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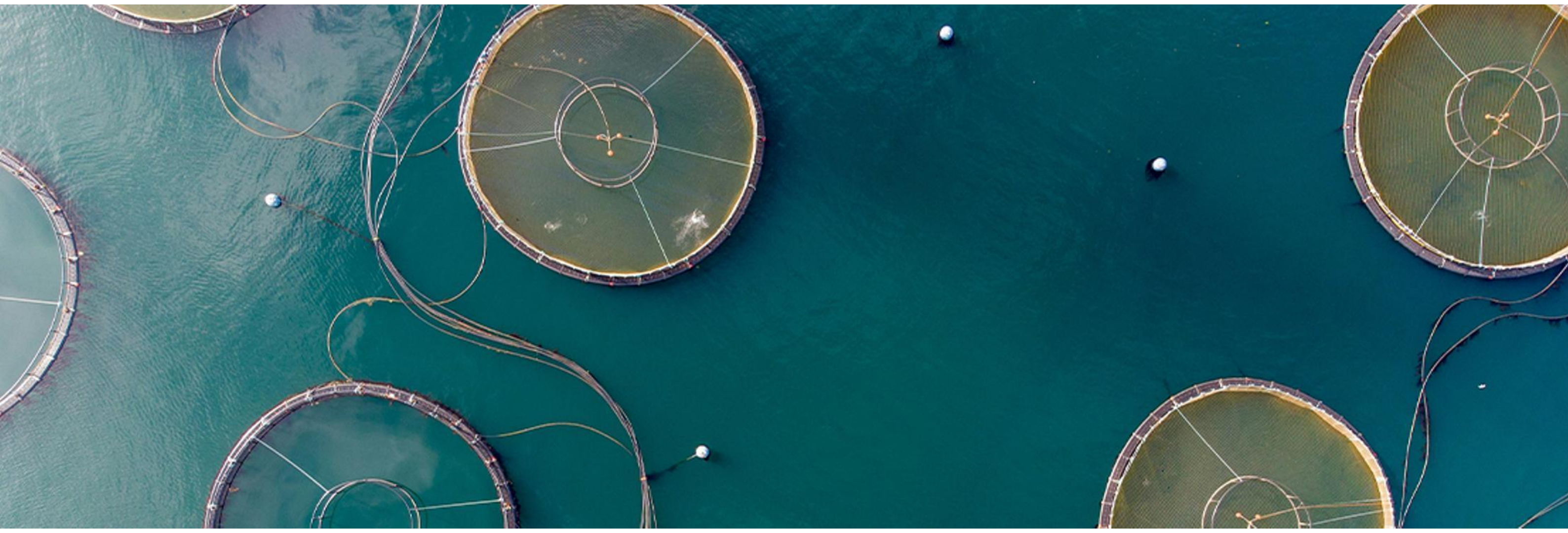

September 2025

Identifying the circularity baseline with the BLUEfasma Circularity Self-Assessment Tool

https://aza4ice.interreg-euro-med.eu

Deliverable ID

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Project priority	Greener MED
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Table of contents

Abbreviations

CA	Circular Aquaculture
CE	Circular Economy
CERI	Circular Economy Readiness Index
IMTA	Integrated Multi-Trophic Aquaculture
OWTF	Organic Waste Treatment Facilities
RAS	Recirculating Aquaculture Systems
SME	Small and Medium-sized Enterprise
WISE	Willingness to InveSt in circular Economy

Executive Summary

The aquaculture sector across the Euro-Mediterranean area is currently highly willing to invest in the Circular Economy (CE) but remains at a low level of actual readiness and operational implementation.

The global economy traditionally operates on a linear 'take-make-waste' model, which in aquaculture means high reliance on finite resources, energy-intensive processes, and the disposal of polluting effluents and solid wastes. The Circular Economy is the necessary paradigm shift, focusing on designing out waste, keeping products and materials in use, and regenerating natural systems (e.g., through 'waste' valorization like Integrated Multi-Trophic Aquaculture (IMTA)).

A survey of 65 businesses across eight Euro-MED territories revealed the following key metrics, quantified using the BLUEfasma Circularity Self-Assessment Tool:

Table 1 - Key metrics, quantified using the BLUEfasma Circularity Self-Assessment Tool (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

Indicator	Score (Range)	Implication
Generalized Circular Economy Readiness Index (CERI)	1.9 (Range: 1.0–4.0)	Low Operational Maturity: The sector is firmly in the 'Eco-Thinking & Green Economy' stage (1.5-2.4), demonstrating basic eco-efficiency but lacking the systemic, deep-level CE integration required for 'Emerging Circularity' (≥ 2.5).
Generalized Willingness to InveSt in circular Economy (WISE)	3.5 (Range: 1–5)	High Willingness Receptivity: Aquaculture stakeholders are actively ready to enhance the transition to circular models.

Introduction

The present report has been developed under the AZAI4CE project co-funded by the Interreg Euro-MED Programme 2021-2027. In the frame of the AZA4ICE Activity 2.2 “Establish and operationalize the LiRRIEs”, this report presents the generalized Circular Economy readiness and willingness indexes for the aquaculture sector in the Euro-MED area by integrating the results of the BLUEfasma Circularity Self-Assessment Tool utilisation in the 8 AZA4ICE territories to identify the circularity baseline of businesses in the sector.

The AZA4ICE territories consist of Black Sea – Bulgaria; Andalusia – Spain; Algarve – Portugal; South of France; Sardinia – Italy; Šibenik - Knin County – Croatia; Greece; and Montenegro covering a wide range of the Euro-Mediterranean areas. AZAI4CE Project Partners involved 65 businesess acting in the aquaculture value chain and received their feedback through the BLUEfasma Circularity Self-Assessment Tool.

Shifting from linear economy to Circular Economy

Traditionally, the global economy operates under a linear 'take-make-waste' model. This outdated system is fundamentally based on resource extraction, followed by production, consumption, and culminating in the disposal of massive amounts of waste. In the context of aquaculture, this translates to practices reliant on finite feed ingredients (like wild-caught fish for fishmeal), high water use, energy-intensive processes, and the resulting effluents and solid wastes that pollute surrounding ecosystems. This model is facing critical limitations, including the irreversible depletion of finite resources and the catastrophic accumulation of pollution.

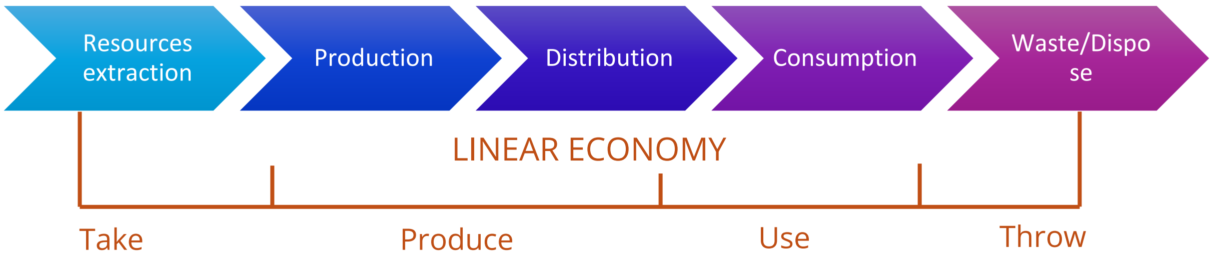

Figure 1 – Linear economy scheme

The Circular Economy (CE) represents a paradigm shift, moving towards a regenerative and restorative system of production and consumption. Its core philosophy is to mimic the cyclic processes found in nature, where the "waste" of one component becomes a valuable resource for another. This principle, often described as 'closing the loop,' seeks to design out waste and pollution, keep products and materials in use, and regenerate natural systems.

In an aquaculture context, the Circular Economy is particularly transformative:

- Resource Cycling & 'Waste' Valorization: Instead of treating fish manure, uneaten feed, or processing by-products as waste, Circular Aquaculture (CA) aims to valorize them.

Example 1: Integrated Multi-Trophic Aquaculture (IMTA): This technique is a prime example of CE in action. The waste from farmed finfish (a fed species) is metabolized by other organisms at different trophic levels, such as filter-feeding shellfish (mussels, oysters) and extractive seaweeds (kelp). The shellfish and seaweeds effectively 'clean' the water by absorbing nutrients (nitrogen and phosphorus) and biomass, which are then harvested as valuable co-products.

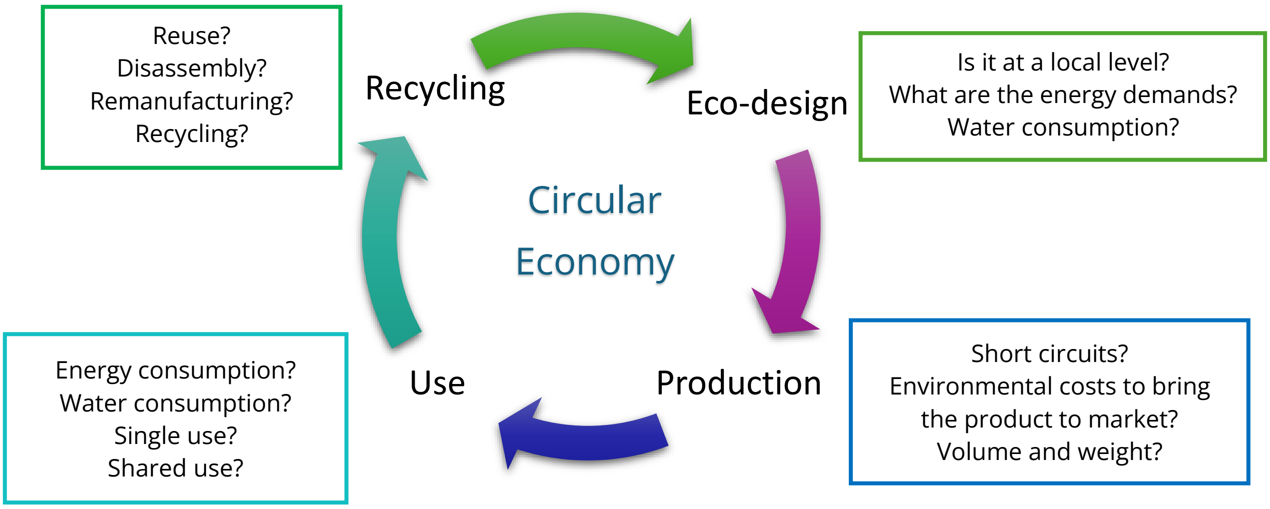

Figure 2 – *Circular Economy scheme*

Example 2: Feed Innovation: Moving away from unsustainable fishmeal, circular approaches include using insect farming to convert food waste or agricultural by-products into high-protein feed for the farmed aquatic species, or utilizing algae cultivated on aquaculture effluent.

- Sustainable Material Use: The CE prioritizes renewable, sustainably-sourced materials that can safely return to the biosphere (composting, biodegrading) after their use, regenerating the natural capital we draw from. For the non-biodegradable but essential components of aquaculture (like pumps, filters, nets, and machinery) the CE mandates a design for longevity and disassembly. This ensures that equipment and materials can be easily recovered, repaired, reused, remanufactured, or recycled to maintain their highest utility for as long as possible, thus minimizing the demand for virgin resources.

By adopting these principles, aquaculture can transition from a potential environmental burden to a sustainable protein source that operates in harmony with, rather than at the expense of, aquatic ecosystems.

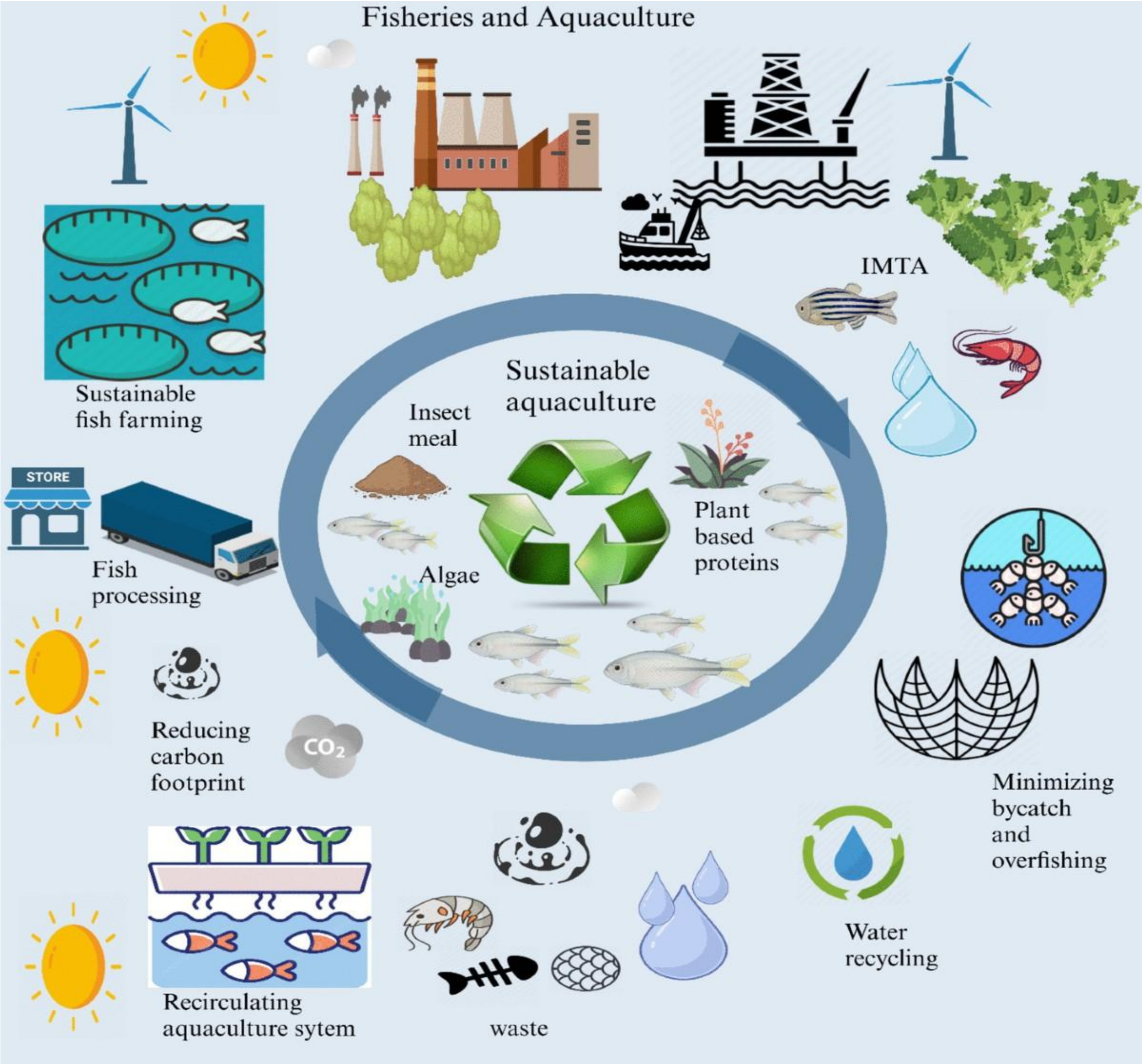

Figure 3 – Applications of Circular Economy in fisheries and aquaculture (© Source: Osei, S.A., Ayisi, C.L., Boamah, G.A. et al. The Circular Economy in Aquaculture and Fisheries: Enhancing Sustainability and Food Security. Circ.Econ.Sust. (2025). https://doi.org/10.1007/s43615-025-00632-1)

The BLUEfasma Circularity Self-Assessment Tool

The BLUEfasma Circularity Self-Assessment Tool was strategically used to quantify and visualize the adoption of Circular Economic principles across the participating territories. The core objective was to create a comprehensive baseline circularity map of the region, providing a clear snapshot of where local businesses stand on the transition from linear to regenerative models.

This diagnostic mapping was powered by two fundamental, weighted indicators:

- **The Circular Economy Readiness Index (CERI)**

The CERI is a critical metric designed to position each aquaculture enterprise on a progressive 'circularity ladder,' thereby defining its maturity in implementing CE practices. This index is scaled from 1.0 to 4.0, delineating four distinct levels of operational evolution as demonstrated in the Figure and Table below.

Figure 4 – The Circular Economy Readiness Index (CERI) ladder (© BLUEfasma project, co-funded under the Interreg MED 2014-2020 Programme)

Table 2 - The Circular Economy Readiness Index (CERI) (© BLUEfasma project, *co-funded under the* Interreg MED 2014-2020 Programme)

CERI Range	Circularity Level	Business Model Description
1.0 – 1.4	**Linear Economy**	The company employs a traditional **'take-make-waste'** model. Practices rely heavily on virgin inputs (e.g. unsustainable fishmeal) and result in high levels of unmanaged effluent and solid waste disposal.
1.5 – 2.4	**Eco-Thinking & Green Economy**	The enterprise adopts initial **eco-efficiency measures**. This might involve basic waste reduction (e.g. more efficient feed conversion ratios), energy saving, or compliance with minimum environmental regulations, but lacks systemic circular loops.
2.5 – 3.4	**Emerging Circularity**	The company has initiated concrete steps towards circular practices. This could include the **valorization of a specific by-product** (e.g. selling fish processing trimmings) or/and piloting small-scale Recirculating Aquaculture Systems (RAS).
3.5 – 4.0	**Fully Circular Model**	The enterprise is actively **implementing a robust Circular Economy model**. This often involves advanced techniques like **Integrated Multi-Trophic Aquaculture (IMTA)**, comprehensive feed reformulation using waste streams, or/and full end-of-life material recovery for equipment.

➢ Willingness to InveSt in circular Economy (WISE)

The WISE indicator complements the operational assessment by gauging the strategic intent and financial capacity of the businesses. It is a vital measure of future progress, using a scale of 1 to 5 to reflect the companies' proclivity and financial ability to adopting, scaling and maintaining Circular Economy investments (where 1 signifies very low willingness and 5 signifies very high willingness).

To generate the comprehensive Circular Economy Readiness Index (CERI) and the Willingness to InveSt in circular Economy (WISE) results, the BLUEfasma Self-Assessment Tool systematically evaluates the user's operation across a structured framework. This diagnostic methodology is segmented into eight distinct assessment modules, ensuring a holistic analysis of the aquaculture business's transition from linear to circular practices: Introduction; Company's building facilities; Company's general approach; Eco-design, Equipment, Energy Efficiency; Choice of suppliers; Distribution channels; Waste Recovering and Repurposing; and Company's willingness towards Circular Economy.

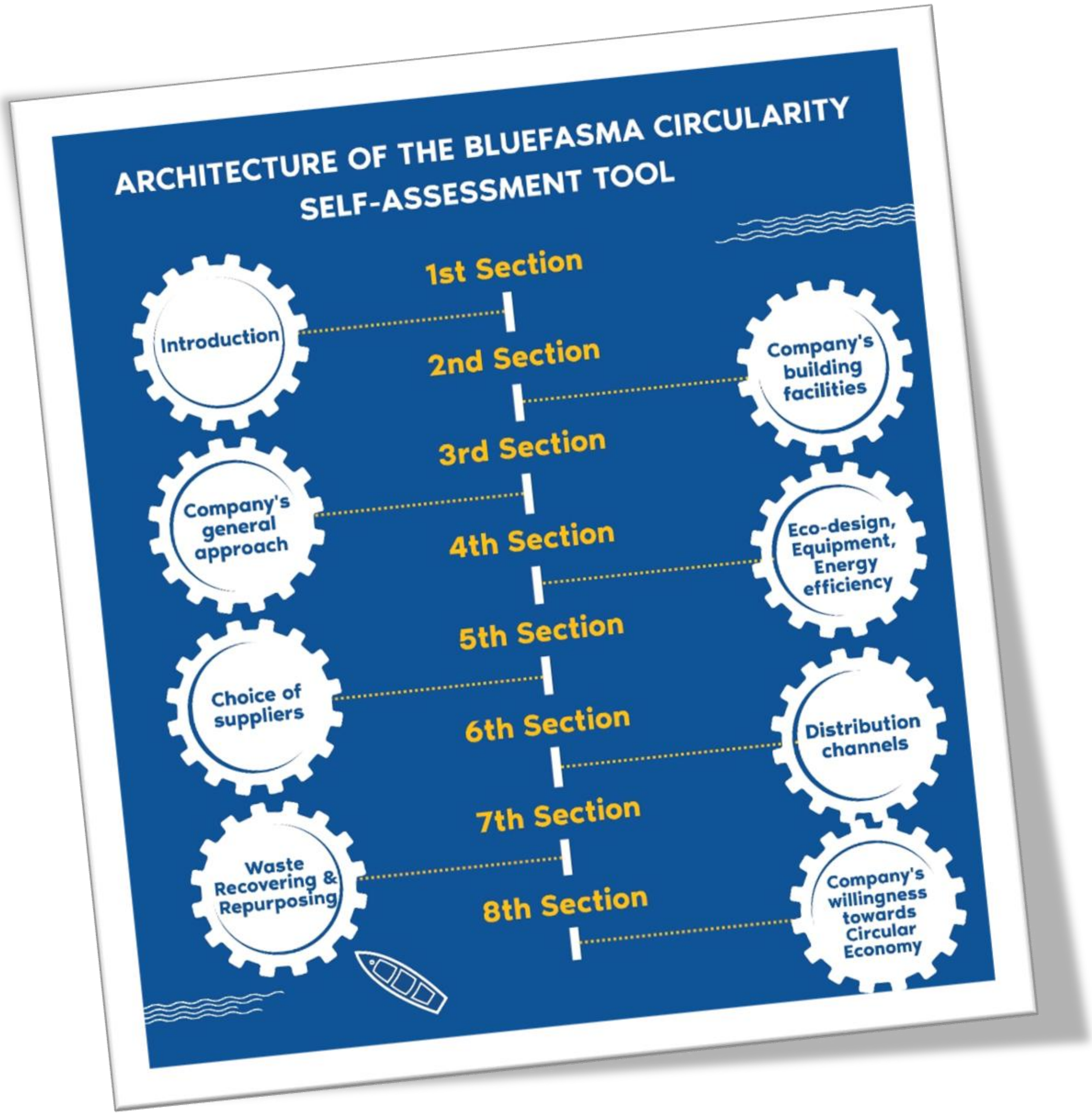

Figure 5 – Architecture of BLUEfasma Circularity Self-Assessment Tool (© BLUEfasma project, co-funded under the Interreg MED 2014-2020 Programme)

Generalized Circular Economy readiness and willingness of the aquaculture sector in Euro-MED area

Analysis results

The BLUEfasma Circularity Self-Assessment Tool was utilised in the 8 AZA4ICE territories to identify the circularity baseline of businesses in the sector, namely in Black Sea – Bulgaria; Andalusia – Spain; Algarve – Portugal; South of France; Sardinia – Italy; Šibenik - Knin County – Croatia; Greece; and Montenegro covering a wide range of the Euro-Mediterranean areas. In total 65 business acting in the aquaculture value chain were involved and took part in this activity. The graph below shows how the total group of Small and Medium-sized Enterprises (SMEs) involved is geographically distributed across the 8 different territories/countries, with all figures expressed as a percentage of the total. The distribution is relatively even, as the percentages for all territories are clustered between 8% and 15%, indicating that the beneficiaries are not heavily concentrated in any single area.

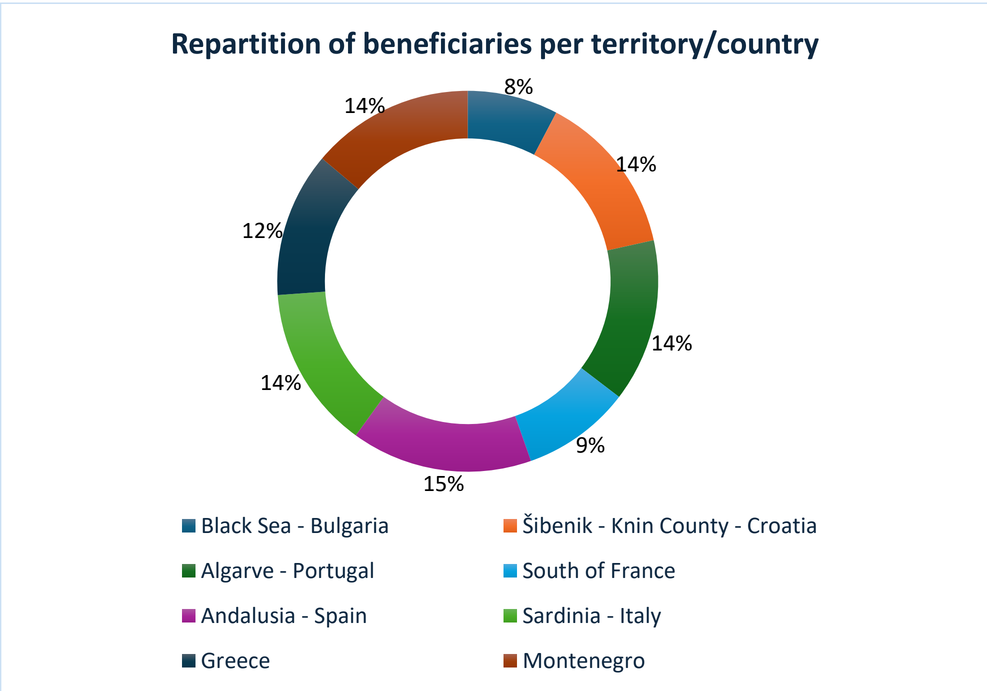

Figure 6 – BLUEfasma Circularity Self-Assessment Tool: Repartition of beneficiaries per territory/country (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The data in the Figure below clearly shows that over two-fifths (43.1%) of the surveyed SMEs (across the Euro-MED area) entirely neglect sustainability and circular economy in their formal business planning. Among those who do engage, the approach is primarily general (29.2%). Only a combined 27.7% (16.9% + 10.8%) integrate these issues at a deep, strategic, or innovative level, suggesting that sustainability and circular economy remain a low priority or are not yet strategically mature for a large portion of the business community surveyed.

Figure 7 – BLUEfasma Circularity Self-Assessment Tool: How do you integrate sustainability and circular economy issues in your business plan? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

As demonstrated in the Figure below, the decision by SMEs to adopt circular economy solutions is dominated by practical resource management concerns (50.8%), followed by a strong influence from ethical and environmental values (36.9%). The need for competitive advantage is the least motivating factor.

Figure 8 – BLUEfasma Circularity Self-Assessment Tool: Why do you want to implement circular economy solutions? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The pie chart below illustrates the response to the question: "What kind of packaging (boxes/crates) do you use for storing goods?". The data reveals that the primary reliance is still on single-use packaging (50%), though the combined use of reusable (24%) and sustainable options (26%) is significant.

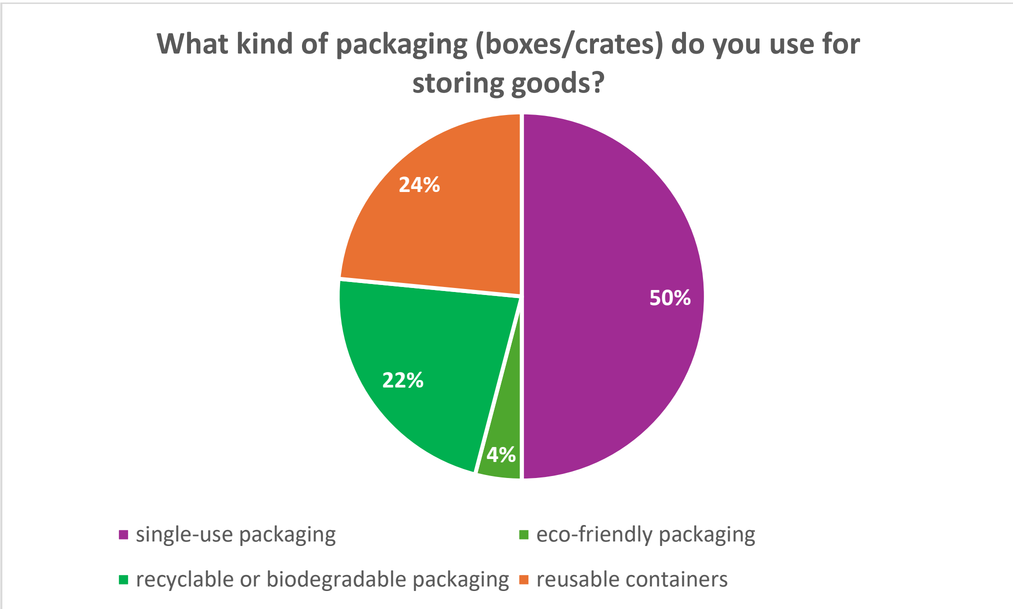

Figure 9 – BLUEfasma Circularity Self-Assessment Tool: What kind of packaging (boxes/crates) do you use for storing goods? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The data shown in the Figure below highlights a significant challenge in transitioning to a circular economy for packaging and storage materials. A majority (49.2%) of companies currently recover items for reuse, but this practice is largely unsystematized (35.4%), with only a small portion (13.8%) having a formal recovery strategy. However, the most critical finding is that nearly half of the companies (46.2%) do not recover items at all due to perceived infeasibility. Furthermore, a low percentage of companies (4.6%) planning future implementation suggests that this gap is unlikely to close rapidly.

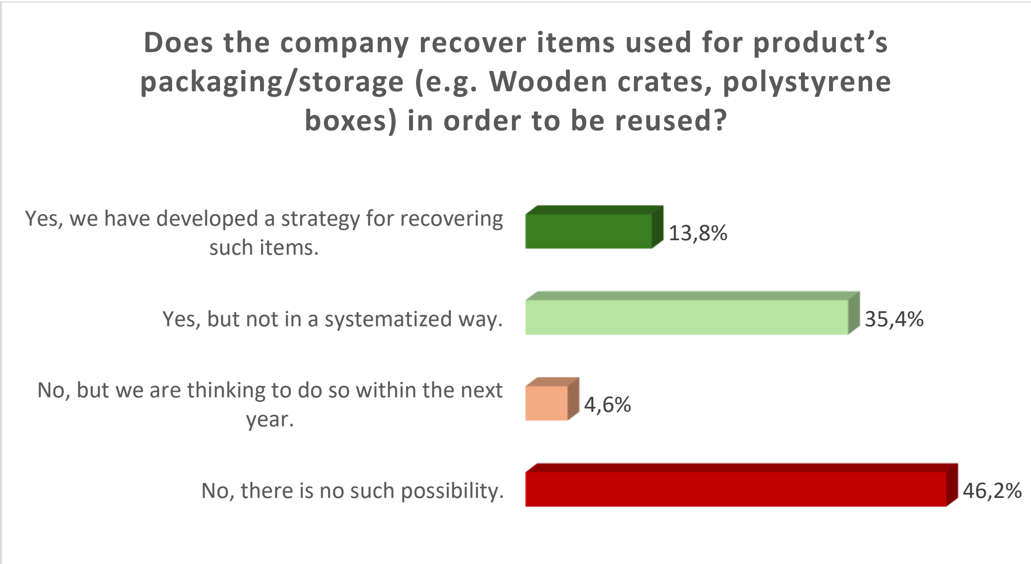

Figure 10 – *BLUEfasma Circularity Self-Assessment Tool: Does the company recover items used for product's packaging/storage (e.g. Wooden crates, polystyrene boxes) in order to be reused? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)*

The data below clearly demonstrates a significant lack of technological modernization and efficiency improvements. The reliance on traditional, high-consumption fuels is the standard practice for nearly nine out of ten vessels (88%). This highlights a substantial need for investment, incentives, and policy intervention to accelerate the transition towards more fuel-efficient, lower-emission, and quieter vessels, as currently, only a small fraction (12%) has begun this transformation.

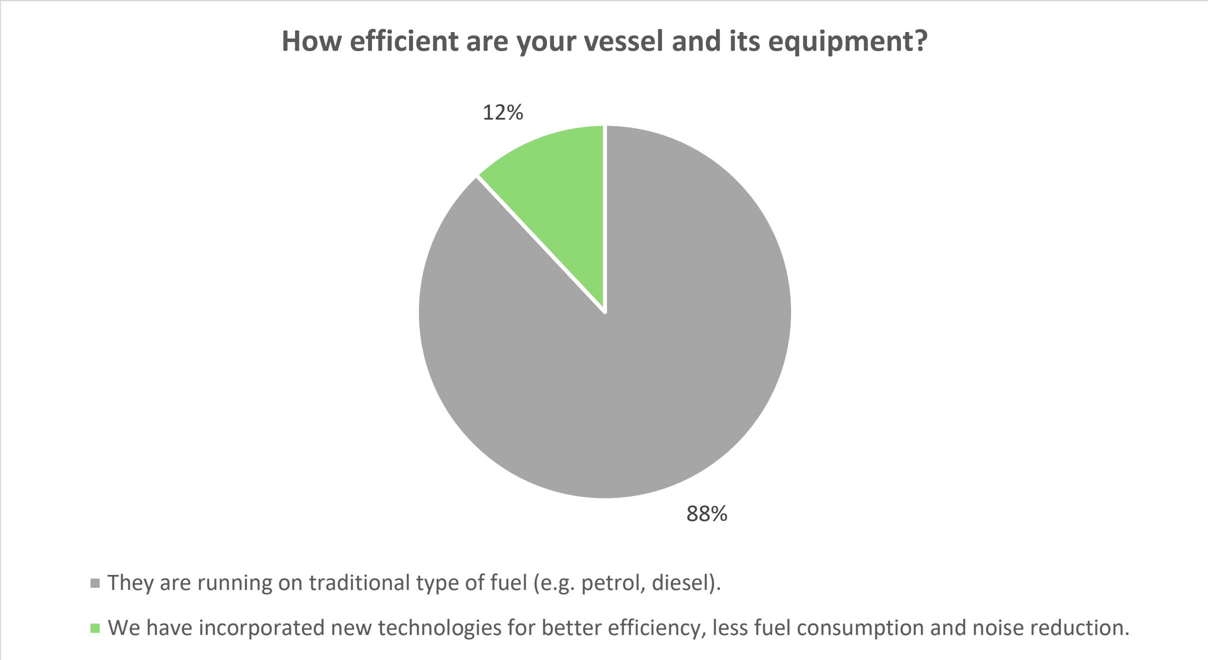

Figure 11 – BLUEfasma Circularity Self-Assessment Tool: How efficient are your vessel and its equipment? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The surveyed SMEs face a dual challenge in waste management:

Industrial/Logistical Waste: The primary challenge is managing high volumes of Packaging (64.4%).

Processing/Biomass Waste: The second major issue is the disposal of processing by-products (55.9%), which are difficult to manage but hold high potential for circular economy solutions.

Collectively, these two categories form the most critical areas for waste reduction and circular intervention for the companies surveyed. The next one is the sea food that cannot be sold and the unsold food.

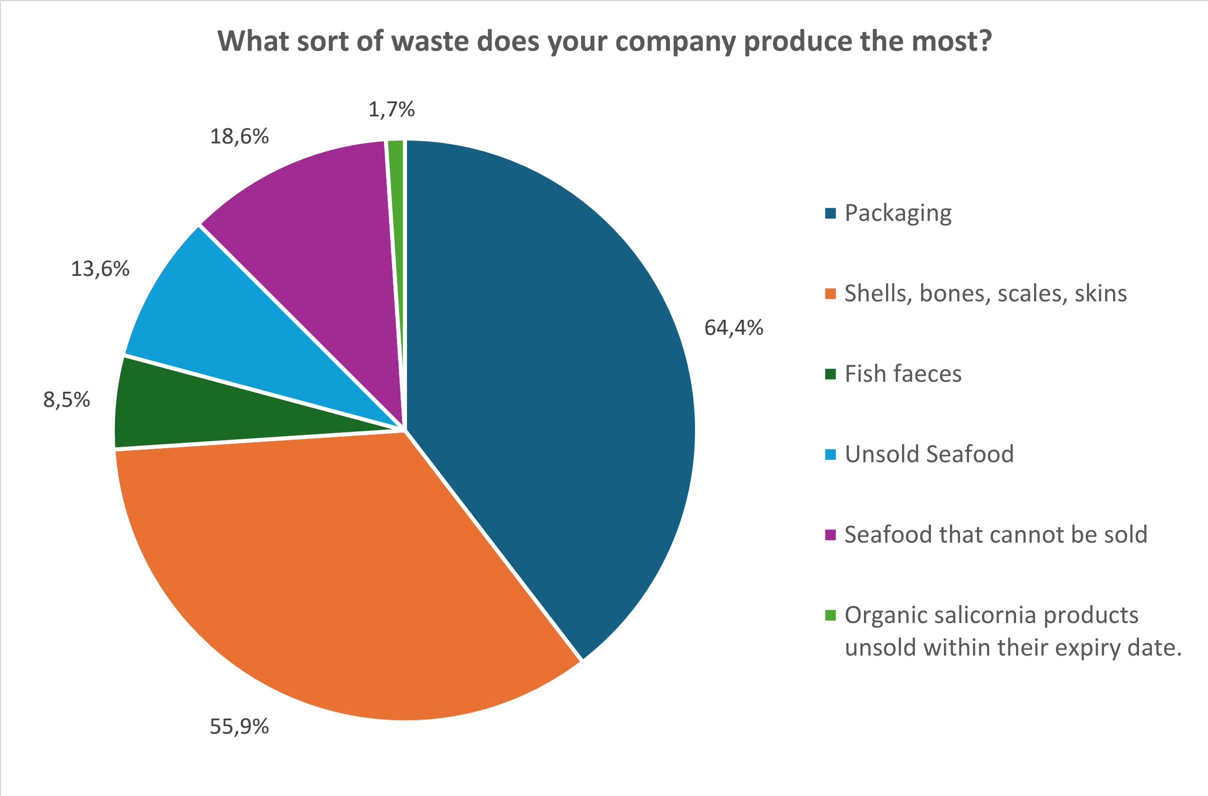

Figure 12 – *BLUEfasma Circularity Self-Assessment Tool: What sort of waste does your company produce the most? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)*

The data in the graph below shows that non-recovery of products' waste is the standard practice among the surveyed companies, with 58.5% of them disposing of it entirely. Only a minority (27.7%) are currently recovering waste, and of that minority, slightly more have a formalized strategy (15.4%) than an informal approach (12.3%). The fact that nearly 60% do not recover waste, and the combined number of current practitioners and those planning to start within a year, highlights that the transition to circular practices for this type of waste is still in its nascent stages.

Figure 13 – BLUEfasma Circularity Self-Assessment Tool: Does the company recover the products' waste (either waste such as fish scales and shells, or food waste such as unsold fish)? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

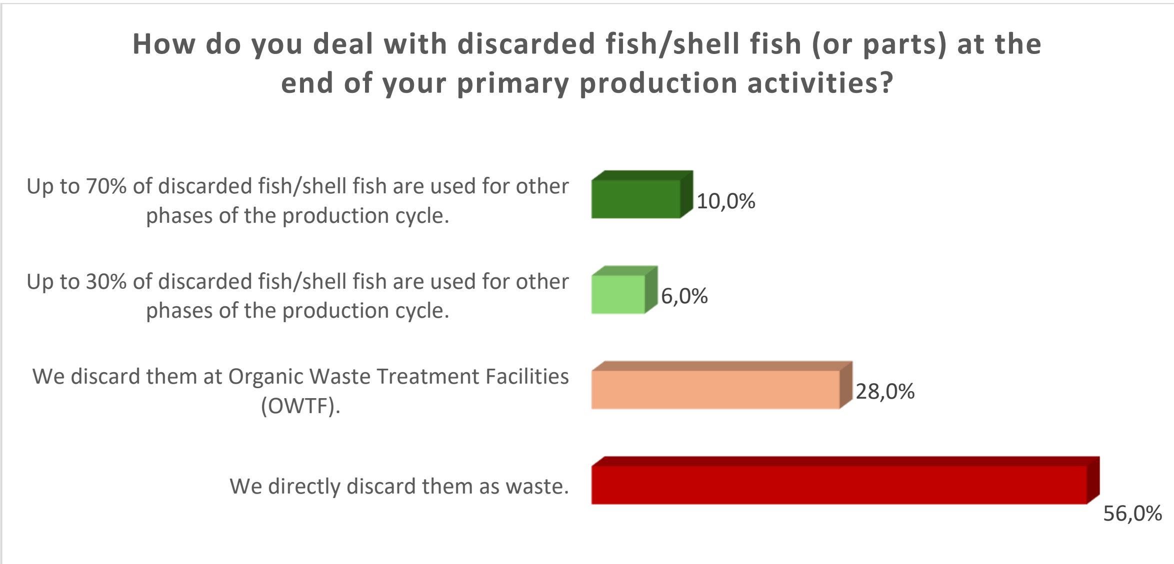

Figure 14 – BLUEfasma Circularity Self-Assessment Tool: How do you deal with discarded fish/shell fish (or parts) at the end of your primary production activities? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The aforementioned data indicates a significant challenge in transitioning this sector toward a circular economy model for biomass waste. An overwhelming majority of companies (56.0%) simply discard their fish/shellfish waste directly, highlighting a major gap in waste valorization. Only a small minority (16.0%) is engaging in circular economy practices by reusing the material internally for other production phases. The combined total of companies discarding the material, either directly or via Organic Waste Treatment Facilities - OWTF, is 84.0%, confirming that for the vast majority, this type of waste is considered an external disposal problem rather than an internal resource opportunity.

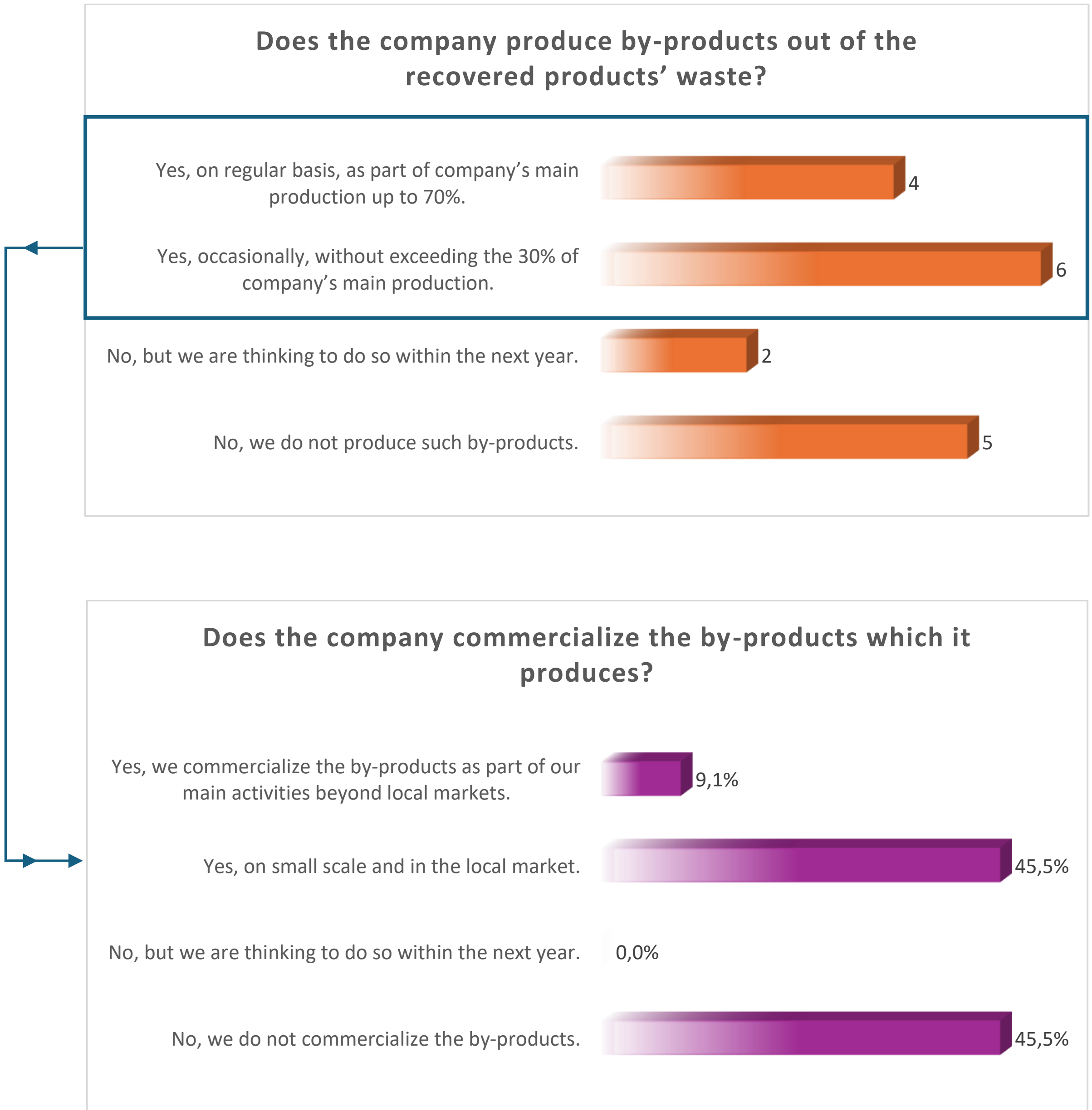

Figure 15 – BLUEfasma Circularity Self-Assessment Tool: Does the company produce by-products out of the recovered products' waste? + Does the company commercialize the by-products which it produces? (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

The data shows a clear pattern of recovery without strong commercialization. A substantial portion (10 out of 17) occasionally produces by-products out of the recovered products' waste. Only 17 out of the 65 participants recover products' waste. However, when it comes to selling these materials, over 90% of the producers either don't commercialize them (45.5%) or only sell locally on a small scale (45.5%). This suggests a significant opportunity gap in developing the business models necessary to turn recovered waste into a profitable, non-local income stream.

The generalized results

In the following table the average Circular Economy Readiness Index (CERI) and the Willingness to InveSt in circular Economy (WISE) index for the SMEs of each participating territory are represented.

Table 3 - The average CERI and WISE indexes for each participating AZA4ICE territory/country (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

	Position at the CE ladder CERI	Willingness to invest in CE WISE
Black Sea - Bulgaria	1,8	3,3
Andalusia - Spain	2,2	3,7
Algarve - Portugal	2,0	3,9
South of France	2,1	4,2
Sardinia - Italy	1,8	3,8
Šibenik - Knin County - Croatia	1,6	3,2
Greece	1,9	3,1
Montenegro	1,7	3,8

In the Sankey Diagram it is shown that in average the SMEs of each participating territory follow an Eco-Thinking & Green Economy as regards their positioning in the CE ladder. The SMEs in Andalusia – Spain, Algarve – Portugal, South of France, Sardinia – Italy and Montenegro demonstrate a high willingness to invest in CE while the ones in Black Sea – Bulgaria, Šibenik - Knin County – Croatia and Greece an average willingness.

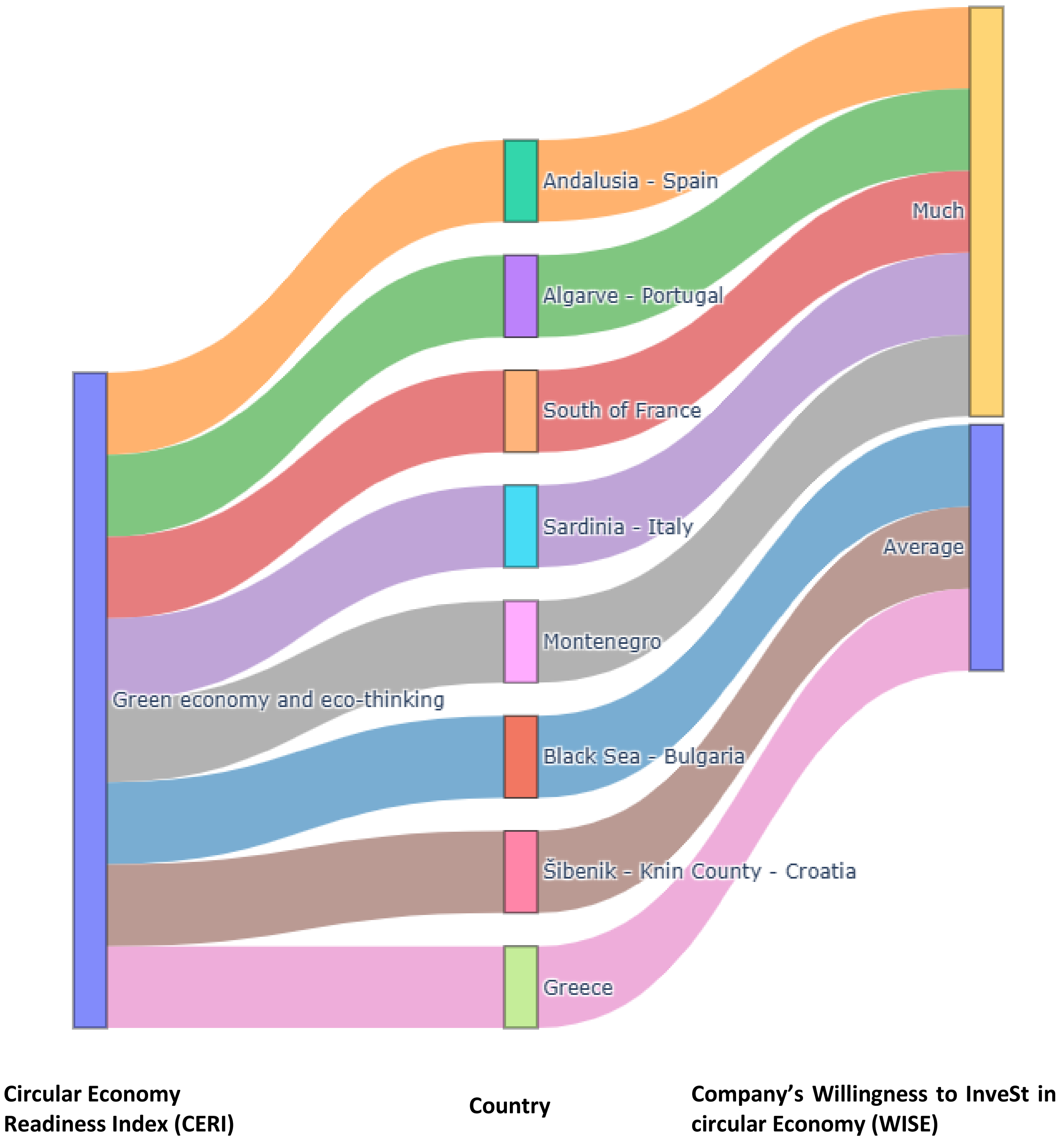

Figure 16 – *Sankey Diagram for the average CERI and WISE indexes for each participating AZA4ICE territory/country (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)*

The aggregated data shows that the **Generalized Circular Economy Readiness Index (CERI)** across the participating territories is **1.9**. This score firmly places the aquaculture industry in the Euro-MED area in the 'Green Economy and Eco-Thinking' category, but short of true circular integration. This suggests that while companies are not operating purely on the outdated 'take-make-waste' linear model (which would yield a score of 1.0-1.4), their primary focus remains on eco-efficiency.

However, a significant takeaway is the uniformity of this position across all the territories involved in this activity. This similarity underscores a deep-rooted challenge: aquaculture remain predominantly traditional domain.

The sector has historically been slow to embrace disruptive technological and operational changes required for the CE transition. Moving beyond eco-efficiency (CERI 1.9) to genuine Emerging Circularity (CERI 2.5+) requires substantial investment and a fundamental shift in mindset, from viewing by-products as 'waste' to seeing them as 'untapped resources' (e.g. using aquaculture nutrient outflow to cultivate valuable seaweed). The current CERI 1.9 serves as a clear benchmark for policymakers and stakeholders, indicating that targeted interventions and incentives are necessary to accelerate the industry's progression up the circularity ladder.

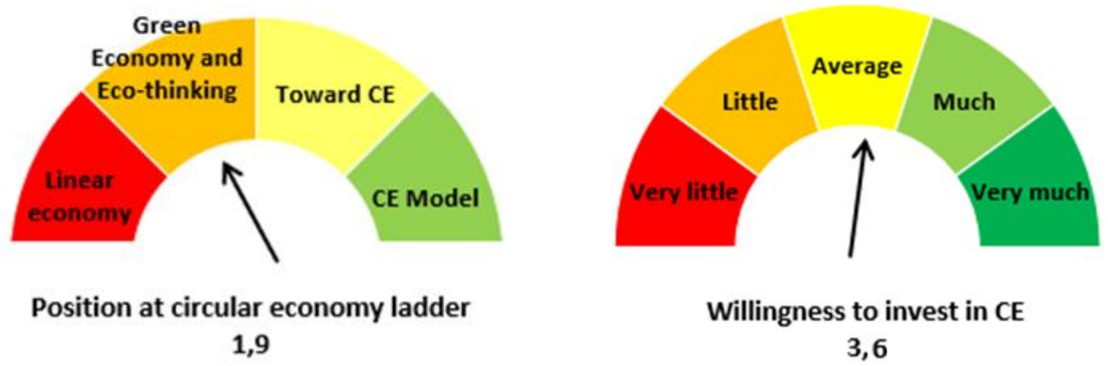

Figure 17 – Generalized Circular Economy readiness and willingness of the aquaculture sector in Euro-MED area (© AZA4ICE project, co-funded under the Interreg Euro-MED 2021-2027 Programme)

In the contrary, the assessment revealed a highly encouraging outcome regarding the financial and strategic commitment of the sector: the **Generalized Willingness to Invest in Circular Economy (WICE)** in the Euro-MED area stands at a robust **3.5** (on a 5-point scale). This 3.5 rating is a clear indication that key industry stakeholders are highly receptive and actively positioned to allocate capital towards systemic change. The score signals a pivotal moment for the Euro-Mediterranean aquaculture, demonstrating that operators aren't just contemplating change, but are actively ready to finance the transition to circular models.

This financial readiness translates into an active search for and adoption of novel, sustainable solutions that can support the shift away from the linear 'take-make-waste' model.

The high WISE score suggests that the financial inertia that often stalls sustainability transitions is giving way to a dynamic investment environment, paving the way for the large-scale implementation of circular practices across the Mediterranean aquaculture landscape.

Conclusions

The analysis of 65 SMEs across the Euro-MED area reveals a significant disparity between intent and action regarding the Circular Economy.

Generalized Circular Economy Readiness Index (CERI)

Low Operational Circularity: The average CERI of 1.9 firmly places the sector in the 'Eco-Thinking/Green Economy' stage, indicating that while companies have moved past the purely linear "take-make-waste" model, their primary focus is on basic eco-efficiency (e.g., resource management) rather than deep, strategic CE integration.

Uniform Traditionalism: The readiness score is uniform across all eight participating territories, underscoring that the aquaculture sector, by its nature, remains a predominantly traditional domain that has been slow to adopt the disruptive technological and operational changes required for CE.

Strategic Neglect: 43.1% of surveyed SMEs entirely neglect sustainability and CE in their formal business planning, confirming that for a large portion of the community, circularity is not a strategic priority.

Generalized Willingness to Invest in Circular Economy (WICE)

High Commitment: The average WISE score of 3.5 is highly encouraging, indicating that industry stakeholders are financially receptive and actively positioned to allocate capital towards systemic change. This score suggests that the financial inertia often associated with sustainability transitions is not the primary roadblock.

Value-Driven Adoption: The dominant motivations for adopting CE are 50.8% practical resource management and 36.9% ethical/environmental values. This suggests that messaging and policy should focus on the immediate operational benefits (e.g., cost savings from resource efficiency) alongside environmental mandates.

Key Areas of Linear Practice

Waste Valorization Failure: There is a major gap in treating by-products as resources. A combined 84.0% of companies either discard fish/shellfish waste directly (56.0%) or send it for external organic treatment. Furthermore, nearly 60% of companies do not recover products' waste at all.

Packaging and Storage: Reliance on single-use packaging remains high (50%), and nearly half of companies (46.2%) perceive item recovery for reuse as infeasible, indicating a lack of formal, systematized recovery strategies.

Vessel Inefficiency: 88% of vessels rely on traditional, high-consumption fuels, highlighting a substantial need for investment and incentives to modernize fleets.

Commercialization Gap: Of the small number of companies that do recover waste and produce by-products, over 90% either don't commercialize them or only sell locally on a small scale, demonstrating a significant missed opportunity in developing profitable, non-local circular business models.

Lessons Learned

The study's findings highlight critical lessons for policymakers and the industry to bridge the gap between high willingness and low readiness.

- Readiness is Not Automatic

A high willingness to invest (3.5) does not automatically translate into high readiness (1.9). The transition to circularity requires more than capital; it needs strategic knowledge, technical capacity, and systemic infrastructure.

- Focus on Waste as a Resource

The primary bottleneck is the treatment of biomass/processing waste and packaging waste as disposal problems rather than resource opportunities. Interventions must focus on valorization technologies (e.g., transforming fish scales into collagen) and developing market linkages for by-products.

- Incentivize strategic planning

Given that 43.1% of SMEs lack a formal CE plan, policy should shift from broad awareness to incentivizing and co-funding the integration of CE into core business strategies. This includes support for deep-level integration and innovation (27.7% currently).

- **Targeted infrastructure investment**

The high WISE score should be leveraged by policymakers to create targeted financial mechanisms (e.g., specialized loans, grants) that specifically fund the move away from linear practices.

- **Develop circular business models**

The low commercialization of recovered by-products (over 90% of producers sell locally/not at all) indicates a critical need for business development support. This includes training on non-local market access, supply chain collaboration, and the creation of shared valorization facilities that can process waste volumes from multiple SMEs efficiently.

Tables and figures

List of sources

BLUEfasma project: https://bluefasma.upatras.gr/

Osei, S.A., Ayisi, C.L., Boamah, G.A. et al. The Circular Economy in Aquaculture and Fisheries: Enhancing Sustainability and Food Security. Circ.Econ.Sust. (2025). https://doi.org/10.1007/s43615-025-00632-1

List of tables

List of figures

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