass power, and 22 GW of storage (Global Factor, 2023).

The development of the BE can be accelerated by adopting digital economic transformation. Digital transformation is a key factor in increasing global competitiveness and enabling communities to access new markets more effectively (Qur'ani & Anshar, 2023). Spain's commitment to digital transformation can be seen through the implementation of digital twins with the creation of an open-source digital platform that will use advanced artificial intelligence and machine learning to optimize maritime operations (Fundación Valenciaport, 2025).

The imperative to transform our existing economic systems is underscored by the pressing challenges posed by climate change, largely attributed to anthropogenic activities. The revision of economic development concepts towards sustainable development has become crucial (Ovchynnykova et al., 2024). Spain's concern about environmental preservation can be shown in the strategic guidelines for a more sustainable and competitive EU aquaculture. With EU support, it will be possible to develop research and innovation on key aspects of Spain's

aquaculture, from its interactions with the environment and health and nutrition of farmed fish, to reproduction and breeding (European Commission, n.d.-b).

Regarding the outputs, most of them remained dedicated to institutional strengthening rather than economic performance. Spain shows its effort through MSP Plans, that allowed the identification and evaluation of the zones that could be used to construct offshore wind energy and marine energy installations, ensuring their compatibility with other current and future uses and activities (Cuatrecasas, 2023) . Recently, maritime spatial planning (MSP) is gaining attention as a new approach to sustainable marine resource management by integrating economic, environmental and social concerns in same management platform. In many countries, MSP has been proven as an effective tool to implement an ecosystem-based approach of planning to achieve a long-term maritime vision (Saha & Afsana, 2018).

Regarding the outcomes, given the difference between policies and different stages of implementation, it is not possible to compare the results obtained. In order to compare them, a group of indicators is needed that would combine both quantitative and qualitative dimensions, but it can be highlighted that efforts are being made to reduce the consumption and dependency on fossil fuels and solidify Spain's energy autonomy.

In the case of the impacts, it can be noticed not only the lack of social and economic impacts, but also the frequent presence of technological and environmental impacts. This suggests the focus on digitalization and decarbonization instead of social and economic outputs. However, as part of these strategies/policies are still in the process of implementation, these results should be assessed again in the future.

Just like Portugal, the assumptions considered for the successful and effective implementation of the strategies/policies presented in this study were the political commitment at a national level and even at the European level, engagement of communities and stakeholders, alongside a wide range of investments, and the promotion of environmental and technological innovation.

#### 3.4. Wrap up of IB BE

The results obtained from the composite indexes applied in this study, first regarding the environmental-economic composite indexes, showed that both Portugal and Spain have a good positioning within the other EU countries, even though Spain occupies a higher position above the average. When looking into only economic indicators, Spain stands out with one of the highest values, showing a solid and competitive positioning among the other EU countries. As for Portugal, the result obtained positions Portugal's performance close to the other EU countries, but there is a considerable amount of room for improvement. Lastly, the environmental performance was analyzed, where both Portugal and Spain got values below zero. These values mean that their

performance is below the average in comparison with the other EU countries, indicating there is a need for improvement regarding this pillar of the BE.

The application of the ToC allows us to showcase, in a simpler way, the strategies/policies implemented for the successful implementation of the BE in Iberian Peninsula countries (Portugal and Spain). The main results from this analysis for Portugal were that, even though there is a noticeable effort to develop BE, there is a lack of policies that support social and economic development within the BE. The same thing can be said about Spain's policies; there is a high frequency of environmental and technological impacts, but not so much of social and economic impacts.

When Portugal's results in the ToC and composite indexes, it can be said that Portugal's policies/strategies are strongly related to the environmental impacts; however, the outputs obtained in the composite indexes for these indicators show that Portugal's performance is below the EU average, with a score of -0,0248. For Portugal's economic indicators, it is seen that the opposite behavior occurs than in the previous indicator; there is a low frequency of economic impacts in the results of the ToC, but Portugal presents an index score of 0.0721, meaning its performance is close to the European average.

Regarding the outputs obtained for Spain, the score obtained in the economic composite index was one of the highest observed scores, showcasing strong economic performance, above the European average. Meanwhile, in the Toc analyses, the economic impacts are not evident. For the environmental index score, Spain got a value of -0.4786, indicating a below-average performance.

This difference in the results of both countries can be justified by the fact that the ToC evaluates only the framework and intention of the policies, while the composite index measures the concrete results of determined indicators.

#### 4. Conclusion

In the present time, sustainability has gained increasing importance; the ocean and its resources are now seen as a valuable yet finite source, generating not only economic value but also contributing to climate regulation and the well-being of the coastal communities. Given the importance BE has, it is now, more than ever, necessary to ensure that the principles defended by the BE are presented in a country's governance, contribution to its implementation, and success.

In this study, the primary objectives were to determine the positioning of the Iberian Peninsula within the European context, highlighting its strengths and weaknesses in each dimension, and to analyze the policies/strategies of the BE within the Iberian Peninsula.

In order to achieve the objectives proposed, a composite index analysis was applied to a group of social and economic indicators to analyze the performance of the Iberian Peninsula countries within the EU countries. To make this study more complete, a methodology was adopted from Zuercher et al., 2023 to conduct a ToC analysis on a set of selected strategies/policies implemented in Spain and Portugal.

The results from the economic and environmental composite index analysis showed, for both Portugal and Spain, a performance above the European average. Spain occupies a higher spot in the table with an index value of 0.846, and Portugal positions itself near the middle of the table with a score of 0.019.

Regarding the economic index, Spain stands out with an output of 2.4366, being the highest score of all the EU countries analyzed, showcasing a solid and competitive positioning. Meanwhile, Portugal's result was 0.0721, slightly above zero, suggesting a performance close to the European average, but with some room for improvement.

Lastly, regarding the environmental index, it was concluded, based on the negative scores, that both Portugal and Spain show a below European environmental average performance, suggesting the need to make some improvements within the indicators selected for this analysis.

The main results gathered from the application of the ToC show Portugal and Spain's commitment to different types of initiatives and policies to become more sustainable and achieve the goals proposed by the EU, but there is a lack of presence of social and economic impacts. The more frequent impacts, at least for the selected strategies, were technological and environmental impacts.

This difference in the results can be justified by the fact that ToC is a methodology that shows how an initiative, such as policy, strategy, program, or project, contributes through a chain of early and intermediate outcomes to the intended results (Serrat, 2017).

Meanwhile, composite indexes have been used to measure and compare results for individual nations in global analyses. Composite indexes are used in global studies to compare results across nations, as national policy formulation and implementation are primarily centered at the national level (Stevens et al., 2023).

Essentially, the difference between these methodologies lies in the fact that ToC evaluates policies and strategies, as well as their intention, while composite indexes assess the actual results of implementation.

For future research, applying the composite indexes to specific policies/strategies outlined in the ToC could lead to more concrete results.

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## 6. Appendix

Table 6- Methodology proposed by Pichon et al.,2021 and Güdemann & Münnich, 2023.

| Author                   | Purpose of composite indexes according to the authors                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               | Application of composite indexes                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|--------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Pichon et al.,2021       | <p>A composite index often proposes a ranking of countries. Such indexes help to capture a comprehensive overview of a given situation and grasp its constitutive elements more easily. They provide for comparisons between countries or regions on a standard basis, and, when they are updated on a regular basis, give a good overview of the evolution of a situation over time. This can help with designing policies to prevent or mitigate risks and to encourage positive development. Indexes can also, up to a certain point, help monitor the impact of policies and support forecasting exercises</p>                                                                  | <p>In this paper we discuss and illustrate quality issues with regard to aspects of the subjective choices made in the construction process of composite indicators, imputation of missing data and the survey design. As an example we construct a composite indicator on sustainable economic development using data of the Sustainable Development framework. Furthermore, we exemplify and discuss strategies and methods for the quality assessment of a composite indicator.</p>                                                                                                               |
| Güdemann & Münnich, 2023 | <p>Composite indicators are a common method used for analysing the development of country performances according to relevant quantitative sub-indicators, especially in economic and social policy support. They benefit from their apparent ease of interpretation and their ability to summarize complex multidimensional issues. Their common use in highly sensitive and important areas urges the need to discuss methodical advantages and disadvantages as well as their adequacy for performance comparisons. Methods of relative comparisons used for policy making need to follow high standards with regard to the data quality and interpretability of the results.</p> | <p>The information in this publication is geared towards supporting policy-makers by providing sources of data and identifying the possible biases built into them. EPRS has picked 10 composite indexes from a range of policy areas. The selected indexes have been taken from reliable sources, already used as references by policy-makers. Dedicated chapters present the producers of each index and describe their objectives, outlining the data compiled and their actual and possible use by policy-makers. The chapters also highlight the limitations inherent in using the indexes.</p> |

