UDC 502.131.1: 639.3
JEL F55, O13, Q22, Q28, Q57

STRATEGIC BLUE TRANSFORMATION OF AQUATIC FOOD SYSTEMS: PREREQUISITES FOR PARTNERSHIP AND SUSTAINABLE DEVELOPMENT

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Received: 30/07/2025
Revised: 17/11/2025
Accepted: 10/12/2025

DOI: 10.61954/2616-7107/2025.9.4-5

Introduction. This study focuses on exploring the opportunities for the "blue" transformation of aquatic food systems in Ukraine and Greece, drawing on international experience. It emphasises that, in global practice, countries face significant challenges in developing comprehensive blue economy strategies, while their effectiveness depends on institutional mechanisms and innovative approaches.

Aim and tasks. This study aims to analyse international approaches and assess the opportunities for implementing an effective "blue" transformation of aquatic food systems in Ukraine and Greece. The tasks include comparing existing strategies and practices, identifying the strengths and weaknesses of national models, and justifying institutional and cluster-based mechanisms that can enhance investment attractiveness and ecological sustainability.

Results. The analysis revealed that Greece possesses substantial practical experience in aquaculture and well-developed institutional forms of cooperation, including sectoral associations and innovation clusters integrated into European support mechanisms. According to the analysis, Greece maintains stable production at around 120-140 thousand tonnes per year. In contrast, Ukraine's marine aquaculture output remained below 5,000 tonnes until 2016, after which official data are unavailable, illustrating a complete loss of national mariculture reporting and control. This study substantiates the relevance of establishing a Greek-Ukrainian innovation cluster in aquaculture as a tool for internationalisation and integration into the European sustainable development framework.

Conclusions. It demonstrates that both countries must consider the proven effective experience of states that already have national blue economy strategies. The comparative analysis showed that the aquaculture sector in Greece generated USD 810 million in 2022 at 2020 prices, whereas the aquaculture sector in Norway generated over USD 10 billion at 2020 prices. These results confirm the significant productivity gap between leading and peripheral countries, underscoring the strategic importance of establishing transnational innovation clusters to close this gap. The application of the cluster model and international cooperation instruments creates a foundation for shaping competitive and ecologically balanced aquatic food systems.

Keywords: Aquatic Food Systems, Aquaculture Clusters, Blue Economy, Sustainability, Water Ecosystems.

1. Introduction.

In recent years, the concept of blue transformation has gradually emerged as a key focus of discussions on sustainable development and food security. Aquatic food systems, which play a crucial role in the broader blue economy, are increasingly viewed as sources of nutrition and employment and as a vital lever for climate adaptation, ecosystem restoration, and long-term economic resilience. Experience from different countries shows that promoting the principles of a blue economy requires more than technological progress. It also demands coherent institutional arrangements, effective investment tools, and the systematic use of knowledge when shaping public policy. However, most states still struggle to move from general declarations to comprehensive operational governance models.

These challenges are even more acute in Ukraine. The country still relies heavily on imported fish and aquatic products, and recent estimates suggest that this dependence exceeds 80% (Iermakova & Bjørndal, 2023; Kupinets & Shershun, 2022). This situation undermines national food security and highlights long-standing structural issues in the aquaculture sector. After 2016, for example, data on marine aquaculture virtually disappeared from international statistical sources, which signals a lack of consistent institutional support for the industry in the country. Consequently, Ukraine remains on the margins of the global blue transformation debate. In the post-war recovery context, this search for suitable international models and adaptable policy mechanisms is especially urgent.

In contrast, Greece provides a valuable empirical example. The flourishing Greek aquaculture sector is primarily attributed to close institutional cooperation, effective trade unions, and active participation in European support mechanisms. Although Greece lacks a formal "blue economy" strategy, its experience in creating aquaculture clusters and participating in EU-funded projects demonstrates how national systems can be integrated into broader regional frameworks. A comparative analysis of Ukraine and Greece highlights the structural challenges faced by both countries and the opportunities for developing joint solutions.

This comparison highlights a cluster-based approach to institutional development that could serve as a suitable model for Ukraine to advance the "blue transition" in its fisheries and food systems.

2. Literature Review.

The issue of how aquatic food systems can develop sustainably within the blue economy has recently attracted growing attention in international research, although the discussion often remains fragmented. While these systems are vital for securing food supplies, supporting coastal employment, and helping communities adapt to climate pressures, such systems continue to be influenced by a mix of environmental stressors, economic uncertainty, and gaps in institutional capacity.

These constraints differ from country to country; however, together they shape the overall vulnerability of aquatic production and limit the pace of the required transformation. A key unresolved issue is the effective integration of environmental sustainability parameters into economic decision-making, as ecological indicators are often treated as secondary or insufficiently operationalised in national economic strategies. Recent scholarship has considerably broadened both the theoretical and practical understanding of the blue transformation. Pournara et al. (2023) designed a decision-support approach to help vulnerable coastal regions navigate the transition toward a sustainable blue economy. Their model combines SDG prioritisation and ecosystem service valuation, offering a structured way for local actors to base their decisions on empirical evidence.

Similar ideas appear in the work of Kniazieva et al. (2025), who examine how scientific cooperation and institutional partnerships can reinforce the development of a sustainable blue economy in the Black Sea region, with particular attention to Ukraine's capacity to integrate environmental and governance considerations into the process.

Brudevoll (2025) adds another layer to the discussion by presenting aquatic food systems within a broader blue economy context.

It focuses on the drivers behind current changes, the policy choices they require, and the opportunities for building resilience.

Agostini et al. (2025) further develop this discussion by proposing an interdisciplinary approach to marine governance, in which ecosystem principles are not an add-on but the core around which innovation processes are organised. Their framework offers a scientific basis for broader structural changes in marine management.

The socio-economic aspects of blue growth are explored by Banousis et al. (2016), who demonstrate that social enterprises and locally embedded human capital can play a crucial role in enhancing community resilience within EU blue growth programmes. In a comparative analysis, Yıldırım (2022) contrasts blue-economy approaches in Turkey, the United States, China, Greece, and Bangladesh, identifying structural benchmarks that could support policy transfer and adaptation.

A growing body of evidence demonstrates the increasing complexity and consequential nature of global aquatic food systems. Short et al. (2021) note that small-scale fisheries and aquaculture (SSFA) sustain the livelihoods of far more people than is often assumed, exceeding 100 million, and provide food for nearly a billion consumers worldwide.

However, this contribution does not shield the sector from serious vulnerability (Short et al., 2021). Climate stress, unstable markets, and the usual governance gaps continue to shape how these systems operate, sometimes with unpredictable consequences. Their study stresses that SSFA cannot be treated as a single, uniform category: the people involved and the conditions in which they operate differ so widely that any attempt to design fair and flexible management tools must consider this diversity seriously.

This argument is taken up by Schutter et al. (2023), who examine how research partnerships in the aquatic-food field actually work on the ground. Their conclusion is rather direct: real change is unlikely if collaboration is reduced to the simple transfer of technology from one actor to another. Instead, they call for approaches that emerge from the local context.

Researchers, communities, and institutions must collaborate on equal terms to reconcile social needs with ecological constraints and developmental ambitions. Sharma et al. (2023) build on these insights to present the Food and Agriculture Organization (FAO) Blue Transformation Roadmap within the Strategic Framework 2022–2031. Rather than offering quick fixes, the roadmap outlines a longer-term direction for reform, one that aims to make aquatic food systems more inclusive and resilient while aligning with the broader goals set by the UN SDGs.

Taken together, these studies form a comprehensive conceptual and empirical basis for understanding the blue transformation of aquatic food systems. However, most existing research focuses on global or sectoral governance frameworks, leaving the methodological linkage between environmental security and economic sustainability at the national level underdeveloped. In particular, there is a notable lack of comparative analyses that would adapt international blue transformation practices to the specific socio-economic and ecological contexts of individual countries. This gap serves as the foundation for this study.

3. Methodology.

The effectiveness of the “blue” transformation of aquatic food systems can only be assessed using representative indicators and a statistical basis. Databases formed by the EU, FAO, and OECD play a crucial role in researching and analysing the blue economy, providing detailed information on its various aspects. Each of these organisations provides access to specific data that reflects the respective institutions’ priorities, areas of competence, and methodological approaches.

The Food and Agriculture Organization (2025) focuses on living aquatic resources, particularly fish and aquaculture. It provides global and regional statistics on fish catch, aquaculture production, and value and contribution to food security. Emphasis is placed on assessing the sustainability of fisheries and indicators that track changes in marine and inland-water ecosystems.

e-ISSN 2786-8958
ISSN-L 2616-7107

When viewed together, these data place the situation in individual countries within the broader global setting. They show that national blue-economy trends emerge not only from domestic policy choices but also from broader forces. Climate change, in particular, has started to influence both the availability of aquatic resources and their productivity.

The European Union, through its statistical platforms, particularly the EU Blue Economy Observatory (2023), provides detailed data on the economic performance of the blue economy in EU Member States. These data cover aspects such as gross profit, gross value added, employment in blue economy sectors, and the level of investment in developing maritime infrastructure. A feature of the EU databases is the possibility of conducting a detailed analysis at the regional level, which enables the identification of differences between countries and individual coastal regions. In addition, EU statistics consider an integration approach that reflects the impact of pan-European policies on the development of the blue economy, such as environmental legislation and strategies for reducing the carbon footprint.

The OECD (2025) compiles a diverse set of indicators related to the blue economy, including figures on product values adjusted to constant prices. Since all countries report these data under the same set of rules, the database facilitates the tracking of longer-term shifts and the identification of when the economic trajectories of different states diverge.

When these OECD (2025) figures are viewed in conjunction with statistical materials from the FAO and the EU, they provide a more realistic understanding of how blue-transformation policies actually work. This combination of sources often reveals not only what current water management approaches achieve, but also the gaps that become apparent once the measures are compared across countries. This helps reveal not only the strengths of existing approaches but also the gaps and shortcomings that require further adjustment. The focus of this study is on living aquatic resources, particularly aquaculture, which is showing growth at the global scale.

A feature of the statistical data used is their comprehensive nature, which allows us to explore different aspects of aquatic food systems. In particular, owing to the specificity of data collection, EU statistics enable the analysis of economic indicators, such as gross profit and value added, in the aquaculture sector. These indicators reflect the economic impact of activities related to aquatic food systems, enabling the assessment of their effectiveness in terms of sustainable development strategies.

FAO data focus on the quantitative indicators of marine aquaculture catches and their value. This type of analysis helps to understand the trends in seafood production, consumption, and pricing. Once the FAO statistics are considered, the global landscape of aquaculture becomes clearer: regional differences, local specifics, and even how catch volumes connect, albeit not always straightforwardly, to the economic gains they bring. Since 1950, FishStat (the Food and Agriculture Organization, 2025) has provided comprehensive and detailed statistics for individual countries that are searchable by year. They are presented in available data collections, including statistics on global and regional production, processed production, imports and exports of aquatic products, consumption of aquatic products, and employment.

The analysis uses OECD (2025) data to estimate the value of aquaculture products at 2020 constant prices. This eliminates the impact of inflationary factors and creates a basis for objectively comparing the economic results between countries. Constant prices contribute to a more accurate identification of long-term trends in the development of aquatic food systems and the assessment of the stability of their transformations. EU statistics cover the following sectors: coastal tourism, living resources, maritime transport, non-living resources, port activities, shipbuilding, and repair. The term “living resources” can be considered a functional equivalent to aquatic food systems, especially for analytical purposes. Both concepts cover the processes of extraction, cultivation, processing, distribution, and consumption of fish, molluscs, crustaceans, and other aquatic resources.

Aquatic food systems add a broader socio-economic and environmental dimension to food security. However, their analysis can be effectively carried out through the lens of EU "living resources" statistics, focusing on key links in the fishery value chain.

The analysis of blue economy indicators, such as gross value added (GVA), considering the length of the coastline of countries, is an important aspect of the study, as it allows us to consider the natural, geographical, and economic characteristics of states. A country's coastline length determines its access to marine and coastal resources, which form the basis of the blue economy. Therefore, the ratio of economic indicators to this parameter enables a more objective assessment of water resource efficiency and the identification of dependencies between geographical characteristics and the results of economic activity. Calculating indicators such as GDP per unit of coastline length creates a basis for comparing countries with different geographical conditions. Countries with long coastlines have significantly greater potential for developing blue economy sectors, including fisheries, aquaculture, maritime transport, and recreation.

Without this parameter, the economic performance of countries with different coastline lengths (Central Intelligence Agency, 2023) can distort the efficiency. For countries with short coastlines or limited access to the sea, high absolute GVA rates may indicate highly efficient resource use. In contrast, the same rates may indicate insufficient realisation of the potential for countries with extensive access to the seas and oceans. In addition to geographical factors, the analysis of indicators in terms of coastline length considers the uneven distribution of resources among countries. Some coastal states have rich natural resources, such as biodiversity, favourable climatic conditions for aquaculture, and unique ecosystems that stimulate ecotourism. Other countries may have long coastlines, but are limited by adverse climatic or environmental conditions. Therefore, the ratio of GVA to coastline kilometres helps account for these natural and economic constraints, providing a more equitable approach to assessment.

4. Aim and Comparative Context.

This study aims to conduct a comprehensive analysis and assessment of the effectiveness of the "blue" transformation of the aquatic food systems of Ukraine and Greece, considering international experience, to identify key factors, barriers, and opportunities for the sustainable development of the aquaculture sectors of both countries.

The selection of Ukraine and Greece reflects their different development paths, relevance to EU integration, and contrasting availability of marine aquaculture data. Missing Ukrainian data after 2016 were considered institutional gaps; therefore, the country was excluded from post-2016 time-series comparisons but remained part of the qualitative analysis. Indicators from FAO, OECD, and EU sources were harmonised using constant 2020 prices and, where relevant, normalised per kilometre of coastline to ensure comparability. No interpolation of missing Ukrainian data was applied to avoid methodological distortions.

5. Results.

In the face of increasing environmental challenges and the need for sustainable development, many countries are developing national blue economy strategies to utilise water resources while rationally preserving their ecosystem value. The study of these strategies enables the analysis of the approaches taken by different countries in developing marine and river resources, and the identification of the most effective policies that can be adapted to other national contexts.

To gain a deeper understanding of the effectiveness of national blue economy strategies, it is important to focus on countries that have implemented these strategies since the end of the previous decade. This time frame enables the assessment of the initial statistical results and the analysis of the strategies' impact on the economy, environment and social sphere. Countries with more experience in implementing such strategies have more empirical data on the dynamics of the fisheries, aquaculture, maritime transport, and renewable energy sectors, which allows for the assessment of their long-term sustainable prospects.

e-ISSN 2786-8958
ISSN-L 2616-7107

The analysis of recent initiatives alone may be insufficient due to the limited time available to detect significant changes, which limits the possibility of determining the effectiveness of the strategies.

This study pays special attention to the strategy for developing the European Union's blue economy, which is unique due to its integrated nature. The EU unites countries with varying levels of economic development, access to marine and inland water resources, and differing environmental conditions, making its approach to forming a blue economy universal and adaptable. This aspect is crucial for Ukraine, since the state has significant potential for using marine and inland waters and seeks to integrate them into a common European economic space. The study of European strategies enables us to identify mechanisms that can be applied in Ukraine, particularly in the context of post-war reconstruction and adaptation to climate change challenges.

Thus, an analysis of national blue economy strategies, focused on countries with long-term implementation experience, is necessary to understand global trends.

Additionally, the study of the integrated approach of the European Union helps in developing effective national policies. This will allow Ukraine and Greece to effectively use their resources and ensure sustainability by integrating them into international economic processes.

Figure 1 presents a map of the coverage of national blue/marine economy strategies. Analysis of the "blue economy" concepts in different countries reflects the diversity of approaches that depend on each state's natural, socio-economic, and political conditions. The blue economy is a comprehensive strategy that encompasses the sustainable development of marine and aquatic ecosystems, promotes economic growth, conserves biodiversity, and fosters social inclusion. Notably, most countries consider the blue economy to be an ocean-connected economy that provides goods and services. As the OECD (Organization for Economic Co-operation and Development) notes, subnational blue economy strategies and policies are still emerging compared to the national level (OECD, 2024). Spain has the most experience in this regard.

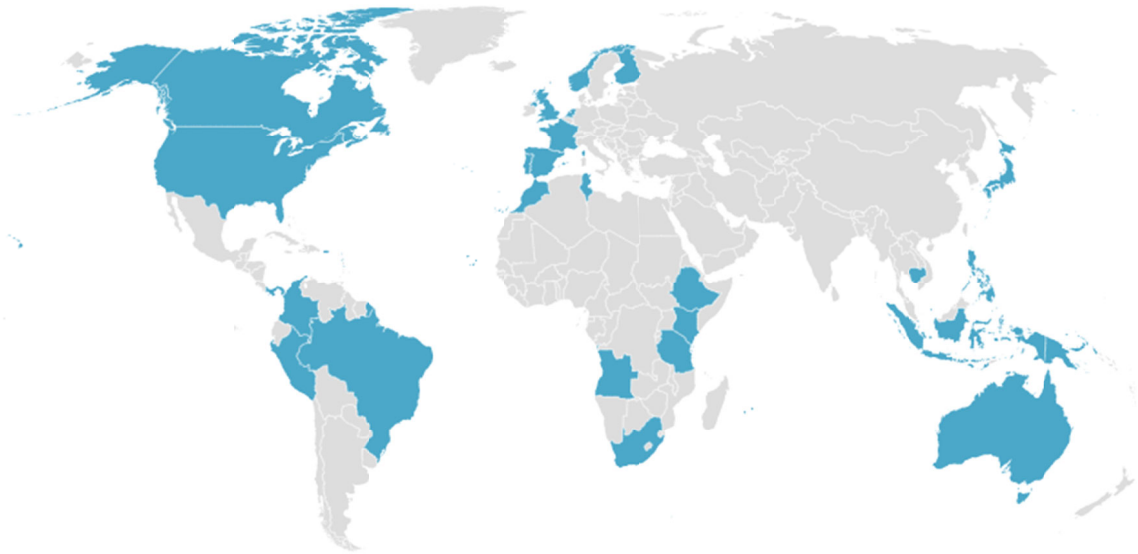

Fig. 1. Coverage Map of National Blue Economy and Marine Strategy Initiatives.

Source: based on Agencia Estatal Boletín Oficial del Estado (2023); Blue Economy CRC (2021); Climate Change Laws of the World (2023); Food and Agriculture Organization (2025); Ministry of Mining, Blue Economy and Maritime Affairs (2023); Ministry of National Development Planning (2024); Nicholas Institute for Energy, Environment & Sustainability (2020); Noordzeeloket UK (2022); OECD (2024).

e-ISSN 2786-8958
ISSN-L 2616-7107

After analysing 30 strategies adopted by various countries in the blue or marine economy field, it was found that most are mainly declarative. The main problem with such strategies is the lack of specific implementation mechanisms and clearly defined instruments to achieve the set goals. Many strategies contain declarative statements about the need for sustainable development, rational use of marine resources, and the introduction of innovations.

These strategies lack details on how to implement these tasks. Such documents are often aimed at forming a positive international image of the country rather than creating a systemic basis for the development of the blue economy. Spain's regional strategy demonstrates a more detailed approach to managing marine resources. These strategies have been developed in recent years and include a thorough analysis of issues and precise formulation of prospects. Strategies contain defined objectives and budgets, demonstrating a practical approach to implementing goals. Their regional focus limits the representativeness of these strategies in other contexts.

Most cover only small parts of the coast and cannot be extrapolated to the national scale. Thus, while the Spanish approach is noteworthy as a potential model for other countries, its scale and impact on the overall economy remain limited.

The next issue is the statistical analysis of data on the Living Resources sector by EU countries. This is because trends must be identified and the effectiveness of management strategies must be assessed. Figure 2 shows the structure of the contribution of EU countries to the gross value added by the Living Resources sector for 2009-2022.

The composition of shares over the period is generally stable: the most significant segments are consistently formed by Mediterranean leaders - primarily Spain, France, and Italy; Denmark, the Netherlands, and Portugal have significant but smaller shares. Against this background, Greece demonstrates a small but relatively constant share, which is significantly inferior to the aforementioned leaders but exceeds the contributions of several smaller or intracontinental EU members.

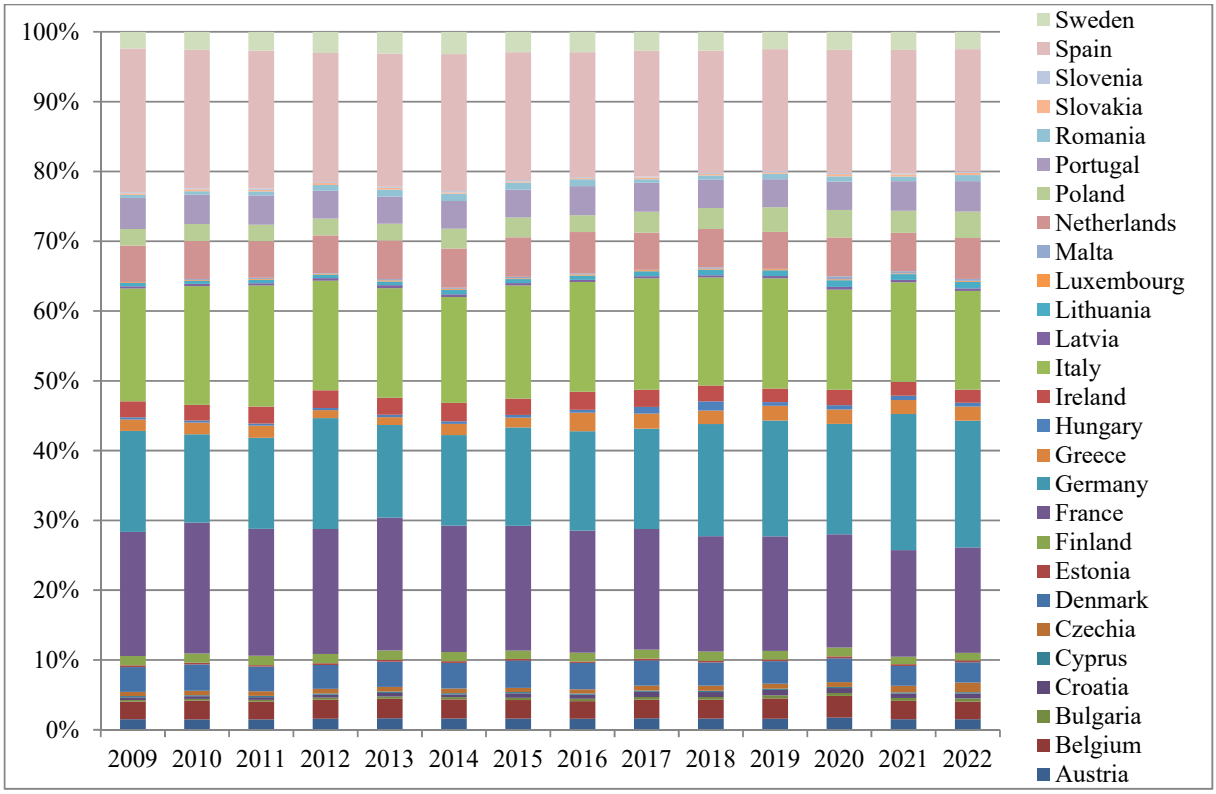

Fig. 2. Contribution to Gross Value Added by the Living Resources Sector in EU countries, 2009-2022.

Source: based on EU Blue Economy Observatory (2023).

e-ISSN 2786-8958
ISSN-L 2616-7107

Ukraine is missing from this figure since the source covers only EU Member States, which emphasises the previously discussed data asymmetry: for cross-country comparisons on "Living Resources" within the EU, a complete picture is possible, while Ukrainian indicators should be sourced from other databases (e.g., FAO).

At the same time, it is worth remembering that the graph reflects relative shares, not absolute volumes of GVA; therefore, the closeness of the profiles by year means the absence of significant redistributions between countries but does not exclude a parallel increase or decrease in the overall European volume.

For Greece, such stability confirms the persistence of specialisation and the role of clustered production. Simultaneously, the involvement of alternative statistical sources and future methodological harmonisation of indicators is required for Ukrainian analytics.

According to the EU Blue Economy Observatory (2023), Figure 3 shows the gross value added of aquatic food systems per 1 km of coastline in France, Germany, Italy, Spain, and Greece. Germany consistently shows the highest values, despite having the smallest coastline among the countries represented, which can be attributed to the sector's developed domestic policy, productivity, and technological sophistication.

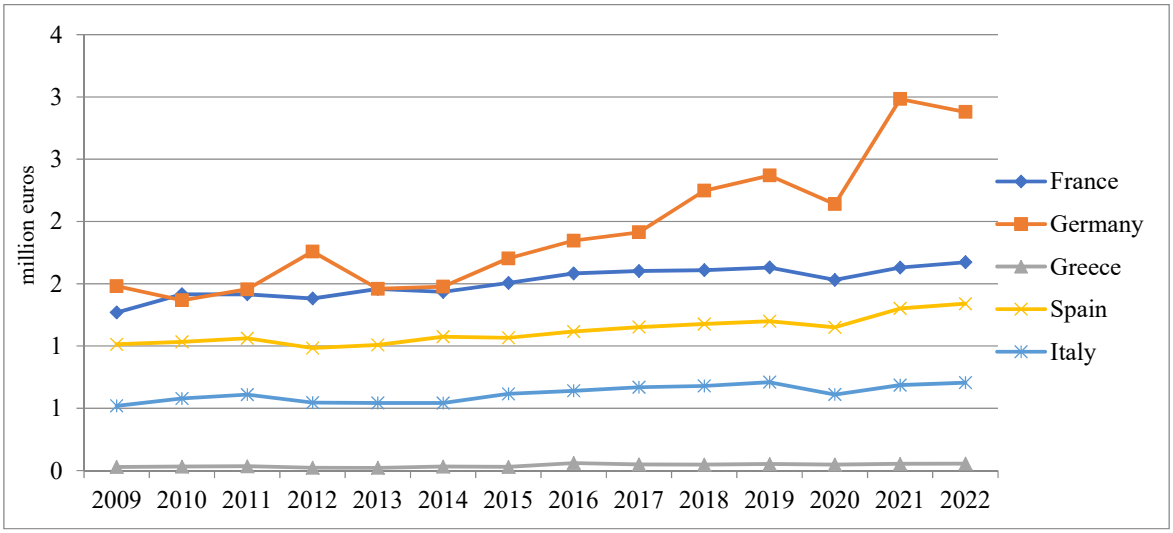

Fig. 3. GVA of the Living Resources Sector per km of Coastline in France, Germany, Italy, Spain, and Greece (2009–2022).

Source: based on EU Blue Economy Observatory (2023).

Spain and France occupy intermediate positions, ensuring stable positive dynamics, particularly due to the integration of marine bioresources into the food industry and the growth of the added value of products.

Against this background, Greece stands out significantly: its indicators remain the lowest among the group, with a notable lag behind the leading countries. Despite the development of aquaculture, the GVA per 1 km of coastline does not reach the level of the initial indicators in Spain and Italy. This indicates narrow specialisation, limited diversification of activities, and lower integration into value chains.

Figure 3 confirms the gaps between Greece and the leading European economies. These results are significant for Ukraine, as the absence of modern marine aquaculture poses the risk of an even larger structural gap in the sector's productivity indicators. Statistical data analysis and an overview of legislative changes in the European Union suggest that the EU policy on the "blue economy" has had a limited direct impact on the economic performance of Member States. Changes in gross value added, especially in countries such as Germany, France, Spain, and Italy, are more likely to be linked to national strategies and private initiatives than to EU coordination efforts.

e-ISSN 2786-8958
ISSN-L 2616-7107

Pan-European policies on the "blue economy", including initiatives such as the European Green Deal, aim to harmonise the development of sustainable sectors such as aquaculture, renewable energy, and tourism. However, the figures clearly indicate that the pace of development differs markedly across countries, implying that the existing instruments work unevenly and are far from universal. The sharp rise observed in Germany in 2021, for instance, appears to stem less from broad EU frameworks and more from the country's policy mix, substantial domestic investments in renewable energy, and strong private-sector incentives. Spain's gradual upward trend also appears to reflect its national priorities, particularly programs supporting tourism and aquaculture, rather than any uniform EU-wide measures.

Additionally, EU policy strategies often face uneven implementation across member states, making it challenging to implement sustainable practices. Most countries rely on localised approaches to developing the blue economy, which allows them to better adapt to domestic needs and resources, but at the same time undermines the effectiveness of centralised European initiatives.

For example, France has shown relatively stable development, but this is primarily due to its national focus on aquaculture rather than pan-European programs. Thus, it can be concluded that EU policy in the "blue economy" plays a more coordinating or advisory role. At the same time, the primary drivers of economic growth continue to be national or private actors. This situation raises questions about the effectiveness of pan-European strategies in promoting the sustainable development of the "blue economy" throughout the Union.

Figure 4 shows the dynamics of marine aquaculture catch volumes (in tonnes live weight) according to FAO data from 2005 to 2023. Norway consistently had the highest figures. Since the mid-2010s, production has been rising almost continuously and exceeded 1.6 million tons by 2023. This trajectory illustrates a European case of a long-term, industry-oriented strategy in fish farming, where technological upgrades are combined with a regulatory framework that works in practice. In contrast, Japan and France maintained comparatively stable, albeit lower, levels. Their figures indicate sectoral stability rather than expansion, since neither country has exhibited a notable upward trend in recent years.

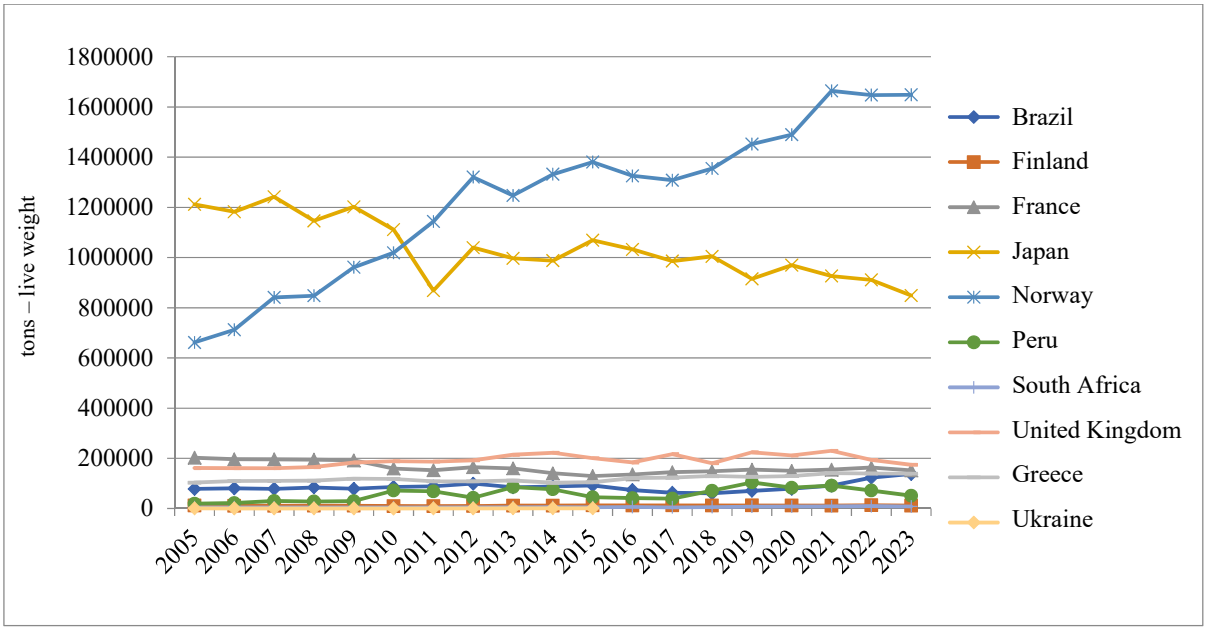

Fig. 4. Marine Aquaculture Catch Volume, 2005–2023.

Source: based on the Food and Agriculture Organization (2025).

e-ISSN 2786-8958
ISSN-L 2616-7107

Greece is represented by relatively small volumes that remain almost unchanged over the period, with fluctuations within the lower range. This indicates a limited scale of production, despite the country being one of the European centres of marine aquaculture production.

Its sector is primarily focused on the cultivation of marine fish, but it has not exhibited significant growth compared to global leaders. Ukraine exhibits a distinct trend: from 2005 to 2016, the data were recorded at an extremely low level, after which they virtually disappeared from the FAO statistics. This is due to the cessation of commercial marine aquaculture fishing, resulting from the loss of part of the coastal water areas and a lack of systemic support for the industry.

Overall, Figure 4 reveals a profound structural asymmetry: Norway and other global leaders exhibit multi-year increases in production, whereas countries on the periphery, including Ukraine and Greece, remain in the limited-volume segment. This highlights the need for Ukraine and Greece to restore and develop mariculture, focusing on integrating into international markets and using the best practices from countries with proven blue transformation strategies.

Figure 5 shows the volume of marine aquaculture catch per kilometre of coastline (tonnes in live weight) according to FAO data for 2005-2023.

This indicator enables a comparison of the efficiency of coastal resource use among countries with varying coastline lengths.

Norway showed the highest values, reaching approximately 75 tonnes/km in 2023. This result is a consequence of the concentration of production on a relatively compact coastline with a developed mariculture infrastructure, making it a global benchmark for aquaculture production intensity. Japan and France hold middle positions (20-40 tonnes/km), reflecting the stability of their industries and the balance between traditional forms of management and modernised technologies.

Greece is located in the lower segment of the graph, with a range of approximately 5-10 tonnes/km and relative stability throughout the period. This indicates the preservation of the fisheries profile, but without the intensive scaling typical of leaders. Despite the presence of significant marine resources, the country lags behind even some non-European participants (e.g. Peru), indicating the need for further optimisation of technologies and increased international integration.

Ukraine, as in the previous indicator, had minimal values until 2016, after which the data are virtually absent in FAO statistics. This demonstrates a systemic loss of positions in the mariculture field, resulting from both external geopolitical factors and a lack of institutional support.

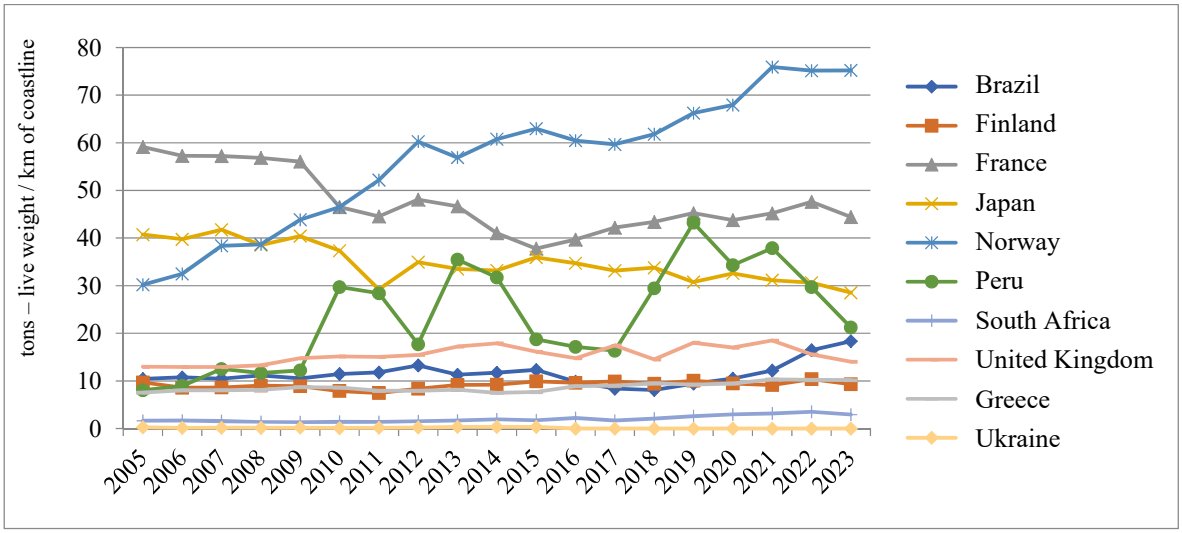

Fig. 5. Marine Aquaculture Catch Volume per km of Coastline, 2005–2023.

Source: based on the Food and Agriculture Organization (2025).

e-ISSN 2786-8958
ISSN-L 2616-7107

Figure 5 confirms that the efficiency of coastline use for aquaculture needs in Norway and other leading countries is strategic, while in Greece and especially in Ukraine, this potential remains largely unfulfilled. This suggests the need to establish innovative clusters that can enhance the intensity and competitiveness of mariculture in the Black Sea Region.

Figure 6 presents the total aquaculture production for marine and semi-marine species (in constant 2020 prices) and the total aquaculture production (for marine and semi-marine species) per 1 km of coastline (in constant 2020 prices) according to the OECD Sustainable Ocean Economy Database.

Norway remains the absolute leader, with exports growing from approximately USD 4 billion to almost USD 9 billion, reflecting an intensive focus on global markets, high-tech salmon farming methods, and effective integration into global value chains. France and Japan maintain average figures within 1.5-3 billion USD, reflecting a stable, less dynamic development model. Other countries, including Greece, demonstrate significantly lower production volumes, not exceeding USD 500 million, and remain on the periphery of the global market. For Ukraine, data are missing in the databases after 2016, indicating a structural decline in the marine aquaculture sector.

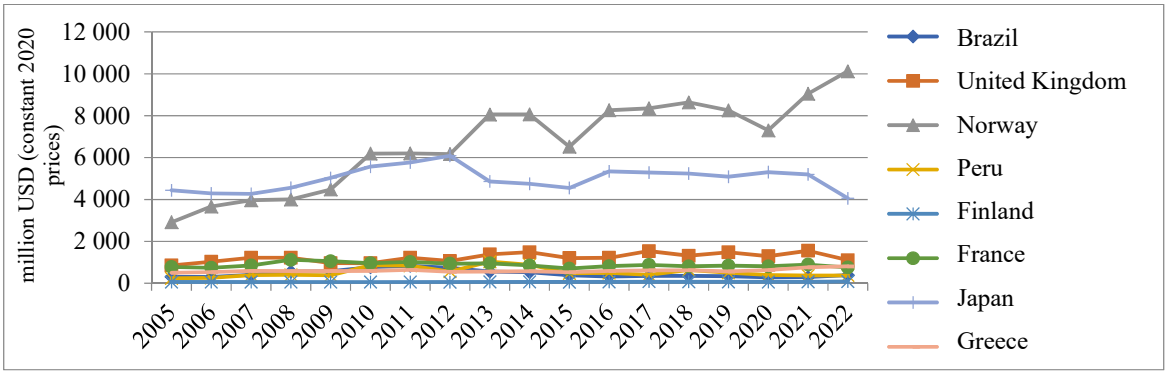

Fig. 6. Total Aquaculture Production of Marine and Semi-Marine Species, 2005–2022.
Source: based on OECD (2025).

Analysis based on the length of the coastline (Figure 7) enables the assessment of the efficiency of spatial resource utilisation along the coast. Norway is the leader, with an intensity exceeding 0.4 million USD/km in 2022, confirming its global competitive advantage in aquaculture. France and Japan maintain levels of 0.1-0.2 million USD/km of coastline, demonstrating relatively stable positions. Despite its favourable natural conditions, Greece's income fluctuates within a range of 0.05-0.1 million USD/km and does not demonstrate breakthrough dynamics, indicating untapped potential. Ukraine's coastline is not accurately reflected due to a lack of relevant statistics.

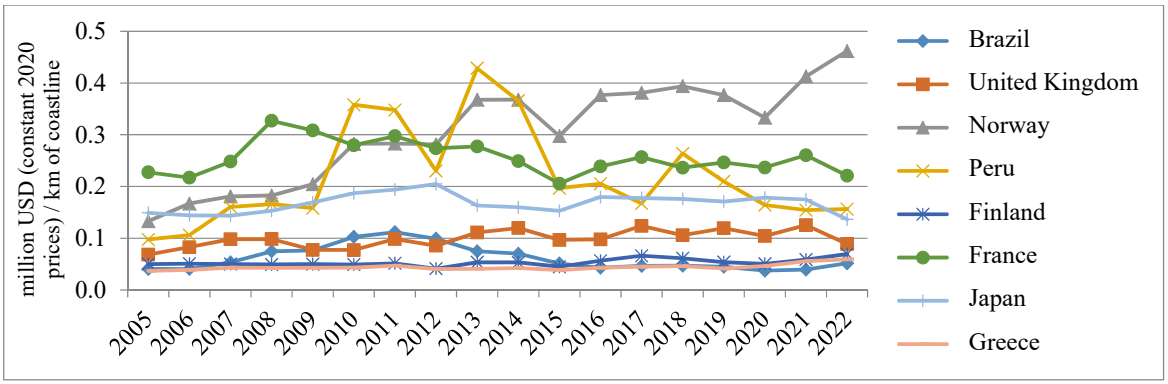

Fig. 7. Marine and Semi-Marine Aquaculture per km of Coastline, 2005–2022.
Source: based on OECD (2025).

Overall, both indicators confirm a high level of intensity and economic efficiency of aquaculture production in Norway, an average level in France and Japan, and a significantly lower level in Greece. For Ukraine, the analysis emphasises the need to revive mariculture by leveraging the experience of leading countries and integrating it into European markets.

Japan and Norway consistently demonstrate leading positions, regardless of whether we are discussing absolute values or data per 1 km of coastline. France is especially notable for its efficient use of resources, as evidenced by its leading position in indicators per 1 km of coastline, regardless of the absolute values of aquaculture activity. The strategies of these three countries are considered in more detail.

Norway's Blue Opportunities (Norwegian Ministry of Trade, Industry and Fisheries, 2019), which was approved in 2019, states that Norway is an ocean economy with abundant living marine resources. Norwegian waters have long supported large fish stocks, providing Norway with a steady source of food, employment, and income for many years. However, aquaculture has only recently become a significant industry in this country. Despite Norway's indicators, its policy regarding the blue economy is declarative and unfocused (Norwegian Ministry of Trade, Industry and Fisheries, 2019). This is due to the country's maritime status and high fish stocks in Norwegian waters.

The "Third Basic Plan for Ocean Policy" (Government of Japan, 2018), which was introduced in Japan in 2018, states that in the fisheries sector, Japan is striving to balance the proper management of fisheries resources with efforts to transform fisheries into a growth industry, increase fisheries income, and create an age-balanced employment structure.

Accordingly, Japan is promoting initiatives in accordance with the Basic Fisheries Plan (Fisheries Agency, 2022). In particular, Japan is striving to enhance the accuracy of resource assessment and management, contributing to international resource management.

In addition to improving the efficiency of the fisheries industry and aquaculture and increasing the income of fishing communities by utilising the industry's technology, knowledge, and capital to enhance their management competence, Japan is also making efforts to enhance the competitiveness of fisheries through the use of fishing vessels.

While revitalising the production activities of the fisheries industry, initiatives are also being promoted to fully demonstrate the multifaceted functions of the fisheries industry and fishing communities, including their roles in border protection and security. Given that approximately five years have passed since the old Fisheries Basic Plan was formulated (April 2017), and the situation surrounding the fishing industry and fishing villages has changed, the Agriculture, Forestry, and Fisheries Basic Plan was revised in April 2021. The Minister of Fisheries of Japan (Fisheries Agency, 2022) consulted the Fisheries Policy Council regarding revisions to the Fisheries Basic Plan.

For Ukraine, in light of the previously identified problem of import dependence, the most notable aspect of these Basic Fisheries Plans is the introduction of the concept of a "target level of self-sufficiency in seafood" in the legislation. This indicator demonstrates the extent to which fish production in Japan meets the national demand for marine products.

The "National Strategy for the Sea and the Coast, enshrined in Decree 2017-222 of February 23 2017" (Légifrance, 2017), represents the general framework policy of France for the management of marine and coastal resources. The document reflects the overview nature of the approach, emphasising the importance of integrating marine spaces and ecosystems. However, it fails to specify clear objectives or to detail the mechanisms for achieving them. The strategy focuses on shaping the directions of long-term development and management, leaving the issues of practical implementation open, which highlights its conceptual orientation. A completely different approach is taken Légifrance (2016), on the blue economy, which amends the current French legislative framework.

Title II of this law (Articles 73-81) is entirely concerned with the support of marine fishing and aquaculture (Légifrance, 2016).

An analysis of international statistics reveals that only France has demonstrated steady growth in economic indicators related to the blue economy since implementing relevant strategies. This success cannot be unequivocally attributed to the blue economy strategy. The regulatory framework governing (Law No. 2016-816) the blue economy likely plays a significant role in this process (Légifrance, 2016). This law establishes a comprehensive legal framework designed to support the development of marine resources, encompassing fisheries, aquaculture, renewable energy, and maritime transport. Its impact is visible in several practical changes: the appearance of new financing instruments, the launch of regional programs, and a gradual push toward technological and organisational innovation.

The French example demonstrates that the effectiveness of such a policy depends not only on strategic declarations but also on a well-designed and implemented regulatory framework. It combines legal, administrative, and economic tools that make real implementation possible rather than merely setting out intentions on paper.

The national legislative framework of France is the primary factor contributing to the growth of economic indicators, while the blue economy strategy serves as a complementary component of the overall policy (Légifrance, 2016). It is essential to recognise that the success of such a policy largely depends on its effective implementation through regulatory measures rather than solely on the formulation of strategic directions. The analysis revealed that most countries worldwide struggle to develop effective blue economy strategies. The example of France demonstrates that to ensure sustainable economic growth, it is necessary to go beyond slogans and declarations and create comprehensive regulatory mechanisms that will support strategic plans but also ensure their implementation. This situation indicates that to overcome the gap between declarative goals and practical results, it is necessary to introduce innovative organisational mechanisms capable of ensuring strategic planning.

In this context, innovation clusters acquire special importance, acting as effective centres of concentration and coordination of knowledge, resources, and technologies in the globalised world. The institutionalisation of production relations is taking on new forms, among which innovation clusters occupy a special role. They function as organisational centres of concentration and coordination of knowledge, resources, and technologies.

Clusters are a promising organisational and economic form for attracting investment, thanks to the combination of science and business. In the modern world, attracting foreign direct investment (FDI) requires not only presenting promising markets but also creating institutional forms that reduce risks, increase transparency, and foster a trustworthy environment. This is the function played by international clusters, which provide the infrastructure for combining innovative production and financial potential between countries. Investment readiness refers to the ability of business entities or regions to demonstrate a clear, structured, and risk-minimised offer to investors. In the context of Ukrainian aquaculture, with its high export potential but weak institutional base, the cluster model serves as a tool for combining fragmented initiatives into a holistic system.

The central mechanism of the cluster's functioning is the "knowledge triangle" or "triple helix" interaction model, which involves close cooperation between science, business and the state. This model creates the conditions for long-term growth, as it allows not only adapting scientific developments to market realities but also shaping policies based on the needs of the innovative economy. In the cluster, all three sectors act as equal partners, each with its own competence, resources, and responsibility for the overall outcome. The cluster development model assumes a clearly defined life cycle, including an initiation phase (establishing partnerships, defining common goals, launching pilot projects), a growth phase (activating R&D activities, attracting financing, expanding into new markets), a maturity phase (institutional strengthening, self-sufficiency, global integration), and possibly a re-innovation or restructuring phase.

e-ISSN 2786-8958
ISSN-L 2616-7107

Such structural logic enables the flexible management of cluster dynamics, assessment of effectiveness at each stage, and adjustment of development strategies. The effectiveness of the cluster model is measured using a comprehensive set of indicators, including the number of jobs created, volume of investments attracted, share of joint research projects, level of technological readiness of enterprises, export volumes, and degree of integration of participants into the international environment. These indicators determine whether the cluster achieves its primary goal of transforming the industry through a systematic renewal of its innovation and economic landscape.

Of particular importance is the internationalisation strategy, which focuses not only on exporting products but also on inclusion in global value chains, participation in international projects, and knowledge exchange with other countries. This approach opens up new opportunities for development through technology transfer, attracting foreign investment, and forming new connections, which often become sources of unexpected innovation. In this context, Ukrainian-Greek initiatives to create aquaculture clusters have strong potential, as they are implemented not only within one country but also form part of a transnational network based on European support instruments, such as Horizon Europe, BlueInvest, and Interreg.

The cluster development model demonstrates an effective mechanism for the structured transformation of economic sectors by creating an environment of cooperation, institutional support, innovative interaction, and international synergy. In terms of attracting investments, the cluster model acts as follows:

- A platform for the synergy of knowledge, capital, and infrastructure.
- An intermediary between investors and local initiatives.
- Guarantor of institutional stability and transparency of projects.
- Tool for building trust through analytics, standardisation, and promotion.
- Mechanism for public-private partnerships with foreign capital participation
- Investor onboarding process from meeting to project implementation.

Continuing to consider the role of international clusters as instruments of investment attractiveness and sustainable development, the idea of creating a Ukrainian-Greek innovation cluster in the aquaculture sector appears extremely promising. The unique geographical and economic position of Greece as a maritime EU member state with a developed blue economy sector makes it a promising partner for Ukraine, which seeks to diversify the economy of the Black Sea region based on the principles of blue growth.

The initiative to create a Greek-Ukrainian Innovation Aquaculture Cluster provides for the institutionalisation of cooperation between enterprises, startups, scientific and educational organisations, and financial structures of both countries. Such a partnership aims to activate transnational knowledge exchange, implement joint Research, Development, and Innovation (RDI) projects in the field of sustainable aquaculture, expand export potential, and establish innovation ecosystems.

The main tasks of the cluster are as follows:

- Creation of a joint platform for Ukrainian and Greek enterprises and research institutions.
- Transfer of technologies and knowledge: mutual dissemination of know-how, adaptation of the Greek experience to Ukrainian conditions, and joint testing of sustainable aquaculture technologies.
- Support for joint RDI projects: preparation of applications for joint programs of Horizon Europe, Interreg, or Blue Growth of EU mechanisms.
- Internationalisation of markets: joint participation in exhibitions, formation of a branded product line, and creation of international marketing content.
- Development of the triple helix model: integrating business, science, and government as a driver of innovation.

Greece has a well-developed structure of aquaculture clusters, the most famous of which is the Hellenic Aquaculture Producers Organization. This industry association coordinates the efforts of fish farming enterprises, which account for approximately 80% of the nation’s production.

e-ISSN 2786-8958
ISSN-L 2616-7107

Additionally, Blue Growth Incubators, such as Blue Growth Piraeus, are actively supporting startups in marine technology. Greek clusters have a high degree of institutional organisation and access to European financial mechanisms (EIT Food and BlueInvest) and experience in creating high-tech value chains, which could serve as a prototype for developing a similar structure in the Ukrainian Black Sea region. Combining Ukrainian-Greek resources in the form of a bilateral cluster will allow for the following:

- Launch pilot RDI projects with joint scientific coordination.
- Leverage Greek certification to enter the European market for Ukrainian products.
- Create a "Blue Startup Track" for new businesses in both countries.
- Initiate a bilateral acceleration platform in the blue economy with the support of municipalities and regional authorities.

Therefore, the formation of the Ukrainian-Greek aquaculture cluster is not only a cross-border initiative but also a systemic strategy for integrating the Ukrainian sector into the European space of sustainable development. This model enables the creation of a network of innovative alliances in the blue economy field, capable of attracting investments and transforming the national production structure into an environmentally responsible and technologically advanced segment of the global market.

Important area of Ukrainian-Greek cooperation within the framework of the "blue" transformation of aquatic food systems should be the exchange of experience in collecting, processing, and verifying statistical data. Greece, as an EU member state integrated into the EU Blue Economy Observatory system and more involved in the OECD Sustainable Ocean Economy Database and FAO FishStat, has established procedures for submitting unified indicators that meet the European standards.

In Ukraine, where there has been virtually no commercial catch of marine aquaculture since 2016 (according to FAO FishStat), and data in international databases (particularly FAO and OECD) are incomplete, establishing a statistical accounting system is no less strategic than deploying mariculture production.

Interaction with Greek institutions will not only enable the adaptation of technical standards for information collection but also facilitate the integration of Ukrainian statistics into international platforms, thereby opening access to a wider analytical toolkit and ensuring transparency for potential investors.

The transfer of experience from databases such as the EU Blue Economy Observatory and the OECD Sustainable Ocean Economy Database, combined with support from the FAO, creates a basis for synchronising indicators and methodologies. This, in turn, will contribute to the development of compatible indicators for assessing the effectiveness of the "blue" economy and enable a direct international comparison of Ukraine's and Greece's progress in this area.

6. Conclusions.

Considering the practical experience of countries that have already implemented national or regional blue economy strategies is critical for both Ukraine and Greece in forming innovative aquaculture clusters. Such strategies, developed based on comprehensive indicators of sustainable development, include institutional, technological, and investment mechanisms that can ensure a balanced combination of economic benefits and environmental responsibility in the long term. Adapting best practices, from standardised procedures for monitoring the state of marine ecosystems to integration into international value chains, can become the basis for reducing risks, increasing investment attractiveness, and ensuring the competitiveness of cluster initiatives.

In the context of creating a Ukrainian-Greek innovative aquaculture cluster, it is advisable to consider the experience of countries that have already gone through the process of institutionalising cluster models within the framework of "blue" strategies, provided systematic access to international financial mechanisms, and implemented tools for integrated coastal zone management. This will allow both sides to avoid repeating typical mistakes in the initial stages of development and immediately focus on high standards of sustainable production, innovative management, and transnational cooperation.

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