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Regenerative economy and local system: insights from the Chioggia fisheries sector

Supervisor
Ch. Prof. Monica Plechero

Graduand
Claudia Bennati
Matriculation Number 888931

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Abstract

Climate change and associated phenomena are placing increasing pressure on local systems, making a transition to sustainable models capable of valorizing existing resources, starting with waste, increasingly necessary. In this context, the Chioggia fisheries system represents a particularly significant case study.

In light of this, the research aims to understand why, in a highly concentrated fishing district like Chioggia, the valorization of fish by-products does not occur at the local level, despite the existence of theoretically applicable regenerative models, such as the one developed in Liguria. To achieve this objective, qualitative research was conducted, based on semi-structured interviews with industry experts and participation in institutional events.

The collected data was analyzed using thematic analysis, which allowed us to identify and interpret the main factors hindering the development of local supply chains for the valorization of fish by-products, highlighting the role of organizational, economic, infrastructural, and governance dynamics in limiting the transition to a regenerative production model.

Introduction

Climate change, resource depletion, market instability, regulatory constraints and growing sustainability expectations are reshaping the conditions within which local systems operate, making the transition towards more sustainable and circular production models a central theme in both academic debate and public policy.

The fishing sector occupies a key position in this context. On the one hand, it brings significant economic, social, and cultural value to coastal areas; on the other, it generates significant quantities of by-products and waste that remain largely underutilized, despite evidence of their potential value. Advances in biotechnology, food processing, and industrial symbiosis have demonstrated that materials formerly considered waste can be transformed into new products, generating both environmental benefits and new economic opportunities.

From a theoretical perspective, the valorization of fish by-products is well documented in the scientific literature. The necessary technologies are available, numerous pilot projects have been successfully implemented, and the European regulatory framework actively encourages resource efficiency and waste valorization. However, despite these favorable conditions, circular economy initiatives often struggle to transcend the confines of isolated experiences and become firmly established. This contradiction highlights a **gap**: if the technologies, knowledge, and opportunities are available, why does the transition to a circular economy remain so difficult to implement in practice?

This thesis addresses this question through the case of the Chioggia fishing system, a context with interesting characteristics for exploring the potential of circular economy approaches. It is a system in which the local economy is closely linked to fishing activities, developing specialized skills, dedicated institutions, and dedicated production facilities. However, like many other areas dependent on fishing, Chioggia currently faces profound environmental and structural challenges. The system generates flows of materials that could be valorized through innovative circular practices, as demonstrated by several regional and European experiences, including the EcoeFISHent project.

In light of this context, the thesis is structured around a central research question*: why, in a highly concentrated fishing district like Chioggia, does the valorization of fish by-products not occur at the local level, despite the existence of theoretically applicable regenerative* *models*? This question is articulated into constituent elements regarding the supply chain's structural and organizational characteristics; potential governance and coordination gaps; potential barriers hindering technical feasibility; and, finally, the conditions necessary for the development of a functioning cluster. The ultimate goal is to understand the systemic conditions required for a local system to evolve from mere waste management to a regenerative cluster capable of creating and retaining value within the local area.

To address this, a qualitative methodology based on case studies was adopted. Empirical data was collected through semi-structured interviews with key stakeholders operating within the local system and supplemented with evidence gathered from industry event and institutional discussions. The analysis was conducted using a thematic approach, interpreting the empirical findings in dialogue with the theoretical framework developed in the previous chapters.

The thesis is structured as follows. Chapter 1 introduces the theoretical framework, explaining the transition from a circular to a regenerative economy and the role of local systems in supporting this transition, with particular attention to barriers and enabling conditions. Chapter 2 focuses on the fisheries sector, the blue economy, the regulatory framework for fish by-products, and the main barriers to their valorization. Chapter 3 presents the EcoeFISHent project as a regenerative model, describing its structure, operating logic, and replication potential. Chapter 4 describes the Chioggia fishing system, its main characteristics, waste flows, and key challenges. Chapter 5 outlines the research methodology. Finally, Chapter 6 presents and discusses the empirical findings in relation to the theoretical framework, that are the key to answer the research question and identifying the conditions needed to support a regenerative transition in the Chioggia fishing district.

Chapter One - From sustainability to regenerative local systems

1.1 - The state of the art of the sustainability

Over the past few decades, the concept of sustainability has undergone numerous transformations, but the most notable has been its shift from a desirable objective to an urgent systemic constraint. The most rigorous contribution in this regard is provided by the **planetary boundaries** framework, originally proposed by Rockström et al. (2009) and subsequently updated by Richardson et al. (2023), who conducted the first systematic assessment of all nine planetary boundaries. The results are unequivocal: six of the nine boundaries have already been exceeded, including climate change, biosphere integrity, biogeochemical flows and soil system alterations. As confirmed by the most recent research, climate change and biosphere integrity act as 'core' boundaries (Rockström et al., 2024); in essence, exceeding them does not produce isolated effects, but amplifies pressures on all other systems, rendering any sectoral policy response structurally inadequate.

Ten years on from the adoption of the 2030 Agenda for Sustainable Development, the progress made in implementing the SDGs is critical. The United Nations' Sustainable Development Goals Report 2025 reveals that, of the 139 assessable targets, only 35% show adequate progress, of which only 18% are on track. By contrast, 48% of the targets show insufficient progress and, most alarmingly, 18% have regressed below the 2015 baseline levels (United Nations, 2025). Obviously, these figures are global averages, so it must not be forgot that there have been positive examples at the regional level, thanks to sound policies, strong institutions and inclusive partnerships. In terms of consumption and production, the same report notes that food waste, food loss and electronic waste are reaching unprecedented levels, increasing inequalities in the distribution of global resources. The overall picture highlights a structural gap between formal commitments and the actual transformation of production and consumption systems.

However, there is a growing institutionalisation of the commitment to sustainability: governments are adopting supportive policies, businesses are expanding their sustainability reporting, and participation in multilateral environmental agreements is on the rise. The launch of the Global Framework for Action at COP29 represents a further sign of institutional momentum, although the question, central to the literature on environmental governance, of how to translate formal commitments into a concrete transformation of consumption and production patterns remains open (United Nations, 2025; Sachs et al., 2025). In terms of natural phenomena, the acceleration of climate change is resulting in increasingly tangible and often irreversible impacts. The SDG Report 2025 documents that extreme weather events are intensifying, with direct consequences for food security and the economic stability of entire regions. Particularly relevant to this argument is the oceanic dimension: ocean warming has reached record levels and will remain 'locked in' for centuries even with drastic cuts to emissions, leading to an acceleration in sea-level rise and an intensification of ocean acidification (United Nations, 2025). The ocean absorbs around 90% of the excess heat trapped by greenhouse gases: since 2005, the rate of ocean warming has more than doubled, triggering irreversible ecosystem degradation. An example, on a local scale, is the clam die-off that occurred in 2024 in the Chioggia lagoon basin due to the rising water temperatures in the northern Adriatic, highlighting the vulnerability of the system to climate change.

These systemic pressures are reflected in coastal ecosystems, which form the immediate context of this research. The FAO's *State of World Fisheries and Aquaculture 2024* (2024) reports a new global production record of 223,2 million tonnes in 2022, with aquaculture exceeding capture fisheries for the first time. However, this production milestone masks a worrying trend: the proportion of marine stocks exploited within biologically sustainable levels fell to 62,3% in 2021, whilst the proportion of overfished stocks rose to almost 38%, continuing a decade-long decline. The situation is particularly critical in the Mediterranean basin, the geographical context of this thesis. Indeed, the Mediterranean and the Black Sea are identified as among the most pressured marine regions in the world: only 35% of assessed stocks are exploited sustainably, a figure well below the global average (FAO, 2025). One of the most recent reviews on sustainability assessment highlights how the gap between scientific knowledge and practical action is not primarily a technical problem but mainly an economic and institutional one (Bond et al., 2025).

Climate change and the **degradation of ecosystems** are not merely a crisis to be managed, but also a structural opportunity for economic transformation. As highlighted by the Capgemini Research Institute (2025), sustainability has gradually ceased to be a mere tool for regulatory compliance and has become a strategic driver of long-term value, innovation and competitiveness. In this context, of all the geopolitical actors, it is the European Union that has developed the most comprehensive and ambitious response, integrating the imperative of sustainability into an unprecedented project of economic and regulatory transformation.

No political initiative of the past decade has sought to incorporate sustainability more systematically into an economic and regulatory framework than the European Green Deal, launched by the European Commission in December 2019. Explicitly framed as Europe's 'growth strategy', the Green Deal promotes a systemic transformation of the EU economy, simultaneously aiming for climate neutrality, the promotion of sustainable economic growth through investment in clean technologies, and the creation of new jobs in the green economy (European Commission, 2019). In the five years since its launch, the Green Deal has generated over 150 legislative and policy measures across the energy, transport, agriculture, biodiversity and financial markets sectors, making it one of the most comprehensive sustainability programmes ever launched by a supranational body (A&O Shearman, 2026).

In terms of financial governance and corporate reporting, the EU has established what can be described as the world's most ambitious sustainability framework, based on three interlinked instruments: the EU Taxonomy Regulation, which classifies economic activities as environmentally sustainable on the basis of six objectives aligned with the Green Deal; the Corporate Sustainability Reporting Directive (CSRD), which requires large companies to report on environmental and social impacts using a 'double materiality' approach; and the Sustainable Finance Disclosure Regulation (SFDR), which introduces transparency obligations for financial market participants (European Commission, 2025; Latham & Watkins, 2025).

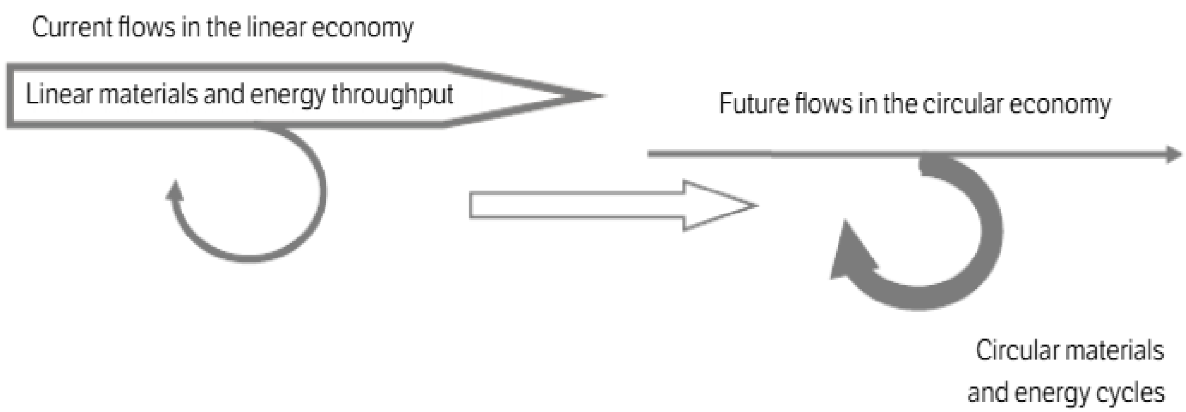
Along with its climate and financial agenda, the European Union has pursued a strategy to transform its resource and waste management systems through the second **Circular Economy Action Plan** (CEAP, 2020). The European path towards a circular economy has its roots in the first Action Plan of 2015, in which the transition from a linear to a circular model was recognised as a necessary condition for achieving environmental, social and economic sustainability. The CEAP 2020 significantly expanded this framework, outlining a governance architecture aimed at decoupling economic growth from resource use and introducing, for the first time in European political discourse, the objective of a 'regenerative growth model', a conceptual evolution that goes beyond circularity, towards the capacity of production systems to regenerate natural capital rather than simply reducing its consumption (Council of the EU, 2020).

Key measures in the plan include funding through Horizon 2020, actions to reduce food waste and a review of the regulatory framework on fertilisers to facilitate nutrient recovery. It is within this framework, in which the circular economy is seen not as an alternative but as a necessary prerequisite for a regenerative model, that the transition towards economic paradigms capable of restoring the balance between human activities and natural systems takes place.

1.2 – From the circular economy to the regenerative economy

The concept of a circular economy is not as current as one might think. Its roots date back at least to 1990, when Pearce and Turner, in the book *Economics of Natural Resources and the Environment*, first introduced the term in contrast to the linear model of production and consumption. Sariatli (2017) summarizes this model in the "produce, use, throw away" paradigm, in which resources pass through the value chain only once before being eliminated: the raw material enters at the beginning of the production process and exits as waste. The limitation of this model is structural: it not only generates waste, but also destroys potentially recoverable value (Szczygieł, 2021). The opposite logic is that of the circular economy, in which the value of resources and materials is maintained within the economic system for as long as possible, minimizing waste production. The growth of the circular economy as an

Figure 1: Moving from a linear to a circular economy



Source: Moreau et al., (2017).

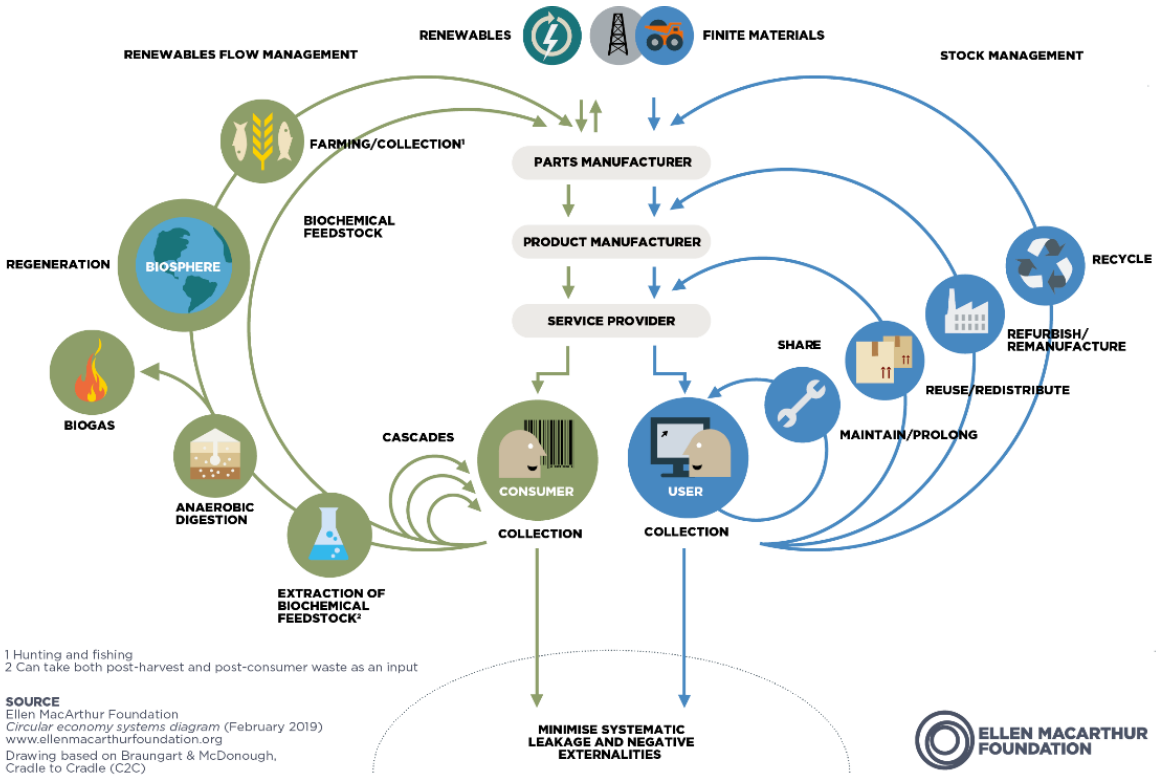
alternative paradigm fits within the broader framework of the **green economy**, which emerged as a systemic response to the climate, food, and economic crises of the 2000s. As Vargas-Hernández and González Ordaz (2018) emphasize, the green economy framework is structured around three objectives: revitalizing the global economy, promoting sustainable and inclusive growth, and reducing carbon dependence and ecosystem degradation. Central to this context is the decoupling mechanism, or the separation of economic growth from environmental impact, pursued on both the resource and impact sides (UNEP, 2011). It is within this logic that the circular economy has established itself as an operational tool, translating the philosophy of the green economy into concretely redesignable production and consumption architectures.

The difficulty in precisely defining the circular economy is itself a significant finding in the literature. Several studies (Kirchherr et al., 2017; Prieto-Sandoval et al., 2018) have identified four recurring components that any definition should include: the recirculation of resources and energy with demand minimization and recovery of value from waste; a multilevel approach; its role as a pathway to sustainable development; and a close relationship with modes of social innovation. The definitional proliferation reflects the paradigm's transversal nature, which intersects industrial design, environmental policy, business economics, and territorial governance. Similarly, as in the case of a linear economy, we can describe it using a set of single words: reduce-reuse-recycle-recover. In this context, the most authoritative and widespread definition is the one formulated by the Ellen MacArthur Foundation (EMF), established in 2010 with the specific mission of accelerating the transition to circular models.

The Ellen MacArthur Foundation defines the **circular economy** as "an industrial system that is regenerative or restorative by intention and design" (EMF, 2013), replacing the concept of end-of-life with that of resource recovery and reuse and promoting the use of renewable energy. In simpler terms, it is a system that aims to minimize resource use, waste production, emissions, and energy losses by slowing down, closing, and optimizing material and energy cycles. Webster (2015) complements this by specifying that the goal is to maintain products, components, and materials at their maximum utility and value "at all times", requiring a review of logistics, design, and business models. Moving from this, Geisendorf and Pietrulla (2018) propose a synthetic definition: the circular economy is “a regenerative system in which resource input, waste, emissions and energy losses are minimised by slowing down, closing and narrowing material and energy cycles”, through durable design, maintenance, reuse, remanufacturing and recycling.

The Ellen MacArthur Foundation articulates the value creation logic of the circular economy around five pillars: systems thinking, the principle that "waste is nourishment," diversity as a factor of resilience, waste-focused design, and the use of renewable energy (EMF, 2014).

Figure 2: Circular economy systems diagram



Source: Ellen MacArthur Foundation, (2019)

From this perspective, waste is not considered a terminal element of the production process, but rather a resource that can potentially be reintegrated into new value cycles. Starting from these pillars, the Foundation also identifies **four principles of valorisation**. The first is the "power of the inner circle," according to which shorter reuse and maintenance loops allow for greater savings in energy, labor, and raw materials. The second is the "power of circulating longer," that links value creation to the duration and frequency of product and component use cycles. The third principle is the "power of cascading use," according to which the same material is progressively reused in different product categories, maintaining its value for as long as possible before becoming waste. Finally, the "power of pure cycles" implies that the end-of-life phase should be considered already in the design phase, facilitate their reintroduction into production processes. These principles, in their interaction, represent a total redefinition of production architectures and business model logic.

Despite its institutional diffusion, the circular economy is often confused with the concept of **sustainability**. The overlap is understandable: both paradigms share an emphasis on intra- and intergenerational engagements (Elkington, 1997) motivated by environmental risks, adopt systemic perspectives on a planetary scale, and recognize design innovation and multi-actor governance processes as the main drivers of change (Geisendorf and Pietrulla, 2018). However, a careful reading of the conceptual differences is necessary because confusing the two paradigms generates incorrect expectations about policies and expected outcomes.

The term sustainability has its roots in the forestry principle of respecting nature's regenerative capacity. Its most widely shared meaning remains that of the Brundtland Commission (1987): "development that meets the needs of the present without compromising the ability of future generations to meet their own needs." Elkington (1997) then developed the concept of triple bottom line people, planet and profit, to underline that sustainability must integrate economic, social and environmental aspects in a balanced way, thus assuming a systemic character.

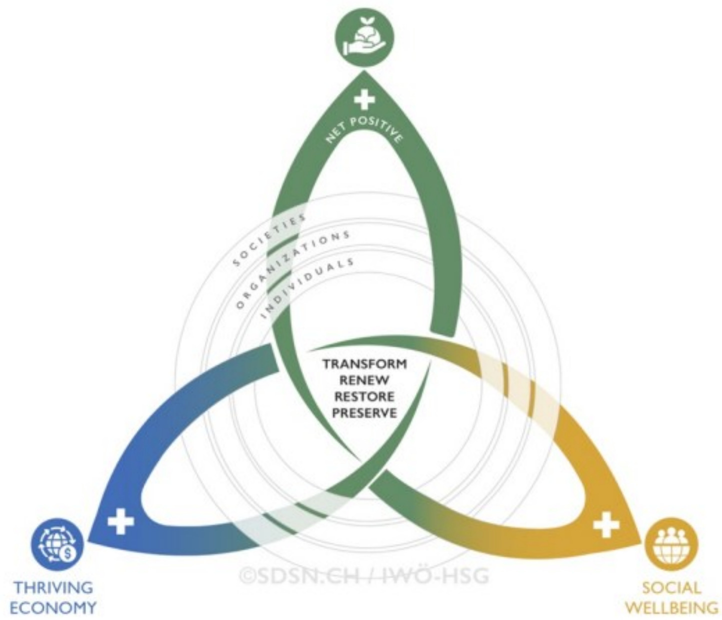
The circular economy, on the other hand, has more recent origins and narrower objectives: it focuses on closing material and energy loops (EMF, 2013), with primary beneficiaries being economic actors (businesses and governments), and environmental and social benefits deriving, often indirectly, from the system's efficiency (Rashid et al., 2013; Webster, 2015). Furthermore, it has been correctly noted on several occasions (Geisendorf and Pietrulla, 2018), while sustainability aims to benefit the environment, the economy, and society at large, the circular economy emphasizes economic and environmental benefits over a linear system, while still prioritizing short- to medium-term efficiency over long-term viability (Geisendorf and Pietrulla, 2018; Elkington, 1997; EMF, 2014). The lever for change also differs: the circular economy acts primarily through structural incentives to guide the behaviour of businesses and consumers, while many sustainability approaches favour engagement and education as tools for transformation (Geisendorf and Pietrulla, 2018).

A critical element of this distinction, often underestimated, concerns the relationship with systemic change. Rashid et al. (2013) describe circularity in business models and supply chains as a necessary condition for sustainable manufacturing, but "necessary" does not mean "sufficient." All in all, the circular economy, as Michelini et al. (2017) also highlight, is the baseline from which to start, not the finish line. It reduces the impact but does not yet generate the conditions for a net systemic positive.

While the circular economy represents a significant advancement compared to the linear model, recent literature converges in believing it is insufficient to address the systemic pressures highlighted in the previous paragraph. The reason is simple as a system that "does not get worse" is not necessarily a system that "gets better."

It is in this conceptual space that the regenerative economy paradigm emerges, although its definition remains a matter of debate and interpretative plurality. The most rigorous starting point is offered by Morseletto (2020), who defines regeneration as "the promotion of the self-renewal capacity of natural systems, with the aim of reactivating ecological processes damaged or overexploited by human action." This is a very important definition for us because it shifts our focus from damage reduction to the active reactivation of ecosystem functions, a clear paradigm shift compared to the efficiency-oriented logic of the circular economy, which is geared towards closing loops. The definitions proposed in the literature converge on some fundamental elements, albeit with differences in emphasis.

Figure 3: Defining a regenerative economy



Source: Unter et al. (2024). *Towards defining a regenerative economy*. SDSN Switzerland & University of St. Gallen. https://doi.org/10.13140/RG.2.2.26291.54566.

According to the State-of-the-Art Report on the Regenerative Economy, the regenerative economy is “an economic system that prioritizes the regeneration of natural and social capital to create sustainable and equitable outcomes, promoting positive feedback loops that favour renewal rather than depletion and degradation.” A similar definition is proposed by Unter et al. (2024), who, emphasizing its proximity to the tipping points of socio-ecological systems (SES), net positive impact. The Capital Institute (Fullerton, 2015) radicalizes this perspective, define the regenerative economy as a model capable of renewing systems while generating a detaching the regenerative economy from any other vision of economic growth: its objective is not to maximize GDP, but “to promote healthy socioeconomic and socioecological relationships for well-being and prosperity.”

Fischer et al. (2024) and Reed (2007) delve deeper into the relationship between regeneration and sustainability, clarifying that regeneration is a co- evolutionary process that aims to “understand the place-based context of an intervention” and to “realize strategies for the most effective transformative change, favouring the self-organization and co-evolution of actors in harmony with the surrounding environment”. The Research Alliance for Regenerative Economics (RARE) offers perhaps the most operationally dense definition stating that is " a socioeconomic system that aims to drive inclusive prosperity by addressing societal needs within planetary boundaries, continuously channelling money, information, and renewable natural resources into self-perpetuating, self-organizing, and adaptive internal circular processes that nurture its capacity to thrive over extended periods of time " (Fath et al., 2019).

This definition is particularly relevant to this research as it situates the regenerative economy within planetary boundaries and, crucially, anchors it to the local dimension and processes of contextual self-organization. An important warning concerns the risk of **overlap** between the regenerative economy and the circular economy. As the scholars presented thus far argue, regeneration should not be considered "a primary principle of the circular economy" due to its conceptual vagueness and apparent incompatibility with technical cycles. The distinction is substantial: the circular economy focuses on closing material loops, whereas the regenerative economy focuses on creating benefits for people and living systems. In regenerative economies, sustainability is not a constraint on efficiency but the result of a system designed to support life.

The overview developed thus far highlights a recurring risk: treating sustainability, the circular economy, and the regenerative economy as variants of the same concept. This interpretation is misleading, those three paradigms have different origins, objectives, and value creation logics. As summarized in Table 1, the differences are structural and concern the relationship with natural systems, policy beneficiaries, timeframes, and levers of change.

Table 1: Sustainability, circular economy and regenerative economy compared

Dimension	Sustainability	Circular Economy	Regenerative Economy
Conceptual origin	Brundtland Commission (1987); triple bottom line (Elkington, 1997)	Pearce & Turner (1990); EMF (2013)	Fullerton (2015); Fath et al. (2019); Morsaletto (2020)
Main objective	Ensure development that meets the needs of the present without compromising those of future generations	Reduce waste and inefficiencies by keeping products, materials and resources in circulation for as long as possible	Restore, regenerate and enhance ecological and socio-economic systems
Starting baseline	Harm reduction compared to the status quo	Harm reduction compared to the status quo	CE as a starting point, not as a finish line
System approach	Balanced holism (people, planet, profit)	Techno-centric; biological and technical cycles	Co-evolutionary; contextual adaptation between system and environment
Approach to resources	Responsible use and reduction of environmental impact	Maximizing the value of resources through reuse, remanufacturing and recycling	Restoring the regenerative capacity of natural resources and social systems
Approach to waste	Reduction of waste production	Waste becomes input for new processes	Eliminating the concept of waste

			through regenerative processes
Relationship with nature	Storage; do not consume beyond regeneration capacity	Reduction of input and waste; eco-efficiency	Active regeneration; net positive
Role of innovation	Support sustainable development models	Technological and design innovation to close cycles	Systemic, territorial and relational innovation
Role of design	Reduce the environmental impacts of products	Ecodesign for durability, modularity, repairability and recovery	Regenerative design geared towards creating net positive impacts
Timeframe	Intra- and inter-generational	Mainly short-medium term (efficiency)	Long-term; self-organization and systemic resilience
Level of change required	Adaptation of existing models	Transformation of production processes and supply chains	Profound transformation of economic, ecological and social relations
Key actors	Widespread: States, businesses, civil society, individuals	Governments and businesses (focus on supply chains and design)	Local communities, ecosystems, multi-actor networks
Main limitations	Broad and often ambiguous concept	Risk of focusing only on efficiency without addressing systemic causes	Difficulty in measurement and operational application still limited

Vision of value	Creating sustainable value	Preservation of the economic value of materials and products	Co-creation of ecological, social and economic value

Source: Own elaboration.

The table highlights a logical progression, not a hierarchy of values: sustainability defines the why of the transition; the circular economy provides an operational how to redesign production and consumption systems; the regenerative economy poses the most radical, with what net effect on the ecological and social fabric. As CIRAIG (2015) points out, the circular business model is only the **baseline**, the starting point for industrial redesign and cultural change, not the finish line.

Moving beyond circularity means acknowledging its structural limits: a system that reduces impact without generating a net positive contribution to living systems remains, ultimately, a system that delays deterioration without reversing it. It is within this perspective that the object of this research fits. The fishing sector of Chioggia, as will be shown in the following chapters, is still in a phase in which waste management follows predominantly linear logics. To understand whether a regenerative model can be applied to a highly concentrated local production system like Chioggia, we need to clarify what we mean by a local system and what structural conditions determine its capacity for innovation towards regenerative models.

1.3 – Local systems and sustainability

The concept of a local system has no single definition, and this ambiguity reflects a broader theoretical debate. The tradition rooted in Marshall's (1920) notion of industrial district and then developed by Becattini (1990, 2004) for the Italian context, interprets local systems primarily through the spatial concentration of firms, the circulation of tacit knowledge, and the presence of a shared socio-cultural fabric. From this perspective, the local dimension is considered above all as a productive resource and a source of competitive advantage, rather than as a normative category.

The agri-food and rural sociology tradition, on the other hand, attributes a more explicitly political and normative value to the local: the territorial reintegration of food production is interpreted as a response to the loss of connection between food production, territory, and local communities caused by the globalization of agri-food supply chains. (Marsden et al., 2000; Renting et al., 2003). The two perspectives are not incompatible; however, their overlap without the recognition of their foundations' risks generating ambiguity in research and in policymaking. In light of these considerations, this thesis adopts a broad definition of a local system, understood as a socio-economic configuration in which actors involved in related productive activities are spatially concentrated within a given territorial context, are connected by relationships of proximity (geographical, organizational, social) and share an institutional and cultural context that guides their behaviour (Kebir & Torre, 2012).

Within this broad definition, various typologies have been proposed, each emphasizing different dimensions. The most influential in the agri-food context is that of Renting et al. (2003), who classify short food supply chains into three ideal typologies, depending on the nature of the producer-consumer relationship:

- **face-to-face** supply chains, in which the consumer purchases directly from the producer, with a personal interaction that conveys complete information on the product's provenance and production method;
- **spatially proximate** supply chains, in which products are sold within a defined local or regional area, through local retailers or farmers' markets, allowing consumers to associate the product with its place of origin without necessarily meeting the producer;
- **spatially extended** supply chains, in which products reach consumers well beyond the place of production, but convey embedded signals (i.e., labels or certifications) that reconstruct the social and spatial connection at a distance.

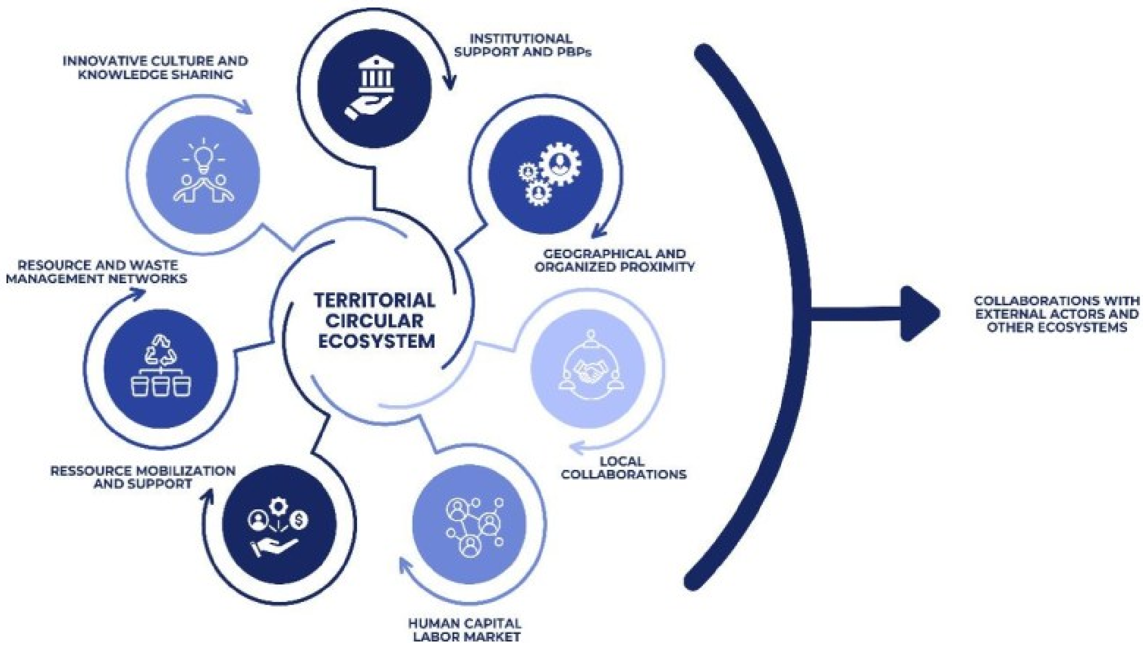
This last typology is analytically relevant because it distinguishes two dimensions that are often confused: the number of intermediaries (organizational proximity) and the physical distance between production and consumption (geographical proximity). As formalized in the European Commission's Joint Research Centre report, local food systems (LFS) are properly defined as systems in which production, processing, and retailing take place within a geographically delimited area, approx. between 20 to 100 km (this is therefore geographical proximity); while SFSCs are defined by the minimization of intermediaries, regardless of physical distance (this is more of an organizational proximity). The distinction is not merely academic because, for example, a fisherman from Chioggia who sells directly to a processor in Milan operates within a SFSC but not a LFS, while a cooperative that supplies the municipal school canteen with fresh local fish operates within both systems.

Kebir and Torre (2012) further articulate this spatial dimension by breaking proximity into three analytically distinct components: **geographic** proximity, i.e., the physical distance between production and consumption; **organizational** proximity, referring to the degree of coordination and shared logic between actors within the same supply chain or network; and **social** proximity, understood as the density of trust, reciprocity, and relational familiarity between actors. This framework recognizes that proximity in one dimension does not imply proximity in the others (Torre and Rallet, 2005); a structural feature that, as will be shown in Chapter 4, characterizes the Chioggia fishing system as geographically concentrated but organizationally fragmented.

A second typological tradition is directly relevant to the subject of this thesis: the circular territorial ecosystem framework proposed by Torre and Bourdin (2025). The **circular territorial ecosystem** is defined as "a dynamic and interconnected set of economic actors, institutions, policies, and practices within a specific territory that collaborate to optimize resource flows, reduce waste, and promote regeneration through the principles of the circular economy" (Bourdin and Torre, 2025). Unlike sectoral or purely technological approaches to the circular economy, the circular territorial ecosystem framework emphasizes the centrality of place: a growing body of literature emphasizes that circularity, to be lasting, must be rooted in the territory (Bourdin et al., 2022). This is so that the coordination mechanisms necessary for circular material flows can be the product of geographical and organizational proximity (Torre & Rallet, 2005).

This theory is closely related to the concept of industrial symbiosis within industrial ecology. Chertow (2000) defines industrial symbiosis as a system of geographically proximate firms that engage in mutually beneficial exchanges of materials, energy, water, and by-products, classified along a spectrum from bilateral waste exchange programs to self-organized symbiotic networks, to intentionally planned eco-industrial parks. The defining characteristic of industrial symbiosis is not the technical level of the exchange, but rather its social embeddedness: Chertow et al. (2008) document that most IS relationships starts and continue through personal relationships and cooperative arrangements. As a socially constituted phenomenon, the conditions that enable circular exchanges of materials cannot be only technical or economic but must be rooted in the social architecture of the local system. Within any territorial configuration capable of sustaining circular dynamics, Bourdin and Torre (2025) identify three analytically

Figure 4: Components of a territorial circular ecosystem



Source: Bourdin & Torre (2026)

distinct but empirically interdependent forms of **cooperation**. The first is technical cooperation between productive and innovative actors oriented towards the organization of flows of materials, energy, and waste. The second is socio-economic coordination among a broader set of local actors, including information exchange and joint planning. The third involves the participation of civil society, whose commitment provides the social legitimacy without which circular initiatives risk remaining isolated experiments.

This multi-layered reading directly overlaps with the structural conditions of the Chioggia fishing system. From a geographical perspective, Chioggia is a concentrated productive cluster: the fishing fleet, the wholesale fish market, the processing companies and logistics infrastructure are all located within a few kilometres of each other, satisfying the spatial proximity criterion that both models identify as a necessary, yet insufficient, condition for circular dynamics. From an organizational and social perspective, however, the system shows the fragmentation identified by Torre and Bourdin as a key limitation of local circular models. Coordination among actors is limited, waste producers and processors are not fully integrated into shared governance arrangements, and value is mainly captured downstream. As a result, primary producers have little incentive or capacity to invest in waste valorisation. The case of Chioggia, in this sense, is a territorial system that meets the geographical prerequisites of the model but has not yet developed the organizational and social architecture that would allow these requisites to translate into circular outcomes.

In the dominant literature, the relationship between local systems and sustainability is theoretically positive: local integration should reduce transaction costs in environmental governance, facilitate collective action on shared natural resources, and allow the emergence of trust-based cooperative arrangements that global markets cannot support (Marsden et al., 2000).

The most effective analytical framework for understanding the success or failure of sustainability transitions in local systems is the **multi-level perspective**, developed by Geels (2002) and later refined by Geels and Schot (2007). The multi-level perspective conceptualizes sociotechnical change as the result of interactions between three nested analytical levels: the **niche**, a protected space in which radical innovations can develop sheltered from market pressures; the **regime**, comprises the established rules, actor configurations, infrastructures, and cognitive frameworks that stabilize existing sociotechnical systems and generate incremental, path-dependent change; and the **landscape**, which refers to slow-moving macro-structural developments that constitute the exogenous context in which niches and regimes interact. (Geels, 2002). Transitions occur when developments at all three levels align: niche innovations mature sufficiently to challenge regime stability, while landscape-level pressures create **windows of opportunity** by destabilizing existing configurations (Geels & Schot, 2007).

This theoretical framework is also useful for interpreting transformations in local food systems. From this perspective, Lamine et al. (2019) distinguish between dominant systems, attributable to the consolidated productivism regime; niche systems, characterized by bottom-up innovations that radically deviate from them; and hybrid systems, which combine elements from both configurations. The authors highlight how niche systems (including those based on the territorial relocalization of supply chains and the circularity of material flows) often present more advanced sustainability performances but are at the same time subject to significant structural fragility. Indeed, their advantages derive precisely from characteristics such as their small operational scale, high relational density, and intense territorial coordination, elements that make economic and organizational scalability complex.

The fundamental contribution of the multi-level perspective model to the understanding of local systems lies in the identification of **blocking mechanisms** that prevent regime-level actors from adopting niche innovations. Geels (2002) distinguishes three classes of blockage: techno-economic blockage (sunk investments in existing infrastructure and economies of scale that make alternatives uncompetitive in terms of costs); socio-cognitive blockage (shared mental models, industry routines, and professional identities that filter alternatives); and political-institutional blockage (regulatory frameworks tailored to the needs of the dominant system to preserve the advantage). These mechanisms are mutually reinforcing, which explains why well-documented niche innovations, including many in the field of circular and regenerative economies, fail to diffuse into dominant regimes.

The literature identifies a consistent **set of barriers** that inhibit sustainability transitions in local production systems, regardless of the sector. Drawing on the circular territorial ecosystem conceptual framework (Bourdin and Torre, 2025), the multi-level perspective (Geels, 2002), and the food systems governance literature (Candel, 2014; Sonnino et al., 2016), these barriers can be organized into three, empirically interconnected, categories.

The first issue is **institutional fragmentation**: local systems, by definition, involve multiple actors with different regulatory statuses, institutional affiliations, and time horizons. Indeed, several authors (Candel, 2014; Sonnino et al., 2016) highlight how food system governance models must more effectively articulate top-down and bottom-up approaches and how the distribution of power and value among actors is a central variable: where value capture is asymmetric primary producers have neither the incentives nor the resources to invest in practices that promote sustainability.

The second barrier is represented by **cognitive and normative misalignment**: actors embedded in a dominant production regime tend to perceive alternative practices not only as economically risky, but as categorically illegitimate, that is, outside the boundaries of what their sector "does". This is the socio-cognitive blocking mechanism identified by Geels (2002), which operates at both the individual and collective levels. In the fisheries context, this manifests itself as a widespread belief within the sector that fish waste is a cost to be minimized and disposed of, rather than a resource to be valorised: a cognitive framework reinforced by regulatory frameworks tailored to this assumption and the absence of economic signals that would make valorisation visible as a business opportunity.

The third barrier is the **inadequacy of markets and infrastructure**: even when actors are willing to adopt sustainable practices, the lack of adequate market channels, processing infrastructure, or logistics systems makes implementation impossible or economically unsustainable. This last barrier is distinct from institutional and cognitive barriers, yet related to them: infrastructural deficiencies can persist long after a shift in cognitive perspectives, as they require capital investments whose returns are uncertain and whose benefits can only be enjoyed collectively.

These three barriers do not operate in isolation. Their interaction is what the multi-level perspective calls **regime stability**: the mutually reinforcing alignment of regulatory frameworks, actor networks, cognitive schemas, and material infrastructures that make it difficult to introduce radical innovations even when they are technically feasible and environmentally necessary.

1.4 – Barriers and enabling factors

Research on barriers to the implementation of the circular economy is an emerging field, however existing contributions are sufficient to identify a set of recurrent obstacles regardless of the sector analyzed or the classification framework adopted. Grafström and Aasma (2021), citing other works, confirm this overlap: barrier categories recur transversally, highlighting not so much a multiplicity of irreducible obstacles as a limited set of critical issues that manifest themselves in different forms depending on the institutional, technological, and cultural context. This suggests that the transition towards circularity is not constrained by a single factor, but by the interaction of multiple barriers operating simultaneously at firm, supply-chain, institutional, and territorial levels.

A preliminary critical observation concerns the relationship between barriers and scale of analysis. Much of the literature tends to treat barriers as macro-level systemic phenomena, neglecting contextual specificity. As will be shown in Chapter 5, the evidence gathered from stakeholders in the Chioggia fishing system confirms this transversal reading but also reveals their local specificity: barriers do not act in isolation but are co-determined in a system of interdependencies that can lead to uncoordinated sectoral interventions to be ineffective.

The first systematic classification contribution in the analysed material comes from CIRAIG (2015), which, by integrating various works, identifies three large macro-areas of obstacles: **economic and financial** barriers (initial costs, short-term corporate governance, virgin material prices), barriers linked to **the complexity of global supply chains** (geographical dispersion, regulatory misalignment between countries, difficulty in separating materials), and **cultural and behavioural barriers**, summarised by the effective formula of Nguyen et al. (2014) as «the curse of the status quo»: the structural tendency to reproduce consolidated practices rather than take the risk of alternative models.

Galvão et al. (2018), expand this repertoire by including **political, regulatory, and managerial dimensions**. Their analysis shows that the barriers that appears more frequently in the literature are technological, political and regulatory, financial and economic, managerial, related to performance indicators, consumer demand, and social pressures. One element they emphasize particularly strongly is the **information barrier**: poor knowledge of the benefits of the circular economy, generates a deficit of social pressure that in turn inhibits the adoption of new policies, especially in cases as Chioggia where the supply chain is fragmented and businesses are small or micro.

Several authors have attempted to organize these barriers into broader classifications. De Jesus and Mendonça (2018) distinguish between hard barriers, **technical and economic**, and **soft barriers**, institutional, cultural, and social. Kirchherr et al. (2018), on the other hand, classify barriers into cultural, market, regulatory, and technological categories. Hart et al. (2019), focusing on the built environment, propose a slightly different classification based on cultural, regulatory, financial, and **sectoral barriers**. The most accurate definition is proposed by Grafström and Aasma (2021), who group the main obstacles into technological, market/economic, institutional, and socio-cultural barriers. Although these classifications differ in terminology, they converge on a common point: the implementation of the circular economy depends on the alignment of technology, markets, regulation, organizational culture, and collaboration along the supply chain.

A relevant aspect, emerging from Grafström and Aasma's (2021) and directly reflected in the case of Chioggia, concerns **regulatory institutional** barriers. The legal classification of by-products as waste leads to a transfer of ownership, effectively making their direct economic valorisation by the producer impossible. In the fishing sector, this dynamic is structural: fish processing waste is normally classified as special waste, resulting in disposal costs that discourage any local recovery and valorisation approach.

The two authors highlight an important systemic connection: removing barriers in one of these categories could act as a catalyst for unravelling the issues in the others. This point is theoretically relevant because it suggests that barriers should not be treated as independent obstacles to be removed one by one, but as a system of interdependencies.

Table 2: Classification of barriers to the implementation of the circular economy

Dimension	Sustainability
Technological and infrastructural barriers	Inadequate waste collection and separation infrastructure; lack of technical know-hows; insufficient IT systems for monitoring flows; niche technologies distant from companies' core competencies
Market and economic barriers	High initial investment costs; low price of virgin raw materials compared to recycled materials; difficult access to credit for SMEs; volatile price of secondary materials; high switching costs for renegotiating supply chains; investors' time horizons are short-term.
Institutional and regulatory barriers	Legal classification of by-products as waste before end-of-life; regulatory complexity and fragmentation across countries; lack of clear policy objectives; lack of fiscal and regulatory incentives; poor support for R&D and training; reverse logistics lacking dedicated infrastructure.
Social, cultural and organisational barriers	Resistance to the status quo by businesses; low awareness of the benefits of CE; poor horizontal collaboration in the supply chain; confidentiality of processes and volumes that hinders industrial symbiosis; conservative and uncooperative sector culture.

Sectoral and management barriers	Lack of a sectoral coherent vision; lack of standardization for recycled materials; lack of CE-oriented design tools and metrics; difficulty in technically recovering end-of-life materials; management and planning complexity; lack of adequate supply and demand networks.
Geographic dispersion and complexity of supply chains	Fragmentation of global supply networks; regulatory misalignment between countries that impedes reverse logistics and take-back on a global scale; complexity of composite materials and lack of labeling; difficulty separating and recovering materials from mixed waste streams.

Source: Own elaboration.

While the literature on barriers is relatively well-established, that on **enablers**, the factors that foster the transition to circular models, is even younger and less systematic. Hart et al. (2019) offer the most structured contribution in this direction, dividing enablers into the same four categories used for barriers.

Cultural enablers revolve around the concept of leadership: several authors identify the company's environmental culture and leadership as the primary project enabler. This is not leadership in the hierarchical sense, but rather the ability to orient the organization's strategic vision toward the long term. Added to this is the role of systems thinking: the ability to reason in terms of systems, flows, and interdependencies is a rare skill in traditional supply chains, but it is a necessary condition for identifying opportunities for circular valorisation in production processes. Added to these is the building of long-term relationships between supply chain stakeholders, which reduces the short-term horizon typical of market transactions.

Regulatory enablers include political support for training and innovation, the reform of obstructive regulations, and the use of public procurement as a demand lever. Fiscal incentives, such as reduced VAT on refurbishment activities or tax recognition for by-product recovery, are identified as particularly effective. In the context of the seafood supply chain, a revision of the regulatory classification of fish waste, from special waste to recoverable by-product, would represent a first-order regulatory enabler.

Financial enablers include valuation methodologies that incorporate environmental, social, and governance (ESG) factors into the value calculation and project aggregation mechanisms that allow small businesses to reach the scale necessary to access investments in circular technologies. This last point is particularly relevant for seafood clusters, as the structural fragmentation of operators is believed to be one of the reasons why waste valorisation opportunities remain latent despite their potential profitability.

Sectoral enablers include building an empirical evidence base for policymakers and businesses, developing CE-oriented collaboration and design tools, standardizing secondary materials, and developing reverse logistics infrastructure—material marketplaces, storage platforms, and upcycling facilities.

A critical point emerging from the literature is that these barriers should not be interpreted as separate or independent. On the contrary, they tend to reinforce one another. For instance, the absence of clear regulation can discourage investment; weak market demand can reduce incentives for technological innovation; lack of coordination can prevent the creation of reverse logistics systems; and cultural resistance can make firms less willing to experiment with new circular business models. In this sense, circular economy barriers are systemic rather than isolated.

In **territorially embedded** contexts, such as specialized local value chains, the transition to circularity requires more than the technical feasibility. It requires the presence of actors capable of coordinating material flows, aggregating volumes, reducing uncertainty, sharing information and connecting waste-generating firms with potential users of secondary resources. Therefore, the issue is not only whether waste can technically be valorised, but whether the local system has the organisational, institutional and infrastructural conditions to make this valorisation economically and operationally viable.

For local systems with high production concentrations, such as the Chioggia fishing district, this systemic interpretation implies that specific, sector-specific interventions are unlikely to produce the expected transition. The research question of this thesis, why fish waste valorization does not occur locally despite the existence of theoretically applicable regenerative models, finds the most likely answer in the convergence of institutional, cultural, and financial barriers.

Chapter 2 – Blue Economy and Fish By-Product Valorisation

2.1 – The fish industry

The fisheries sector occupies a structurally significant position within the global food system, extending far beyond its immediate contribution to food supply. Growing demand for animal protein, the growing world population, and changing dietary habits have led to a significant expansion in seafood production and consumption, making fish one of the most important food commodities internationally.

Globally, fish production has reached historically unprecedented levels, with a new global production record of 223.2 million tonnes in 2022 (FAO, 2024). This growth masks a profound and problematic ecological undercurrent. The share of fish production destined for direct human consumption has increased over time: from approximately 67% in the 1960s to approximately 89% in 2020, equivalent to over 157 million tonnes. The remaining 11% (over 20 million tonnes) was used for non-food purposes, of which 81% was processed into fishmeal and fish oil, while the remaining fraction was used in various applications, including aquaculture feed, pharmaceuticals, and bait (FAO, 2022). Added to these further issues related to the environmental impacts of global fish supply chains. Contrary to a commonly held perception, fish cannot automatically be considered a "low-impact" protein source.

In Europe, the fisheries sector presents a unique configuration. The EU contributes approximately 4% of global fisheries and 1% of aquaculture production, while serving as one of the world's largest fish markets, with per capita consumption of approximately 24 kg per year, significantly higher than the global average (EUMOFA, 2023). In Italy, in particular, per capita fish consumption reaches approximately 29 kg per year (EUMOFA, 2023), among the highest in Europe, supported by dietary habits deeply rooted in Mediterranean tradition.

From this perspective, waste from the fish supply chain takes on increasing strategic importance. They simultaneously represent an environmental problem, an economic cost, and a potential resource for the development of new value chains based on the marine bioeconomy.

2.2 – Blue economy, growth & transformation

In recent years, the concept of the **blue economy** has become increasingly central to the international debate on sustainability and marine resource management. The term was systematized by Gunter Pauli in his 2010 work "*The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs*", which extended the logic of the circular economy to the marine and aquatic sector (Pauli, 2010). For Pauli (2010), the blue economy is not limited to the use of marine resources: it is a production model inspired by the functioning of ecosystems, in which nothing is treated as waste because every output of one process becomes an input for another. This logic resonates directly with the mechanisms of industrial symbiosis described in Chapter 1 and operationalized in the EcoeFISHent project that will be analysed in Chapter 3. The United Nations has integrated the blue economy into the 2030 Agenda for Sustainable Development, particularly through SDG 14 - Life Below Water, which calls for the conservation and sustainable use of oceans, seas, and marine resources (UN, Agenda 2030).

One of the most relevant aspects of the blue economy is its highly interdisciplinary and multisectoral nature. Indeed, marine-related economic activities encompass a variety of highly heterogeneous sectors (European Commission 2021): fishing, aquaculture, port logistics, coastal tourism, marine renewable energy, shipbuilding, marine pharmaceuticals, and blue biotechnology (the set of industrial applications developed from marine organisms and biomass). This makes the blue economy a complex system characterized by material, energetic, and institutional interdependencies between actors from different sectors. The blue economy is structured around several interconnected dimensions, relevant to this thesis.

The first concerns **sustainable fishing and aquaculture**. This dimension is regulated at the EU level by the Common Fisheries Policy (Regulation (EU) No 1380/2013), which establishes multiannual catch quotas based on scientific assessments and imposes a reduction of unwanted catches through the landing obligation, introduced in 2019. The landing obligation is relevant for this thesis: by prohibiting the discarding of regulated species, it increases the volume of low-value biomass that must be managed on land.

The second concerns **marine biotechnology**, which the European Commission identifies as a priority area for innovation within the blue economy. Marine biotechnology involves the development of products derived from marine organisms, ranging from pharmaceuticals and nutraceuticals to cosmetics and biomaterials. This sector, currently characterized by small businesses often linked to universities and publicly funded research (Rotter et al., 2021), is directly relevant to the valorisation of fish processing by-products, as many of the most commercially promising products can be extracted from fish waste streams (Kim and Mendis, 2006).

The third dimension is the one most directly connected to the research question of this thesis: the integration of **waste management and resource efficiency** within the framework of the blue economy. The goal is not only to reduce waste, but to increase overall resource efficiency, that is, to maximize the value obtained from each unit of raw material extracted from the marine ecosystem, through the creation of industrial ecosystems in which the residue of one activity becomes the resource of another. Some critical literature (Barbesgaard, 2018; Bennet et al., 2021) highlights the risk of the concept being used primarily as a narrative of economic growth, without truly questioning the ecological limits of marine ecosystems.

In the context of the evolution of European policies related to marine sustainability, one of the most relevant concepts is **Blue Growth**, the strategy developed by the European Commission to promote the sustainable growth of the maritime and coastal sectors. Blue Growth represents the translation of the principles of the blue economy and is part of broader EU strategies aimed at ecological transition, industrial innovation, and the use of marine resources. The strategy was launched in 2012 as a part of the European Union's Integrated Maritime Policy, in response to the growing awareness that seas and oceans represent as important source of economic growth, employment, and innovation. The blue growth is based on the idea that the sea should not be considered as a resource for economic exploitation or environmental conservation, but as a complex productive ecosystem in which economic growth and sustainability can be integrated through innovation, research, and coordinated governance. The European Commission (2012) identifies five sectors with high growth potential:

- sustainable aquaculture;
- coastal and maritime tourism;
- marine renewable energy;
- blue biotechnology;
- sustainable extraction of marine resources.

Among these, **blue biotechnology** plays a particularly strategic role in the valorisation of fish waste. In this context, fish processing waste is no longer viewed as simple organic residues, but as sources of biomoleculesand functional compounds potentially exploitable for industrial purposes. Waste valorisation therefore represents one of the most relevant emerging themes of this strategy (European Commission, 2012), as it allows for:

- increasing the efficiency of marine biomass use;
- reducing the environmental costs of disposal;

- ❖ developing new industrial supply chains;
- ❖ creating additional economic value;
- ❖ generating employment in coastal areas.

In this sense, this approach not only supports the quantitative growth of the maritime economy but also aims to foster the economic diversification of coastal areas, with the aim of building more integrated, circular, and territorially resilient marine production systems. However, the literature also highlights some of the limitations of blue growth. Several scholars (Barbesgaard, 2018; Bennet et al., 2021) highlight the risk that the strategy remains excessively oriented towards economic growth and technological innovation, without fully addressing territorial asymmetries, inequalities between actors, and the structural limitations of local production systems.

In the contemporary debate on the sustainability of aquatic food systems, one of the concepts that has gained increasing relevance is that of **Blue Transformation**, promoted by the FAO as a strategic framework for the future of global fisheries and aquaculture. The Blue Transformation strategy was formalized by the FAO in the most recent editions of *The State of World Fisheries and Aquaculture (SOFIA)* report and is based on the idea that the transformation is not just about increasing fish production, but above all about building supply chains capable of generating economic value while minimizing environmental pressures, waste, and social inequalities. For this reason, blue transformation proposes a **systemic approach** based on three main pillars (FAO, 2022; 2024).

The first concerns the **sustainable expansion of aquaculture**. According to the FAO, the growth of aquatic food production will increasingly depend on aquaculture, as many wild fish stocks have now reached or exceeded biologically sustainable limits (FAO 2024; 2025). However, this expansion must occur through more efficient and less impactful production models, capable of reducing the use of antibiotics, limiting the release of nutrients into aquatic ecosystems, and decreasing dependence on fishmeal and fish oil from industrial fishing.

The second related direction concerns **improved fisheries management**. In this context, it promotes the strengthening of marine resource governance through monitoring systems, scientific quota management, combating illegal fishing, and greater involvement of local communities. The goal is not simply to reduce catches, but to ensure the long-term regenerative capacity of marine ecosystems.

The third direction, particularly relevant to this research, concerns the **streamlining of supply chains and the reduction of losses and waste** along the entire value chain. In many cases, potentially recoverable by-products are treated as waste, generating significant environmental and economic costs. The blue transformation therefore proposes developing production systems capable of more efficiently utilizing all marine biomass, promoting waste recovery and the creation of new value chains based on the blue bioeconomy. In this sense, the FAO strategy is directly linked to the principles of the circular economy and, increasingly, those of the regenerative economy. The valorization of fish waste is not seen solely as a technical solution to reduce waste, but as a tool to increase the economic resilience of supply chains, diversify revenue sources, and reduce pressure on natural resources.

However, the FAO recognizes that this transformation does not depend only on the availability of innovative technologies. The blue transformation requires infrastructure investments, efficient logistics systems, multilevel governance, and coordination between public and private stakeholders. Without conditions, even potentially high-value biomass risks being disposed of or diverted to marginal applications. However, as will emerge in the case of the Chioggia fishing district, the existence of technological and biological potential does not automatically guarantee the local system's ability to retain and valorise this value economically and territorially.

Table 3: Comparative analysis of the blue economy, blue growth, and blue transformation

Dimension	Blue economy	Blue growth	Blue transformation
Rationale	Balance between economic development and marine sustainability	Promoting economic growth and competitiveness of blue sectors	Transforming aquatic and fisheries systems towards sustainability and resilience
Approach to natural resources	Sustainably managed resources	Efficiently exploited resources for growth	Resources regenerated and circularly valorised
Governance focus	Multilevel governance and maritime policies	Industrial policy and sectoral development	Coordination, inclusiveness and systemic governance

Role of innovation	Supports sustainable marine activities	Foster competitiveness and productivity	Enables systemic transition and circular valorization
Approach to waste and by-products	Reduction of environmental impact	Efficiency and optimization of resources	Waste transformed into economic value for the territory
Territorial dimension	Present but not always central	Often focused on a specific and scalable sector	Strong territorial and local system orientation
Main criticisms	The concept is sometimes too broad and ambiguous	Risk of prioritizing growth over true sustainability	Difficult to implement due to coordination and infrastructure requirements.

Source: Own elaboration

2.3 – Regulatory framework

The growing focus on fish waste recycling is part of a broader European regulatory framework geared toward the transition to a circular economy. The foundational instrument of European waste governance is the Waste Framework Directive (WFD), 2008/98/EC, revised and strengthened by Directive 2018/851/EU. The WFD establishes the general regulatory architecture for waste management across the EU, introducing a set of key conceptual instruments of direct relevance. The directive stems from the need to move beyond an approach traditionally oriented toward the final disposal of waste, instead promoting more efficient resource management throughout the entire life cycle of products (Gharfalkar et al., 2015).

In this sense, the 2008 Directive establishes a precise hierarchy that is it is operationally binding on Member States in defining waste management policies and on operators. It establishes a priority order for management strategies, identifying environmentally preferable options over less sustainable ones. At the top of the hierarchy is **prevention**, the set of measures aimed at reducing waste generation and inefficient resource usage. **Reuse** comes second, aiming to extend the life cycle of products without substantial transformation. This is followed by

recycling and various forms of **recovery**. Only at the last level is **final disposal**, considered the least desirable solution from an environmental perspective.

Figure 5: Waste hierarchy

Source: European Commission (2025), *Waste Framework Directive*. - https://environment.ec.europa.eu/topics/waste-and-recycling/waste-framework-directive_en

The Commission's Circular Economy Action Plan (CEAP, 2020) reinforces this approach by prioritizing bio-based materials, and their sustainabiity and reducing food waste by 20% through the Farm to Fork Strategy (European Commission, 2020; Farm to Fork Strategy, 2020). From this perspective, the valorisation of waste to produce collagen, biomolecules, nutraceuticals, or functional ingredients represents a more advanced form of recovery than simple destruction or energy recovery (Coppola et al., 2021; Rustad et al., 2011).

The Waste Framework Directive also introduces a fundamental distinction between "waste" and "by-product," which is particularly relevant in the context of fish waste valorisation. This distinction directly impacts costs, administrative requirements, and the possibilities for industrial valorisation. A material classified as waste is subject to much more restrictive management, transport, and disposal procedures; while, classification as a by-product allows the biomass to be more easily reintroduced into new production processes. However, establishing by-product status is not always simple in practice (Grafström & Aasma, 2021; Coppola et al., 2021), especially for small operators who lack the administrative capacity to document the required conditions and who face regulatory uncertainty.

In the fisheries sector, however, the situation is complicated by the fact that much of the waste falls under the category of animal by-products (ABP), regulated by Regulation (EC) No. 1069/2009. This regulation (ABPR) defines animal by-products as "*whole animal bodies or parts, products of animal origin, or other products obtained from animals, not intended for human consumption.*" Residues from fish processing (heads, bones, skins, viscera, fins) fully fall within this definition, with the exception of materials discarded at sea during fishing operations. The regulation identifies three risk categories:

- Category 1 materials, representing the highest level of risk
- Category 2 materials, considered to be of intermediate risk
- Category 3 materials, which represent the lowest-risk category

Fish processing by-products generally fall within category 3, which includes aquatic animals and their parts that have not shown signs of diseases, as well as aquatic animal by-products originating from establishments producing products intended for human consumption (Regulation (EC) No 1069/2009, Art. 10). Those materials can be employed the production of fishmeal and fish oil for feed applications, bioconversion processes, fertilizer production, composting, anaerobic digestion, and energy recovery (Regulation (EC) No 1069/2009).

2.4 – Valorisation pathways

Waste generation is not an occasional aspect of fish processing: it is a structural part of the fishing supply chain, present at every stage, from harvesting to landing, primary processing, and secondary transformation. These volumes are generated continuously and predictably, a structurally important characteristic (Coppola et al., 2021) which in principle facilitates the planning of collection, aggregation, and valorization logistics.

The literature generally distinguishes between **low-value** and **high-value added applications**. The most widespread forms of valorisation concern the production of fishmeal and fish oil, notable low-value valorisation pathways. According to the FAO (2024), over 16 million tons of aquatic biomass are transformed into fishmeal and fish oil every year. Fishmeal is a protein source with a high nutritional content and is used in feed intended for intensive aquaculture. Fish-derived oils, on the other hand, are rich in omega-3 fatty acids and are used both in animal feed and in some sector of the nutraceutical industry.

Another low-value-added application concerns the use of waste as organic fertilizers and compost. Fish waste, in fact, contains high concentrations of nutrients essential for soil fertility, and can be used directly in agricultural soils or integrated into composting processes with other organic materials. Several studies highlight how compost derived from fish waste and marine biomass can significantly improve agricultural yields, while also contributing to the reduction of chemical fertilizer use (Coppola et al., 2021). Interest in these practices also stems from the possibility of developing short regional supply chains, reducing logistical costs and environmental impacts associated with the transportation of industrial fertilizers (Arvanitoyannis and Kassaveti, 2008).

Although these applications contribute to reducing the volumes of waste destined for disposal, they tend to generate relatively little economic value. For this reason research and industry attention has gradually shifted toward **high-value-added valorization** methods. These are based on the extraction of bioactive compounds and biomolecules with high technological content, primarily intended for the nutraceutical, pharmaceutical, and biomedical sectors.

The most commercially significant protein fraction in fishery by-products is collagen, the main structural protein of connective tissue, concentrated primarily in the skin, scales, bones, and fins of fish. Collagen constitutes between 15% and 30% of the total protein content of fish (Caruso et al., 2020). Its applications extend to dietary supplements, skincare and cosmetic formulations, wound dressings, tissue engineering scaffolds, and pharmaceutical delivery systems. Recent research conducted within the EcoeFISHent project has specifically demonstrated the potential of extracting fish collagen from fishery waste as a commercially viable application in the skincare and nutraceutical sectors (Dondero et al., 2025). By-products as viscera and liver fractions, are rich in long-chain polyunsaturated fatty acids (Kim & Mendis, 2006; Coppola et al., 2021). These are the omega-3 fatty acids for which the demand in the nutraceutical, infant nutrition, and functional food markets has grown steadily.

Fish skin, head, and viscera are rich in carotenoids, natural pigments with antioxidant properties, used as natural food colorings, anti-inflammatory pharmaceutical supplements, and anti-aging cosmetic ingredients with UV-protective properties (Caruso et al., 2020). Fish by-products, such as bones, also contain significant concentrations of vitamins A, D, E, and the B group, as well as many minerals (Caruso et al., 2020), which are used in the enrichment of functional foods and, in demineralized form, in pharmaceutical and biomedical applications. Chitin, one of the most abundant natural biopolymers, can be extracted from crustacean shells and carapaces. Chitin can be converted into chitosan, which has a wide range of applications: in wastewater treatment, in the agri-food industry as a gelling agent, in tissue regeneration, and in pharmaceutical formulations as a drug delivery carrier (Kim and Mendis, 2006).

Table 4: Valorisation pathways of fish processing by-products

Fraction	Key Compounds	Main applications	Destination Sector	Value Level
Skin & scales	Collagen, gelatine precursors, carotenoids	Collagen hydrolysates; gelatine for food coatings; anti-ageing cosmetic actives; wound dressings; tissue engineering scaffolds	Nutraceutical, cosmetics, biomedicine, food packaging	High
Bones & cartilage	Calcium, phosphorus, collagen, GAGs, hyaluronic acid, heparin	Mineral supplements; bone meal; pharmaceutical GAG extraction; functional food fortification; biomedical scaffolds	Pharmaceutical, nutraceutical, food fortification	High Medium
Viscera & liver	Omega-3 PUFAs lipids; vitamins A, D, B-group	Functional food & infant nutrition; omega-3; biodiesel feedstock; vitamin concentrates	Nutraceutical, energy, pharmaceutical	High Medium
Heads & frames	Proteins, collagen, lipids, minerals	Fishmeal for aquaculture feed; protein hydrolysates; bioactive peptides	Aquaculture, food industry, nutraceutical	Medium Low
Shells & carapaces	Chitin, chitosan, calcium carbonate	Wastewater treatment; food gelling; drug delivery; tissue regeneration scaffolds	Environmental remediation, pharmaceutical, agri-food sector	High

Whole residual biomass	Mixed organic matter, nitrogen, phosphorus	Organic fertiliser; anaerobic digestion for biogas; black soldier fly bioconversion	Agriculture, energy, bioconversion	Medium Low
Pigmented fractions (skin, roe)	Carotenoids, antioxidant pigments	Antioxidant & anti-inflammatory supplements; UV-protective cosmetics	Food industry, cosmetics, pharmaceutical	High

Source: Own elaboration

The distinction between low- and high-added-value applications is directly intertwined with another key issue in the valorisation of fish waste: whether or not these by-products can be used for human consumption. Generally, the waste most suitable for human consumption or as ingredients for the nutraceutical, cosmetic, and biomedical sectors is that derived from relatively "clean" biomass, collected and processed quickly after primary fish processing. High-added-value applications are therefore closely associated with materials that maintain high biological quality and can be processed through advanced industrial processes. Conversely, waste characterized by lower biological quality, greater degradation, or less commercial interest tends to be directed towards applications not intended for human consumption and is generally associated with low-value-added valorisation.

2.5 – Barriers to fish by-product valorisation

The value of these applications demonstrates that fishing by-products are not material waste but rather a resource with high economic value. However, their valorization remains limited by numerous technical, logistical, and structural challenges (Nawaz et al., 2020). The following sections analyze these critical issues by **applying** the theoretical framework of **barriers to circularity** developed in the previous chapter **to the fishing sector**.

The first category of obstacles is **technical and logistical** in nature. The primary challenge is **perishability**. Fish by-products are biologically active materials that begin to deteriorate immediately after separation from the edible fraction, as enzymatic and microbial processes rapidly degrade the relevant compounds (Rustad et al., 2011; Coppola et al., 2021). In contexts where the cold chain infrastructure is inadequate or where a single operator's volumes are too small to justify dedicated logistics, by-products are often disposed of before their valorisation is possible. The second challenge concerns **quality and safety**. The potential contamination of fish by-products by microbiological agents, heavy metals, pesticide residues, and antibiotics imposes stringent requirements for the handling, processing, and documentation of materials intended for food or pharmaceutical applications (Socas-Rodríguez et al., 2021). The third challenge is **scale**. Many valorisation processes require minimal input volumes to be economically viable. In fragmented fishing districts, where individual operators generate small quantities of by-products, aggregating sufficient volumes requires coordination mechanisms that are often lacking. This challenge of scale is precisely the one that EcoeFISHent addresses through its territorial cluster architecture and is central to understanding the case of Chioggia.

The second category is **economic and financial**. The profitability of fish by-product valorisation is not a given for individual operators, especially small-scale ones. Investments in processing equipment, quality management systems, regulatory approvals, and market development entail significant upfront costs and uncertain returns, particularly in markets where quality standards are high and value chain integration with downstream buyers is essential (Grafström & Aasma, 2021; Galvão et al., 2018). The low price of virgin raw materials (such as synthetic collagen or chemically derived omega-3 supplements) compared to marine-based alternatives further compresses the profitability of valorization (CIRAIG, 2015). For small operators operating on tight margins, as is typical in Chioggia's processing sector, these economic barriers are more than challenging.

The third category is **regulatory and institutional**. As shown before, the ABPR imposes approval, infrastructure, and documentation requirements on valorization pathways, creating asymmetric compliance burdens for small operators compared to large industrial players (Grafström & Aasma, 2021; de Jesus & Mendonça, 2018). The lack of standardized procedures for determining by-product status and the risk of misinterpretation of the legislation further discourage investment in valorisation initiatives that depend on legal certainty. As Grafström and Aasma (2021) point out, regulatory barriers of this kind do not operate in isolation but amplify other barriers: unclear regulation discourages investment, which limits the development of markets by reducing the financial incentive to seek regulatory clarification.

The fourth category concerns **organization and governance**. The valorisation of fishery waste is not an activity that individual companies can carry out in isolation (Bourdin & Torre, 2025; Grafström & Aasma, 2021): it requires the alignment of multiple functions across organizational boundaries. Indeed, collection, storage, pre-treatment, logistics, compliance, transformation, and market access activities are typically controlled by different actors. In contexts where there is no governance arrangements capable of managing flows and investments along the value chain, these functions remain disconnected. This governance gap is arguably the most fundamental obstacle, as it impedes the translation of technical feasibility into operational reality.

These four classes of barriers are not independent; they form a system of **interdependencies** in which each barrier reinforces the others. The lack of efficient logistics discourages investment; the lack of investment impedes the accumulation of processing capacity; the lack of processing capacity eliminates buyers for valorizable by-products; the absence of a buyer eliminates any incentive for operators to invest in logistics. This reinforcing loop is closely similar to what the MLP identifies as regime stability (Geels, 2002), and explains why, even in districts like Chioggia, where the material conditions for valorisation appear structurally present, the transition does not occur spontaneously.

Chapter Three - EcoeFISHent as a model of systemic sustainability

3.1 - The EcoeFISHent project

In this chapter the European project, EcoeFISHent, is presented and understood as a operational benchmark, to explore and understand how fish processing waste can be valorised through interconnected circular value chain in a systematic way, and which mechanism need to be deployed and implemented constantly at the territorial level to overcome possible barriers. Despite the importance recognized to the theorical description of the project, the main aim of this chapter is not only to give a broad ideas of the system itself, but also to draws on the EcoeFISHent's experience to grasp relevant insight and lessons which are relevant to increase our understanding about under what conditions can a local fishery system transition towards a regenerative economic model based on waste valorisation.

The project responds to a concrete and well-documented problem: current fish processing practices generate increasing quantities of side streams, such as skins, heads, frames, viscera, and fillet cut-offs , that can represent between 30% to 70% (FAO, 2022) of the biomass used in industrial processing, generating huge amount of waste, which is not fully exploited. This is mainly due to a critical constraint: the rapid perishability and microbial contamination of organic side-streams, which makes collection, storage and transport logistically and economically challenging, often resulting in low-value solutions or waste management being treated as a cost rather than a value-generating activity. Consequently, as shown in Chapter 2, many side streams flow into low-value applications such as fishmeal and fish oil for animal feed, despite their high protein and molecular content. Improved utilisation would enhance sustainability while contributing to industrial development and economic growth.

EcoeFISHent addresses this gap by developing a replicable territorial cluster based on **industrial symbiosis**, where side streams from one sector become raw materials for another, enabling the transformation of fish by-product into diversified, high value-added outputs, employing multiple complementary applications across cosmetics, nutraceuticals, packaging, biomedicine, agriculture, and materials sectors. What EcoeFISHent does is to demonstrate the potential of circular economy approaches through a replicable territorial socio-economic cluster based on the development of innovative, profitable, and climate-neutral circular value chains while implementing territorial systemic solutions and preserving marine ecosystems. In simple words, the project transforms discarded materials from fishing industry activities into valuable resources. The project aims to address the main barriers that limit the sustainable exploitation of fishery side streams.

Its **core objective** is to transform fish-processing waste from a disposal cost into a source of economic value through the development of interconnected circular value chains. At the same time, it promotes the valorisation of both fishery and agri-food residues for sustainable packaging applications and supports the full utilisation of biomass. Another important objective concerns the reduction of marine plastic pollution through the recycling of end-of-life fishing and aquaculture nets, alongside actions aimed at improving the environmental sustainability of fishing practices, such as the adoption of selective fishing tools and measures to reduce by-catch and ghost gear impacts. More broadly, the project seeks to contribute to climate-neutrality and resource-preservation goals by optimising material flows, reducing transport distances, and encouraging the diffusion of sustainable practices among local stakeholders.

To do so EcoeFISHent develops technologies and processes such as advanced biomass pre-treatment and extraction technologies that enables sustainable exploitation of fish-processing side streams for bioactive compounds and gelatine production for high value-added food supplements and skincare products. Additional side streams are converted into soil fertilisers, biodiesel feedstock and chitin, while discarded fishing nets are repurposed into components for the automotive sector.

As mentioned, a common risk for circular initiatives is that they remain isolated experiments. This means that the objective here goes beyond technological validation and seeks to make circular solutions operationally viable within real territorial conditions, to make sure that circularity translates into durable and coordinated configurations.

The **territorial cluster** (mainly located in Liguria and North-West Italy) functions not just as a co-location of actors but as an organised network supported by coordination mechanisms and shared tools. In fact, the consortium is composed of 34 partners from several countries, i.e. Italy, Spain, Norway, France, covering the full range of activities required to address fishery side-streams systemically. The project coordinator is FILSE SpA which favours the strategic integration of research activities, industrial applications, and territorial deployment. It also includes actors directly involved in fisheries, aquaculture, and fish processing activities, ensuring access to primary material flows and operational realities.

Industrial partners range from large food industry actors such as Coop Italia, Generale Conserve SpA, and ICSS SpA, to specialised companies including MICAMO Srl, Green Evolution Soc. Coop., GOMEH Solutions Ltd, and LimHealth Srl, which contribute with specific capabilities in transforming fishery side-streams into higher value-added outputs, addressing different stages of the value chain.

The consortium integrates **research and academic institutions** with expertise in biotechnology, bioeconomy, and sustainable materials. The Università degli Studi di Genova plays a central role in developing valorisation processes for bioactive compounds, while international partners provide specialised knowledge. Public bodies and policy-oriented partners align project activities with regulatory frameworks at local, national, and European levels. Environmental and territorial actors such as WWF Italia and the Consorzio di Gestione dell'Area Marina Protetta del Promontorio di Portofino integrate valorisation strategies with marine ecosystem protection, including ghost gear recovery and selective fishing practices.

International technical and intermediary **partners** provide complementary expertise in research, bioconversion technologies, and cross-regional replication. These actors connect heterogeneous partners, managing information flows and support cooperation, reducing coordination costs and mitigating the fragmentation circular economy initiatives. The composition of the consortium shows the effort of putting together the technical capabilities required for fishery waste valorisation and the organisational and institutional capacities necessary for systemic sustainability.

3.2 – Operational architecture and systemic design

For the purpose of this thesis, beyond the basic idea, it's worth examining some of the more operational aspects in detail. Indeed, it's important to understand that this project's operational architecture is designed to advance from technological development to full systemic validation. The project unfolds over three main phases marked by specific temporal milestones reflecting increasing levels of technological maturity, actors' integration, and territorial embeddedness.

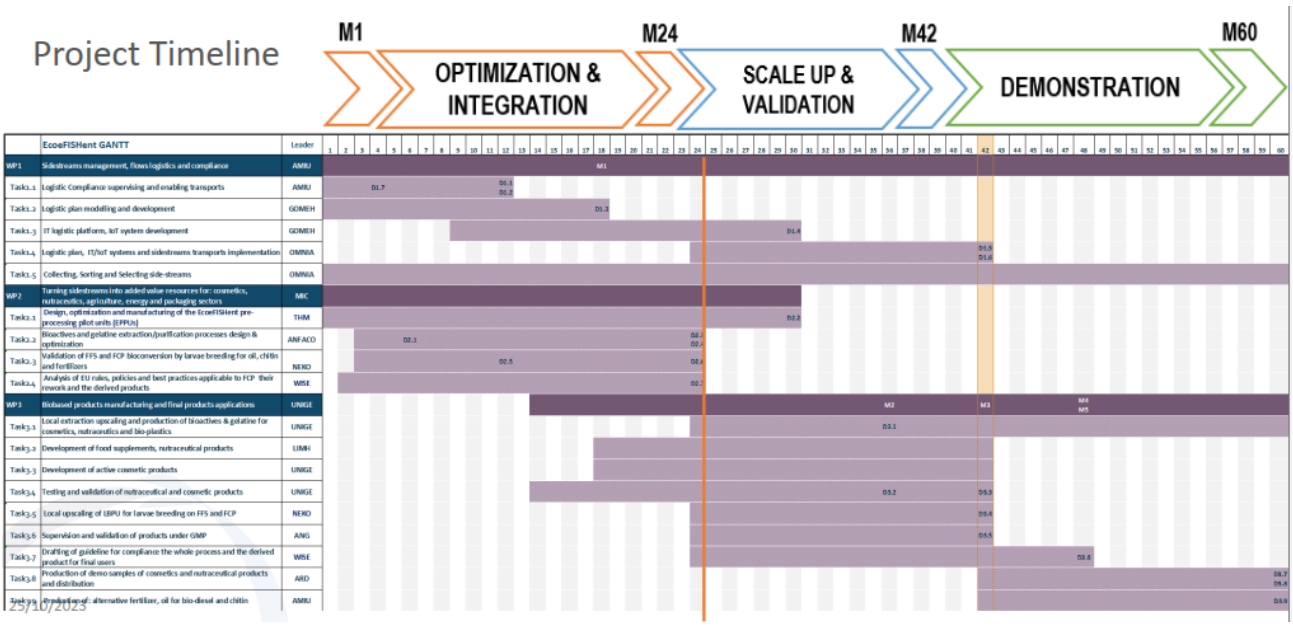
The **first phase**, optimization and integration (M1–M24), optimises technologies and processes at laboratory and semi-pilot scale while integrating project components. The foundations are established: biomass side-streams, polymers and biopolymers, the digital platform, and ecosystem-related actions are developed in parallel and progressively aligned.

The **second phase**, scale-up and validation (M24–M42), transitions from experimental solutions to pilot and pre-industrial implementation. Technologies developed during the initial phase are transferred to operational contexts and validated along multiple dimensions, as several analyses are performed from the technical to the economical or environmental type.

The **final phase**, demonstration (M42–M60), operates the full EcoeFISHnet system. Multiple interconnected circular value chains operate at the same time within a defined territorial setting, demonstrating the project's systemic nature.

The focus shifts towards territorial deployment, market consolidation, and validation of replicability and scalability.

Figure 6: Project Timeline



Source: Eco-eFISHent Project (2023).

This architecture comprises **several work packages**, each addressing a specific dimension partially overlapping and distributed across the **three macro-phases** of the project. WP1 focuses on biomass collection, logistics, and regulatory compliance; WP2 and WP3 on the technological valorisation of fishery side streams and the development of biobased products; WP4 on circular solutions for plastics and bioplastics; WP5 and WP6 on sustainability assessment, scalability, and replicability; WP7 on stakeholder engagement and dissemination; and WP8 on the overall coordination and management of the project.

These work packages are progressively integrated throughout the project. The initial phase focuses on establishing the operational foundations, including biomass management, logistics, regulatory compliance, and the first technological activities. The second phase focuses on the production of biobased products and circular materials, while sustainability assessment and scalability activities are introduced. The final phase involves the demonstration and validation of the circular system, supported by impact assessment, stakeholder engagement, and project coordination. A key enabling element is the **cluster digital twin**, a virtual replica of the physical cluster that collects real-time data and simulates system performance under different scenarios, supporting both operational management and future replication.

EcoeFISHent is structured around **four interrelated pillars**, with communication and stakeholder engagement as a common element. The **first** pillar focuses on transforming biomass side-streams into sources of positive value. The **second** pillar addresses polymers and biopolymers, providing solutions for recycling fishing nets. The **third** pillar is dedicated to ecosystem preservation, encompassing actions to reduce by-catch, remove ghost gear, and prevent environmental impacts. The **fourth** pillar concerns digital platforms and decision-support tools, aimed at optimising logistics, minimise environmental footprints, and support scalability and replicability.

These four pillars are necessary for the creation of a **multilevel circular territorial cluster**. Here the cluster is conceptualised as a demonstrable and replicable socio-economic and environmental system connecting public and private stakeholders within a coherent geographical area, characterised by industrial symbiosis, cradle-to-cradle material flows, and the integration of green and blue economy principles. Basically, is conceived as a **functional network** whose boundaries reflect the availability of complementary competences and infrastructures rather than strict administrative limits, based on three complementary types of connections: vertical connections along value chains between providers and manufacturers; horizontal connections between producers of complementary goods; and institutional connections linking firms with public authorities.

However, **systemic integration** does not emerge automatically, but is actively constructed through governance arrangements, intermediary actors, and shared infrastructures that align individual project components. This occurs through different **coordination**

mechanisms that allows the cluster to function as an integrated industrial symbiosis system. A **first** coordination mechanism is embedded in the project's phased architecture and overlapping WPs, which enable continuous interaction between technological development, operational implementation, sustainability assessment, and governance activities. A **second** mechanism is represented by intermediary and orchestrating actors operating across the project, aligning objectives among industrial, institutional, and research partners. Systemic integration is **further** reinforced by shared digital and logistical infrastructures, as the cloud-based logistics platform and the cluster digital twin that facilitate real-time coordination, data exchange, monitoring activities, and system-level modelling. **Finally**, community involvement and behavioural nudging activities contribute to aligning local practices and stakeholder behaviour with the objectives of the circular cluster, while economic and policy modelling tools support coordination at the institutional level. What makes those mechanisms relevant for this thesis, in addition to their real and technical function, is what they teach us about the necessary conditions for circular economy transition in practice.

Putting together all those actors from universities, industrial firms, public bodies, environmental organisations, to local communities within a single operational system requires more than shared objectives: it is required an active governance infrastructure capable of managing conflicting timelines, regulatory constraints, and asymmetric capabilities. This shows that the interdisciplinarity that we can note is not a case but is deeply and structurally embedded in the structure itself: scientific partners validate processes, industrial actors manage transformation and market access, public institutions ensure compliance, and intermediary organisations reduce coordination costs by managing flows.

The real lesson here, before even thinking of replicating this type of model, is that the most important effort is in the design of the organisational and institutional architecture itself, as it does not emerge automatically from the mere co-location of actors; and according to this logic the technical feasibility of waste valorisation is a necessary but not sufficient condition.

Another element that matters for this thesis, and that is one of the cores of EcoeFISHent contribution, we have to properly focus on are the already mentioned **six circular value chains**. The theoretical definition of circular value chains helps for the understanding of its functioning, in fact we can define a circular value chain as a closed-loop system in which resources, materials, and products are continuously reused, recycled, or repurposed in order to minimise waste generation and maximise resource efficiency. Unlike linear value chains, circular value chains feature cascading uses of materials, multi-output processes, and the integration of environmental and economic objectives.

Concretely, instead of treating fish processing waste as a problem characterized by a single macro-type of output, the project demonstrated that those side streams can be exploited through multiple, successive and interconnected valorization pathways, though a variety of alternative approaches. What makes EcoeSISHent' approach notable is that there are no self-contained loops, meaning that no circular value chain operates in isolation as the residual flows from one chain systematically become inputs for another.

If we look closely, it is possible to say that those value chains follow a multi-level logic as they include several dimensions, from the industrial to the institutional one, but more than that the circular value chains are defined to be cascading, cross-sectoral, and place-based at the same time. The cascading logic ensures that the same biomass can support multiple successive uses, basically maximises resource efficiency by directing biomass towards high-value extraction first, then redirecting remaining fractions towards bioconversion. The cross-sectoral dimension connects traditionally separate industries, including fisheries, agriculture, cosmetics, packaging, automotive, and energy. And lastly, those circular value chain are territorially embedded simplifying the coordination of material and knowledge flows within a geographically coherent cluster.

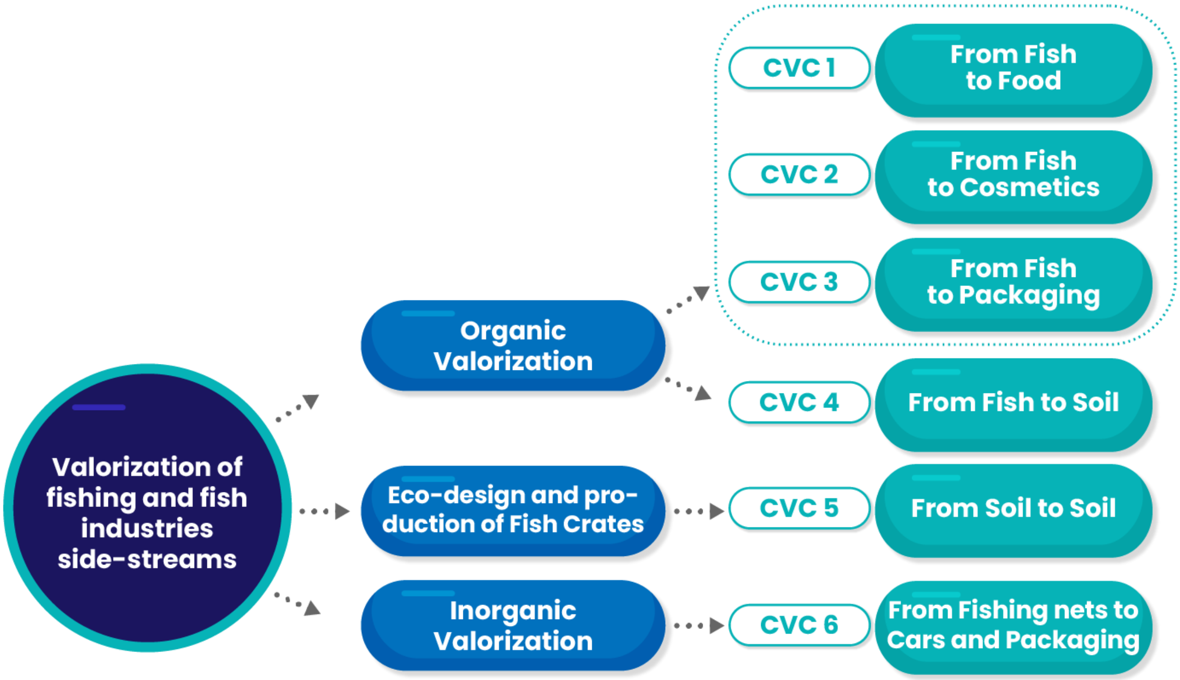
As a result, real value creation resides not within the circular value chain itself, but in the **interconnection** of the whole six circular value chains; but this reasoning implies that there is a level of coordination and multi-actor governance that goes well beyond what a single firm or sector can achieve alone.

EcoeFISHnet generates six circular value chains that explicitly connect the blue and green economy.

- ❖ The **first** circular value chain, from fish to food, focuses on the extraction of bioactive compounds, such as omega-3 fatty acids and peptides, from fish processing side-streams, subsequently employed as high-value ingredients for food supplements and nutraceutical products.
- ❖ The **second** circular value chain, from fish to cosmetics, valorises the same biomass streams through the extraction of collagen hydrolysates and other bioactives used in skincare and cosmetic applications.

❖ The **third** circular value chain, from fish to packaging, is based on the extraction of gelatine from fish side-streams and its application as a bio-based barrier coating for sustainable food packaging.

Figure 7: The six circular value chain



Source: Eco-eFISHent Project (2023).

❖ The **fourth** circular value chain, from fish to soil, addresses bioconversion of organic residues through black soldier fly larvae rearing, generating byproducts as insect oil, chitin, and alternative soil fertilisers.

❖ The **fifth** circular value chain, from soil to soil, integrates eco-design principles into production of biodegradable and compostable fish crates (eco-FISH-boxes) derived from agro-side streams. At end-of-life, these crates are managed through bioconversion processes to obtain soil improvers for agricultural use, closing the loop from soil back to soil.

❖ The **sixth** CVC, From Fishing Nets to Cars and Packaging, addresses the inorganic valorisation of end-of-life fishing and aquaculture nets made of PA6, PA66, and PE. Through recycling, these materials become secondary raw materials for automotive and cosmetic packaging applications, reducing marine plastic litter while generating industrial value.

The integrated design of these circular value chain s allows for **value creation** at several level. Economic value is generated through high-value outputs; environmental value emerges from the overall reduction of waste, emissions, and marine litter. Territorial value, instead, is created by retaining processing activities and revenues at the local level; reinforced by the cognitive value in the form of shared data and operational know-how created while working together.

The integration of value creation, coordinated flows, and functional complementarities allows the system to operate as a coherent industrial symbiosis model. Rather than optimising individual value chains, the project prioritises system-level performance, supporting environmental, economic, and territorial sustainability.

3.3 – EcoeFISHnet as a territorial tenchmark

Beyond its most technical aspects, EcoeFISHnet serves as a territorial benchmark for systemic circular sustainability. By implementing circular value chains and ecosystem-oriented actions, the project generates measurable and connected **impacts** at the local level, aiming for a structural transformation in how economic activities, natural resources, and social practices interact within a geographical area. A first systemic impact concerns the progressive decoupling of economic activities from the consumption of finite resources and greenhouse gas emissions. Through the integrated circular value chains, industrial symbiosis mechanisms, and optimised logistics, EcoeFISHnet demonstrates a concrete reduction in global warming power and a transition pathway towards a circular and climate-neutral economy.

Closely related, EcoeFISHnet also improves the sustainability and circularity of local economic sectors, natural ecosystems, and resource management practices through its capacity to orchestrate different types of actors within a shared governance framework. This orchestration enables a coherent decision-making across the circular value chains, allowing for an equilibrium between economic performance, environmental objectives, and territorial constraints. From an economic perspective, the project facilitates new circular business opportunities and the structuring of an investment pipeline oriented towards regenerative activities.

However, value creation at the cluster level does not automatically ensure equitable distribution among local actors; but, it reflects the cluster's capacity to govern interdependencies in a way that prevents externalisation of high-value activities. Governance therefore functions not only as an enabler of value creation, but as a determinant of value allocation and territorial retention. Employment creation represents another territorial impact, particularly in the short to medium term, that strength the territory's socio-economic fabric and enhance its capacity to retain value. New processing units, logistics infrastructures, digital platforms, and ecosystem-related activities generates demand for new skills and professional profiles. EcoeFISHnet also generates social and behavioural impacts through community involvement and behavioural nudging, as fishers, processors, retailers, and consumers are engaged as active participants, These social dynamics reinforce the legitimacy and durability of the circular transition.

These elements establish EcoeFISHnet as a territorial benchmark, as its significance lies in its capacity to make visible the governance, coordination, and infrastructural conditions under which local value creation and distribution become systemically achievable.

However, it's important to keep in mind that **replicability** is not automatic, but depends on enabling conditions such as biomass availability, logistical infrastructure, governance capacity, and institutional support. What is replicable is not the exact configuration of the EcoeFISHnet cluster, but its systemic architecture, coordination mechanisms, and decision-support tools. In fact, replicability can be defined as conditional and modular: different territorial contexts may adopt specific components, as logistics solutions, coordination mechanisms, or selected circular value chains, depending on local structural and institutional characteristics. This conditionality is what makes this project useful as a benchmark for the analysis performed in the following chapters.

Essentially, EcoeFISHnet relies on some enabling conditions, such as sufficient and consistent side streams flows, logistical and processing infrastructure, diverse and complementary local actors, governance and coordination capacity, and the willingness of local communities and institutions to support circular transitions, which tent to be not equally distributed across fishery system.

In fact, in a context as Chioggia, where, as we will see, fishing activity is significant and primary processing activities are dominant, but high value-added processing takes place largely outside the local system, what we have to figure out in not only if a model like this can be fully copied. The real question, instead, is which are the **components** of this project that can be applied in Chioggia, which barriers need to be addressed first and whether there are or not the conditions for a circular transition, even if partial.

Chapter Four - The Chioggia fishery district

4.1 – The Chioggia fishery system

Before deepening into our empirical study, we need to take a closer look to our unit of study the Chioggia fishery system, one of the most historically consolidated and economically relevant fisheries hubs in Italy. Chioggia can't be defined as a merely coastal town with a fishing port, but as a territorially embedded **local system** whose economic, social and organisation has been structured around fishing and related activities. As it will be evident, it's characterized for the dense territorial concentration of extraction, landing, first-sale and early processing functions within a relatively small area. It can be definitely said that Chioggia is important not because it hosts an isolated fishery function, but because fisheries permeate the local economic structure and organise a wide set of interconnected activities.

For instance, from a territorial perspective Chioggia occupies a strategic position within the Northern Adriatic maritime area. Its fishery system benefits from direct access to fishing grounds and from the presence of port and market infrastructures. The local system is institutionally embedded within broader administrative and logistical frameworks, including the Port System Authority of the Northern Adriatic Sea, which links Chioggia to the wider port and transport infrastructure of the region. The economic significance of the district is reflected in an estimated annual turnover of at least €800 million per year. This figure reflects not only the direct value of fishing activities, but also the broader economic relevance of the local system in terms of associated logistics, trade, first processing and commercial transactions.

Its relevance is also confirmed by the existence of long-term structured statistical monitoring, in fact the local fishing fleet has been documented through dedicated databases, specifically the Clodia database (2023) managed by the Università di Padova, since 1991, while landed catches have been recorded since 1945. The productive capacity of the system is tied to its fishing fleet, which constitutes the upstream segment of the local value chain and the primary source of biomass.

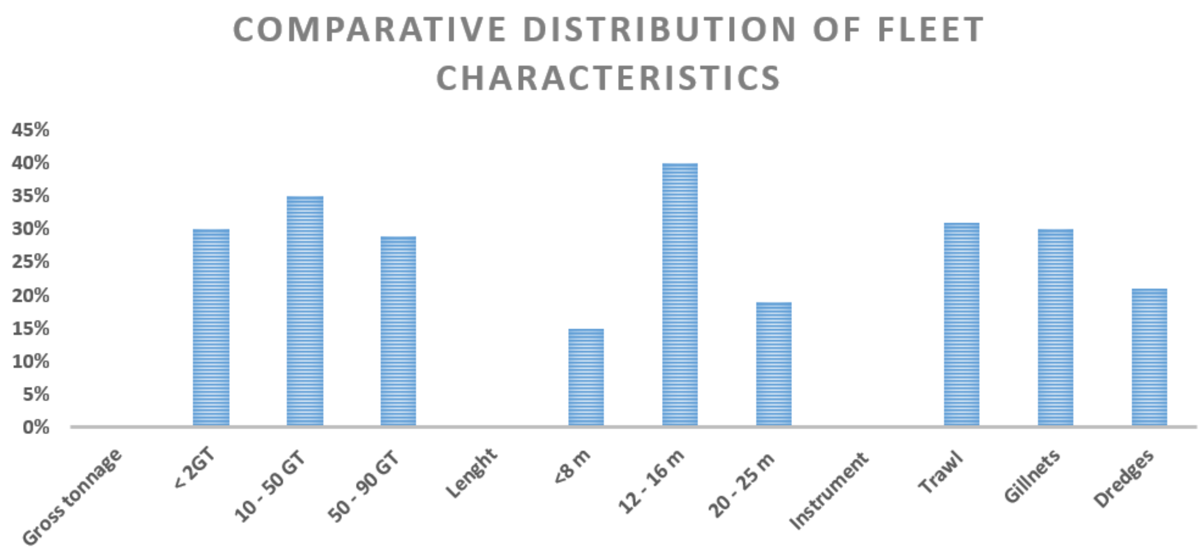
As of 2025, the fleet comprises 224 vessels, indicating a high concentration of fishing activity within a relatively limited territorial space. The number of vessels is not the only relevant information, but also the structure of the overall fleet. In terms of gross tonnage, approximately 35% of vessels fall within the 10–50 GT range, while around 30% are very small vessels below 2 GT and a further 29% lie between 50 and 90 GT. This distribution points to a system based on the **aggregation** of numerous relatively small and medium-sized units.

A similar pattern emerges when vessel length is considered. Around 40% of the fleet measures between 12 and 16 metres, approximately 15% is below 8 metres, and a further 19% falls within the 20–25 metre range. These figures confirm the prevalence of small and medium-scale operations within the district. While the aggregate figure indicates a substantial fishing capacity (i.e., tot. 43,538 kW of engine power), its distribution across a large number of vessels suggests a productive structure in which **capacity is dispersed** among many operators rather than concentrated in a few industrial actors.

The district's relevance, in other words, is generated by **density and continuity** rather than by concentration in the hands of a few large enterprises. The structure of the fleet is further characterised by the diversity of fishing gears employed. The most widely used gears include trawl nets, accounting for 31% of vessels, followed by gillnets and set nets used by 30% of vessels, and hydraulic dredges, employed by 21% of the fleet.

This combination of gears reflects a system that targets both demersal species and molluscs. It also confirms that Chioggia is not specialised in a single narrow niche but instead hosts a diversified extraction system with a broad biological and commercial base.

Table 5: Comparative distribution of fleet characteristics



Source: Clodia database, 2023. Fisheries database in Chioggia, Northern Adriatic. – Own Elaboration – http://chioggia.biologia.unipd.it/banche-dati/

The volume of landings channelled through Chioggia's infrastructures provides a further measure of its capacity. In 2023, approximately 6,319 tonnes of locally caught fish products were landed, while in 2024 landings increased to around 6,610 tonnes. These figures confirm the substantial and continuous **throughput** of biomass handled by the district. The composition of landings is also relevant. In 2024, anchovies and sardines alone accounted for approximately 3.4 thousand tonnes; molluscs also constitute a major component of the catch, with volumes approaching one thousand tonnes.

The structure of the local fishery **value chain** can be reconstructed as a sequence of closely connected but functionally distinct stages. In simplified terms, the chain includes fishing activities upstream, followed by landing and first sale, primary processing, and distribution towards regional, national and large-scale retail channels.

The **upstream** segment is mainly composed of local fishers operating through independent vessels, that as seen tends to be characterised by small operators. Their activities include extraction and basic handling at sea, generating the primary material inflow. **Once landed**, fish products enter the main node of the local system, the wholesale fish market. The market acts as the main node for first sale, product classification, price formation and logistical redistribution. Fish landed through the port are channelled into this centralised marketplace where products are sorted, traded and directed towards downstream buyers and distribution channels. This function makes the market a key point of articulation between fishing activities and the wider commercial system. The **next phase** consists of primary processing activities carried out by local small and medium-sized enterprises. These firms typically engage in low- to medium-complexity operations such as cleaning, filleting, packaging, cold storage and refrigeration. Finally, products move into distribution channels directed towards wholesalers, retailers, the horeca sector and large-scale organised distribution.

This sort of structure is reinforced its **institutional recognition**, in fact the local system of Chioggia is included within the Fishery District of Rovigo and Chioggia, officially recognised at regional level in 2017. This recognition was than implemented into a framework which was subsequently operationalised through multi-year strategic tools, including an Operational Plan for the period 2021–2024. In fact, the presence of cooperatives, consortia, local authorities and sectoral bodies contributes to the institutional density of the system; which, with the fish market and port infrastructures, form the overall architecture composing the system's productive base.

Going back to the concrete configuration of the system, it is clear that the fishery value chain in Chioggia is territorially concentrated in its core upstream stages. Fishing, landing, first sale and early processing are all strongly localised within the district. However, the majority of actors are micro-enterprises and small firms, often family-owned or cooperative-based, and are concentrated in fishing and primary processing activities. The local market provides a centralised mechanism for first sale and product circulation, while processing firms add immediate commercial value through basic transformation and preparation.

The local productive structure can therefore be described as **dense** and **specialised**, but also strongly oriented towards extraction, landing, first sale and early-stage processing. This configuration is not only a descriptive feature of the local system, but a structurally significant one. To sum up, the value chain in Chioggia is dense in its upstream phases but becomes more thinner as we focus on the downstream phases, towards more advanced forms of transformation or waste management activities. As it's possible to understand from what highlighted up to now fishing, landing and first sale concentrate a large number of operators with significant infrastructure and substantial biomass flows.

However, a first relevant insight that we can grasp is that the phases in which **residual materials** could be converted into higher value-added outputs are largely absent from the local productive fabric. In other words, Chioggia generates enough fish processing side stream, but it's the system itself which is not enough developed to economically exploit the biomass produced. This type of structural imbalance, the huge difference in density between upstream and downstream, introduces one of the core elements that will be analysed in other section, which is that the **gap** between waste generation and local value creation is not a temporary absence, but the outcome of a **path-dependent trajectory**.

4.2 – Waste generation

A critical element of our local system to consider is the waste generation. In the fishery sector, waste should not be interpreted as a marginal outcome of production, but rather as a residual material flow that emerge across different stages of the local value chain. Specifically, in a high-intensity fishery system as Chioggia, characterised by significant landing volumes, a structured fish market, and a dense network of operators, these residual flows are generated on a continuous basis, representing a stable and recurring output of the local system. Basically, the relevance of these flows consists not just in their environmental implications, but also in their potential to be the material basis for new local value creation processes.

Within the Chioggia fishery system, waste is generated along the entire value chain and can be linked to **three main phases**, each associated with specific actors and activities.

A **first** relevant source of waste generation is the harvesting phase itself. Fishing activities may produce residual biomass in the form of non-commercial catches, undersized species, damaged fish, and by-catch that cannot enter regular market channels. The specific composition and quantity may var, but they represent an upstream source of biological residuals. In addition to organic outputs, harvesting operations may also generate non-organic waste as worn ropes, damaged nets, gear components, and on-board packaging.

A **second** critical point of waste generation is the landing and first-sale phase, centred around the Chioggia wholesale fish market and associated activities. Once landed, fish products are sorted, classified, stored, transported, and prepared for sale, generating potential losses and residuals linked to handling, quality selection, damaged lots, unsold products, and low-value fractions that do not meet market requirements.

A **third** major source of waste generation is related with post-landing handling and primary processing activities. At this stage, whenever fish is cleaned, filleted, or prepared for sale or catering, a significant share of the biomass is separated from the edible portion. Importantly, this phase concentrates substantial volumes of biomass and related materials in a limited area and within a short time span.

This concentration, in theory, creates favourable conditions for the organisation of collection, sorting, and pre-treatment activities, reducing logistical barriers to local valorisation processes. However, these processes are generally characterised by a low level of transformation and limited integration with more advanced industrial activities. As a result, despite the presence of substantial quantities of biomass, the local system does not develop valorisation processes capable of extracting economic value from these secondary flows.

A critical step here is the **quantification** of the volume of those fishery waste generated with the Chioggia system as no systematic monitory of by-product production could be found. This absence speak for itself, in fact the lack of a specific measurement system reflect the absence of an approach oriented toward waste valorisation. However, what can be done is an estimation of the volumes based on the literature and the landing of the system. As previously mentioned, established by the FAO and confirmed by extensive scientific literature, fish processing by-products typically represent between 30% and 70% of the total fish weight, depending on the species and processing method (FAO, 2022; Coppola et al., 2021).

Looking more closely, for filleted fish waste can represents up to 50% (Rout et al., 2025) of the weight of the raw material, while for species such as sea bream, which is widely traded in Chioggia, by-products have been found to represent approximately 61% of the total fish weight (Pateiro et al., 2020). Since we have, with a good degree of certainty, the official landing volumes in Chioggia, we can apply those values and what we obtain as a hypothetical estimate of the residual flows potentially generated within the system. Total landings in 2024 amounted to appr. 6,610 tonnes. Anchovies and sardines, small pelagic species that generate little waste, accounted for over half of this volume (appr. 3,400 tonnes). The remaining fraction, consisting of demersal species, molluscs, and fish of greater value, is more subject to local processing, generating larger volumes of transformable byproducts. Applying **a conservative average byproduct ratio** of 30-40% to the remaining quantities (appr. 3,200 tonnes), we obtain an **estimate** of approximately **960 to 1,280 tonnes of organic byproducts** resulting from processing.

From a **compositional** perspective, the waste generated in the Chioggia fishery system can be broadly divided into two main categories: organic residuals and inorganic residuals. **Organic** residuals include fish processing by-products such as heads, bones, skins, viscera, and filleting waste, as well as non-commercial catches, shell fractions in the case of mollusc-related activities and other biological materials. These streams are particularly relevant because they contain compounds such as proteins, oils, and collagen, which are widely recognised in the literature as inputs for higher value-added applications. **Inorganic** residuals, by contrast, include materials such as expanded polystyrene fish boxes, plastic packaging, disposable handling materials, and end-of-life fishing gear. Although these streams differ substantially from organic side-streams in terms of composition, treatment, and valorisation pathways, they remain an integral part of the sustainability challenge, that extends beyond biomass alone. However, the relevance of these residual flows lies not only in the fact that they are generated in significant quantities, but also in the fact that they possess recognised economic potential.

According to the literature, fishery by-products are increasingly considered suitable inputs for a wide range of value-added applications. The FAO itself highlights that how fish processing by-products can be transformed into multiple value-added outputs such as fishmeal and fish oil, fertilisers, biofuels, silage, and that their underutilisation represents a missed opportunity in terms of economic value creation.

Beyond these more conventional outlets, recent research has also shown that fishery side-streams may serve as raw materials for higher-value industrial and bio-based applications. For example, Gaikwad and Kim (2024) note that fish by-products such as skins, scales and bones can be used for the extraction of collagen, which is increasingly employed in the food, cosmetic, biomedical, and pharmaceutical sectors. The importance of this perspective is clear, as it directly links the issue of waste generation to the broader question of preserving local value. If fishing by-products can be used to fuel new industrial and commercial applications, then their disposal, outsourcing or low-value-added processing represent not only an environmental inefficiency but also a missed economic opportunity for the local production system.

This line of reasoning, and the relevant literature, is also reflected more concretely in the EcoeFISHent project, which states that fish side-streams can be pre-treated and transformed into higher-value outputs, opening new circular value chains in several different sectors. To make this **gap** more concrete, it is useful to return briefly to the EcoeFISHnet project introduced in Chapter 3. As we have explained already that project identifies six circular value chains, and each of these represent a technically viable valorisation pathway, requiring specific competences, infrastructure and inter-organisational coordination.

When mapped against the Chioggia system, the contrast is immediate: none of these value chains appears to be structurally embedded in the local system. What is being highlighted is that **in theory** the system produces the inputs for alle the six value chains, but what is considered to be absent are all those conditions that are needed to activate at least one circular value chain. In other words, EcoeFISHnet is not just a model to replicate, but a clear reference of what could be achieved changing the structural configuration described in the section 4.1.

4.3 – Structural and systemic barriers

As we have said the Chioggia fishery system mainly hosts the core upstream phases of the fishery value chain, with a number of companies that operate in primary processing activities.

However, the analysis clearly shows a discontinuity between upstream and downstream phases. While extraction, first sale and low-complexity processing are strongly localised within the district, higher value-added activities are not present locally and are instead externalised outside the territory. This suggests that Chioggia functions primarily as a production and transit node, rather than as a site of integrated value creation along the entire fishery value chain.

If we look closely, the analysis of the local system shows a configuration characterised by a high concentration of production activities and the continuous generation of fishery by-products along the value chain. Such conditions would, in principle, favour the emergence of locally embedded valorisation processes. However, this potential remains largely unexploited and in fact the Chioggia system does not appear to have developed structured pathways for their local transformation into higher value-added products. This means that the **main constraint** is not the lack of material resources, but the limited capacity of the local system to retain and process value within the territory.

A critical issue concerns the disconnection between waste generation and value creation. Although fishery by-products are generated within the local system as a direct consequence of fishing, handling and processing activities, the conditions required to transform these materials into higher value-added outputs appear to be much less developed. In other words, while Chioggia produces the biological input necessary for a wide range of valorisation pathways, it does not seem to control the downstream stages in which such input would be converted into economic value.

The problem is not simply that some activities are performed elsewhere, but that the local system remains functionally concentrated in the upstream segments of the value chain while more advanced forms of transformation are largely absent or externally performed. As a result, the territory contributes to the generation and concentration of biomass but captures only a limited share of the value that could potentially be derived from it.

Seen in this light, the Chioggia case reveals that on the one hand, the system displays several conditions that would theoretically support the emergence of regenerative pathways: productive concentration, continuity of biomass flows, territorial specialisation and spatial proximity between actors. On the other hand, these same conditions have not translated into a locally embedded valorisation system. Basically, this means that fishery waste remains materially embedded within the local system but not economically embedded within it. This situation is not a **temporary gap** or the simple absence of a single initiative, but it points to a more structural condition of the local production system. In this sense, the issue is not that some advanced activities are located somewhere else, but that the local system has evolved around a productive architecture that privileges extraction and primary commercialisation over secondary transformation and regeneration. The transition from waste generation to waste valorisation requires more than the physical availability of by-products: it requires technological competences, treatment infrastructure, specialised firms, stable inter-organisational linkages and the ability to coordinate different phases of a new value chain.

This case suggest that the absence of local valorisation should be read as the outcome of a **path-dependent development trajectory**. Over time, the system appears to have consolidated around those activities in which it already possesses experience, routines, infrastructures and market functions. From this perspective, the challenge is not simply to improve waste management practices, but to understand why the territorial conditions necessary for a more advanced form of valorisation have not realized.

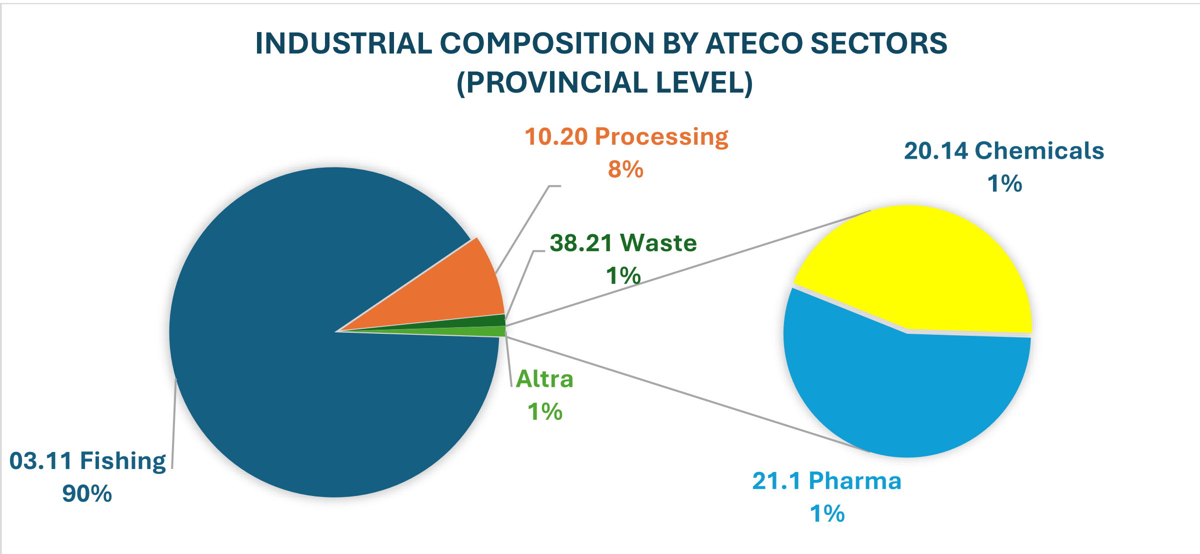
This structural criticality in Chioggia can be more clearly understood by looking at a set of **interrelated constraints** that shape the functioning of the system. This do not refers to waste management in a narrow sense, but rather the broader territorial conditions through which fishery by-products may, or not, be transformed into new economic activities. In this respect, the limits of the local system appear to lie but in the absence of a sufficiently integrated productive and organisational environment able to support valorisation pathways in a stable and territorially embedded way.

A first issue concerns the **fragmentation** of actors and activities across the local fishery value chain. The Chioggia system is composed of a plurality of operators involved in different phases of fishing, sale, and distribution, many of which are relatively small in scale and specialised in specific functions. This structure reflects the historical evolution of the district and contributes to its productive base, but it also creates important limitations from the perspective of regenerative valorisation. The transformation of fishery waste into higher value-added outputs requires not only the availability of residual biomass, but also the capacity to ensure continuity of supply, coordinate collection and organise shared investments. In a fragmented system, these conditions are harder to achieve.

This issue is closely linked to a second constraint: the **externalisation** of higher-value processing and transformation activities. While Chioggia plays a central role in the generation, landing and initial circulation of fishery products and by-products, the more advanced phases through which these materials could be converted into bio-based, nutraceutical, cosmetic or industrial outputs do not appear to be present in the local economy. As a consequence, the territory remains strongly involved in the production of the inputs, but only marginally involved in the phases where these inputs are technologically re-elaborated and economically upgraded.

A further dimension of this problem emerges from the **local industrial composition**. As previously said the productive structure of the area is heavily concentrated in primary fishing activities, while the presence of firms operating in more advanced processing, biochemical transformation or industrial valorisation remains extremely limited, and this is confirmed by available evidence. In fact, the analysis of ATECO classifications offers a useful, although not exhaustive, indication. The data reveal a strong concentration of fishing activities (ATECO 03.11), with approximately 800 enterprises registered at the provincial level. This confirms the high degree of productive specialisation in marine fishing within the territory. By contrast, only 30 enterprises are registered under ATECO 10.20 (fish processing and preservation), indicating

Table 6: Industrial composition by ATECO sectors (provincial level)



Source: Istat, Statistical Register of Active Enterprises (ASIA - Enterprises), 2023. – Own Elaboration

a significantly smaller presence of primary processing activities relative to extraction. Even more significant is the almost complete absence of enterprises operating in higher value-added transformation sectors. No firms are registered locally under ATECO 21.1 (pharmaceutical products) or 20.14 (basic organic chemicals), suggesting that advanced bio-refining or ingredient extraction activities are not embedded within the local productive structure. Similarly, waste treatment activities (ATECO 38.21) appear to be marginal and primarily located outside Chioggia, notably in the Venice urban area.

These data must be interpreted with caution, given the aggregation limits of ATECO codes and the fact that provincial statistics may not fully capture the local productive base of Chioggia. Nevertheless, they point to an important structural issue: the local system appears to lack the industrial complementarities that would be necessary to absorb, stabilise and transform fishery by-products into higher value-added outputs. Basically, the problem is not to "find a use" for waste, but to have a territorial production system capable of exploiting it economically.

Finally, these critical points are enhanced by the limited presence of **coordination** mechanisms able to connect actors, activities and potential valorisation opportunities within a coherent territorial strategy. Fishery waste valorisation is not a process that can emerge spontaneously from the actions of individual firms operating in isolation. On the contrary, it requires the alignment of multiple functions that are usually dispersed across different organisational and institutional domains: collection, storage, pre-treatment, logistics, compliance, technological processing, market access and investment. In contexts where no clear orchestrating actor or stable governance arrangement exists, these functions tend to remain disconnected, even when the underlying material flows are sufficiently relevant.

To sum up, those conditions of which we have spoken about up to now are the starting point from which any transition toward circularity and waste valorisation need to understand to depart. Those are not just problems or constraint to be listed for academic purposes but are the outcome of a specific history and trajectory that has always preferred to continue on its way without any modification. Understanding this is a condition to make sure whether if it is possible, and under which conditions, to move toward a new and more sustainable trajectory.

It is this line of reasoning and questioning that the following chapter addresses through empirical investigation. Drawing on field interviews with local actors the next chapter explores how these barriers are perceived from inside the system and what concrete conditions and actions need to be put in place for the Chioggia system to begin capturing the economic value of its own side streams.

Chapter Five – Methodological approach

5.1 – Research context and design

This chapter presents the methodological choices underlying the empirical component of the thesis. The research aim is to understand why, in a highly concentrated fishing district like Chioggia, local valorization of fish waste does not occur despite the existence of theoretically applicable circular and regenerative economy models.

Epistemologically, the research is in the tradition of **critical realism** (Jessop, 2005; Jessop, 2005). This approach was chosen because it offers a coherent framework for investigating real but not immediately observable phenomena, such as governance failures, institutional inertia, or the lack of coordination between actors. At the same time, some elements of the research also draw upon the perspective of **social constructionism**, as particular attention is paid to the interpretations and perceptions of the actors involved. The interviews allowed us to explore how different stakeholders in the local fishing system interpret the concept of sustainability, perceive the opportunities associated with waste valorisation, and attribute significance to the main obstacles that characterize the local context. From a logical perspective, rather than testing predefined hypotheses or building a theory from data, the research follows **abductive reasoning** as it moves iteratively between empirical observations and theoretical frameworks, starting with a surprising phenomenon and working backward to identify plausible explanatory mechanisms (Reed 2005).

The study adopts a **qualitative research approach**, appropriate given the complexity and context-dependent nature of the phenomenon under study. Qualitative methods are particularly suited to exploratory and explanatory research, whose goal is to understand processes, meanings, and causal mechanisms rather than measuring frequencies or correlations (Creswell & Poth, 2018; Denzin & Lincoln, 2018). Consistent with these premises, the **research strategy** adopted is that of a **case study**. This methodology was chosen because the research question requires an in-depth investigation of a real-world context in which the boundaries between the phenomenon (the lack of local valorisation of by-products) and its context (the structural and institutional characteristics of the local system) are not clearly distinguishable (Yin, 2018; Dubois & Gadde, 2002). The case of Chioggia represents a particularly significant context for investigating the phenomenon under study. This is not meat to be representative of all fishing districts; however, it is believed to offer analytical insights into the conditions under which regenerative transitions can emerge in local production systems, particularly agri-food. Finally, the methodological approach adopted is consistent with the **four objectives** of the research:

- ❖ To examine the theoretical foundations of the circular economy, local systems, and the blue economy as applied to fish waste valorisation;
- ❖ To map the methods of waste generation and management in the Chioggia fisheries district;
- ❖ To identify the main barriers hindering local valorisation;
- ❖ To evaluate the potential applicability of regenerative and symbiotic models in the analysed territorial context.

The entire research design was therefore constructed to understand not only whether local waste valorisation is possible, but also why, under current conditions, this process is unable to develop within the local system of Chioggia.

5.2 – Sampling

Primary data collection was conducted through a combination of **semi-structured interviews**, exploratory contacts with industry players, and direct observation of discussions between local stakeholders. The study is based on **non-probability sampling**, which combines two approaches: purposive sampling and heterogeneous (maximum variation) sampling (Patton, 2015; Saunders et al., 2019). The goal, in fact, was not to obtain a statistically representative sample of the entire population involved, but rather to gather in-depth information from individuals capable of providing privileged knowledge.

The initial selection of interviewees was guided by a **purposive sampling** approach, favouring stakeholders with specific knowledge of the Chioggia system, its governance structure, and the management of fish by-products. **Heterogeneous sampling** was then applied to ensure that the selected participants reflected the diversity of roles, positions, and interests present in the local system. This combination is particularly valuable in case study research with small samples: although it may seem contradictory to look for variation in a limited number of cases, Patton (2015) argues that any emerging patterns across highly diverse participants carry significant analytical weight.

Table 7: Rationale for category sampling

Analytical category	Why interview them	What we want to understand
1. Productive actors (fishermen, cooperatives, processors)	They are the material source of waste and represent the production base of the local system, through primary processing and marketing activities.	Current waste management methods; economic and logistical constraints; perceived opportunities or obstacles to local valorisation.
2. Intermediaries / Coordinating Actors	They influence the level of integration and cooperation between local actors as they coordinate and represent businesses, the supply chain, and the region.	Level of systemic vision; orchestration mechanisms; ability to activate collective projects; degree of fragmentation or integration
3. Institutions / Public Actors	They influence the enabling conditions for systemic transition, as they define the regulatory, infrastructural & strategic framework.	Existence of policies, incentives, or support tools; regulatory barriers; public role in waste valorization.

Source: Own elaboration

This methodological choice is consistent with the research objectives. Indeed, what is examined in this thesis cannot be directly attributed to a single actor, but emerges from the interaction between businesses, coordination bodies, institutions, and the local context.

5.3 – Interview protocol and data collection

Primary data were collected between March and May 2026 through three complementary sources: semi-structured interviews with key stakeholders, telephone contacts with operational actors, and participant observation during a public conference on the blue economy.

In the first phase, a list of potential participants belonging to the various identified categories was prepared. Numerous attempts were made to contact them via email and subsequently through direct telephone contacts, however, many organizations showed limited willingness to participate in the research. Several participants did not respond to interview requests, while others stated they were not interested or not involved in waste management.

The primary data collection tool was semi-structured interviews (Ruslin et al., 2022; Creswell & Poth, 2018), a method that ensures a shared thematic framework across all interviews while maintaining the flexibility to explore spontaneously emerging themes. Given the heterogeneity of the three analytical categories (see Table 5.1), semi-structured interviews allowed each conversation to be tailored to the participant's specific role and experience, while maintaining consistency with the research objectives. All interviews were conducted remotely via videoconferencing platforms, lasting approximately 45 minutes each, and were conducted in Italian to ensure clarity of expression and facilitate a more natural and open discussion.

In a preliminary phase, the definition of the main areas of investigation was guided by the literature review presented in the previous chapters. At the same time, to obtain a comprehensive overview, a preliminary discussion was held with the project manager of the European EcoeFISHent project. This step played a very important role in orienting the interviewees, allowing for a better understanding of some of the technical and organizational aspects that characterize the organization of initiatives aimed at valorizing fish waste. The interview guide was structured around a series of common basic questions, posed to all interviewees regarding their role in the system, their relationship with sustainability, and their perception of the sector's main challenges. The outline was subsequently adapted based on the interviewee's category. This customization was necessary to consider the different responsibilities, skills, and perspectives of the stakeholders involved.

- For **production stakeholders**, the focus was primarily on the operational aspects of waste management, the costs incurred, logistical constraints, and the perception of potential economic opportunities associated with valorisation.
- For **coordination stakeholders**, interest was focused on the functioning of the supply chain, the level of cooperation between operators, and the local area's capacity to develop collective initiatives.

- ❖ Finally, for **institutional stakeholders**, the questions were aimed at understanding the role of public policies, local infrastructure, and support tools capable of fostering transitions toward more sustainable models.

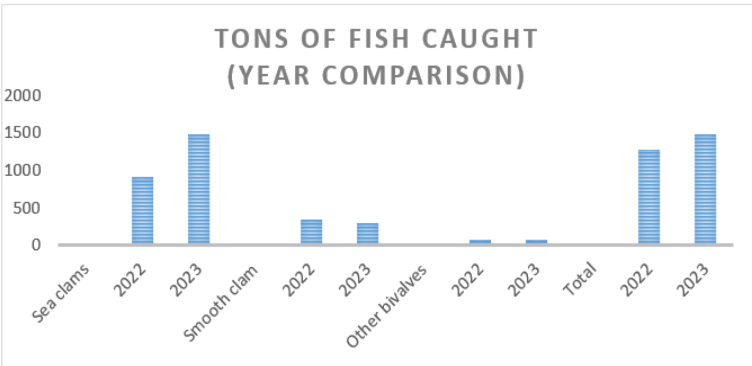
Despite the differences between the interview tracks, all interviews were structured around some common thematic cores, then the semi-structured nature of the interviews also allowed to delve deeper into themes that emerged spontaneously during the conversations, which had not been considered central in the literature, but which the interviewees highlighted as relevant.

- ❖ **Co.Ge.Vo. – Consorzio di Gestione della Vongola**

The first interview was conducted with a representative of Co.Ge.Vo. (Clam Management Consortium). The consortium plays a central role in managing one of the most significant production activities in the area: it brings together approximately **85 fishing** companies that catch bivalve mollusks, such as sea clams, cockles, and razor clams, operating along the entire Veneto coastline. In terms of production, they caught a total of **1,845 tons** of bivalve mollusks in 2023, recording a 43.7% increase in production compared to the previous year. Although this sector remains subject to marked seasonal and cyclical variability, Co.Ge.Vo. represents an essential point of reference for numerous operators in the local supply chain. The choice to include this entity stems from its ability to offer a perspective directly related to the management of production activities and the operational issues that characterize the sector. The interview provided insight into the operators' perceptions of sustainability, the main challenges associated with waste recovery, and the conditions considered necessary to make any initiatives economically and organizationally sustainable.

Figure 8: Contextual data

Consortium enterprises **~85**	Turboblower boats **77**
Total production 2023 **1.845 t**	Variation vs 2022 **(+43,7%)**



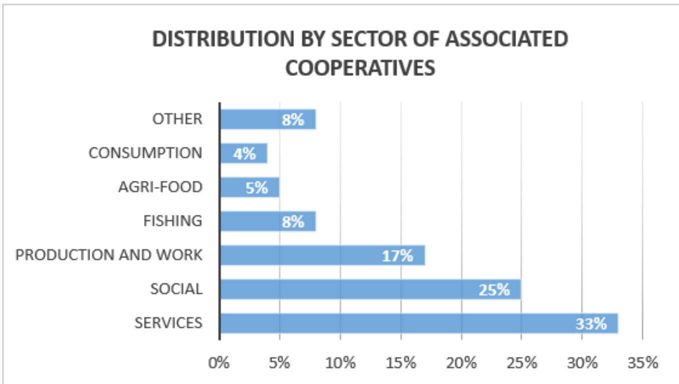
Source: Own elaboration based on data from CO.GE.VO. (n.d.) - https://www.cogevo.it/

❖ Legacoop Veneto

The second interview was conducted with a representative of Legacoop Veneto, active in the fishing sector. Legacoop is one of the main cooperative representative organizations at the regional level: it has 335 member cooperatives active in various sectors, including fishing (8% of the total), with a total production value exceeding €2.3 billion. At the national level, Legacoop's Fisheries Department brings together **300 cooperatives and 95 companies**, with a turnover of approximately €300 million, equal to 25% of the Italian fishing GNP, and manages over **3,100 vessels**, or approximately 25% of the total national fleet, with **8,600 members** (27% of Italian fishing and aquaculture workers).. The presence of this representative was particularly important because it allows for an observation of the system from a perspective midway between the production and institutional levels. Through direct contact with cooperatives operating in the region, Legacoop has in-depth knowledge of the operational criticalities that characterize the sector, as well as the difficulties that arise in implementing collective projects and innovative initiatives. The interview allowed us to gather information regarding the level of coordination among operators, the main criticalities perceived by stakeholders in the supply chain, and potential enabling conditions.

Figure 9: Contextual data

Fishing turnover **~300 M€** 25% of national fish GNP	Fishing cooperatives **300** 95 partecipating enterprises
Managad boats **3.100+** 25% of national fleet	Memebers **8.600** 27% of fishery workers



Source: Owns elaboration based on data from Legacoop (n.d.) - https://legacoop.veneto.it/ e https://www.dipartimentopesca.it/

❖ Distretto Ittico di Chioggia e Rovigo

The third interview was conducted with the President of the Chioggia and Rovigo Fishing District. The District is one of the main aggregating bodies of the local fishing system and serves as a link between businesses, cooperatives, trade associations, institutions, and other stakeholders involved in economic activities related to fishing and aquaculture. In terms of its structural importance, it is a leading entity at the national level: founded in 2004 as the "Distretto Itico di Rovigo," it is now the largest fishing district in Italy in terms of territorial size and number of businesses. In the fishing and aquaculture sector alone, there are approximately **2,000 companies in the province of Rovigo**, while the province of Venice has 862; the total annual turnover **exceeds €800 million**, with approximately 8,500 employees. The District covers the entire fishing supply chain, establishing itself as an integrated production system with strong local roots. The interest in this interlocutor stems from his privileged position in observing local dynamics. The interview provided insights into the structure of the local system, the level of cooperation among operators, the development prospects of the area, and the conditions for promoting waste recycling initiatives.

Figure 10: Economic data

District's enterprises	Total annual turnover	Total employees	Export (2017)
~2.862	**~800 M€**	**~8.500**	**102,8 M€**
RO ~2.000 · VE ~862	Entire seafood supply chain	Fishing, processing and trade	Monitor Intesa Sanpaolo

Source: Owns elaboration based on data from Consorzio distretto ittico di Rovigo e Chioggia (n.d.) - https://distrettoittico.it/site/

In addition to the three in-depth interviews, telephone contact was made with different production actors. Several organizations were contacted via email; given the low response rate, telephone contact was also attempted. Most calls ended with the interlocutors being unavailable, being redirected to other contacts, or explicitly refusing to answer. Some organizations were available for a few minutes of conversation. Although their brevity and informality preclude them from being classified as true interviews, they provide relevant complementary information, particularly regarding the perception of waste generation and the receptivity to valorization initiatives among operational actors.

An additional source of empirical material was a public conference on the blue economy held at Ca' Foscari University on February 11, 2026, in which I participated along with my thesis advisor. The event included a roundtable discussion that brought together stakeholders from the fishing sector, cooperative organizations, and regional institutions. The discussion offered a collective and relatively spontaneous expression of perspectives on the state of the sector, the obstacles to the transition to sustainability, and the role of various stakeholders. Roundtable participants included: Antonio Gottardo (Legacoop Veneto) and Roberto Varagnolo (Co.Ge.Vo), Giuseppe Cherubini (institutional stakeholder, Veneto Region), Alberico Simioli, Andrea Fabris, Renato Palazzi, and Flavio Rizzoli.

Once data collection was completed, the interviews were transcribed in full into Italian to preserve the original meaning of the interviewees' statements and allow for an in-depth analysis of the empirical material collected. Data analysis was conducted using an approach inspired by thematic analysis (Braun & Clarke, 2006), a technique suited to identifying, organizing, and interpreting recurring patterns within qualitative data. The goal is not only to describe the interviewees' statements, but also to identify recurring patterns and key divergences that can be interpreted in relation to the developed theoretical framework. In parallel with the analysis, the notes collected during the Blue Economy conference and the information emerging from telephone conversations were also used as triangulation tools to strengthen the understanding of the context and verify the coherence of the interpretations developed.

5.5 – Methodological limitations

As is inherent to any qualitative study, and particularly one based on a limited number of interviews, this study presents limitations that must be acknowledged to properly understand the significance of its findings.

The **first** limitation concerns the size of the interviewed sample. Although the initial research design envisioned the involvement of a larger number of individuals, the data collection process revealed limited willingness to participate on the part of many of the organizations and businesses contacted. Consequently, the number of in-depth interviews conducted was lower than initially anticipated. This inevitably limits the possibility of considering the results as representative of the entire local system; rather, they should be understood as a comprehensive description of the positions within the supply chain. In this sense, the informative value of the interviews derives not so much from the sample size as from the strategic position of the interlocutors within the system.

A **second** limitation concerns the composition of the sample itself. Despite the initial attempt to gather perspectives from all key levels of the supply chain, the research received greater availability from those operating in coordination and representation roles than from those directly involved in production activities. This limits the possibility of systematically gathering the views of the companies most directly involved in the generation and management of fish by-products. In particular, the difficulty in accessing this category of stakeholders is an empirical finding in itself: the pattern of non-response and disengagement reflects a certain degree of institutional distance and cultural resistance that is analytically relevant.

A **third** factor to consider is the specific territorial nature of the case study. The Chioggia fishing district has historical, organizational, and production characteristics that make it a particularly interesting context for analyzing the topic of fish waste valorization, but at the same time, they limit the direct transferability of the findings to other areas.

All in all, these limitations do not undermine the analytical value of the empirical work, but rather define its scope: the findings of this chapter should be understood as in-depth and contextualized interpretations of how key actors in the Chioggia system perceive and explain the obstacles to the valorisation of local by-products.

Chapter 6 – Empirical findings

6.1 – Thematic analysis

This chapter presents the results of the empirical analysis conducted using the methodological approach outlined in the previous chapter. As mentioned, the collected data were analyzed using thematic analysis, which allowed us to identify and interpret the main themes emerging from the interviews.

In the following paragraphs, the empirical findings will be presented and discussed in light of the theoretical framework guiding the research's interpretative framework. We will also be comparing the perspectives of the various interviewees, as to highlight convergences, divergences, and significant relationships among the information collected.

6.1.1 - Generation and location of waste

The first theme that emerged from the thematic analysis, and was also addressed in the interviews, concerns the **generation and location of waste**. We primarily sought to understand both the technical knowledge of the interviewees and whether this topic was part of their cognitive horizon. Indeed, in Chapter 2, we assessed where the waste we are interested in is concentrated; this waste is not generated uniformly along the production chain but is concentrated in the processing and transformation phases. For example, for fish like sea bream (very common in Chioggia), the percentage of waste reaches values such as 61% of the original weight (Pateiro et al., 2020).

When trying to understand where waste is generated, a certain convergence of ideas emerged from the various interviewees. The first interviewee, a COGEVO representative, clarifies that the role of the fisherman is not actually relevant to the issue of waste: "*The fisherman catches the product and delivers it. He doesn't process it. Therefore, all the waste resulting from processing (...) is generated further downstream, in the processing and transformation centers. That's where the problem arises, not on board the vessel*." He was also careful to point out, however, that there are few such actors. This, in simple terms, means that a waste valorization chain requires not only the existence and involvement of processing actors, but that they be understood as the producers of these raw materials and not simply the fisherman. The interviewee, however, adds a specific element regarding shellfish fishing: during onboard grading, the shells and fine material are discarded into the sea along with the juveniles, thus deeming separation impractical, even if, as we will see, this isn't strictly correct.

The second interviewee, a representative of Legacoop, confirms the localization of waste downstream, but goes further, differentiating between marine litter (nets and plastics) and organic by-products. In terms of localization, his position is aligned with that just discussed above, but highlights a distinctly local element: the SST, the public company that manages the Chioggia fish market, as a potential institutional pivot for waste management. This territorial actor would correspond to the **intermediary function** that Chertow (2008) identifies as socially constitutive of industrial symbiosis, but which currently has only "*latent potential*" and which "*should be stimulated*."

The third interviewee, a representative of the Fisheries District, directly provides two cases in which the District has transformed waste into a resource. The first, although counter to COGEVO's claims, involves mollusk shells. Through research, the District has reused them as a secondary raw material, creating a material with characteristics similar to conventional plastic. The second is the case of the blue crab: an invasive species that four years ago was 95% disposed of as waste ("*at costs that could reach €10,000 per day for consortia*") and which today is over 50% valorised by the food industry. These are relevant examples for us because, as mentioned in Chapter 2, the distinction between waste and resource is not a fixed category, but depends on the presence of technologies, infrastructure, and organizational relationships.

The second example is a small-scale local case of the logic presented with EcoeFISHent: valorisation is technically possible but requires an industrial entity that translates research into scalable production, and in this case, a Sri Lankan company established in Scardovari. Here we note a first contrast with the literature: Bourdin and Torre (2025) theorize the circular territorial ecosystem as a system in which valorisation occurs in a territorially rooted way, while this case instead shows that valorisation can also occur with an external industrial entity: value is created starting from a local resource, but the production chain is **hybrid** with an industrial entity capable of closing the cycle.

It's also important to mention the calls made, as they reflect a unanimous position from stakeholders who claim they only engage in trading and therefore generate no waste. For example, "*we just trade. In general, even the fish market itself doesn't generate any real waste*" or "*All the catch is sold; as far as we're concerned, we don't have any waste*".

At the blue economy conference, the topic of waste localization emerges indirectly through two separate contributions. Rizzolio presents research on the valorization of fish oil extracted from sardine waste, combined with wine residues to produce advanced nutraceuticals.

Fabris instead cites a case of circularity in the fish farming sector: entrepreneurs valorizing trout waste in a line of pet food. Both contributions confirm that the generation of valorizable waste occurs during the processing stages, and that it would require an industrial step beyond the competence of the primary producer. It is significant that this research, conducted in Venice, does not involve the actors of the local system of Chioggia; therefore, it means that the research exists and the potential is demonstrated; but as Grafström and Aasma (2021) also argued, the infrastructural and organizational barrier persists even after a cognitive change and a demonstration of feasibility.

The theoretical position emerging from Chapter 4 is fully supported by the empirical evidence: the location of vaporisable waste in the processing phase, and not in fishing, is shared by all stakeholders in the sample. The **first analytical contribution** that distances from the theory is the absence of local processors as a critical structural factor. The literature on circular territorial ecosystems (Bourdin and Torre, 2025) and local food systems (Kebir and Torre, 2012) indicates that the circular valorisation of waste flows requires geographic, organizational, and social proximity between those who generate waste and those who process it.

However, processors capable of activating the circular supply chains described by EcoeFISHent are **structurally absent** from the local production fabric. This point is not explicitly stated as such by any of the interlocutors, who treat it as a neutral fact. This collective silence on the lack of local processors is more informative than direct statements. The literature on industrial symbiosis (Chertow, 2000; 2008) clarifies that industrial symbiosis relationships do not automatically emerge from co-location; in fact, what EcoeFISHent does is a sort of supply chain orchestration. However, from what has emerged so far, such a figure is completely absent in Chioggia; at most, we have the District, which performs research and prototyping functions.

Finally, there is an element that emerges from the empirical material and that the literature does not discuss: the **perceived ownership of waste**. Theory treats waste generation as a supply chain issue, while empirical data show marked cognitive fragmentation: fishermen consider waste a processor's problem; retailers do not perceive themselves as part of the system; and the industrial segment capable of closing the loop is external to the local area. This **fragmentation** is the local empirical form of the stability regime identified by Geels (2002): as long as no subject perceives the problem as their own, no one has the incentive to build the organizational infrastructures that would make valorisation possible.

6.1.2 – Barriers to waste valorisation

The second theme that emerged concerns a central element: **barriers to the valorization** of waste. The questions posed to various interlocutors on this topic led to similar but sometimes polar opposite visions of the topic, and it was precisely the semi-structured nature of the interviews on topics such as this that found its fullest expression.

As we have seen, the literature on barriers to transition identifies four macrocategories: de Jesus and Mendonça (2018) distinguish between hard barriers (technical and economic) and soft barriers (institutional, cultural, and social); Grafström and Aasma (2021), in the most comprehensive synthesis available, group obstacles into technological, market/economic, institutional, and sociocultural ones. A point that is frequently highlighted both in the literature and, as will be seen, also in the interviews, is that barriers do **not operate in isolation**, but rather reinforce each other: for example, the lack of clear regulation discourages investment; a lack of investment impedes the formation of markets; weak markets reduce incentives to seek regulatory clarity, etc.

These barriers, which are generally addressed in the literature, are specifically addressed in Chapter 2 for the fishing sector: i.e., among the regulatory barriers we include the classification of waste as special waste pursuant to ABPR Regulation 1069/2009, etc. It should be noted that the chapter concludes that the category of governance-related barriers is the most relevant because it impedes the translation of technical and economic feasibility into operational reality. However, as we will see shortly, this is not necessarily the case; rather, what emerges is in line with an often overlooked dimension that Galvão et al. (2018) add, namely the **information barrier**, The lack of knowledge about the benefits of the CE reduces social demand, limiting the adoption of new practices and political pressure to remove other barriers.

According to the COGEVO representative, the primary barriers are the regulatory and structural rigidity of the fishing system. Indeed, he tells us, "*the State issues specific authorizations to harvest a certain species using a certain technique*" which means that a vessel equipped for hydraulic dredging of bivalve molluscs cannot be reconfigured (which would require "*an amount between €100,000 and €300,000 per vessel*") for another activity without dismantling the existing investment and obtaining a new authorization. The profile that emerges is that of an operator trapped in a **specialization** that has worked for thirty years but is now trapping him. He then states that diversification is impossible not due to a lack of will, but because it would require a series of unrealistic conditions, such as full reinvestment, new authorization, and entry into markets already occupied by other specialized operators. He concludes by saying, "*If we were to return to clam fishing in the future, we would have to reinvest again to restore the original configuration. It is not economically sustainable*." What emerges empirically is the combined action of two processes that are usually identified separately in the literature. The first is Geels's (2002) **technoeconomic blockage**: investments in existing infrastructure render alternatives uncompetitive in terms of switching costs. The second is the same author's **political-institutional blockage**: the regulatory regime of ministerial licenses by species and technique anchors specialization. Another element that draws attention is the confirmation of a **systemic effect**: extreme specialization, produced by a regulatory regime that incentivizes it and by investments that make it irreversible, has prevented the formation of the transversal skills and critical mass of diversified actors that would be necessary to build any circular supply chain.

The Legacoop representative takes a different view, offering a perspective that differs from the dominant narrative on the sector: "*It's not a technological problem. The logistics are there, the space is there, and the funding is there." By ruling out these elements as primary barriers, the bottleneck is identified as a specific point: "the lack of definition of ministerial standard costs for collection by fishermen."* Waste brought ashore automatically triggers special waste disposal procedures, with costs borne by the fisherman, who is therefore discouraged from carrying out this collection. Essentially, the argument is that until the standard cost is defined by the Ministry, a circular supply chain project cannot be structured with certainty about raw material procurement costs that is sustainable for the fisherman, and no funding can be adequately scaled. This interlocutor was one of the few to bring this conversation to a more concrete and operational level, and we believe this confirms that the information barrier identified by Galvão et al. (2018) operates asymmetrically along the supply chain: those with institutional positions and access to policy networks know the levers, while those operating at the individual business level are blind to them.

The District representative's view does not contradict the one presented above but shifts the focus toward more structural cultural and organizational barriers. In his opinion, "*unfortunately, what is lacking is the ability, and sometimes even the will, to go further, to have a systemic vision and action. The core business of these fishermen and these cooperatives is planting clams and catching them*." In other words, they lack a systemic vision and an industrial entity capable of scaling up research. Indeed, he explains that every District initiative in research and prototyping has encountered the same barrier: the transition from research to industrial production requires a stakeholder with skills not found in the traditional fishing supply chain. A unique element introduced in this case is the widespread distribution of public funds. In fact, we are told that "*the institutions are there, the calls for tenders are there, but politics often prefers to give little money to many operators rather than finance structured projects with systemic repercussions*". This vision is the most directly connected to Geels's socio-cognitive blockage (2002): the actors of the dominant regime are not hostile to innovation but do not perceive it as part of their own space for action, in fact "*there are good intentions. Then, in practice, everyone thinks that the other should do what they do not do*".

The three exploratory calls reveal a profile of barriers dominated by economic arguments, but structured along a growing gradient of closure that reveals something more than a simple lack of convenience. In fact, they start from a pseudo-openness with "*I understand its importance, but today there is nothing that makes participation economically sustainable*". This position is consistent with the economic barriers common to the general literature as well as the specific ones highlighted in chapter 2. We then move on to the doubt that the volumes of waste produced do not justify a sufficient economic return ("*I don't know if, for the quantity of waste produced, there would be a sufficient return*"), even if this is more of a barrier of scale than a cultural one; and to the resistance of older operators, who do not see concrete benefits for their business, which should however be interpreted as a sign of a generational cognitive block, i.e. it is not an ideological refusal but an inability to see the impact on their own business. This position can be identified as the purest form of the information barrier identified by Galvão et al. (2018). Simply put, it's not just the operators who fail to recognize the problem as real, but there's a genuine information gap where no one has ever made the problem or the resulting opportunities visible for this segment of the supply chain.

At the blue economy conference, barriers are presented from complementary perspectives that complement the empirical framework with elements not present in the individual interviews. First, the critical issues facing the sector are highlighted: lengthy administrative and bureaucratic processes, lack of assistance, difficulty accessing production spaces with timeframes incompatible with those of competitor countries, the absence of a central coordinating body, and multi-level regulations that create legal uncertainty. These are barriers that the literature classifies as regulatory-institutional and managerial (Galvão et al., 2018; Grafström and Aasma, 2021). Of particular relevance to us is the introduction of a barrier that does not appear in any of the individual interviews: the lack of qualified human capital. "*We have sensors, we collect data, but we are unable to interpret the data. There is a lack of professionalism and structured, specific training for the fishing sector*." This is a **managerial barrier** in the sense of Galvão et al. (2018), but in the fishing context, it means that the transition towards circular models requires skills (such as flow analysis, design, economic evaluation) that do not belong to the traditional repertoire of operators in the sector. Finally, Simioli concludes the conference by introducing a system barrier that the literature discusses at a theoretical level but that is rarely quantified empirically in specific local contexts: the asymmetry of value capture along the supply chain. This finding transforms the theoretical argument of Candel (2014) and Sonnino et al. (2016), according to which where value capture is asymmetric, primary producers have neither incentives nor resources to invest in sustainability, in a measurable and localised reality: with compressed margins, any investment in waste valorisation is economically unattainable for the individual operator, regardless of his open-mindedness.

A **first** comparison that stands out is that between the last two interviewees. They offer similar insights, each with a sort of inverted order. In one case, the **regulatory barrier** is prioritized as the element that unlocks the situation; in the other, the cultural/organizational barrier is prioritized as the unlocking element. The two interpretations of these barriers should not be interpreted as if they were sequential elements, but rather as mutually dependent: removing one is necessary but not sufficient (Grafström and Aasma, 2021). Simply put, one can solve the standard cost problem and still face the absence of a party capable of implementing the project; and vice versa, with the presence of an adequate party, not the necessary regulations.

A **second** element that seems worth mentioning concerns the **cognitive barrier** along the supply chain. Drawing on the literature (Geels, 2002), one would expect any cognitive blocks to be more pronounced among actors with high levels of investment in the system (i.e., fishermen). However, what emerges is a significant blockage in the commercial sector, despite the lack of investment in the system in the traditional sense. The information barrier proposed by Galvão et al. (2018) does not arise from a general lack of knowledge of the benefits of the circular economy, but rather from a cognitive closure to a system in which the benefits have never been made visible locally by any actor. One key to understanding this issue is the possibility of tracing everything back to a governance barrier, which is the result of the absence of a coordinating body with a communication and information function.

A **final** element worth mentioning, which is not examined in the literature, is the **transition** from research to industrialization. The literature treats the transition to circular models as a continuum from research to implementation and industrialization, without distinguishing the fundamental step separating the two. What emerges from Chioggia, and is confirmed by the District, is that this separation between phases is structural and requires a specific actor (i.e., an industrial partner) to be operationalized.

6.1.3 – Governance and coordination of the local system

The third theme that naturally emerged concerns **governance**. Questions on this topic were posed by asking the interviewees to describe the operations they work on, the degree of coordination among local system actors, and who should be the person capable of leading a potential transition towards waste valorization.

In Chapter 1, governance was identified as the **main enabling condition** for the transition towards sustainable local systems. Kebir and Torre (2012) articulate proximity into three dimensions, including organizational proximity, and emphasize that geographic proximity does not necessarily imply the other two. Simply put, a system can be geographically concentrated but organizationally fragmented, and this asymmetry is precisely the configuration that Chapter 4 attributes to Chioggia. Similarly, Bourdin and Torre (2025), in their circular territorial ecosystem framework, identify three necessary forms of cooperation, among which we consider socioeconomic coordination among a broader set of local actors, including information exchange and joint planning, as relevant.

As has been repeatedly highlighted, a fundamental point in the literature is that the concept of industrial symbiosis (Chertow, 2000; 2008) is a socially constituted phenomenon and is maintained through personal relationships and cooperative agreements, not through simple co-location. This implies that the organizational infrastructures necessary for symbiosis do not emerge spontaneously, but must be actively constructed by actors who identify opportunities, reduce coordination costs, and manage the inevitable asymmetries of interest among actors.

The COGEVO representative describes it as an advanced self-management model: the consortium manages fishing quotas, operating days, biological closures, and harvesting methods, and interacts with the Port Authority and the Ministry. "*Management consortia represent the most advanced form of management evolution, because in this case, the fishermen* *themselves organize themselves*." In terms of fish resource management, this is a form of horizontal governance that the literature on common pool resources (Ostrom, 1990) recognizes as effective in highly interdependent local systems. However, compared to our theoretical framework, it emerges that COGEVO is concerned only with resource management, but does not address any aspects related to valorization, circular transition, or supply chain innovation. When asking what would be needed to address the crisis and innovate the system, what emerges is that "*more coordinated governance is needed, capable of supporting the sector in times of crisis and of considering medium- and long-term strategies*."

The Legacoop representative articulates the issue of governance, with perspectives that move on multiple levels: the level of current failure and the level of conditions for possible change. Regarding the current failure, "*professional fishermen look after their own affairs*" arguing that rightly, "*if you leave individual fishermen alone in the fishing supply chain, they're like farmers: alone, they're bypassed by the supply chain. The supply chain takes advantage, pays little, all to the detriment of the producer*." Regarding possible change, the stakeholders who should activate innovation processes emerge, arguing that "*this is precisely the role of cooperatives, consortia, and producer organizations*." An interesting idea is to see SST, the company that manages the fish market, as a potential institutional pivot for waste management, capable of serving as a stable interlocutor. Here, too, the connection with the literature that emerges is interesting. Indeed, we note the **parallel** with the situation of the Chioggia fisherman and the concept of industrial symbiosis, where the latter requires cooperative agreements that the individual actor has neither the incentive nor the capacity to build alone. The identification of cooperatives and consortia as natural aggregating entities is consistent with the framework of Bourdin and Torre (2025), according to which the circular territorial ecosystem requires entities that manage technical and socioeconomic cooperation between the actors.

Finally, the District representative's interpretation of the topic is based on two concrete cases that serve as empirical evidence. Indeed, "*when there is someone who represents them operationally and invests on their behalf, things move forward. If, on the other hand, everything is left to the individual, only sporadic cases of individuals evolving*" are found; and in this case, reference was made to the Scardovari Consortium, which represents 14 associated cooperatives, has an effective operational mandate, direct investment in technology and marketing, and the ability to respond to crises (particularly the blue crab crisis by coordinating numerous operators). The representative then goes on to acknowledge that "*unfortunately, it's a sector in which there are 3,000 VAT numbers. There are consortia, there are cooperatives, but* *fundamentally, there are many small-scale fishermen, and each tends to their own little patch. There's no overall vision."* From this, it emerges that Chioggia's governance has institutional depth but lacks a body with an operational mandate capable of operationalizing it.

At the conference, the topic of governance emerged as the most consensual of the entire day, but also the most heterogeneous. First and foremost, the lack of a coordinating body was identified as one of the main structural obstacles to the sector; in fact, operators "*lament the lack of a central coordinating body that should support the sector and guide companies through these transitions*." Interestingly, the necessary governance model was described as a non-hierarchical ecosystem, built through a "prototypical approach" that starts with the operators' real problems. "*Solutions are no longer imposed from above, but are developed together with the operators, starting from real problems*."

A key institutional perspective is that "*it's easier for the Region to work with an aggregate system than with 3,000 separate businesses. Diversification is more successful when there's aggregation, because an individual business has little opportunity to diversify. Cooperatives hold up better, especially those with multiple types of activities within them*." The final important element that introduces the conference, and which the literature insufficiently articulates, is the tension between the level of governance required for the transition and the actual capacity of public institutions to build it. In short, a gap emerges between institutional availability for support and the operational capacity of stakeholders to access it, which isn't simply a problem of information but of the supply chain's organizational structure.

A first point of comparison concerns the empirical **confirmation** that **fragmentation** is universally recognized as a problem by all stakeholders and the need for an aggregating entity that operates transversally. This convergence reinforces what Kebir and Torre (2012) and Bourdin and Torre (2025) identify as the structural characteristic of local systems that fail to translate geographic proximity into circularity if organizational and social proximity is lacking, and without it, co-localization does not produce symbiosis.

The second and most relevant empirical specification concerns the distinction between **representative governance and operational governance**. Indeed, the literature reviewed treats governance as a single category: either you have governance or you don't. However, the Chioggia data show that this is an inadequate simplification. The system has consolidated representative governance structures but lacks operational governance, that is, a body with the mandate, resources, and capacity to physically coordinate flows. This distinction affects the feasibility of any waste-to-energy project. A representative governance body can build consensus and represent interests, but it cannot purchase raw materials, negotiate with a waste manager, structure a contract with an industrial partner, or manage collection logistics.

6.1.4 – Openness to innovation and sustainability

The fourth theme that emerged concerns innovation and sustainability, but from the perspective of the **degree of openness** to these issues. Questions about openness were formulated by asking participants to assess whether the sector's crisis could be an opportunity to rethink the production model, and whether it was realistic to imagine a transition to sustainable practices.

Chapter 1 identifies **socio-cognitive blockage** as the second of three classes of blocking mechanisms theorized by Geels (2002): actors locked into a dominant production regime tend to perceive alternative practices not only as economically risky but also as external to what their sector does. In the fishing context, this manifests itself as the belief that fish waste is a cost to be minimized and disposed of, rather than a resource to be valorized. Hart et al. (2019) identify cultural enablers as the most relevant category of enabling factors: leadership as the ability to orient strategic vision towards the long term; systems thinking as the ability to reason in terms of flows and interdependencies; and the construction of long-term relationships between actors in the supply chain, which modifies the typical time horizon of market transactions.

A timid opening on the topic comes from the COGEVO representative, who suggests that the crisis can become an opportunity, but "*we need to be realistic*": the sector is *"very rigid both from a regulatory and economic standpoint*" companies are highly specialized, boats are built for a single activity, and permits are issued for a specific species and technique. The margin for adaptation for individual companies is therefore "*very limited*." In essence, change is necessary, but individual companies have neither the tools nor the resources to implement it alone. From a theoretical standpoint, this is the classic profile of the regime actor described by Geels (2002): a subject who recognizes the need for change on a cognitive level, but is blocked on a practical level by scuttled investments, regulatory constraints, and the absence of visible alternatives.

A clearer stance on innovation comes from Legacoop, which conveys the utmost urgency on the issue; and in fact, "if this is not the case, this sector has no future, at least as we understand it. Either we embrace this vision, or slowly and inexorably, due to European policies to reduce fishing days, the lack of generational turnover, energy costs, and international trade, the fishing sector risks losing its future." In short, it confirms that the transition to a circular economy is "*inevitable, whether we like it or not, because it is a central issue for the European Community.*" A unique element that emerges is the connection between transition and generational turnover, a necessary condition for its implementation: the model must become attractive to young people, as happened in agriculture through diversification and innovation.

The District's perspective on innovation is highly open, but partially mitigated by its governance experience. This perspective is not contingent on resolving the structural constraints of individual firms, but on the existence of an aggregating entity with an operational mandate and the pressure of **the crisis as a coordination driver**. What emerges uniquely is the introduction of a previously undiscussed element: the role of consumers as a demand lever. This connection between system innovation and consumer demand is consistent with what Hart et al. (2019) identify as a sectoral enabler, but specifies it concretely: it is not generic communication on sustainability, but rather consumers are educated on the value of local products, thus becoming the source of economic convenience that operators currently lack for investing in innovation.

At the Blue Economy conference, the topic of openness to innovation is discussed at the most systemic level, with an important methodological caveat. "*Digital technology and new sustainable models often stem from highly advanced contexts, and attempts are made to apply them to systems comprised of small and micro-enterprises. Forcing these models can be counterproductive, as companies are faced with investments and technologies that are not aligned with their capabilities and operating context*." It is thus recognized that openness to innovation depends not only on the willingness of the actors, but also on the compatibility of the innovative model with the organizational structures and operational capabilities of the companies it addresses.

The **first element** that emerges from the comparison between theory and practice concerns the **distribution** of cognitive blockage along the supply chain. The practical example is COGEVO (aggregator of producers with the largest investments) that recognizes the need for change, understands the problem, and does not deny the reality of the opportunities. Its blockage is structural-practical; in fact, it knows the system must change, but it does not see a viable path from its position. From the three exploratory calls, with subjects who have no investments rooted in the regime in the classic sense of the term, what emerges is the very rejection of the benefits of circular innovation. This reversal is not trivial. It suggests that socio-cognitive blockage does not depend exclusively on potential investments but on information exposure and the perceived relevance of the problem. A primary producer who loses income because the resource has disappeared is still exposed to the problem, even if he or she cannot see the solution. A trader who sells fish regardless of its origin or how it has been treated is not exposed to the problem in the same way.

The **second element** of productive tension concerns the **relationship** between cognitive openness to innovation and the structural capacity to implement it. All stakeholders with a systemic vision agree that the transition is necessary and desirable. Yet, the transition does not occur. The literature on enablers (Hart et al., 2019) treats cultural openness as a sufficient condition, or at least necessary and close to sufficient, for the transition. The Chioggia case is a system in which awareness of the need for change is widespread among stakeholders with a systemic vision, yet change does not occur because the organizational, infrastructural, and institutional conditions that would make it operationally possible are lacking.

The **third contribution** emerging from the empirical material concerns scale as a specific constraint on openness to innovation. It explicitly introduces an argument overlooked in the literature: that circular innovation models are developed in organizationally advanced contexts and risk being inapplicable to microenterprise systems if they are not adapted. In practice, it is recognized that a fisherman with a boat and a dependent sailor cannot adopt digital traceability systems, cloud logistics platforms, or bioconversion processes without supporting infrastructure. EcoeFISHent, as shown in Chapter 3, has addressed this issue through a consortium architecture that offloads onto collective infrastructure the costs that individual businesses cannot sustain.

Finally, there is one element only briefly mentioned but which can be considered a full-fledged enabler: **the consumer**. The literature (Hart et al., 2019; Galvão et al., 2018) identifies consumer demand as one of the most powerful sectoral enablers for the circular transition, insofar as it creates market pressure that makes innovation economically viable. This collective silence is significant: it indicates that the final consumer market is not perceived by local stakeholders as a lever to leverage to build the viability of innovation, and that the consumer is not a potential interlocutor with whom to build demand for more sustainable products and practices.

6.1.5 – The sectoral crisis

One theme that was highlighted was **the crisis in the sector**, which was not the subject of direct questions, but emerged across almost all interviews as an essential context for understanding any other dynamics of the system.

The most relevant analytical framework for this topic is the multi-level perspective of Geels (2002) and Geels and Schot (2007). In the MLP, landscape-level pressures do not automatically produce the transition towards more sustainable configurations, but rather create windows of opportunity by destabilizing the dominant regime. These windows open when external pressures are sufficiently intense to weaken regime stability, making it possible for niche innovations to emerge and spread, provided they are sufficiently mature. Lamine et al. (2019), in the context of local food systems, further refine this logic: monocultural systems are more vulnerable to external shocks, but they are not necessarily the ones that innovate most in response to crises, unlike what is the case for hybrid systems.

Here, the COGEVO representative gives a very precise description of what he calls "*the perfect storm*": persistent fog in the Po Valley between January and April 2024 caused water stagnation in the upper Adriatic, reducing salinity and raising temperatures to 28 degrees Celsius at the bottom. This thermal anomaly was compounded by floods in Ferrara and Bologna, which added freshwater to the Adriatic, and finally by the blue crab, which preyed on the remains. "*The result: 100% of production decimated starting October 1, 2024*." The interpretation offered to us of the crisis is not that of a window of opportunity: it is that of a trauma that has destroyed thirty years of history without yet producing anything structurally alternative. "*This economy, which over the years has managed to capitalize, and this is allowing us to resist today*" is the only available buffer, but it is running out. So the system persists, waiting for the resource to replenish itself; it doesn't build an alternative model. This is what's theoretically called reactive adaptation, or a sustained response in the event of a crisis.

Legacoop offers a more positive perspective, according to which the crisis is not a mere interlude to be navigated while waiting for a return to normalcy. The sector risks burnout, not only financially but also in terms of identity, in the sense that representative associations risk focusing all their activities on requesting survival funds, losing sight of the strategic perspective. "*The only chance we have is to understand that nothing will ever be the same again, but that we must implement innovative activities and initiatives."* This interpretation is consistent with the model of Geels and Schot (2007): the crisis as landscape pressure that destabilizes the regime and opens the window for innovation. But here it emerges that the window does not open on its own; someone must keep it open while the system is in crisis, and this someone is the institutional associative body that maintains the pressure for innovation.

The third perspective we are offered is that the crisis does not open the window uniformly for all actors in the system, but selectively, amplifying the capabilities of those who were already organized and accelerating the decline of those who were not. The case of the blue crab in Scardovari is the empirical case for this thesis; in fact, precisely because the Consortium had operational governance, a mandate to act, it was able to respond to the crisis with innovation. In short, the crisis acted as a selective driver: "*those who had the strength and ability to change the seeding system did so.*" Those who lacked it exited the sector. The crisis did not transform the system: it selected it, eliminating the most vulnerable players and concentrating innovative capacity in those who were already better organized. Applying this logic to Chioggia, if a similar crisis were to strike, it would act as an amplifier of pre-existing structures, that is, the fragmentation of the system, not its innovative capacity.

Finally, the conference on the blue economy reaffirms that the crisis has not affected everyone uniformly: it has selectively affected those systems most vulnerable to dependence on a single production system, empirically confirming the literature's thesis on the fragility of monocultural systems. Furthermore, the conference describes the crisis as "*proof of the economic and social consequences of climate change*" and introduces an element of historical cyclicality: about thirty years ago, the first clam plan was born as a response to a severe crisis in the sector, and that crisis laid the foundation for the subsequent thirty years of prosperity.

The first and most significant analytical contribution emerging from the comparison between theory and empirics concerns the mechanism by which **the crisis operates as landscape pressure** in the Chioggia case. Geels and Schot (2007) theorize the crisis as a factor that destabilizes the regime and creates space for niche innovations, essentially universally for all actors in the system. Empirical data, however, show a radically more selective mechanism: the crisis does not open the window uniformly, but selectively amplifies pre-existing asymmetries in the system. Where an aggregative structure with an operational mandate already existed, the crisis forced innovation; those who could respond as a system, did so. Where the aggregative structure was absent or only representative, the crisis produced paralysis and a wait for a return to normality. The crisis is therefore a factor that cuts **across the system**, but its effects are profoundly heterogeneous depending on the pre-existing organizational structure, an empirical element that, as we have seen, is not theorized by the MLP, which views the crisis as a simple exogenous variable.

Another important element emerging from the empirical material concerns the relationship between the crisis and **operators' time horizons**. This dimension is introduced directly during the conference, with the fisherman, in fact, thinking about the next day, not the transition in the production model. This observation implies that the crisis, however severe, does not automatically lead to an extension of operators' time horizons. The window of opportunity theorized by Geels and Schot opens only if there is a person (the so-called transition manager) who can think long-term while primary operators are preoccupied with immediate survival.

6.1.6 – Replicability

The final thematic element to be analyzed concerns the possible **replicability** of the Ligurian model described in Chapter 3. The question of EcoeFISHent's replicability was explicitly introduced in only two cases, asking whether the conditions for launching a local waste supply chain similar to the Ligurian one exist in the Veneto region, and in Chioggia in particular, and what elements would be necessary to make it possible. In the other cases, the question was asked whether, if a concrete project existed, they would be interested in participating.

Chapter 3 concludes that EcoeFISHent's replicability is conditional and modular: what is replicable is not the cluster's exact configuration, but its systemic architecture, coordination mechanisms, and decision-making support tools. The enabling conditions identified are: by-product flows, logistics and processing infrastructure, diverse local actors, and governance and coordination capacity.

It is also emphasized that the main lesson of EcoeFISHent, even before considering replication, concerns the design of organizational and institutional architecture: this does not emerge automatically from the co-location of actors, but must be **actively built**. This framework is consistent with what Bourdin and Torre (2025) indicate for the circular territorial ecosystem: vertical connections along value chains, horizontal connections between producers of complementary goods, and institutional connections between firms and public authorities must be built simultaneously, not sequentially.

Our first interviewee is never explicitly asked about Ecoefishent, but the interview generally reveals a mixed opinion regarding its replicability or potential participation. Indeed, we are told that primary fishermen are not potential players in a waste supply chain: they do not generate recoverable organic byproducts, they lack the skills to transform them, and the structural constraints of their business make any diversification economically unsustainable. Therefore, even if a potential recovery facility were present, potential participation would still be uncertain.

The Legacoop representative, however, responded in a much more practical manner. "*In my opinion, yes*," it's feasible. But this is a "yes," as he explained, requiring a series of factors: from defining the standard cost, to the existence of an aggregating entity and its cooperation with a pivotal institution; and finally, the allocation of compatible funds. The conclusion is that "*it's not a technological problem. The logistics are there, the space is there, and the funding is there*." What's missing is orchestration. This diagnosis aligns precisely with the conclusion of Chapter 3 on the main lesson of EcoeFISHent: the problem is not the technology, but the design of the organizational architecture.

The representative of the Fishing District shares a similar opinion, emphasizing that "*there are positive and virtuous experiences, but there is still much to be don*e." In addition to the factors outlined above, in this case one more factor is added: communicating the value of local products to consumers, which is the demand lever that creates the economic convenience that operators currently lack to invest.

The three exploratory calls do not contain any references to EcoeFISHent, but what can be deduced is that these entities do not see themselves as part of the system. Indeed, even in their case, if a recovery plant existed, they might be interested, but as already explained in previous topics, most of the responses revolved around "*I don't see the economic viability*" or "*we don't produce waste*."

The first and most direct comparison concerns **the convergence** between the conditions identified by the interlocutors and those identified in Chapter 3 as the enabling conditions for EcoeFISHent. The empirical evidence provides a framework that confirms the thesis of Chapter 3: the technical feasibility is present, but the organizational and institutional architecture has not yet been built.

The second productive tension with respect to theory concerns the question of the **model's territoriality**. Chapter 3, drawing on Bourdin and Torre (2025), describes EcoeFISHent as a territorially rooted circular cluster model, in which the value chain is fully localized. The case of the blue crab shows that the most advanced valorization achieved so far in the Veneto context has occurred in a hybrid form (with an industrial partner from Sri Lanka). This does not invalidate the EcoeFISHent model as a benchmark, but suggests that the replicability of its principle does not necessarily imply the replicability of its form. Indeed, the logical principle is that in contexts where industrial skills do not exist locally, valorization can occur through extra-territorial partnerships that still generate value from the local resource. This hybrid form could be the most realistic version for the Chioggia context in the short-medium term.

The third element that emerges from the empirical material, and which the literature does not address, is the problem of the **visibility of best practices** within the sector's knowledge networks. EcoeFISHent is an active European project, presented in academic and institutional settings, with documented and published results. Yet, no conference participant spontaneously mentions it. This is a problem of the circulation of best practices within the sector's operational knowledge networks, those that connect researchers, practitioners, and institutions in everyday practice, not just in academic publications.

Table 8: Comparative table of the evidence from the thematic analysis

Theme	Convergence	Divergence	Asymmetries	Theoretical match
Generation & location of waste	All interviewees agree that fish by-products are mainly generated during the processing stage.	-	No stakeholder identifies the lack of local processing industries as the core problem. Responsibility for waste is fragmented across the supply chain: fishermen defer to processors, traders exclude themselves.	**Confirmation:** Processing is the main source of by-products. **Specification:** absence of processors as a structural barrier. **Extension:** empirical evidence introduces that waste ownership is fragmented across stakeholders.
Barriers to waste valorisation	All stakeholders recognise that valorisation is prevented by multiple systemic barriers, but especially the economic barrier.	Different perspectives emerge some identify regulatory barriers as an obstacle to economic feasibility for fisherman, while others prioritise cultural, organisational and industrialisation barriers.	Only the conference highlights the lack of qualified human capital. No respondent explicitly separates governance from technological barriers, nor properly highlights the transition from research to industrialisation	**Confirmation:** empirical evidence confirms interconnected barriers. **Specification:** information asymmetries emerge as more influential than expected. **Extension:** the research-to-industrialisation gap is an additional barrier.

Theme	Convergence	Divergence	Asymmetries	Theoretical match
Governance and coordination	There is agreement that fragmentation is the major weakness and that coordinating actor is required to transition.	Actors identify different potential orchestrators (e.g., cooperatives, producer organisations, SST, or external industrial partners). Awareness of available support instruments (e.g., FLAG/GAL) is uneven.	No organisation currently performs a genuine operational coordination role. Existing governance structures are primarily representative rather than operational.	**Confirmation:** governance is confirmed as the main enabling condition identified in literature. **Extension:** empirical findings distinguish between representative and operational governance, absent from other studies.
Openness to innovation and sustainability	All interviewees with a systemic perspective recognise that innovation is necessary for the future of the sector.	Innovation is viewed as either desirable but constrained by structural rigidity, an urgent necessity, or dependent on aggregation and consumer demand.	Commercial actors display stronger cognitive closure than producers. Advanced circular technologies often exceed the capabilities of local micro-enterprises.	**Confirmation:** cultural and cognitive factors influence innovation. **Extension:** organisational scale and micro-firm structure emerge as constraints overlooked in existing frameworks.

Theme	Convergence	Divergence	Asymmetries	Theoretical match
Sector crisis	All participants describe the current crisis as structural and recognise that the sector will be no longer the same in the future	Three interpretations emerge: survival challenge, transformation opportunity, and selective mechanism favouring organised systems.	Few interviewees explicitly discuss long-term strategic adaptation beyond immediate survival. Commercial actors do not perceive the sectoral crisis as affecting them directly.	**Confirmation:** crisis operates as landscape pressure. **Extension:** Rather than creating a uniform window of opportunity, it selectively amplifies pre-existing organisational asymmetries, challenging the mlp assumptions.
Replicability of EcoeFISHent	Stakeholders generally agree because material conditions does exist (logistics, spaces, EU funding).	Interviewees differ regarding which enabling condition should be prioritised: governance, industrial partner, logistics, or institutional support.	No interviewee refers to the Ligurian governance model. EcoeFISHnet is absent from local knowledge networks. The Sri Lankan case challenges the territorial assumptions of the regenerative model.	**Confirmation:** replicability is conditional rather than automatic. **Specification:** what is transferable is the organisational architecture. **Extension:** local governance capacity emerges as the decisive replication factor.

Conclusion

This thesis asked whether the valorization of fish waste could represent a viable path to more sustainable development of the Chioggia fisheries system. The work carried out thus far has constructed the analytical framework and empirical context necessary to answer.

The research first established the theoretical framework by distinguishing sustainability, the circular economy, and the regenerative economy, and by introducing the MLP as the main framework for understanding why sustainability transitions often fail to occur, also highligthing the role of local systems.

The study then focused on the fisheries sector within the blue economy, showing that fishery by-products are mainly generated during the processing and transformation stages. The EcoeFISHent project was analysed as a benchmark to identify the key conditions that enable local waste valorisation. The research then examined the fishery system of Chioggia, analysing its productive structure and the generation of fishery by-products.

Finally, a qualitative research approach based on semi-structured interviews and participation in institutional events was adopted. The collected data were analysed through thematic analysis, allowing the identification of six main themes: waste localisation, barriers to valorisation, governance and coordination, openness to innovation, the role of the current sectoral crisis, and the replicability of regenerative models.

The answer to the research question is not straightforward. Rather, it emerges from the interaction of several factors identified throughout the empirical analysis. The results suggest that the response cannot be explained by single factors, but is the result of a path-dependent development trajectory. In short, the failure to valorize waste is the consequence of a systemic condition: the absence of an operational governance architecture capable of coordinating fragmented actors, aligning incentives, and transforming resources into collective action.

From a **structural and organizational perspective**, we have seen that the Chioggia system is concentrated in the early stages of the supply chain, confirming that the availability of raw materials is not the main constraint. Indeed, the successful experiences discussed demonstrate the technical feasibility of waste valorization in comparable contexts. The real limitation is fragmentation, which makes it impossible to guarantee, without an aggregating entity, the continuity and standardization of the inputs required for a valorization infrastructure.

From a **governance and coordination perspective**, the most significant finding is that Chioggia does not suffer from an absolute lack of governance, but rather from a lack of operational governance. The system has consolidated representative structures that can build consensus and represent interests; however, none of these structures has the mandate, resources, and operational capacity to manage entire regenerative supply chains. It is precisely this lack of operational orchestration that blocks any valorization project.

Regarding **barriers to feasibility**, empirical evidence suggests that the barriers identified in the literature certainly exist, but the key barriers have been shown to be primarily cognitive and organizational. No stakeholder in the system perceives fish by-products as their own problem: fishermen perceive they do not generate waste, and commercial operators do not consider themselves directly involved. This fragmentation of perceived ownership is the reason why no stakeholder has the incentive to build the organizational infrastructures required.

Regarding the **conditions necessary** for the **development of a regenerative cluster**, this fragmentation also explains why regenerative models, such as EcoeFISHent, have not replicated spontaneously. EcoeFISHent has been able to build vertical, horizontal, and institutional connections—connections that in principle would be feasible in Chioggia, but the absence of certain stakeholders prevents their formation. The analysis indicates that the limiting factor is not the lack of a viable model, but rather the lack of the organizational conditions necessary to make it operational.

The findings also suggest that the current crisis affecting the fishing sector does not automatically create favorable conditions for this transformation. Crisis raises awareness of the need for change, but fails to generate coordination where it is lacking. This is why fragmented systems respond with adaptive strategies aimed at short-term survival.

The answer to the research question is that the lack of local valorization of fish by-products in Chioggia cannot be explained by a lack of resources or capacity. Indeed, we are talking about a system that has reached a threshold of production maturity without developing the corresponding organizational maturity. Consequently, the area possesses many of the individual conditions necessary for the circular transition; what is lacking is the systemic capacity to combine these elements.

In addition to answering the research question, this study offers theoretical contributions to the literature on the circular economy, industrial symbiosis, and circular transitions.

The **first contribution** concerns the role of governance in circular transition processes. The literature identifies governance as one of the main enabling factors, but tends to conceive of it as a relatively homogeneous condition. The case of Chioggia, however, suggests that this interpretation oversimplifies local systems, highlighting the need to distinguish between representative and operational governance. Although the local fishing system is characterized by a dense network of cooperatives, consortia, and trade associations, a single actor capable of translating this representation into a genuine capacity for collective action is lacking. What appears crucial, therefore, is not the mere presence of representative bodies, but rather the existence of organizations with the mandate, resources, and expertise to coordinate material flows, promote partnerships, manage logistics, and implement innovation projects.

The **second contribution** concerns understanding the barriers to the circular economy. The literature classifies these obstacles into technological, economic, institutional, and socio-cultural categories. While this is useful, it fails to capture a dynamic observed in Chioggia: the necessary technologies are available, financing opportunities exist, and institutional support tools are present, yet circular initiatives remain largely absent. What appears to be lacking is not technology, capital, or logistics, but rather the organizational and cognitive infrastructure needed to make these resources concretely accessible to local actors. A further analytical element concerns the distribution of the socio-cognitive barrier along the supply chain: contrary to what one might expect, this obstacle is not concentrated among actors with the largest fixed investments, but rather in the commercial segment, which is characterized by low investment. This suggests that resistance to change depends not only on the economic rigidity of investments, but also on the degree of exposure to the problem and its perceived relevance.

The **third contribution** expands the literature on industrial symbiosis, highlighting the role of perceived responsibility for the by-products. In Chioggia, different stakeholders tend to systematically attribute responsibility for the problem to others other than themselves: fishermen identify the source of the problem with processors, commercial operators do not perceive themselves as involved in the issue, and institutions primarily assume a facilitating role. Added to this is an obstacle rarely discussed in the literature on circular transitions: the gap between research and industrialization. The District has demonstrated the technical feasibility of valorization, but no local actor is in a position to translate that feasibility into scalable industrial production, a function that requires a partner with capital, expertise, and market access that currently lacks in the local system.

The **fourth contribution** qualifies the interpretation of the multilevel perspective (on the role of crises as transition pressures). Empirical evidence shows that crises do not affect all actors equally, nor do they automatically generate innovative processes: rather, they act as selective amplifiers of existing organizational capabilities. Actors with solid governance structures are able to transform crises into opportunities for innovation, while more fragmented systems tend to adopt predominantly defensive strategies. Windows of opportunity, therefore, do not simply open as a result of external pressures, but can be exploited only where consolidated organizational capabilities already exist.

The **fifth contribution** concerns the replicability of circular economy initiatives. The literature tends to focus primarily on the transferability of technologies and business models. However, the comparison between EcoeFISHent and the case of Chioggia suggests that what is truly transferable is not a project's technological configuration, but rather its organizational architecture, i.e., the governance mechanisms capable of connecting stakeholders, resources, and expertise specific to the local context. Replication should therefore be understood less as the reproduction of a standard model and more as the adaptation of coordination structures to specific conditions. It follows that hybrid forms of collaboration, involving industrial partners external to the local area, may represent a more realistic path than entirely localized supply chains, at least in the short to medium term.

These contributions support a synthetic **theoretical proposition**: the transition from waste management to a regenerative economy requires the simultaneous presence of four conditions. The **first** is a structurally complete supply chain, in which the relevant actors are present and recognize themselves as part of a system. The **second** is operational governance, i.e., a body with the mandate, resources, and relational capital necessary to coordinate actors with different interests. The **third** is the sharing of a common time horizon, without which the crisis acts as a pressure factor rather than an opportunity. The **fourth** is the visibility of demand, i.e., the ability of consumers to recognize and economically value products resulting from the valorization of by-products.

These four conditions define what can be conceptualized as a threshold of **organizational readiness for the regenerative transition**. Below this threshold, technological, financial, and institutional resources are insufficient to trigger circular economy processes, as the organizational architecture necessary to integrate them into effective collective action is lacking. The case of Chioggia shows how the main obstacle to transition lies not in the absence of individual enabling factors, but rather in the system's inability to combine them within a coherent organizational structure.

The findings of this research have several **practical implications**, primarily on governance and organizational innovation. As can be seen, the most important implication is the need to overcome fragmented approaches. For this reason, the creation or strengthening of a coordinating actor should be considered a strategic priority. This actor should not necessarily own infrastructure or directly carry out waste treatment activities. Rather, its function would be to facilitate cooperation between stakeholders, identify opportunities for industrial symbiosis, coordinate pilot projects, and reduce the transaction costs associated with collaboration.

Finally, empirical evidence suggests that **public institutions** should increasingly focus on creating enabling environments that facilitate collaboration and experimentation. This could involve simplifying regulatory procedures, reducing uncertainty surrounding waste management regulations, supporting pilot projects, and encouraging partnerships between fisheries organizations, research institutions, and industry stakeholders. Indeed, particular attention must be paid to bridging the gap between the availability of public support tools and the ability of local actors to access and use them effectively.

The strategic role that **cooperatives, producer organizations**, and sector associations could play in supporting transition processes was also highlighted. Rather than focusing exclusively on their traditional representational functions, fisheries organizations may need to increasingly develop operational capacities, acting as innovation facilitators, partnership coordinators, and promoters of collaborative projects.

As with any research project, the results must be interpreted in light of several **limitations**. This study was designed to develop a thorough understanding of the dynamics of the Chioggia system, rather than produce statistically generalizable results. A second limitation is that the sample does not represent all stakeholders potentially involved in fish waste valorization processes. A third limitation is the lack of a concrete waste valorization project currently operating in Chioggia, making many of the discussions based on perceptions, expectations, and interpretations, rather than direct observation.

Despite these limitations, the study offers a solid empirical contribution and lays the foundation for further theoretical and empirical developments. A **first research direction** involves extending the analysis beyond the case of Chioggia. Studies involving other fishing districts would allow us to assess whether the governance challenges identified are specific to Chioggia or reflect structural characteristics common to other fishing systems. Such comparisons could also help identify alternative governance models and best practices capable of facilitating circular innovation.

A **second area of future research** concerns the role of governance in sustainability transitions. Among the main findings is the distinction between representative and operational governance. Future studies could further explore this distinction across different sectors and territorial contexts, exploring how various forms of governance influence the ability of local systems to translate sustainability objectives into concrete actions.

A **third direction** would examine the role of consumer demand as an enabling condition for regenerative transitions. The consumer has been identified as a lever that is under-theorized in the existing literature, but consumer attitudes have not been investigated. Future research combining supply-side analysis (as conducted here) with demand-side analysis of consumers' willingness to pay for locally valued seafood would provide a more complete picture of the enabling conditions for the transition.

This thesis began with a relatively **simple question**: could fishing waste become a resource capable of supporting a more sustainable future for the Chioggia fishing system? The results suggest the answer is a **timid yes**. The research demonstrated that the challenge Chioggia faces is the lack of organizational and institutional infrastructure that would allow system actors to coordinate their capabilities, aggregate resources, and build supply chains for circular valorization. Empirical evidence suggests that circular transitions are not triggered simply because valuable resources or innovative technologies exist, but when actors develop governance structures and collaborative relationships capable of transforming potential opportunities into operational realities. Ultimately, the future of circular fishing systems may depend less on the discovery of new resources and more on the ability to effectively coordinate existing ones.

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