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"Development of a Framework for Integrating Blue Economy Nature-Related Risks into Bank Credit Risk Management. A Case Study of Sicilian SMEs"

Prof. Riccardo Sallustio

SUPERVISOR

Prof. Luna Kappler

CO-SUPERVISOR

CANDIDATE

Marco Di Mauro – 631873

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INTRODUCTION

In recent years, risk management and information transparency in the European banking sector have been undergoing a phase of structural transformation, driven by the progressive integration of ESG factors and, increasingly, nature-related dimensions into decision-making processes, governance arrangements, and risk management systems. In this context, the environment is no longer considered solely a "reputational" dimension or a matter of voluntary reporting: to an increasing extent, it is observed as a potential source of risk and economic-financial vulnerability, capable of affecting, directly or indirectly, the stability of cash flows, business continuity, and firms' investment needs.

This work is positioned precisely at this operational juncture: it addresses the question of how to make the environmental drivers that characterize economic activities in coastal contexts "bankable", with particular attention to "blue" and nature-related drivers. The object of the research is not the default event per se, nor the construction of alternative prudential models, but the preceding phase: the way in which environmental pressures, territorial quality, climate shocks, and ecosystem dependencies can be reflected in pre-default economic-financial variables, altering over time the capacity to repay and, therefore, the credit risk profile.

The empirical focus is confined to a specific territorial and sectoral perimeter: Sicilian SMEs operating in the accommodation and food service segments in coastal areas. This choice responds to two considerations. First, coastal contexts represent a particularly significant laboratory for observing the convergence between environmental risk and economic performance: here, sea and beach quality, water availability, the frequency of extreme events, and pressure on ecosystems are potentially decisive variables for destination attractiveness, demand, seasonality, and service continuity. Second, the SME segment makes the methodological problem even more stringent: data availability is often limited, reporting capacity is heterogeneous, and the proportionality principle becomes central to avoid information requests translating into an unsustainable burden or a barrier to access to capital.

Building on these premises, the research develops a “bridge” between two worlds that tend to speak different languages. On the one hand, environmental phenomena and ecosystem dependencies, often complex, localized, and difficult to synthesize into operational metrics. On the other, banking credit risk processes, which require information that is comparable, auditable, and insertable at defined control points along the credit life cycle. The underlying hypothesis is that integration is possible, but only if it occurs through a “translation layer” capable of transforming environmental drivers into indicators with economic meaning, and of positioning them coherently within banking controls without conflating drivers with default.

The main contribution of the work is the construction of an operational framework that starts from the European Investment Bank’s Blue Economy Sustainability Framework (BESF), strengthened on the “nature” component through TNFD (LEAP) logics, and reorganized in a way that is functional to the information needs of credit risk. This framework distinguishes: (a) a territorial (location-specific) block based on official proxies and public datasets useful for geographic screening; (b) a borrower-level block, based on normalized operational KPIs (water, energy, waste, volumes) to make different firms comparable; (c) a block on managerial and adaptive capacity, relating to governance, plans, and investments. The translation layer further makes explicit the step from indicator to the relevant economic-financial channel and to the control point in the credit cycle, prioritizing a logic of progressive integration: first as a signal and a tool for dialogue, then, only under conditions of informational maturity, as a more structured element.

The empirical phase of the research has an objective consistent with this setting: not to estimate regulatory parameters, but to test informational feasibility and perceived materiality among firms. To this end, a questionnaire is administered to three coastal case studies, with questions aimed at measuring monitoring maturity, the perception of the economic impacts of environmental drivers, and the feasibility of periodically sharing a minimum set of information. The results are interpreted as a proof-of-concept: feedback on the consistency between the theoretical-operational framework and business reality in the SME segment.

In summary, this work aims to demonstrate that the “bankability” of coastal environmental drivers requires methodological rigor: clarity in defining drivers, geographic anchoring, data traceability, normalization, and positioning within banking processes according to a gradual pathway. In a context such as Sicily, where the competitiveness and economic sustainability of coastal tourism and food service are closely linked to environmental quality and territorial resilience, making such linkages measurable becomes a concrete condition to improve bank–firm dialogue, reduce information asymmetries, and steer decisions and capital toward transition trajectories that are credible and robustly sustainable.

METHODOLOGY

The research was conducted through several phases aimed at building a coherent perimeter of "blue" and nature-related drivers in the coastal context; translating them into an operational indicator framework (KPI/KRI) that can be used along the credit life cycle; and verifying, through a questionnaire, informational feasibility in the SME segment.

Desk research and perimeter definition (Chapters 1–2)

In Chapters 1–2, a documentary and literature review was carried out in order to: delineate the "Blue Economy" domain and its main pressures/impacts; reconstruct the relevant risk categories and the related transmission channels to the economic-financial vulnerability of SMEs. Operationally, the work was set up as desk research based on academic contributions and institutional reports; European policy documents and tools; and territorial/sectoral sources useful to frame the context of SMEs in Sicily.

Analysis of banking constraints and "entry rules" into credit risk (Chapter 3)

Chapter 3 was developed through documentary analysis of regulation and supervisory practices to define the constraints within which environmental indicators can be used in banking processes. Specifically, the analysis covered upstream requirements (default definition and observational granularity) and their implications for the use of drivers along the credit life cycle; robustness/validation and governance constraints connected to potential use in a PD[1] perspective; and the forward-looking perimeter related to SICR/ECL[2], where drivers more naturally enter as prospective signals and documented triggers.

Construction of the operational framework and information architecture (Chapter 4)

Chapter 4 was developed through a three-step procedure:

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[1] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16).

[2] Wells, M., & Frerejacque, P. (2017, September). IFRS 9 financial instruments: Impairment. Practical workshop for the National Bank of the Republic of Belarus. Centre for Financial Reporting Reform, World Bank.

1. Selection of reference baselines and indicator "extraction". As a baseline, indicators were derived from the BESF of the European Investment Bank (Main Report[3], Guidelines[4], Annexes[5]), preserving the dimension–criteria–indicators logic and measurement units. For the methodological structuring of the "nature" component and the traceability of dependencies/impacts, the TNFD[6] and the NGFS[7] conceptual framework for transmission channels to financial risk were used as references; for informational consistency, alignment with the ESRS[8] architecture was also considered.
2. Design by information blocks and translation layer. Indicators were organized into three layers: territorial context; firm operational profile; managerial/adaptive capacity. The "translation layer" links each indicator to the economic-financial channel (revenues, OPEX, CAPEX, continuity) and to the integration point in the credit life cycle.
3. Minimum requirements for verifiability and georeferencing. A minimum operational requirement was introduced: georeferencing the predominant site in order to ensure consistency between territorial proxies and borrower-level data. Information sources were classified into public/official datasets and verifiable firm-level data.

In addition, indicators were converted into KRIs through a standard procedure: normalization; benchmarking; threshold definition; association of triggers/actions, while maintaining an audit trail and consistency with a progressive integration logic.

Empirical verification: questionnaire (Chapter 5)

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[3] European Commission. (2021). Sustainability criteria for the blue economy: Main report. Publications Office of the European Union.
[4] European Commission. (2021). Sustainability criteria for the blue economy: Guidelines. Publications Office of the European Union.
[5] European Commission. (2021). Sustainability criteria for the blue economy: Annexes to the main report. Publications Office of the European Union.
[6] Taskforce on Nature-related Financial Disclosures. (2023, March). Nature-related risk and opportunity management and disclosure framework: Beta v0.4 Annex 4.6—Guidance on LEAP: Methods for assessing nature-related risks. TNFD.
[7] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors
[8] European Commission. (2023). ESRS E3 – Water and marine resources (Annex I to Commission Delegated Regulation (EU) 2023/2772).

The empirical phase was designed as a feasibility assessment / proof-of-concept rather than as a quantitative pilot of the framework: the questionnaire is intended to test monitoring maturity, perceived materiality, and the feasibility of sharing a minimum set, without collecting sensitive data or estimating regulatory parameters.

LITERATURE REVIEW

Blue Economy, European governance and sustainability standards: from the regulatory ecosystem to the translation into "bankable" indicators

The Blue Economy has emerged as a development paradigm that integrates economic growth, social well-being, and ecosystem protection in the marine–coastal context. In the literature, it is described as a transformation pathway for production models and governance systems, grounded in the sustainable use of ocean and coastal resources and in the reduction of pressures on ecosystems. From this perspective, the Blue Economy is not merely a sectoral label; rather, it is an integrated framework in which traditional activities (fisheries, aquaculture, maritime transport, coastal tourism, shipbuilding) and emerging ones (offshore renewable energy, blue biotechnology, marine observation and surveillance, applications of robotics and artificial intelligence, enhancement of underwater cultural heritage) are expected to develop within increasingly binding ecological constraints and governance rules.[9]

A first major issue in the literature concerns the definition of the Blue Economy itself and its operational ambiguity. The concept is used in non-uniform ways and is often conflated with "ocean economy", "marine economy", and "blue growth". The coexistence of different interpretative lenses (natural capital, livelihoods, business opportunities, innovation) creates the risk that "blue" strategies may be pursued through extractive or growth-centric approaches without effective sustainability guarantees. This has led to critical strands of research stressing the need for verifiable criteria, monitoring tools, and accountability mechanisms, as well as for the explicit integration of equity and justice dimensions in governance choices. The simultaneous expansion of multiple ocean-based activities further increases complexity: spatial congestion; conflicts across sectors (for example between fisheries and offshore renewables); environmental externalities (pollution, noise, plastic waste); impacts on habitats and biodiversity; and cultural tensions linked to the transformation of traditional practices. In parallel, benefit distribution is often uneven, with risks of

[9] Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). Shades of blue: What do competing interpretations of the blue economy mean for oceans governance? Journal of Environmental Policy & Planning, 20.

marginalising weaker actors and of privatising marine spaces historically perceived as commons (dynamics frequently discussed under the notion of "ocean grabbing").

The literature situates the Blue Economy within a biophysical framework defined by the planetary boundaries, which identify critical thresholds beyond which the stability of the Earth system is jeopardised. References to boundaries such as climate change, biosphere integrity, biogeochemical flows, freshwater change, and ocean acidification highlight that the growth of sea-related economic activities must be measured against ecological thresholds that have already been partly transgressed. Oceans are described as a global ecological infrastructure: they regulate climate, absorb CO_2, sustain essential ecosystem services, and depend, regarding their resilience, on the integrity of marine biodiversity. This framing makes clear that Blue Economy sustainability is not automatic, but rather a contingent outcome shaped by the compatibility between economic uses and the regenerative capacity of ecosystems.[10]

The European ecosystem: strategies, criteria, and policy instruments for a sustainable Blue Economy

Within the European Union, the Blue Economy is defined as the set of industries and economic sectors related to oceans, seas, and coasts, whether operating directly in the marine environment or on land while being functionally connected to it. The literature shows how the EU has progressively framed the Blue Economy as a core component of the ecological transition, recognising seas and oceans as both natural capital and a driver of innovation and growth, with a role in climate resilience and in the objective of climate neutrality by 2050.

In this trajectory, a key pillar is the **EU Biodiversity Strategy for 2030**[11], which aims to protect a significant share of European marine areas, restore degraded coastal and ocean ecosystems, and promote the sustainable management of marine resources and fisheries. The strategy is connected to a more operational dimension through policy

[10] Sakschewski B., Caesar L, Andersen L, et al. (2025). *Planetary Health Check 2025. Postdam Institute for Climate Impact research.*
[11] European Commission. (2020, 20 maggio). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — EU Biodiversity Strategy for 2030: Bringing nature back into our lives (COM (2020) 380 final).

orientations and communications emphasising the restoration of the "good ecological status" of marine ecosystems. Within this framework, several instruments and directives that structure EU action are explicitly recalled: the implementation of the **Common Fisheries Policy**[12], the **Marine Strategy Framework Directive**[13], and the **Habitats Directive**[14] and **Birds Directive**[15], alongside an ecosystem-based approach to managing human activities that affect sensitive species and seabed habitats. A central aspect concerns planning: **national maritime spatial plans**[16] are presented as instruments intended to cover all maritime activities, integrating zone-specific conservation and management measures. In the same logic, the introduction or strengthening of measures to limit the use of fishing gear with high biodiversity impacts is envisaged, with particular attention to bottom-contact practices, and to bringing fishing mortality back to levels consistent with stock sustainability. The focus on reducing bycatch and strengthening data collection completes a set of tools that, over time, translates conservation objectives into binding constraints and operational standards.

The EU has also consolidated the "blue" dimension of transition policies through the **New Approach for a Sustainable Blue Economy (2021)**[17], which seeks to fully integrate the Blue Economy into ecological transition policies by promoting the decarbonisation of maritime transport, the development of offshore renewables, the reduction of marine pollution, and circular economy practices in sea-related sectors.

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[12] European Parliament & Council of the European Union. (2013, December 11). Regulation (EU) No 1380/2013 of the European Parliament and of the Council on the Common Fisheries Policy. Official Journal of the European Union, L 354, 22–61.

[13] European Parliament & Council of the European Union. (2008, June 17). Directive 2008/56/EC of the European Parliament and of the Council establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive). Official Journal of the European Union, L 164, 19–40.

[14] Council of the European Union. (1992, May 21). Council Directive 92/43/EEC on the conservation of natural habitats and of wild fauna and flora. Official Journal of the European Union, L 206, 7–50.

[15] European Parliament & Council of the European Union. (2009, November 30). Directive 2009/147/EC on the conservation of wild birds. Official Journal of the European Union, L 20, 7–25.

[16] European Parliament & Council of the European Union. (2014, July 23). Directive 2014/89/EU of the European Parliament and of the Council establishing a framework for maritime spatial planning. Official Journal of the European Union, L 257, 135–145.

[17] European Commission. (2021, May 17). Communication on a new approach for a sustainable blue economy in the EU: Transforming the EU's Blue Economy for a Sustainable Future (COM (2021) 240 final). Publications Office of the European Union.

The literature also recalls **The EU Blue Economy Report 2025**[18] as an interpretative and guidance tool, presented as a document capable of offering an overall view of the contribution and potential of the Blue Economy within the Union, aimed at informing policymakers and stakeholders and focusing on investment opportunities linked to the energy and digital transitions.

Alongside strategies, EU policy is expressed through financial instruments: the **European Maritime, Fisheries and Aquaculture Fund (EMFAF 2021–2027)**[19] is described as a lever for sectoral transformation, with resources dedicated to supply-chain sustainability, innovation, and research, and with an orientation towards low-emission technologies and the responsible management of marine resources. Consistently, targeted interventions for coastal protection and enhancement are also recalled (environmental and cultural improvement of beaches, social inclusion, reduction of marine pollution), together with initiatives connected to critical issues such as plastic waste management, the recovery and reuse of wrecks, and the development of pilot desalination solutions.

In summary, European scholarship outlines an ecosystem in which strategies, regulatory instruments, and funding schemes define an environmental baseline and a set of expectations that increasingly shape the economic feasibility and bankability of "blue" activities. This architecture is particularly relevant for regions with high coastal dependence, such as Sicily, where hospitality and food service sectors are strongly linked to water quality, environmental attractiveness, and ecosystem stability.

Physical, transition and nature-related risks: integration into the European financial and supervisory framework

Recent literature stresses that nature degradation and biodiversity loss generate economic and financial risks which, if neglected, may create systemic vulnerabilities. The conceptual framework distinguishes between **physical risks** (acute and chronic)

[18] European Commission. (2025). The EU Blue Economy Report 2025 edition. Publications Office of the European Union.
[19] European Parliament & Council of the European Union. (2021, July 7). Regulation (EU) 2021/1139 establishing the European Maritime, Fisheries and Aquaculture Fund and amending Regulation (EU) 2017/1004; Official Journal of the European Union, L 247, 1–49.

and **transition risks**, highlighting their interdependence. Physical risks include extreme events and progressive phenomena (ecosystem deterioration, sea-level rise, resource scarcity), with impacts on real-economy sectors and key economic-financial variables. Transition risks stem from the adoption of policies and regulations, technological development, and shifts in market preferences and stakeholder confidence; failure to adapt may translate into higher costs, reduced competitiveness, and constraints on access to credit.[20]

On the supervisory and banking regulation side, the literature points to the progressive formalisation of expectations for integrating ESG risks into banking processes. In particular, the approach assigns relevance to a systematic integration of ESG risks into strategic processes, business models, risk policies, and monitoring systems. This integration requires framing ESG risks in relation to traditional risk categories (credit, market, liquidity, operational, reputational, concentration) and identifying indicators, thresholds, or limits consistent with the institution's risk appetite. In parallel, there is an expectation to set out **transition plans** with timelines, quantitative intermediate targets, and milestones, capable of supporting resilience across differentiated time horizons.

Supervisory sources and institutional practices cited in the literature reinforce this direction: on the one hand, guidance and supervisory expectations shape governance, processes, risk management, and disclosure; on the other hand, analyses and stress tests highlight data gaps and reliance on proxies, with implications for methodological robustness and the need for prudent approaches. At national level, indications are also recalled that encourage intermediaries, including smaller ones, to define action plans for integrating climate and environmental risks into their ordinary governance and risk management frameworks.[21]

From transparency to the translation into indicators: CSRD, ESRS, EU Taxonomy, EBA ITS and SME standards

[20] OECD. (2023). Assessing biodiversity-related financial risks. OECD Publishing.
[21] Ranger, N., et al. (2023). The green scorpion: The macro-criticality of nature for finance – Foundations for scenario-based analysis of complex and cascading physical nature-related risks. Oxford: Environmental Change Institute, University of Oxford.

A central line of the literature concerns the transition from principles and objectives to **measurable and traceable information**, which is necessary both for reporting and for risk assessment and credit allocation. The growing regulatory and reporting pressure is interpreted as a transition driver and, at the same time, as a competitive opportunity for firms and intermediaries able to structure high-quality data.

In this context, the **Corporate Sustainability Reporting Directive (CSRD)**[22] is the backbone of the new European transparency architecture, with effects across value chains. Reporting obligations for larger companies generate a growing demand for ESG information also from smaller counterparties and suppliers, including SMEs, which are indirectly involved through supply chains and financial relationships. This dynamic is reinforced by the role of the **EU Taxonomy**[23] as a tool for identifying sustainable activities, and by the evolution of informational requirements for significant banks regarding the share of portfolios associated with aligned activities, according to the **EBA Implementing Technical Standards (EBA ITS)**. This results in a convergence between corporate reporting, financial reporting, and prudential assessment: the availability of ESG data becomes relevant both for reputation and access to capital, and for risk measurement.

The **European Sustainability Reporting Standards (ESRS)** operationalise the obligations introduced by the CSRD, harmonising the content, structure, and logic of disclosure on the basis of **double materiality** and the representation of **impacts, risks, and opportunities**. The literature emphasises that the first, "sector-agnostic" set includes cross-cutting standards (**ESRS 1** and **ESRS 2**) and thematic E-S-G standards, establishing a framework that, although not sector-specific, produces specific implications for activities with high dependence on natural resources. From a Blue Economy perspective, particular relevance is assigned to **ESRS E3 "Water and marine resources"**, which structures disclosures around pressures, dependencies, and the management of water and marine resources across activities and value chains. For Sicilian SMEs in hospitality and food service, the highlighted implication is mainly

[22] European Commission. (2023). *Corporate sustainability reporting (CSRD)*
[23] European Parliament & Council of the European Union. (2020, June 18). Regulation (EU) 2020/852 on the establishment of a framework to facilitate sustainable investment (EU Taxonomy Regulation). Official Journal of the European Union, L 198, 13–43.

indirect: although they are not always subject to the same obligations as large firms, they are progressively pulled into the information perimeter through data requests from lead firms and from financial counterparties required to report under ESRS.[24]

Regarding proportionality and information feasibility for SMEs, the literature recalls dedicated bank–enterprise dialogue tools. The **Sustainability Dialogue between SMEs and Banks[25]** is described as a voluntary and structured framework, featuring modular indicators across environmental, climate, social, and governance dimensions, designed to make information understandable and usable by intermediaries in analytical processes. The instrument is grounded in standardisation, efficiency, cost-effectiveness, and proportionality criteria, and it is accompanied by capacity-building measures (training and pilot projects) to strengthen ESG capabilities in SMEs. Within the same trajectory, the gradual adoption of voluntary standards for SMEs (**VSME**)[26] is framed as a tool for harmonisation and the reduction of information asymmetries.

Implications for banks: from the credit lifecycle to PD and SICR/ECL

The regulatory and standardisation evolution described in the literature converges on a practical implication: the need to "translate" environmental and nature-related drivers into normalised indicators (KPIs) and risk indicators (KRIs) that can be used along the **credit lifecycle**. From this perspective, "blue" drivers (water quality, coastal erosion, water stress, pressures on ecosystems and biodiversity, regulatory and market constraints linked to the transition) do not constitute default events per se, but can structurally affect antecedent economic-financial variables (revenues, margins, costs, capex, operational continuity), altering repayment capacity and thus credit risk.

The banking literature recalled highlights that the integration of such drivers must comply with prudential and accounting constraints: the regulatory definition of default, requirements for estimating and validating risk parameters, and consistency with the forward-looking impairment approach (SICR/ECL). This leads to an integration

[24] European Commission. (2023). Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards. Official Journal of the European Union, L 2023/2772
[25] Ministero dell'Economia e delle Finanze (MEF). (2024). *Dialogo di sostenibilità tra PMI e Banche*.
[26] European Financial Reporting Advisory Group. (2024). Voluntary Standard for SMEs (VSME).

hierarchy: environmental and nature-related indicators first enter as deterioration signals and monitoring factors (early warning), and only subsequently, once supported by data, governance, and traceability, can they contribute, directly or indirectly, to creditworthiness estimates and rating reviews.[27]

Synthesis

Overall, the literature shows a growing convergence among:

- European strategies for protecting marine ecosystems and promoting a sustainable Blue Economy;
- Policy and financing instruments that translate environmental objectives into operational constraints;
- Supervisory frameworks requiring banks to integrate ESG and nature-related risks into governance and risk management processes;
- Reporting standards and dialogue tools that make it possible to translate environmental pressures into comparable and usable data.

The consequence is a paradigm shift: sustainability, particularly in dimensions linked to water and marine resources, becomes a structural element of competitiveness and bankability, but also a source of risk that must be measured and managed throughout the credit lifecycle. Within this framework, the key methodological challenge is to make "blue" drivers measurable, traceable, and proportionate, enabling a progressive and credible integration into banking controls (PD, SICR/ECL) and into bank–enterprise dialogue, especially for SMEs and in coastal territories with high ecosystem dependence.

[27] European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06).

RESEARCH QUESTION

This thesis investigates whether, and to what extent, banks can integrate into their credit risk management processes the impacts and environmental dependencies typical of the Blue Economy, with particular reference to Sicilian SMEs operating in the accommodation and food service sectors. The underlying assumption is that specific "blue" and nature-related drivers (including water quality, coastal erosion, water stress, pressures on ecosystems and biodiversity, as well as regulatory and market constraints linked to the transition) do not in themselves constitute default events, but may structurally affect economic and financial variables antecedent to default: revenues, margins, operating costs, investment needs, and operational continuity, thereby altering repayment capacity and, ultimately, credit risk.

Within this framework, the Research Question is as follows: **How can banks translate environmental and nature-related drivers of the coastal Blue Economy into measurable and traceable information, usable along the credit life cycle and potentially integrable, directly or indirectly, into the assessment of the Probability of Default (PD) of Sicilian SMEs in the accommodation and food service sectors?**

The research pursues three operational objectives:

- to identify the "blue" and nature-related drivers that are materially relevant for the two sectors under consideration and to reconstruct their transmission channels toward economic and financial performance;
- to define a methodology for "translating" such drivers into normalized indicators (KPIs) and risk indicators (KRIs) usable at key banking integration points (origination, monitoring, rating review, and forward-looking deterioration assessments);
- to verify, through a questionnaire addressed to the target SMEs, the informational feasibility (availability, ease of collection, verifiability) of the proposed minimum set of indicators, with the aim of enabling a progressive integration consistent with prudential, accounting, and governance constraints.

CHAPTER 1 — BLUE ECONOMY AND ECOLOGICAL LIMITS: DEFINITIONS, GOVERNANCE, AND THE SICILIAN TERRITORIAL FRAMEWORK

1.1 Definition of Blue Economy

The need to integrate economic development with environmental protection is nowadays an increasingly pressing requirement that also represents a strategic imperative for businesses and companies of all sizes.

In such a context, the Blue Economy grows and develops as an innovative paradigm of doing business, which sets among its main objectives the protection of marine ecosystems, offering prospects for growth and competitiveness through new integrated business models.[28]

The Blue Economy is an important component of global economies, as it promotes employment, innovation, and also ensures opportunities for economic development and investment for local communities.

In other words, it goes beyond a merely theoretical concept and represent a concrete pathway toward a more sustainable future based on the responsibles use of marine resources. This approach fosters economic growth, job creation, and innovation while ensuring the health of oceans and coastal communities.

The Blue Economy also plays a central role in reducing pressures on terrestrial resources and supports both mitigation and adaptation strategies in the face of climate change.

Consequently, there is a growing need to develop and promote sustainable blue-economy activities based on a shared international understanding. Establishing common criteria and methodological frameworks is essential to assess the productivity and sustainability of blue-economy practices.[29]

Academic research on the Blue Economy and its evolution has been characterized by the recognition of its multifaceted nature, and indeed, the concept itself began to gain

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[28] European Commission. (2025). EU Blue Economy Report 2025. Publications Office of the European Union.

[29] European Commission. (2021). Sustainability criteria for the blue economy: Main report. Publications Office of the European Union.

traction starting in 2012, during the United Nations Conference on Sustainable Development, highlighting as the main response the need to harmonize economic development through environmental protection.[30]

In essence, the Blue Economy requires an integrated approach to the sustainable management of marine resources.

This is essential not only to promote economic and social growth, improving the livelihoods of populations and job opportunities, but, even more importantly, to ensure the health of biosystems, as the two objectives are intrinsically linked.

From a legal perspective, the Agreement on the protection of marine ecosystems beyond national waters represented a success and was later postponed by a few years to make a decision regarding the development of a specific international instrument under the United Nations Convention on the Law of the Sea (UNCLOS).[31] Article 1 of the Convention, explains the premises[32]:

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[30] Lee, K.-H. (2020). The Blue Economy and the United Nations' sustainable development agenda.

[31] http://www.comitatoscientifico.org/temi%20SD/Rio2012/

[32] "*For the purposes of this Convention:*

(1) "Area" means the seabed and ocean floor and subsoil thereof, beyond the limits of national jurisdiction;

(2) "Authority" means the International Seabed Authority;

(3) "activities in the Area" means all activities of exploration for, and exploitation of, the resources of the Area;

(4) "pollution of the marine environment" means the introduction by man, directly or indirectly, of substances or energy into the marine environment, including estuaries, which results or is likely to result in such deleterious effects as harm to living resources and marine life, hazards to human health, hindrance to marine activities, including fishing and other legitimate uses of the sea, impairment of quality for use of sea water and reduction of amenities;

(5) (a) "dumping" means:

(i) any deliberate disposal of wastes or other matter from vessels, aircraft, platforms or other man-made structures at sea;

(ii) any deliberate disposal of vessels, aircraft, platforms or other man-made structures at sea;

(b) "dumping" does not include:

(i) the disposal of wastes or other matter incidental to, or derived from the normal operations of vessels, aircraft, platforms or other man-made structures at sea and their equipment, other than wastes or other matter transported by or to vessels, aircraft, platforms or other man-made structures at sea, operating for the purpose of disposal of such matter or derived from the treatment of such wastes or other matter on such

vessels, aircraft, platforms or structures;

(ii) placement of matter for a purpose other than the mere disposal thereof, provided that such placement is not contrary to the aims of this Convention.

2. (1) "States Parties" means States which have consented to be bound by this Convention and for which this Convention is in force.

(2) This Convention applies mutatis mutandis to the entities referred to in article 305, paragraph l(b), (c), (d), (e) and (f), which become Parties to this Convention in accordance with the conditions relevant to each, and to that extent "States Parties" refers to those entities.", Article 1, Use of terms and scope, in United Nations. (1982). United Nations Convention on the Law of the

The article defined the key terms related to the governance and protection of the marine environment, providing the essential legal and regulatory foundations for the development of a sustainable Blue Economy and ensuring that human activities in the oceans are conducted responsibly, for the benefit of both human communities and the marine ecosystem.

The Convention does not explicitly define the Blue Economy, but it represents a crucial early step in establishing the legal conditions necessary for its later conceptual development.

In contrast, the World Bank explicitly defines the Blue Economy as «the sustainable use of ocean resources for economic growth, improved levels, and jobs while preserving the health of ocean ecosystems». In this sense, the blue economy represents a paradigm that combines three fundamental dimensions: economic growth, social well-being and environmental protection, but it does so specifically in the marine, coastal and aquatic context, enhancing resources that have traditionally been less considered in development models.[33]

The main elements to be considered in such an approach are

1. sustainable exploitation of marine and coastal resources, which includes traditional activities such as fisheries, aquaculture, maritime transport and coastal tourism, and emerging activities such as offshore renewable energy, marine biotechnology, port infrastructure and marine spatial planning.
2. social inclusion and benefits for coastal communities, i.e. ensuring that economic development generates jobs, improves livelihoods and distributes benefits equitably, preventing local communities from being excluded or harmed.
3. protection and regeneration of aquatic and marine ecosystems, i.e. that economic activities are compatible with the conservation of biodiversity, ecosystem productivity and natural functions — so that resources can also be used by future generations.

Sea (Article 1: Use of terms and scope). Retrieved from https://www.un.org/Depts/los/convention_agreements/texts/unclos/unclos_e.pdf

[33]Veríssimo, N. V., et al. (2021). From green to blue economy: Marine biorefineries for a sustainable ocean-based economy. Green Chemistry, 23(23), 9377–9400.

4. integrated governance, innovation and cross-sectoral cooperation, which requires policies and institutions capable of coordinating various sectors (economy, environment, spatial planning) and multiple actors (government, businesses, local communities) from a systemic perspective.[34]

Generally, it is widely believed that the concept revolves around the idea of marine systems understood in different ways, including:[35]

1) **Natural Capital**, meaning defining the Blue Economy based on the protection and restoration of ecosystems, and thus conducting business by prioritizing sustainable development, environmental protection, and the well-being of the entire community.
2) **Means of Livelihood**, understood as a tool dedicated to social and economic resilience, linked to economic opportunities aimed at achieving the United Nations' Sustainable Development Goals (SDGs).
3) **Means of Business**, conceived from the perspective of the private sector with the aim of economic growth and employment.
4) **Driver of Innovation**, related to the previous point and focused on the potential of marine biosystems for innovation in production processes through the development of new ways to use available resources in the sector.

At the regional and international levels, several scholars have begun to invoke the concept of the Blue Economy, to grasp the multisectoral and multiscalar goals of ocean governance. The blue economy, studied over time as a process aimed at balancing sustainable economic benefits in a manner consistent with sustainable development and its commitment to intra - and intergenerational equity. The term Blue Economy has been used often and according to different opinions, including to give greater recognition to the many oceanic and non-oceanic values, which give cultural value and from village-based subsistence economies to commercial and industrial raw materials.

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[34] Yuan, H., & Failler, P. (2025). Defining the Blue Economy – in a language functional approach. Maritime Studies.
[35] Voyer, M., Quirk, G., McIlgorm, A., & Azmi, K. (2018). Shades of blue: What do competing interpretations of the blue economy mean for oceans governance? Journal of Environmental Policy & Planning, 20.

According to this definition not all ocean activities are consistent with the Blue Economy concept, because many ocean activities are not sustainable.
In several articles of modern literature the concept of the Blue Economy is examined according to an analytical framework in order to better assess how it is faster to achieve sustainable development of the oceans, with a focus on fisheries as an example of an important sector within a Blue Economy. Still using the existing literature, a conceptual framework of the Blue Economy is developed and then a case study approach is used to evaluate its usefulness in the analysis of the issues and opportunities related to the management and development of the approach itself. The policy implications of a rapidly changing blue economy, across multiple sectors, are highlighted in several studies. The blue economy has become a commonly used term that includes several objectives in order to support economic development opportunities while preserving the health of the ocean ecosystem in order to have a means of promoting and recognizing cultural ties with the ocean deriving from tradition and marine property customs.[36]

Over time, various challenges and shortcomings have emerged in putting planned objectives into practice, both environmentally and socially, especially within marine and coastal communities.
There has always been a need to complement the expansion of research with the integration of Blue Economy principles into a much broader framework of sustainable growth.

Today, the field of the Blue Economy is expanding its scope, embracing a critical vision that carefully examines issues of equity, justice, and governance.
At the same time, it is dedicated to exploring innovative development models that go beyond the established paradigms of the circular economy and the green economy, seeking new solutions and approaches for a sustainable future.

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[36] Towards defining the Blue Economy: Practical lessons from pacific ocean governance Author links open overlay panel Meg R. Keen a , Anne-Maree Schwarz b , Lysa Wini-Simeon c IN "Marine Policy" Vol 88, February 2018, Pages 333-341

Indeed, research on the Blue Economy by various governments shows significant growth year by year, both in terms of the number of publications and the experts joining the sector and discipline, studying a wide range of possible solutions.

Taking 2021 as a reference year, for example, a Web of Science database search highlights that 162 countries have published literature related to the sustainable development of the Blue Economy over the past 15 years, with an increase in publication frequency of nearly 30% between 2012 and the reference year itself.[37]

Research in the field of the Blue Economy is projected toward the future, with a focus on exploring innovative approaches to build sustainable contexts.[38]

The European Union provides a definition of the Blue Economy as: "all industries and economic sectors related to oceans, seas, and coasts, whether they operate directly in the marine environment or on land."[39]

The European Union has clearly demonstrated its commitment to leveraging the Blue Economy to achieve its sustainability goals, and several acts adopted in recent years underscore this commitment, including the EU Biodiversity Strategy.

The European Union through various attestations and improvements over the last few years has consistently and clearly demonstrated its commitment to promoting and enhancing the Blue Economy as a strategic tool to achieve the environmental, economic and social sustainability objectives outlined in the European Green Deal. The EU vision recognises that seas and oceans represent not only a priceless natural resource, but also an engine of innovation and sustainable growth, capable of generating employment, protecting marine biodiversity and contributing to climate neutrality by 2050. This commitment translates into a series of policies, strategies and regulatory acts that demonstrate the Union's desire to build a blue development model based on sustainability, technological innovation and the protection of marine ecosystems. Among these, a central role is played by the EU Biodiversity Strategy for 2030 (EU Biodiversity Strategy), which represents one of the fundamental pillars of

[37] Liang, J., Yin, Z., Yang, J., Li, Y., Xu, M., Li, J., Yang, M., & Niu, L. (2022). Bibliometrics and visualization analysis of research in the field of sustainable development of the blue economy (2006–2021). Frontiers in Marine Science, 9.

[38] Pace, L. A. (2023). Exploring future research and innovation directions for a sustainable blue economy, 148.

[39] European Commission. (2021). The EU blue economy report 2021. Publications Office of the European Union.

the Green Deal. This strategy aims to protect at least 30% of Europe's marine areas, restore damaged coastal and ocean ecosystems and promote sustainable management of marine and fisheries resources.

The EU also introduced the New Approach for a Sustainable Blue Economy in 2021, with the aim of fully integrating the blue dimension into ecological transition policies. That agenda encourages the decarbonisation of maritime transport, the development of offshore renewable energies (such as wind and wave energy), the reduction of marine pollution and the adoption of circular economy practices in sea-related sectors.

Similarly, financial instruments such as the European Maritime, Fisheries and Aquaculture Fund (EMFAF) support projects aimed at improving the sustainability of fisheries, promoting ecological aquaculture and boosting research and innovation in the maritime field. These initiatives further strengthen the EU's role as a global leader in promoting a sustainable blue economy.

Through these integrated policies, the European Union demonstrates a systemic and forward-looking approach: the Blue Economy is not only conceived as an economic sector, but as an essential component of the European strategy for climate resilience, environmental protection and the prosperity of future generations. In this way, the EU not only consolidates its global leadership in environmental policies, but also promotes a development model that combines economic growth and the safeguarding of natural capital marine[40]

The EU countries most involved in the Blue Economy from an economic perspective are Germany, Italy, Spain, and France.[41]
According to a recent report, it has been demonstrated that
"*The share of the blue economy in national economies - the report explains - varies from one EU country to another, as the blue economy of island nations or those with archipelagos contributes more significantly to national GVA and employment. In*

[40] *EU Biodiversity Strategy for 2030: Bringing nature back into our lives*.
[41] Borriello, A., et al. (2025). The EU Blue Economy Report 2025. European Commission, JRC.

terms of employment, the shares range from 11.4% in Greece to 0.2% in Austria. When it comes to GVA, the range extends from 6% in Croatia to 0.1% in Luxembourg."[42]

Unlike the Green Economy, which often focuses on reducing environmental impact through increased investment in cleaner technologies, the Blue Economy seeks to redesign production models by drawing inspiration from natural ecosystems.

Its core objective is to transform waste into resources, promote innovation, and create economic value while minimizing environmental externalities. Rather than requiring additional capital expenditures, the Blue Economy encourages the use of locally available resources and efficient processes to generate more value with less, fostering sustainability, job creation, and reduced waste generation.[43]

The eighth edition of *The EU Blue Economy Report 2025*, presented with a new graphic design, a result of collaboration between the European Commission's Directorate-General for Maritime Affairs and Fisheries and the Joint Research Centre, provides a comprehensive overview of the contribution and potential of the Blue Economy within the European Union. The document outlines the EU's objectives for a sustainable, competitive, and resilient marine economy, while highlighting investment opportunities in this crucial sector.[44]

Its primary objective is to provide guidance to policymakers and stakeholders in promoting the growth of ocean-based markets and the maritime sector, as well as the sustainable use of coastal and marine resources.

The sectors of the Blue Economy play an increasingly important role in achieving the European Commission's key priorities aimed at making the EU more competitive, sustainable, resilient, and secure.

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[42] European Commission, Directorate-General for Maritime Affairs and Fisheries. (2025). The EU Blue Economy Report 2025.

[43] Pauli, G. (2010). The blue economy: 10 years, 100 innovations, 100 million jobs. Paradigm Publications.

[44] European Commission. (2025). EU Blue Economy Report 2025. Publications Office of the European Union.

By providing economic insights into the opportunities arising from the energy and digital transition, the Report also aims to attract investments in the Blue Economy sectors.[45]

1.2 Sectors and Impacts connected to the Blue Economy

The most widely shared international interpretations of the Blue Economy encompass all coastal and marine activities within a tripartite vision that promotes the protection of oceanic ecosystems, societal well-being, and economic development.[46]
Interest in the evolution of sectors related to oceanic activities includes traditional fields such as fishing, maritime tourism, and transportation, but also embraces sectors like marine renewable energy, biotechnology, and carbon sequestration.
The breakdown is outlined as follows:

Traditional sea-related activities, such as fishing, aquaculture, maritime transport, coastal tourism, and shipbuilding, constitute the historical maritime sectors.
While these sectors represent a significant component of the marine economy, they face pressing challenges related to ecological sustainability, market competitiveness, and digital integration.

Innovative maritime sectors include activities that capitalize on new opportunities generated by the marine environment.
These notably include marine renewable energy, blue biotechnology, marine environment observation and surveillance, the application of robotics and artificial intelligence to the maritime sector, eco-friendly tourism, and the enhancement of underwater cultural heritage.
These fields show significant potential for expansion but require constant investment, research, and innovation, as well as appropriate regulation.

Enabling sectors refer to the infrastructure, services, and expertise essential to supporting the development of the Blue Economy.

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[45] European Commission. (2025). *EU Blue Economy Report 2025*. Publications Office of the European Union.
[46] H. Yuan (2025). *Defining the Blue Economy – in a language functional to sustainability*. *Maritime Studies*.

These include ports, communication networks, specialized training and education, as well as maritime governance and planning.
These areas are crucial for creating an environment conducive to the growth of the Blue Economy.

However, it is essential that they are coordinated and harmonized both among themselves and with other public policies to maximize their impact.[47]

1.3 In-depth analysis: Critical issues and weakness of the Blue Economy

After having examined several dimensions of the Blue Economy, it is also essential to focus on further elements that may entail criticalities, both at the conceptual level and in terms of implementation and governance. Recent scholarship shows that, although the Blue Economy is often presented as a largely positive framework for growth and sustainability in maritime sectors, it is also characterised by definitional ambiguity, conflicts among uses and actors, risks of social exclusion, and accountability gaps that can undermine alignment with sustainability and justice objectives.

A widely discussed limitation concerns the lack of a single, standardised definition. The field is relatively recent and marked by inconsistent use of key terms: “Blue Economy” is frequently used with different meanings and often interchangeably with “ocean economy,” “marine economy,” and “blue growth,” sometimes without clear conceptual boundaries. This semantic overlap does not resolve confusion; rather, it increases the likelihood that different actors will adopt whichever definition best fits their interests and sectoral agendas.[48]

This lack of clarity is not merely terminological. Blue Economy and Blue Growth have been criticised because their goals are not sufficiently defined, allowing stakeholders to interpret them in different ways. In addition, multiple interpretative “lenses” coexist: some emphasise natural capital and the livelihoods of coastal communities, while others frame the ocean primarily as a space for business and innovation. Such

[47] https://sni.unioncamere.it/notizie/blue-economy-cose-come-funziona-e-quali-sono-i-vantaggi-litalia.
[48] Martínez-Vázquez, R. M., et al. (2021). Challenges of the Blue Economy: Evidence and research trends. Environmental Sciences Europe, 33, 61.

divergence creates a structural risk that "blue" strategies may be pursued in ways that are not consistent with sustainability.[49]

The same concern emerges in policy-oriented analysis, which highlights the absence of a shared operational definition across global, regional, and national levels. Without a strong framing, policy aims can be interpreted to support increased extraction, potentially in opposition to sustainability objectives. This is not only about what the Blue Economy is supposed to mean, but also about who gets to set priorities and targets without robust mechanisms of verification.[50]

A further sign of how contested the concept remains is visible in research trends. Alongside the growth of academic output, critical strands such as "blue degrowth" are increasingly discussed, explicitly questioning the growth-centric orientation often associated with Blue Economy and Blue Growth. This development reinforces the point that the concept's limitations are not peripheral, but rather constitute a core line of debate within the field.

At the conceptual level, an intrinsic conflict is frequently highlighted between interests focused on economic growth and development, and interests centred on safeguarding ocean resources. This tension is not incidental but embedded in the very ambition of "blue" development: pursuing economic and social progress while maintaining environmental sustainability. The coexistence of these objectives can become problematic, calling for approaches that explicitly identify threats to the ocean economy rather than assuming automatic compatibility between growth and sustainability.[51]

Policy analysis makes this tension even more explicit. "Economic growth" and "technological innovation" are often positioned as central drivers for both sustainability and blue economy agendas. Yet they also appear among the most

[49] Hoerterer, C., et al. (2020). Stakeholder perspectives on opportunities and challenges in achieving sustainable growth of the blue economy in a changing climate. *Frontiers in Marine Science, 6*, 795.
[50] Niner, H. J., et al. (2022). Issues of context, capacity and scale: Essential conditions and missing links for a sustainable blue economy. Environmental Science & Policy, 130, 25–35.
[51] Martínez-Vázquez, R. M., et al. (2021). Challenges of the Blue Economy: Evidence and research trends. Environmental Sciences Europe, 33, 61.

ambiguous in relation to the SDGs: without contextual framing, interactions can be either positive or negative. Innovation can enable cleaner production, but it can also facilitate the intensification of potentially highly damaging extractive industries, including deep seabed mining. In short, growth is not automatically sustainable, and innovation is not automatically just or environmentally benign.[52]

From an operational perspective, a growing set of criticalities arises from the rapid expansion and simultaneous presence of multiple ocean-based activities. Shipping, offshore renewable energy, fisheries, aquaculture, coastal tourism, marine biotechnology, and deep seabed mining are all expanding, and their coexistence increases the probability of inter-sector and intra-sector conflict because these activities frequently overlap in the same ocean space. While such growth may deliver short-term economic benefits and livelihood opportunities, it also multiplies friction points and governance complexity.

Spatial congestion is further reinforced by the geography of ocean governance and production. A large share of fisheries catches occurs within Exclusive Economic Zones, and the same is true for offshore oil and gas production. Aquaculture in the high seas is described as virtually non-existent, leading to additional concentration near coastlines and within national jurisdictions. This implies that competition for space and resources is not evenly distributed but becomes particularly intense in highly used coastal and EEZ areas, increasing the likelihood of disputes among sectors and users.

Several pathways for conflict are identified: competition for space (for example, offshore wind and tidal projects reducing fishing grounds), environmental impacts (oil spills, plastic waste, and noise), habitat damage (coastal development and seabed mining affecting coral reefs and mangroves), regulatory disputes (zoning, marine protected areas, exclusive zones for energy and tourism), compliance and enforcement challenges (including risks connected to overfishing and illegal activity), and cultural conflicts (including threats to traditional practices and heritage). In this framework,

[52] Niner, H. J., et al. (2022). Issues of context, capacity and scale: Essential conditions and missing links for a sustainable blue economy. Environmental Science & Policy, 130, 25–35.

conflict is not a single issue but a systemic pattern generated by crowding and overlapping uses.

A particularly sensitive point concerns the interaction between rapid economic expansion and conservation objectives. The expansion of ocean industries is likely to intersect with areas designated, or potentially designated, as Marine Protected Areas, especially in light of global ambitions such as protecting 30 percent of ocean space by 2030. Power asymmetries around MPAs are emphasised, with the risk that conservation processes and blue economy expansion may exacerbate existing inequalities, especially when local actors, small-scale fishers, and Indigenous and local communities face stronger economic players acting on behalf of development agendas.[53]

Empirical work based on stakeholder perspectives provides concrete evidence of perceived constraints. When asked which sustainability dimension represents the main limiting factor for sustainable growth, most respondents identified economic barriers as the primary hurdle, followed by social and environmental barriers at comparable levels. A non-negligible share of respondents reported that they perceived no obstacles at all, signalling heterogeneity in priorities and perceptions across actors.

In this context, a key example is the spatial conflict between fisheries and offshore wind energy. As offshore wind expands, available fishing space becomes more limited, particularly where additional areas are planned for wind farms in which other uses are not allowed. Nature conservation interests further intensify pressure on contested space, because protected areas that have historically been fished and used by local communities may be closed to commercial and recreational fishing. These restrictions disproportionately affect communities targeting coastal species and operating in nearshore waters.

Additional frictions are also reported, including perceived reputational tensions between seafood actors and nature conservation groups, and concerns about

[53] Sumaila, U. R., & Villasante, S. (2025). Surging blue economy, increasing conflict risks and mitigation strategies. Frontiers in Marine Science, 12, 1499386.

interactions between tourism and transport. The growth of cruise tourism is associated with worries about additional pollution from cruise vessels, especially when combined with cargo vessel pollution in harbours. This highlights how one sector's expansion may generate negative externalities that other sectors perceive as direct threats to sustainability trajectories.

A recurring limitation concerns unequal benefit distribution and the risk of excluding weaker actors. A widely cited concern is the potential privatisation of ocean spaces traditionally treated as common property, leading to "ocean grabbing" that neglects the needs and rights of smaller sectors in favour of private profit interests. In this sense, the Blue Economy may reshape access and control regimes in ways that disadvantage pre-existing users and livelihoods.[54]

Distributional issues are also illustrated through fisheries governance. Conflicts between small-scale fishers and large industrial fleets may intensify as the Blue Economy expands. Market access, technological advantages, and the structure of regulatory instruments can deepen inequalities. For instance, mechanisms such as Individual Transferable Quotas, initially designed to improve sustainability, may lead to financialisation and consolidation under corporate control, increasing inequality and disadvantaging smaller operators.[55]

From a governance standpoint, a central vulnerability lies in the limited capacity to ensure accountability against sustainability commitments. Without clear strategies to monitor and evaluate Blue Economy development across the spectrum of SDG targets, there are few checks and balances to determine progress. This creates an institutional vulnerability, effectively leaving an "open door" for extractive and potentially unsustainable practices to proliferate under "blue" narratives.

Quantitative patterns in SDG interaction analyses reinforce this point: when interactions are considered as being driven by Blue Economy policy aims, a substantial

[54] Hoerterer, C., et al. (2020). Stakeholder perspectives on opportunities and challenges in achieving sustainable growth of the blue economy in a changing climate. *Frontiers in Marine Science, 6*, 795.
[55] Sumaila, U. R., & Villasante, S. (2025). Surging blue economy, increasing conflict risks and mitigation strategies. Frontiers in Marine Science, 12, 1499386.

share remains neutral or ambiguous, illustrating uncertainty and the need for contextual interpretation. Such ambiguity indicates that, unless sustainability is explicitly embedded through framing, indicators, and governance design, the Blue Economy can evolve independently of sustainability aims rather than reinforcing them.

Another critical issue concerns weak support for empowerment and participation goals. Interactions with SDGs linked to equality, representation, and access to information are described as relatively weak when Blue Economy development is not explicitly bounded by the SDGs. Gender equality is also assessed as having a weak interaction with blue economy trajectories, suggesting that power, agency, and participation can remain marginal unless deliberately integrated into governance processes.

More broadly, even where governance aims appear strongly linked to multiple SDGs, top-down implementation pathways risk reproducing or deepening patterns of exclusion for those who depend on marine resources locally. Capacity development, therefore, is framed not only as a need for marginalised groups, but also as a requirement for institutions and policymakers to enable equitable participation and meaningful inclusion in decision-making.

A further area of concern relates to the security and control of ocean wealth. Although only a minority of policies explicitly emphasise the securitisation of marine resources, when national security is framed as control over access to ocean wealth it does not uniformly complement sustainability objectives. Misalignment can risk excluding historically marginalised groups while reinforcing rights and access control. Since many blue economy dimensions cross jurisdictions, national prioritisation of security requires negotiation and consensus-building, consistent with partnership and cooperation commitments.

Important blind spots also emerge in relation to operational safety. While safety at sea is particularly significant for developing economies and the maritime industry, it can be difficult to assess at a high policy level, and its interaction with sustainability targets may appear neutral or weak in aggregated analyses. Still, the socio-economic relevance is emphasised through documented links between occupational health and

safety, productivity, and national economic performance, alongside evidence that a substantial share of blue economy policies includes operational safety aims. This underscores the need for clearer targets and indicators, such as internationally recognised safety standards across blue economy sectors.[56]

Ecological pressures and climate change also impose structural limits. Coastal socio-ecological systems provide essential goods and services, yet they are increasingly threatened by anthropogenic pressures and climate-related changes, including warming, acidification, sea level rise, and shifts in circulation and nutrient inputs. These pressures can affect biodiversity, species distribution, and ecosystem functioning, constraining Blue Economy pathways regardless of the sustainability narrative attached to them. [57]

At the policy level, while resilience and adaptation are recognised as important, the Blue Economy is not framed as a direct vehicle for the most urgent intervention needed to address ocean acidification, namely emissions reductions. Weak linkages between Blue Economy aims and acidification-related targets further illustrate how policy framing may fall short of translating environmental pressures into operational commitments.[58]

Beyond conceptual and ecological tensions, practical institutional barriers can strongly shape outcomes. Stakeholder evidence highlights demands for regulatory adaptation, while also pointing to administrative burdens that discourage small and medium-sized enterprises from applying for funding programmes because processes are perceived as overly complex, unclear, and lengthy. Such barriers reduce the capacity of actors to engage in sustainable innovation and may structurally advantage organisations with greater administrative and financial capacity. [59]

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[56] Niner, H. J., et al. (2022). Issues of context, capacity and scale: Essential conditions and missing links for a sustainable blue economy. Environmental Science & Policy, 130, 25–35.
[57] Hoerterer, C., et al. (2020). Stakeholder perspectives on opportunities and challenges in achieving sustainable growth of the blue economy in a changing climate. *Frontiers in Marine Science, 6*, 795.
[58] Niner, H. J., et al. (2022). Issues of context, capacity and scale: Essential conditions and missing links for a sustainable blue economy. Environmental Science & Policy, 130, 25–35.
[59] Hoerterer, C., et al. (2020). Stakeholder perspectives on opportunities and challenges in achieving sustainable growth of the blue economy in a changing climate. Frontiers in Marine Science, 6, 795.

At the level of research and strategic development, the need to strengthen evidence bases and policy integration is also emphasised, including the limited development of linkages between the Blue Economy and the circular economy within both scholarship and strategy. This reflects a broader maturity gap: a concept that is rapidly expanding in policy and rhetoric may still lack coherent integration mechanisms and sufficiently robust operational foundations.[60]

Overall, the Blue Economy is not inherently sustainable, nor inherently just. Its main limitations relate to definitional ambiguity and competing interpretations, the structural tension between growth and protection, rising conflict risks due to spatial overlap and externalities, distributional risks including “ocean grabbing” and marginalisation of small-scale actors, and governance deficits in monitoring, evaluation, indicators, and institutional capacity. Without operationally verifiable frameworks and context-sensitive governance, these criticalities can enable extractive trajectories to advance under a “blue” label, rather than delivering effective sustainability and justice outcomes.

1.4 Planetary Bounderies

In 2009, Johan Rockström and Will Steffen, leading a team of 28 scientists, introduced a fundamental concept for the Blue Economy, namely the "planetary boundaries."[61]
This model, based on a strictly scientific and highly rigorous analysis, identifies nine critical processes essential for the stability and resilience of the Earth system, and further defines the ecological thresholds to be respected to avoid and reduce irreversible changes.
The advent of the Anthropocene has highlighted the urgent need to quantify the resilience of the Earth system, establishing the limits beyond which abrupt and catastrophic alterations are risked.

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[60] Martínez-Vázquez, R. M., Milán-García, J., & de Pablo Valenciano, J. (2021). Challenges of the Blue Economy: Evidence and research trends. Environmental Sciences Europe, 33, 61.
[61] Crona, B., Wassénius, E., Parlato, G., & Kashyap, S. (2024). Doing business within planetary boundaries. Stockholm Resilience Centre (Stockholm University) and Beijer Institute of Ecological Economics (Royal Swedish Academy of Sciences).

The primary objective is to maintain conditions similar to those of the Holocene, the era of stability that enabled the flourishing of agriculture and contemporary societies, particularly safeguarding the climate, biodiversity, and the planet's vital processes.[62] Respecting these boundaries allows humanity to operate within a safe operating space, a concept linked to the planet's carrying capacity, in other words, its ability to withstand human actions without irreversible alterations.

Regarding the exceeding of these thresholds, the risk of sudden and harmful environmental changes increases on a global scale, necessitating, in such cases, intervention and the pursuit of one direction over another.

Below are the nine planetary boundaries:

1) **Climate Change[63]**
2) **Novel Entities (chemical pollution)[64]**
3) **Stratospheric Ozone Depletion[65]**
4) **Atmospheric Aerosol Loading[66]**
5) **Ocean Acidification[67]**
6) **Biogeochemical Flows (nitrogen and phosphorus)[68]**
7) **Freshwater Change[69]**

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[62] https://www.scienzainrete.it/articolo/limiti-planetari-terra-oltre-punto-di-non-ritorno/giulia-olivero/2025-04-16

[63] The climate change boundary has been exceeded since the 1990s, largely due to significant emissions of greenhouse gases and anthropogenic aerosols. This phenomenon is profoundly altering the Earth's energy balance, manifesting in extreme weather events and severe global environmental impacts.

[64] The increasing introduction of synthetic chemicals, such as microplastics and PFAS, has surpassed safety limits. With over 350,000 compounds released into the environment, the lack of thorough testing makes their long-term effects on human health and ecosystems uncertain.

[65] Unlike other boundaries, the stratospheric ozone layer is currently in a safe condition. This success is a direct result of international efforts to ban harmful substances like chlorofluorocarbons (CFCs). The ozone layer is crucial for protecting life on Earth from harmful ultraviolet radiation. Despite serious threats faced in the late 1990s, the ozone layer has stabilized and shows clear signs of recovery

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[67] The increased absorption of atmospheric CO2 by oceans is causing a rise in water acidity. This chemical alteration severely impacts marine organisms that form calcareous structures and reduces the ocean's capacity to absorb additional CO2, with serious consequences for marine ecosystems. The current aragonite saturation state, a key indicator of acidification, remains within the safe operating space but is dangerously approaching the critical threshold.

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8) **Land-System Change (land use)**[70]
9) **Biosphere Integrity (biodiversity loss)**[71]

The study and understanding of planetary boundaries have evolved significantly since their initial formulation, showing a careful awareness of the anthropogenic impact on the Earth system and the complex links between different ecological thresholds.
Addressing the exceedance of planetary boundaries requires a holistic and transformative approach that involves all levels of society: governments, businesses, communities, and individuals.
There is no single solution but a series of interconnected possibilities that must be implemented urgently and globally.
In 2009, the exceedance of three crucial boundaries, namely *biosphere integrity*, *climate change*, and the *biogeochemical flows*, showed significant planetary instability, concerning experts and pushing the scientific community to develop urgent and global actions.[72]
Further changes occurred in 2015, a year that marked a fundamental milestone for an increasingly evident environmental crisis and a climate debate that culminated in the COP21 in Paris.[73]

At the beginning of 2022, the same scientific community raised another alarm, recognizing the exceedance of another boundary related to "novel entities," another cause for concern that highlights the need for swift actions to avoid further environmental degradation.[74]

consequences for marine ecosystems. The current aragonite saturation state, a key indicator of acidification, remains within the safe operating space but is dangerously approaching the critical threshold.

[70] The transformation of natural landscapes through activities such as deforestation and urbanization is drastically reducing essential ecological functions for the Earth system's health, such as carbon sequestration, moisture recycling, and habitat availability for wildlife. Globally, the remaining forest areas in the three main biomes (tropical, boreal, and temperate) have fallen below safe levels.

[71] This boundary concerns the health and diversity of ecosystems and species. Current species extinction rates have exceeded safe levels. The decline in both genetic diversity and the overall health of ecosystems poses serious risks to the biosphere's ability to maintain essential functions and services for the planet. Rockström J., Grande mondo, piccolo pianeta. La prosperità entro i confini planetari, Edizione Ambiente, 2015

[72] Rockström, J., et al. (2009). A safe operating space for humanity. Nature.

[73] https://www.consilium.europa.eu/en/policies/paris-agreement-climate/

[74] Linn Persson, et al. (2022) — *"Outside the Safe Operating Space of the Planetary Boundary for Novel Entities.*

In the same year, the methodology for assessing freshwater use was also revisited, dividing it into:

- **Blue water**, meaning surface and groundwater, evaluated based on variations in runoff compared to pre-industrial levels;
- **Green water**, meaning water available for vegetation, studied through changes in soil moisture.

With the deviations to the planetary boundaries framework, the need for strong, transformative, and significant changes has emerged, as the simple adjustments made over the years are no longer sufficient.

Further updates and revisions followed in September 2023 by the Stockholm Resilience Centre, confirming that six of the nine boundaries have been exceeded and reiterating, once again, the urgent need for efficient and effective global governance and the use of proactive strategies.[75]

For continuous monitoring of the situation, since September 2024, the Potsdam Institute for Climate Impact Research has annually published the Planetary Health Check.[76]

This is a global scientific initiative that comprehensively and regularly monitors and assesses the state of health of the Earth system, intervening in various cases and with different activities. The Planetary Health Check recognizes that human health and well-being are intrinsically dependent on the health of natural ecosystems. It is not just about protecting the environment for its intrinsic value but also about safeguarding the conditions that allow human civilization to thrive.

The following figures show the graphs and trends from 2009 up to the exceedance of the latest boundaries, highlighting the state of the planet's health:

- **Green Zone** (Safe Operating Space);
- **Yellow Zone** (Zone of Uncertainty);
- **Red Zone** (High-Risk Zone).

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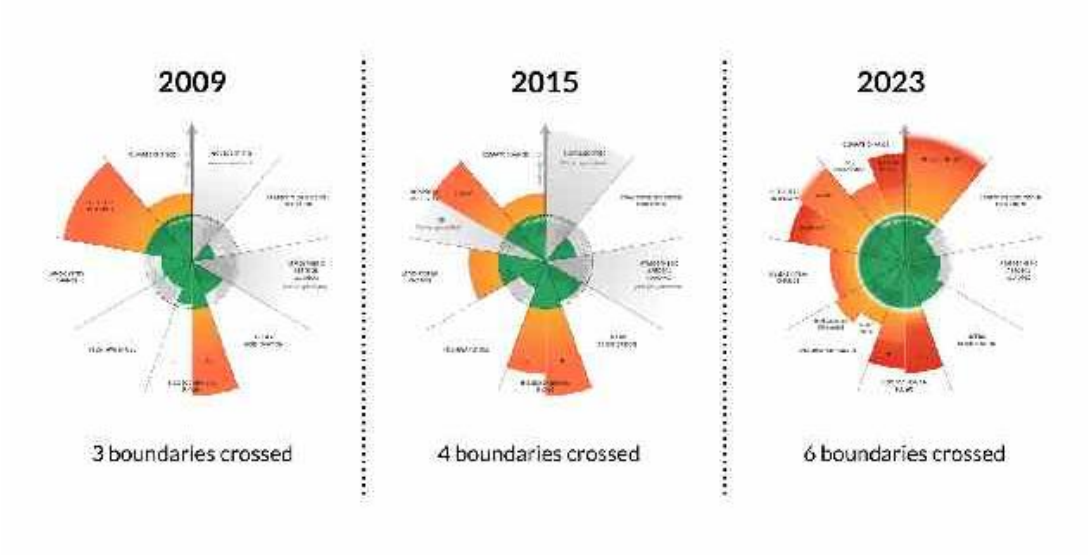
[75] Richardson, K., Steffen, W., Lucht, W., et al. (2023). Earth beyond six of nine planetary boundaries. Science Advances, 9 (37)

[76] Sakschewski B., Caesar L, Andersen L, et al. (2025). *Planetary Health Check 2025. Postdam Institute for Climate Impact research.*



Source: La nuova ecologia

Regarding the oceans, which cover a significant portion of the global surface, they represent one of the unique and fundamental elements of our planet.

The sea, in fact, sustains life, generates oxygen, producing over 50% of the oxygen in the atmosphere, absorbs carbon dioxide, and regulates many processes involving the climate.

Collectively, the volume of the oceans accounts for over 98% of the total volume of global ecosystems and, not surprisingly, constitutes the largest biome on Earth.[77]

Roughly 250,000 marine species have been recorded, with some likely still undiscovered, thus increasing the total number.[78]

The countries richest in marine biodiversity are known as "biodiversity hotspots," and coral reefs, for example, are considered the "nursery of the ocean," hosting up to 1,000 species per square meter.[79]

The ocean is better protected from climate change when it contains more species, and in this sense, marine biodiversity determines the ocean's resilience, playing a key role in adapting to and mitigating climate change.

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[77] Crowe, T. P., Austen, M., & Frid, C. L. J. (2015). Marine ecosystems: Human impacts on biodiversity, functioning and services. Cambridge University.

[78] Appeltans, W., et al., (2012). *The magnitude of global marine species diversity*. Current Biology, 22(23), 2189–2202.

[79] Copernicus Marine Service. (2024). Why the ocean is important: biodiversity tank. Retrieved from https://marine.copernicus.eu/it/explainers/why-ocean-important/biodiversity-tank

Marine ecosystems produce half of the Earth's oxygen and store large amounts of carbon, while marine biodiversity, defined differently, can indicate larger fluctuations in the oceanic environment.

Indeed, biodiversity is also a key factor in enabling ecosystems to provide extremely valuable and necessary services for human sustenance, while also supporting employment for a significant number of people.

According to the United Nations Development Programme, over three billion people depend on marine and coastal biodiversity for their livelihoods and employment.[80]

In this context, clean and healthy marine ecosystems protect coastal regions from multiple risks, provide essential food and ensure food security, maintain water quality, contribute to social, cultural, and mental well-being, and supply resources for other sectors, such as pharmaceutical treatments.

1.5 Focus On Sicilian SMEs

Sicilian SMEs represent an indispensable driver for the development of the regional Blue Economy and indeed contribute to the island's economic growth, job creation, and the protection of the marine environment.

Unioncamere Sicilia and the Chamber of Commerce of Messina, for example, have promoted enhancement initiatives in this field, also recognized by the Sicilian Region as a strategic priority in the "Relazione Previsionale e Programmatica".

It is believed that, thanks to innovation and research, the Blue Economy can become a driver of development for the regional economy, improving competitiveness in international markets.

At the provincial level, the sector has a significant impact on Messina, where it generates about €2.4 billion, contributing 24% to the total local economy.

This figure is almost three times the national average and places Messina in second place among Sicilian provinces for the value of the sea economy, after Palermo.

In terms of employment, the Blue Economy employs about 20,000 people, equivalent to over 10% of the total workforce in the province (2022).[81]

The Sicilian government considers the development of a maritime economy in line

[80] United Nations Development Programme. (2025, June 11). Sustainable ocean economy is a human development imperative.

[81] Camera di Commercio di Messina. (2023). *Relazione previsionale e programmatica 2023*.

with the natural balance of the marine environment one of the priorities of the Blue Economy.

This, therefore, also represents the set of human activities that depend on land-sea interactions in the context of sustainable development.[82]

It is necessary to create value for local, national, and institutional partners through conferences, events, and exhibitions involving the community and target audiences. The goal is comprehensive marketing and communication, ranging from traditional to digital, to bring stakeholders and citizens closer together by using available resources efficiently and promoting environmental awareness.[83]

For example, SMEs can take on a proactive role in the development of marine tourism, offering a wide range of activities such as coastal excursions, water sports, diving, and nautical tourism.

This approach not only diversifies the offering but also contributes to enhancing the natural resources of Sicily's coasts and islands.

At the same time, businesses can build synergistic relationships with the fishing industry.

Such integration can take shape through the creation of catering services based on fresh, local products, fostering sustainable fishing and stimulating innovation in the processing and sale of marine products.

The adoption of innovative technologies offers SMEs new perspectives for the sustainable management of the marine environment. In particular, such technological tools can improve ecological monitoring and facilitate the creation of digital tourist offerings. At the same time, businesses can contribute to the safeguarding and promotion of maritime cultural heritage. Collaborations in this sector concern the enhancement of museums, submerged archaeological sites, and local seafaring traditions.

In 2024, Sicily grew significantly compared to the previous year's data, as highlighted by the Tagliacarne Report. The number of businesses in the Blue Economy sector increased from 28,640 to 28,807, a growth of 0.6%, placing it as the third region in

[82] https://italplanet.it/mission-restore-our-ocean-and-waters-by-2030-conference-marseille-13-14-june-2022/

[83] https://www.blueconomysicilia.it/

Italy, with Trapani and Agrigento ranking third and fourth among provinces in terms of specialization, and Palermo ranking fifth for the number of enterprises in the maritime sector linked to tourism, with 4,698. Despite this increase, the island is still far from fully efficient use of the resources and opportunities of the Blue Economy. In fact, it ranks only fifth in terms of the incidence of added value on the total regional economy (5.7%) and just fourth in terms of the incidence of employment on the regional total (6.5%).[84] In the context of Sicily's sea economy, the province of Palermo holds the lead in the number of businesses, with 5,596 units accounting for 22.4% of the regional total. Messina ranks second, contributing 18.2% of companies in the sector. They are followed by Trapani (15.3%) and Catania (15.1%), Siracusa (10.6%), Agrigento (8.1%), and Ragusa (8.1%). Caltanissetta, with its limited coastline, and the inland province of Enna, without access to the sea, are placed respectively second to last (1.9%) and last (0.2%).[85]

In conclusion, observing the international landscape of the blue economy, the trajectory defined by planetary boundaries, and the specific impacts on the Sicilian context, it becomes clear that Sicily finds itself at a crucial point in its socio-economic and environmental development. Globally, the blue economy represents a model in which the exploitation of marine and coastal resources can generate economic growth and employment, but it must be carefully balanced with the safeguarding of marine ecosystems. Scientific evidence related to planetary boundaries highlights how the current pressure on natural resources and marine ecosystems imposes specific limits on economic development, in order to avoid crossing critical thresholds that could compromise ocean resilience and, consequently, long-term sustainability.

In the Sicilian context, this tension between economic opportunities and environmental constraints is particularly pronounced. The region, characterized by an extensive coastline, significant marine biodiversity, and traditional sea-related economic activities, such as fishing, tourism, and port operations, faces concrete environmental challenges, including marine pollution, coastal erosion, and anthropogenic pressure on fish stocks. The analysis of the current situation shows that Sicily is moving towards

[84] Centro Studi Tagliacarne. (2024). Rapporto Tagliacarne 2024
[85] Centro Studi Tagliacarne. (2021, July). Economia del Mare – Messina Report 2021.

a blue economy model, but still in a fragmented manner compared to international standards, which foresee a fuller integration between technological innovation, sustainable resource management, and environmental governance.

In response to these challenges, the Sicilian Region has adopted several strategies aimed at promoting sustainable maritime development: incentives for businesses investing in green technologies, programs for the enhancement of sustainable tourism, and initiatives for the monitoring and protection of coastal and marine ecosystems. However, for these measures to translate into genuine alignment with global best practices, a coordinated and systemic approach is needed, one that integrates economic development, technological innovation, and strict adherence to the ecological limits defined by planetary boundaries.

In conclusion, Sicily's path toward a sustainable blue economy can be interpreted as a critical phase of transition: the economic potential linked to the sea is considerable, but the ability to harmonize growth and environmental protection will determine its long-term sustainability. This chapter has therefore laid the groundwork for understanding not only the current state of the region but also its strategic implications and future challenges: any sea-related economic development must inevitably confront global ecological limits and the need for integrated and forward-looking governance, so that Sicily may position itself competitively and responsibly within the international context of the blue economy.

CHAPTER 2 — PHYSICAL RISKS, TRANSITION RISKS, AND NATURE-RELATED RISKS IN THE BLUE ECONOMY: REGULATORY PRESSURES AND IMPLICATIONS FOR SICILIAN SMES

2.1 Physical and Transition Risks

The degradation of nature and all actions taken to restore and, where possible, preserve it have repercussions on global economies and the financial systems of each country. To date, nature-related risks are scarcely considered in the scenarios used by financial institutions, central banks, and supervisory authorities, leaving the financial system exposed to potential systemic risks and contributing to the misalignment of capital flows with societal objectives.

According to EBA guidelines, financial institutions are required to systematically integrate ESG risks, particularly environmental risks, into their strategic processes, business models, risk policies, and monitoring systems.

In this context, the identification, measurement, management, and monitoring of ESG risks must take into account not only direct exposure to climate change, but also ecosystem degradation, biodiversity loss, and the associated potential systemic effects.

The guidelines require institutions to assess the relevance of ESG risks in relation to traditional financial risk categories: credit, market, liquidity, operational, reputational, and concentration, and to define key risk indicators, thresholds, or limits consistent with their risk appetite and sustainability commitments.

In addition, the guidelines require the preparation of specific transition plans that include timelines, quantitative intermediate targets, and milestones, suitable for ensuring the institution's short-, medium-, and long-term resilience to the EU's strategic objectives on climate neutrality and sustainability. This regulatory integration strengthens the alignment of the financial system with the desired trajectory of the

European Green Deal and with the progressive internalization of environmental risks in creditworthiness and portfolio risk assessment.[86]

The uncertainty and lack of understanding for these risks represent a market uncertainty, meaning that the way capital is allocated in the economy is not aligned with the goals of the Global Biodiversity Framework (GBF) and is directed toward activities that unintentionally generate risks.

Indeed, nature-related risks can be even more immediate than physical climate risks and, in fact, act as amplifiers of climate change risks.[87]

The GBF proposes, among various requests, an alignment of all financial flows by 2030 to achieve its established goals and targets.

The urgency of acting globally to protect and restore biodiversity and natural capital is clear and widely accepted, with financial institutions and central banks having a crucial role to play.

The political direction is clear and well-defined toward concrete and precise solutions. The Kunming-Montreal GBF, the equivalent of the Paris Agreement for climate change, was adopted in 2022 and established an ambitious path toward a global vision of a world living in harmony with nature by 2050, with four goals for 2050 and 23 targets for 2030.

The methods of pricing and capital allocation within the economy by financial institutions will play a fundamental role in achieving these objectives.

The GBF represents an increasingly strong driving force for action, just as the Paris Agreement has been for climate.[88]

On the other hand, the lack of understanding and failure by banks and their counterparties to comply with the principles of the GBF can generate transition risks, linked to the failure to assess external dependencies that impact counterparties. At the

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[86] European Banking Authority. (2025, January 8). Final report: Guidelines on the management of environmental, social and governance (ESG) risks (EBA/GL/2025/01).

[87] Ranger, N., et al. (2023). The green scorpion: The macro-criticality of nature for finance – Foundations for scenario-based analysis of complex and cascading physical nature-related risks. Oxford: Environmental Change Institute, University of Oxford.

[88] OECD. (2023). Assessing biodiversity-related financial risks. OECD Publishing.

same time, proactive attention to these dependencies represents a significant opportunity for the most attentive and forward-looking financial institutions.[89]

Based on findings from a joint NGFS-INSPIRE study group, it has been acknowledged that nature-related financial risks could have significant macroeconomic implications, and the failure to mitigate and adapt to these implications represents a source of risks to financial stability.[90]

To effectively address these risks, the Network for Greening the Financial System (NGFS) established a task force on biodiversity loss and nature-related risks with the goal of considering these risks within the NGFS framework.

In pursuit of this objective, the Task Force is tasked with developing a conceptual framework for nature-related financial risks to guide the actions of central banks and supervisory authorities, providing greater clarity on the definition of key concepts and aiming for a more evolutionary approach.[91]

Specifically, the financial institutions targeted by the framework assess risks appropriately in three precise phases:

1) Identification of the sources of physical and transition risks;
2) Assessment of economic risks;
3) Assessment of risk from multiple perspectives, namely toward, from, and within the financial system.

In general, human society and the global economy cannot thrive without ecosystem services, and yet, human activities are the ones that have led to unprecedented degradation of nature and its biodiversity in recent decades, threatening the continuous provision of the very ecosystem services on which humans depend.

Five main drivers of nature degradation have been identified, ranked by their global impact:

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[89] United Nations Environment Programme. (2022). Kunming-Montreal Global Biodiversity Framework.

[90] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors

[91] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors

1) Changes in land and sea use;
2) Overexploitation of natural resources (i.e., the extraction of living and non-living materials);
3) Climate change;
4) Pollution;
5) Invasive species.

Regarding the issue of the sea, through a communication[92], the European Commission clarifies certain points to be implemented without delay but with extreme urgency within a short timeframe and in line with the goals of the 2030 Agenda.

"*2.2.6. Restore the good ecological status of marine ecosystems*
The existence of adequately restored and protected marine ecosystems is synonymous with substantial health, social, and economic benefits for coastal communities and the Union as a whole.
In the presence of marine and coastal ecosystems where biodiversity loss is greatly exacerbated by global warming, it is more urgent than ever to act with greater determination.
To restore marine ecosystems to a "good ecological status," including through strictly protected areas, it is essential to reconstitute carbon-rich ecosystems as well as important spawning and nursery grounds for juvenile fish.
Some of the ways in which we exploit our seas today jeopardize food security, the livelihoods of fishermen, and the fishing and seafood sectors.
The exploitation of marine resources must occur sustainably and in a context of zero tolerance for illegal practices: for reality to reflect this principle, it is essential to fully implement the Common Fisheries Policy, the Marine Strategy Framework Directive, and the Habitats and Birds Directives.
The application of an ecosystem-based management approach under EU legislation will reduce the negative effects of fishing, extractive activities, and other human activities, particularly on sensitive species and seabed habitats.

[92] European Commission. (2020, 20 maggio). *Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — EU Biodiversity Strategy for 2030: Bringing nature back into our lives* (COM (2020) 380 final).

To this end, the national maritime spatial management plans, which Member States are required to submit in 2021, should aim to cover all maritime activities and sectors, as well as zone-specific management-conservation measures.

The Commission also intends to propose a new action plan to conserve fishery resources and protect marine ecosystems.

If necessary, it will introduce measures to limit the use of fishing gear most harmful to biodiversity, including seabed habitats, and will review how to reconcile biodiversity objectives with activities using bottom-contact gear, currently the most damaging to this environment.

It will be mandatory to address this issue in a fair and just manner. The transition to more selective and less harmful fishing techniques must also be supported by the European Maritime Affairs Fund.

The good health of fish stocks is crucial for the long-term prosperity of fishermen and for the health of our oceans and biodiversity.

It is therefore of utmost importance to maintain or reduce fishing mortality to levels equal to or below those of maximum sustainable yield, in order to achieve a population distribution by age and size indicative of the good health of all fish stocks.

It is also necessary to eliminate bycatch of endangered species or reduce it to a level that allows their full recovery; this also applies to species in poor ecological or conservation status.

Bycatch of other species must not be tolerated either, or, if it cannot be completely eliminated, it must be kept to minimum levels that do not threaten their conservation status.

To support these objectives, it is necessary to intensify data collection on bycatch of all sensitive species.

Finally, for all marine protected areas, fisheries management measures must be established based on clearly defined conservation objectives, drawing on the best available scientific advice."[93]

[93] European Commission. (2020, 20 maggio). Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions — EU Biodiversity Strategy for 2030: Bringing nature back into our lives (COM (2020) 380 final).

This is followed by a point on the restoration of freshwater ecosystems.

The economic and financial instability closely linked to nature degradation involves two types of risks: physical and transition.
The first, **physical risk**, refers to the economic impact resulting from the increase in natural events, affecting the stability of businesses and households[94], and can be defined as:

- **Acute**, meaning the risk depends on the occurrence of extreme environmental phenomena such as earthquakes, floods, or hailstorms, leading to actual climate changes that increase their intensity and frequency.

- **Chronic**, meaning the risk is determined by climatic events that develop gradually and progressively, such as ecosystem deterioration, biodiversity loss, rising temperatures and sea levels, and resource scarcity.

The impact affects the real economy in this case, with the main sectors involved being agriculture, fisheries, forestry, transportation, infrastructure, and others.
As for the second risk, **transition risk**, it arises from the commitment of the international community[95], including:

- The economic impact that businesses may face as a consequence of implementing laws, regulations, and policies aimed at reducing carbon emissions and promoting the development of renewable energy.

- Technological advancements and adjustments, as well as changes in consumer preferences and market confidence.

Failure to adapt, neglect progress, or even avoid it leads to higher taxation, a shift in market preferences, and complex access to credit for companies.

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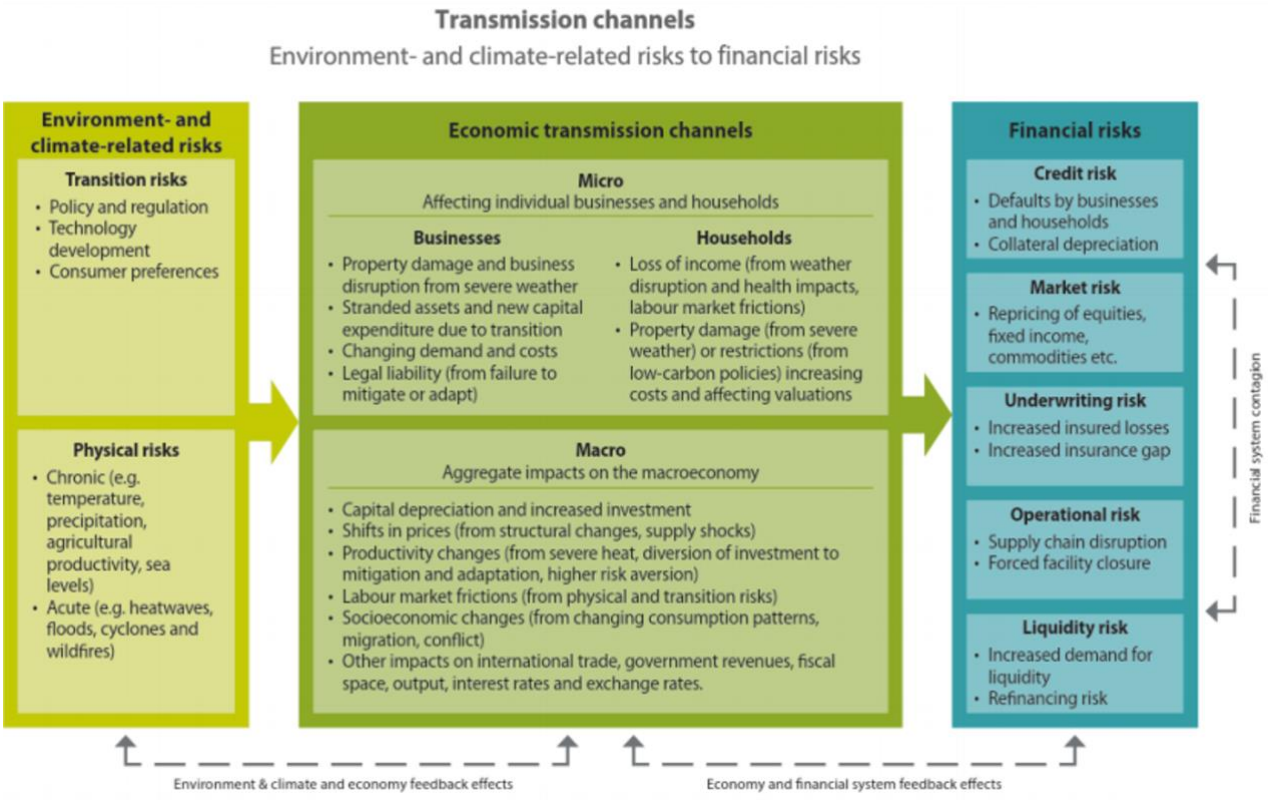
[94] Linciano, N., Cafiero, E., Ciavarella, A., Di Stefano, G., Levantini, E., Mollo, G., Nocella, S., Santamaria, R., & Taverna, M. (2021, giugno). La finanza per lo sviluppo sostenibile: Tendenze, questioni in corso e prospettive alla luce dell'evoluzione del quadro regolamentare dell'Unione europea (Quaderno di finanza sostenibile n. 1). CONSOB.
[95] Di Febo, E. (2025). Transition Risk in Climate Change: A Literature Review. Risks, 13(4), 66.

In all cases, the two types of risks are closely interconnected. It is also true that, in the absence of appropriate environmental protection measures, the costs that market operators would have to face would be increasingly significant in both cases.

At this point, it is useful to highlight how these risks are already being operationalized by institutions and integrated into risk management practices.
Several institutions, including the Bank of Italy with its publications, along with other concrete examples addressing the issue and becoming increasingly focused on advancing research, highlight that a proper approach to risk management by both banks and businesses can enable adequate measurement and prevention of climate-environmental risks, both physical and transition, mitigating or at least delaying the negative impact of traditional financial risks such as credit, market, and liquidity risks.[96]
These nature-related financial risks, in other words, refer to the risks of negative effects on economies, individual financial institutions, and the financial system, which depend both on the degradation of nature and biodiversity, as well as the loss of ecosystem services stemming from physical risks, or the misalignment between economic actors and their actions aimed at protecting, reducing, or avoiding negative impacts on nature, like the transition risks.
The following figure outlines the process through which risks lead to actions and reactions, resulting in actual financial risk.

[96] Kedward, K., Ryan-Collins, J., & Chenet, H. (2022). Biodiversity loss and its interactions with climate change: Implications for financial stability for central banks and financial supervisors. Climate Policy.



Source: Gullo A. (2024) *Banking Law and Climate Change: Key Legal Issues, ResearchGate*

"*In April 2022, the Bank of Italy issued a first document on Supervisory Expectations for Climate and Environmental Risks, containing non-binding guidelines regarding the integration of climate and environmental risks into governance and control systems, business models and corporate strategies, organizational systems and operational processes, risk management systems, and market disclosures of supervised banking and financial intermediaries.*

In relation to this, in the second quarter of 2022, the Bank of Italy conducted an initial structured survey on the level of integration of climate and environmental risks into the management frameworks of directly supervised Less Significant Institutions (LSIs), participating, with a sample of 21 intermediaries, in the thematic survey conducted by the ECB on larger banks (Significant Institutions).

In this regard, an information note is published with the findings that emerged – including a more detailed report – which, among other things, requires the governing bodies of all less significant banks to define and approve specific action plans for the

effective integration, over the next three years, of climate risks into the ordinary governance and risk management framework.".[97]

2.2 Sicilian SMEs and regulatory dependencies

Sicilian SMEs operate in a context that is still largely unexplored yet rich in potential, but also marked by fragility. The article by Valenzuela and colleagues[98] highlights that the credibility of corporate transition plans strongly depends on factors external to the firm itself, such as regulatory frameworks, market conditions, and technological readiness, which companies do not directly control. In the case of Sicilian SMEs, these "regulatory dependencies", meaning the obligation to comply with environmental, energy, tax, and safety regulations, as well as with EU directives, have a significant impact: on one hand, they limit operational capacity (in terms of size, resources, and expertise) to adapt promptly; on the other hand, they generate perceptions of constraint rather than opportunity.

Local firms often perceive such dependencies as burdens. For example, the obligation to comply with environmental and sustainability standards is perceived in Sicily as an additional source of difficulty, to the extent that local SMEs are ranked "at the bottom of the environmental compliance scale."[99] In this scenario, the research field remains relatively underexplored: few analyses have examined in depth how SMEs, particularly in regional contexts such as Sicily, experience, perceive, and relate to these regulatory dependencies.

From the perspective of engagement strategies, Sicilian SMEs can adopt a variety of approaches:

- Monitoring and anticipation: recognizing that regulations (e.g., on energy use, emissions, waste management, workplace safety) are evolving, and assessing

[97] Banca d'Italia. (2022). Rischi climatici e ambientali: indagine tematica su un campione di banche meno significative. Retrieved from https://www.bancaditalia.it/media/notizia/rischi-climatici-e-ambientali-indagine-tematica-su-un-campione-di-banche-meno-significative/
[98] Di Febo, E. (2025). Transition Risk in Climate Change: A Literature Review. Risks, 13(4), 66.
[99] https://www.blogsicilia.it/palermo/sicilia-fondo-classifica-adeguatezza-ambientale-piccole-medie-imprese/1064071/

how such dependencies could become enabling factors (e.g., access to funds and incentives) rather than mere constraints;

- Active involvement: collaborating with business associations, territorial networks, and chambers of commerce to influence local regulatory processes or to share best practices and compliance costs;

- Internal structuring: defining company roles dedicated to regulatory compliance (even in simple forms), integrating regulatory adaptation into operational strategies and investment plans, and fostering a mindset that views compliance not merely as a cost but as a lever of competitiveness;

- Dialogue with financial intermediaries: since regulatory sustainability, for example, environmental compliance can influence a firm's bankability (in Sicily, it has emerged that companies with high ESG standards obtain more credit)[100].

Finally, by mapping the most relevant regulatory dependencies for Sicilian SMEs, which may also be considered as transmission channels of risk for financial institutions, the following can be identified:

1. Environmental and energy regulations (e.g., energy audits, consumption reduction, installation of renewable systems): impact capex, timing, and skills;
2. Sustainability/ESG requirements (including those indirectly transmitted through supply chains or partner demands): affect credit access and reputation;
3. Fiscal and accounting regulations (e.g., simplified regimes, transparency obligations, process digitalization): may affect corporate structure;
4. EU and regional agreements/regulations (e.g., ERDF funds, regional calls, state aid rules, incentives): define opportunities but also binding access conditions;

[100] https://www.blogsicilia.it/palermo/sicilia-fondo-classifica-adeguatezza-ambientale-piccole-medie-imprese/1064071/

5. Sector-specific regulations (tourism, agri-food, manufacturing, logistics): require certifications, inspections, and compliance processes that are often burdensome for micro-enterprises.

This regional perspective provides a useful backdrop for understanding how Blue Economy dynamics can translate into both strategic opportunities and compliance-related transition pressures.

2.3 Blue Economy opportunities

The Blue Economy is an innovative economic development model based on durability, renewability, and reuse, aiming to revolutionize and enhance human productive activities while eliminating all polluting emissions.

Opportunities related to the Blue Economy are discussed, as oceans, lakes, seas, and rivers are considered an extraordinary heritage for the entire planet and its population. The main issue remains that these are increasingly becoming veritable dumping grounds, and the actions aimed at reducing this progressive degradation.

According to recent UNEP reports, approximately 11 million tons of plastic end up in the sea annually, with significant and severe impacts on marine biodiversity.[101]

In this case, decisive action to combat environmental pollution and the abandonment of outdated, traditional economic models seem to be among the most effective solutions to mitigate risks and prevent further deterioration.

For this reason, an innovative business model like the Blue Economy is essential for the recovery and reintroduction of raw materials and waste into the production cycle.

It represents a sustainability-based model capable of creating a positive, medium- to long-term impact, particularly on ocean health.

With the Blue Economy, emerging sectors such as wave energy, offshore wind, green hydrogen production from marine sources, and algae cultivation for food and industrial purposes have been discussed for some years now.[102]

[101] UNEP. (2024). Emissions Gap Report 2024.

[102] European Commission. (2025). *EU Blue Economy Report 2025*. Publications Office of the European Union.

In truth, it is not merely a concept but an expression of a true framework for healthy sustainable development for all activities related to oceans and coasts.
Among its main objectives is to decouple economic growth from environmental degradation by sponsoring and promoting new, modern, and problem-aligned solutions that are profitable and respectful of the entire marine ecosystem.

Based on various data provided annually at both national and international levels, two Italian regions stand out for their contribution to the Blue Economy:

• The **Liguria region**, driven in particular by excellence in shipbuilding and its robust port infrastructure, generates an annual turnover of approximately 5 billion euros.[103]

• The **Sicily region**, thanks to the significant contribution of sea-related tourism and maritime transport, ranks just behind, with an estimated turnover of 4.5 billion euros.[104]

The aforementioned analysis highlights how the nation is already leveraging its maritime heritage through key sectors, demonstrating the enormous potential of the Blue Economy for economic growth and environmental protection.

In line with this regional positioning, a recent statement published in the context of the conference promoted by Fondazione UniVerde and Stazione Zoologica Anton Dohrn frames Sicily as a strategic testing ground for an innovative and sustainable Blue Economy, highlighting offshore floating wind and water-supply solutions for islands as emblematic transition vectors:

"*Sicily is establishing itself as a strategic laboratory for the development of an innovative and sustainable blue economy and the creation of new green jobs. At the heart of this transformation, offshore wind power with floating technology emerges not only as a cutting-edge solution for the energy transition but also as a pillar for national and local energy independence and democracy.*

[103] https://genova.repubblica.it/dossier/cruscotto-economia/2025/01/03/news/blue_economy_liguria_prima_il_settore_vale_57_miliardi-423727951/
[104] https://www.tp24.it/2025/10/17/mare-e-pesca/la-sicilia-tra-le-regioni-leader-della-blue-economy-presentato-il-report-economia-del/224781.

Similarly, innovative systems for the water supply of smaller islands and archipelagos, such as the marine mobile desalinator, align precisely with the direction of a just ecological transition that listens to, protects, and enhances territories."[105]

Against this regional backdrop, research, monitoring tools, and technological development play a key role in supporting sustainability outcomes across Blue Economy activities. In this context, one of the main pillars of the Blue Economy is fundamental research for the development of all activities related to the sea and its sustainability.

Developing a sustainable Blue Economy is important to ensure its continuity; otherwise, every activity would be destined to collapse if the environment is not healthy or if the ecosystem does not function properly.

Useful elements are needed to monitor and plan economic development based on scientific knowledge.

In the corporate sphere, moreover, no KPIs have yet been identified that can distinguish between initiatives with concrete repercussions and those with low impact.

Technological intensity can also make a strong contribution to reducing risks for companies.

For example, the South Tyrolean company Hydrocell, a technological SME created in 2020 by three experienced entrepreneurs, was awarded at the Italian Hydrogen Technology Awards (IHTA) for a project to convert a fishing vessel. The recognition was granted during the Hydrogen Expo in Piacenza, in the category dedicated to applied innovation.[106]

With regard to the sustainability goals set out in the United Nations 2030 Agenda and the European Union's goal of achieving climate neutrality in all economic sectors by 2050, a significant commitment can be expected from both businesses and the financial system.

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[105] https://www.opera2030.it/sicilia-e-mediterraneo-rinnovabili-innovazione-e-green-jobs-per-la-blue-economy-convegno-a-il-9-luglio-a-roma/

[106] https://www.ilsole24ore.com/art/ricerca-applicata-e-pmi-creare-futuro-sostenibile-AG73PX?refresh_ce

2.4 Policy tools and financial instruments supporting the Blue Economy

Among the many projects frequently discussed by the European Commission is the FEAMPA, the European Maritime, Fisheries, and Aquaculture Fund 2021-2027.
This represents a key and indispensable financial instrument to support maritime policies, such as fisheries and aquaculture, in the European Union.
In this case, the total funding allocated for the 2021-2027 period is estimated to be around 6.14 billion euros.[107]
This fund is not only a means to allocate significant resources to the maritime sector but a true driver for its transformation.
It represents a component aimed at ensuring and supporting the sustainability of humanity's future.
To enhance and preserve its beneficial impact, it is essential and a priority to allocate resources to low-emission technologies and responsible management of precious marine resources.

Alongside the major instruments of the European Union, targeted funding in the Blue Economy sector can support initiatives to enhance the coastline and protect ecosystems. Interventions focus on the environmental and cultural improvement of beaches, promoting social inclusion projects and reducing marine pollution. In particular, the funds can support:

- Projects to protect the marine ecosystem and reduce pollution, with a focus on plastic management and the use of biological purification methods;
- Interventions for the recovery and reuse of wrecks and the development of pilot projects for water desalination, a fundamental strategy for addressing possible water crises;

[107] European Commission. (n.d.). *European Maritime, Fisheries and Aquaculture Fund (EMFAF) 2021–2027*.

- Projects to enhance the cultural and environmental heritage of beaches, improve the accessibility and inclusiveness of public beaches, and redevelop coastlines and provide general beach maintenance.[108]

2.5 Regulatory and reporting pressure as a driver of transition and opportunity

The analysis of the state of the art highlights that the Blue Economy represents a key area for Europe's sustainable transition, but also one of the most exposed to transition risks linked to increasing regulatory and financial pressure. Sicilian enterprises, particularly SMEs, find themselves at the crossroads between dependence on marine resources and the growing demand for compliance with ESG standards imposed by some regulations such as the CSRD, ESRS, VSME, EU Taxonomy, and EBA ITS.

And it is precisely SMEs, which have a predominant presence in the Italian production system, that can play a central role in the transition.
They are asked to gradually communicate to the market, that is, to banks, investors, and large companies, information about their operations and sustainability performance, understood as information concerning impacts, risks, and opportunities related to the environmental, social, and governance effects of their activities.
Indeed, following a significant evolution of European legislation, such as the Corporate Sustainability Reporting Directive (CSRD), supported by the Taxonomy Regulation for the identification of sustainable activities and for significant banks the communication of their share of portfolio regarding sustainable activities as required under the EBA ITS (Implementing Technical Standards). Under the sustainability reporting directive, larger companies must now provide detailed reports on their environmental and social performance. This obligation is not limited to their direct operations but extends to the entire production chain, including small and medium-sized enterprises.[109]
As a result, SMEs are called upon to cooperate by providing the necessary information to enable companies to comply with the new reporting requirements.

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[108] European Investment Bank. (2024). Preserving our oceans: Financing sustainable blue economy projects.
[109] European Commission. (2023). *Corporate sustainability reporting (CSRD)*

Taking part in the effort to collect and report sustainability data offers to SMEs a range of strategic benefits. This information does not only represent an obligation but also an opportunity for growth and development.

The availability of accurate sustainability data allows SMEs to better identify and assess risks, not only environmental but also operational, thus improving strategic planning and investment management.

Being able to demonstrate commitment to sustainability can facilitate access to new forms of financing. Financial institutions and investors are increasingly inclined to support companies with solid ESG profiles, often offering more favorable conditions.[110]

Adopting sustainable practices, such as energy efficiency, increases the ability of SMEs to cope with potential shocks, such as fluctuations in energy prices or instability in supply chains.

The production of more sustainable goods and services strengthens the company's reputation and market positioning.

Consumers and business partners are increasingly attentive to sustainability-related aspects, which can translate into greater market demand and improved competitive advantage for those enterprises able to demonstrate their environmental, social, and governance performance. Banks, in light of recent regulatory developments, are also refining their creditworthiness assessment methodologies to incorporate sustainability and climate-related risks associated with their counterparties.[111]

In this context, a dedicated tool has recently been developed: the Sustainability Dialogue between SMEs and Banks. This instrument, promoted by the Italian Ministry of Economy and Finance together with national supervisory authorities, provides a structured and voluntary framework that helps small and medium-sized enterprises collect, organise, and communicate key ESG information in a way that is understandable and usable for financial institutions. The tool includes modular indicators covering environmental, climate, social, and governance dimensions, and

[110] European Financial Reporting Advisory Group. (2022). SMEs and sustainability reporting.
[111] Chen, S.-L., Wang, D., & Chen, H.-W. (2025). The impact of ESG factors on credit ratings: An empirical study of European banks. International Review of Financia*l* Analysis.

aims to facilitate a more transparent and efficient interaction between firms and lenders. Its primary purpose is to support SMEs in aligning with emerging expectations while enabling banks to integrate sustainability-related factors into their risk analyses.[112]

Consider, for example, the facilitation of information exchange, taking into account criteria of standardization, efficiency, cost-effectiveness, and proportionality.
Furthermore, there is an increase in SMEs' awareness of the importance of sustainability information also with a view to a gradual approach toward the possible and hoped-for adoption of the VSME ED standard of EFRAG.[113]

Building on the Sustainability Dialogue, the associated Document also envisages capacity-building measures, including training initiatives and pilot projects aimed at strengthening SMEs' ESG skills. These initiatives are intended to be developed with the support of the European Commission and the relevant trade associations.[114]

Overall, these capacity-building and financing instruments should be read against the backdrop of the EU's broader regulatory shift toward sustainability transparency, most notably the Corporate Sustainability Reporting Directive (CSRD), which entered into force on 5 January 2023, and which is increasing the demand for ESG data from SMEs through value chains and financial institutions. Although SMEs are not subject to the same obligations as large companies, they are increasingly encouraged to comply with ESG criteria.
Large enterprises and financial institutions, their business partners, are in fact requesting increasingly detailed data on sustainability.
This pushes SMEs to adapt in order to maintain their competitiveness and open up to new market and financing opportunities.

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[112] Ministero dell'Economia e delle Finanze (MEF). (2024). *Dialogo di sostenibilità tra PMI e Banche*.
[113] European Financial Reporting Advisory Group. (2024). Voluntary Standard for SMEs (VSME).
[114] Ministero dell'Economia e delle Finanze (MEF). (2024). *Dialogo di sostenibilità tra PMI e Banche*.

Adhering to ESG criteria offers SMEs privileged access to various sources of capital. Credit institutions and banks are showing a growing preference for companies that demonstrate a concrete commitment to sustainability. This can translate into easier access to private financing, public funds, and guarantees dedicated to sustainable projects.[115]

Building on this regulatory and market context, it is important to clarify the role of the European Sustainability Reporting Standards (ESRS), which specify in practical terms how sustainability-related information must be structured and disclosed under the CSRD, with clear implications for firms operating in the Blue Economy and for SMEs involved through value chain and financial counterparties.

The European Sustainability Reporting Standards (ESRS) are the European standards that operationalise the reporting obligations introduced by the CSRD, defining in a harmonised manner what sustainability information companies must include in their reporting, based on a double materiality approach and on the disclosure of impacts, risks, and opportunities. The first "sector-agnostic" set, adopted by the European Commission through Commission Delegated Regulation (EU) 2023/2772[116], includes the cross-cutting standards ESRS 1 and ESRS 2, as well as the thematic E-S-G standards. Within a Blue Economy perspective, one particularly relevant standard is ESRS E3 "Water and marine resources"[117], which structures disclosure requirements around pressures, dependencies, and the management of water and marine resources across a company's activities and value chain. For Sicilian SMEs, the main implication is often indirect: even where they are not directly subject to the same reporting obligations as large companies, they are increasingly drawn into the ESRS framework through data requests from lead firms in their supply chains and from financial

[115]Ministero dell'Economia e delle Finanze (MEF). (2024). *Dialogo di sostenibilità tra PMI e Banche*.

[116] European Commission. (2023). Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards. Official Journal of the European Union, L 2023/2772

[117] *European Commission. (2023). ESRS E3 – Water and marine resources (Annex I to Commission Delegated Regulation (EU) 2023/2772).*

counterparties that must report under ESRS, making the availability of consistent, traceable ESG data a strategic requirement.[118]

A joint reading of these instruments shows that the transition toward more sustainable production models does not merely translate into reporting obligations, but rather into a structural change in how businesses access capital, manage risks, and interact with coastal ecosystems. In this context, regulatory dependency becomes a central component of transition risk: the ability of SMEs to understand and adapt to these standards will determine their future resilience and competitiveness.

For financial institutions, this implies the need to integrate increasingly detailed ESG assessments into the credit-granting process, recognizing not only the risks but also the opportunities offered by the Blue Economy, for example, in terms of technological innovation, energy efficiency, and the sustainable enhancement of marine resources.

In conclusion, the Blue Economy emerges as a laboratory of transition, where European regulation, financial strategies, and territorial dynamics, such as those in Sicily, interact in defining new paradigms of economic and environmental sustainability.

[118] *https://finance.ec.europa.eu/publications/commission-presents-voluntary-sustainability-reporting-standard-ease-burden-smes_en*

CHAPTER 3 — BANKS AND CREDIT RISK: INTEGRATION OF "BLUE ECONOMY" AND NATURE-RELATED DRIVERS INTO THE CREDIT LIFE CYCLE AND THE PROBABILITY OF DEFAULT (PD)

The previous Chapters defined the scope of the Blue Economy, the main channels of environmental pressure, including pollution, coastal degradation, physical risks and transition risks, and their potential to translate into economic and financial vulnerabilities for Sicilian SMEs. In parallel, the evolution of the regulatory and supervisory framework (ECB/SSM, Bank of Italy, EBA) has already been outlined, which requires banks to incorporate climate and environmental risks as drivers of traditional risk categories, in particular credit risk.[119]

Against this backdrop, the aim of this Chapter is to clarify how environmental and nature-related drivers relevant to the Blue Economy can enter credit risk processes, with particular focus on the Probability of Default (PD) parameter. This focus stems from two considerations:

1. Centrality of credit risk in banks' business models: The ECB climate stress test (2022) shows that, on average, a very significant share of banks' profitability derives from net interest income, which accounts for 65.2% of revenues for the sample of European banks considered, with non-negligible exposures to high-emitting sectorsand therefore potentially exposed to transition risk.
2. Growing relevance of the "nature" dimension (biodiversity/ecosystems) as a financial risk: which can have direct implications for Blue Economy sectors such as hospitality and food service, which depend on ecosystem services such as water quality, beach erosion, natural attractiveness, and water availability, and therefore for the repayment capacity of SMEs.[120]

In the following sections, the Chapter will seek to embed Blue Economy drivers into the banking framework by analysing the following topics:

- the regulatory definition of default;

[119] European Central Bank. (2020, November). Guide on climate-related and environmental risks: Supervisory expectations relating to risk management and disclosure. ECB Banking Supervision.
[120] European Central Bank. (2022, July 8). 2022 climate risk stress test. ECB Banking Supervision.

- the PD estimation and validation logic within IRB systems;
- the link with IFRS 9 (ECL and SICR) and with supervisory expectations on climate/environmental risks;
- governance, data, and modelling implications for integrating climate and nature-related drivers.

3.1 The role of PD in the banking framework: prudential function and accounting function

Within the banking framework, PD is a core variable because it captures, over a defined time horizon, the probability that a counterparty enters default. In regulatory terminology, PD may refer to the default of an obligor or, in the retail portfolio and under specific conditions, to the default of a credit facility. This distinction can affect the construction of the default data set and the modelling approach.[121]

Under EU law, the prudential architecture for credit risk is based on the Capital Requirements Regulation (CRR)[122] and the Capital Requirements Directive (CRD)[123], which govern capital requirements, governance, and banking supervision. Within this framework, banks may calculate credit risk capital requirements using the Standardised Approach or, if authorised by the competent authority, the Internal Ratings-Based Approach (IRB), under which risk parameters: PD, Loss Given Default (LGD), Exposure at Default (EAD), feed directly into the quantification of risk-weighted assets and, therefore, the capital requirement.[124]

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[121] European Banking Authority. (2017, January 18). Guidelines on the application of the definition of default under Article 178 of Regulation (EU) No 575/2013 (EBA/GL/2016/07).
[122] European Parliament and Council of the European Union. (2013, June 26). Regulation (EU) No 575/2013 on prudential requirements for credit institutions and investment firms and amending Regulation (EU) No 648/2012. Official Journal of the European Union, L 176.
[123] European Parliament and Council of the European Union. (2013, June 26). Directive 2013/36/EU on access to the activity of credit institutions and the prudential supervision of credit institutions and investment firms, amending Directive 2002/87/EC and repealing Directives 2006/48/EC and 2006/49/EC. Official Journal of the European Union, L 176, 338–436.
[124] Basel Committee on Banking Supervision. (2022, June). Principles for the effective management and supervision of climate-related financial risks (BCBS 532). Bank for International Settlements

From an accounting perspective, International Financial Reporting Standard 9 – Financial Instruments (IFRS 9) introduces an impairment model based on Expected Credit Losses (ECL). Expected loss is estimated using forward-looking information, on a probability-weighted basis, and varies depending on the staging of the exposure and the assessment of a Significant Increase in Credit Risk (SICR). In particular, IFRS 9 distinguishes between:

- **12-month ECL:** expected loss associated with default events that are possible within the next 12 months (Stage 1);
- **lifetime ECL:** expected loss associated with default events that are possible over the remaining life of the instrument (Stage 2/3).[125]

This has a decisive methodological implication: any integration of "Blue Economy" drivers into PD cannot be treated as a standalone exercise, because it must be consistent with:

- the regulatory definition of default and the related level of granularity;
- EBA requirements for the estimation and validation of parameters within IRB systems;
- the credit life cycle (origination, monitoring, forbearance, recovery), i.e., the point at which ESG drivers first enter as metrics, including as early warning indicators, and only subsequently, if supported by evidence and data quality, as variables within the rating system. The EBA Guidelines on loan origination and monitoring explicitly require ESG factors to be considered in policies, procedures, and controls throughout the credit life cycle.[126]

3.1.1 Definition of default: regulatory constraints for PD modelling

The definition of default is the logical and legal constraint upstream of PD, it is not possible to estimate a robust probability of default if default is not defined in a

[125] Wells, M., & Frerejacque, P. (2017, September). IFRS 9 financial instruments: Impairment. Practical workshop for the National Bank of the Republic of Belarus. Centre for Financial Reporting Reform, World Bank.
[126]European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06).

consistent and time-replicable manner. Within the EU framework, the definition is anchored in Article 178 of the CRR and is harmonised by the EBA Guidelines on the application of the definition of default.[127]

In summary, default occurs when at least one of the following two conditions is met:

- **Unlikeliness to pay (UTP):** the bank considers it unlikely that the debtor will fully meet its credit obligations without the realisation of collateral;
- **Past due criterion:** the breach of the time threshold, typically 90 days, of arrears on a material credit obligation, assessed against the materiality of the past-due amount.

The EBA Guidelines clarify the application of the definition of default at:

- **obligor level:** default "contaminates" all exposures to the same debtor when the definition is applied at counterparty level;
- **facility level:** for certain exposures, especially retail, default may be identified at the level of the individual credit facility, without automatic propagation to all other exposures, subject to specific conditions and UTP assessments.

For the purposes of this research, these foundations lead to three methodological implications:

1. **Separation between environmental shock and regulatory default.** Events such as coastal contamination, erosion, heatwaves, or administrative/health restrictions (e.g., temporary bathing bans) may reduce revenues and increase past-due amounts, but they become "default" only if CRR conditions are met, i.e., UTP and/or past due beyond the relevant threshold and materiality. Therefore, Blue Economy drivers enter as economic determinants along the pathway to default, not as the definition of default itself.
2. **Materiality and information granularity as determinants of the quality of the default sample.** In SME exposures, the correct application of thresholds

[127] European Banking Authority. (2017, January 18). Guidelines on the application of the definition of default under Article 178 of Regulation (EU) No 575/2013 (EBA/GL/2016/07).

and contagion rules materially affects the quality of the data set, with consequences for calibration and backtesting; this becomes particularly critical when ESG drivers are introduced, as they may increase the non-stationarity of historical data.[128]

3. **Tracking "pre-default" triggers within the credit life cycle.** The EBA Guidelines on loan origination and monitoring require ESG factors to be considered ex ante and during monitoring: many environmental drivers act as leading indicators, i.e., early signals of deterioration (revenue volatility, higher insurance/maintenance costs, water stress, reduced environmental attractiveness), before a default event emerges.[129]

3.1.2 PD estimation in IRB systems: EBA requirements, calibration, and margins of conservatism

Within the IRB framework, PD is a parameter subject to strict prudential constraints: it is not a simple statistical output, but an estimate that must comply with definitions, data quality, performance requirements, governance, and traceability. The EBA Guidelines on PD and LGD estimation (EBA/GL/2017/16) are the main technical reference source for requirements on segmentation, risk drivers, time horizons, calibration, and the Margin of Conservatism (MoC).[130]

a) Segmentation and representativeness:

The Guidelines require PD estimation to be performed on homogeneous portfolios/segments and that data sets are representative of the current portfolio and its risk conditions. This point is central for the Blue Economy: if physical and transition risk structurally change the risk distribution (e.g., increasing

[128] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16).
[129] European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06)
[130] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16)

frequency/intensity of extreme events), historical data may become less informative, and specification errors increase.

b) Risk differentiation and calibration.

Two key requirements of IRB systems are:

- Discrimination/risk differentiation: the ability of the system to correctly rank riskier counterparties above less risky ones;
- Calibration: consistency between estimated PD levels and observed default frequencies.

The introduction of Blue Economy drivers into PD is methodologically justifiable only if it improves or preserves discriminatory power and maintains calibration consistency, avoiding systematic bias. This constraint is particularly relevant for SME portfolios, where information granularity is typically more limited and idiosyncratic noise may be higher.[131]

c) Margin of Conservatism (MoC) and additional uncertainty from ESG drivers.

A crucial point is that nature-related drivers, by their nature, introduce additional uncertainty, such as incomplete data, proxies, long time horizons, and non-linearities. The EBA Guidelines require the application of margins of conservatism where shortcomings and uncertainties affect estimation; validation also expects MoC quantification to meaningfully cover the uncertainties identified in data and methodological deficiencies. As a result, integrating Blue Economy drivers into PD requires an explicit uncertainty management framework, including documentation of sources and a sensitivity analysis.[132]

d) Model governance.

The robustness of PD depends on governance: separation between development and independent validation, approval, ongoing monitoring, change management, and an audit trail. When ESG modules/variables are involved, governance needs increase

[131] Aabo, T., Pantzalis, C., & Park, J. C. (2017). Idiosyncratic volatility: An indicator of noise trading? Journal of Banking & Finance, 75, 136–151.

[132] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16)

(model risk, data risk, interpretation risk). Supervisory evidence shows that data availability remains a bottleneck: in the ECB 2022 climate stress test, many banks relied extensively on proxies and estimates, signalling a data gap that reinforces the importance of conservatism and governance controls.[133]

3.1.3 Link with accounting impairment: SICR, staging, scenarios, and implications for climate and nature-related drivers

In the ECL model, the forward-looking component implies the use of prospective information and scenarios. Macroeconomic scenarios are not a single set imposed by the prudential framework, they are instead developed by the institution and used to estimate the evolution of credit risk. For the purposes of this research, the point is not to define ex ante which scenarios should be used, but to clarify how climate and nature-related drivers can be incorporated coherently into triggers and forward-looking assessments of deterioration.

From this perspective, two elements are particularly relevant:

1. **Staging and the ECL time horizon.**

   The shift from a 12-month logic to a lifetime logic has significant impacts on the level of provisions. The SICR channel is therefore a natural entry point for environmental/nature-related drivers that operate as forward-looking deterioration factors (e.g., loss of environmental attractiveness, water stress, rising insurance costs, coastal physical vulnerability). Consistently, the EBA Guidelines on loan origination and monitoring require ESG factors to be considered in the assessment and monitoring of credit risk, making the use of such indicators methodologically defensible also as early signals of a significant increase in risk.

2. **30 days past due rebuttable presumption.**

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[133] European Central Bank. (2022, July 8). 2022 climate risk stress test. ECB Banking Supervision.

> Exceeding 30 days past due represents a rebuttable presumption of a significant increase in credit risk. This is relevant because many environmental shocks do not generate immediate default, but can produce liquidity stress and payment delays, anticipating deterioration and therefore increasing ECL before regulatory default occurs.[134]

From a methodological standpoint, this leads to two particularly relevant implications. Even where the integration of Blue Economy drivers into prudential PD is partial, due to data limitations or statistical robustness constraints, the impairment channel allows a complementary integration via triggers and forward-looking scenarios, provided that there is documentary consistency, traceability, and appropriate modelling controls. Alignment between prudential PD and PD/ECL is not automatic, as it requires a mapping between rating migration and SICR triggers, as well as between environmental, physical, and transition indicators and expected impacts on cash flows and repayment capacity.

3.1.4 Where "Blue Economy" drivers enter the credit life cycle: EBA/ECB expectations and modelling constraints

European authorities converge on one point: climate and environmental risks must be treated as drivers of traditional risks, and for credit risk they must be incorporated throughout the entire life cycle of an exposure.

- The EBA Guidelines on loan origination and monitoring require ESG factors and associated risks to be embedded in risk appetite, policies, procedures, and controls, explicitly including the need to identify and manage climate and environmental risks and to put monitoring arrangements in place;[135]
- The EBA Guidelines on the management of ESG risks (EBA/GL/2025/01) strengthen the end-to-end approach by requiring a structured process for

[134] European Banking Authority. (2020, May 29). Relazione finale sugli orientamenti in materia di concessione e monitoraggio dei prestiti (EBA/GL/2020/06)
[135] European Banking Authority. (2020, May 29). Relazione finale sugli orientamenti in materia di concessione e monitoraggio dei prestiti (EBA/GL/2020/06)

identifying and measuring ESG risks and integrating them into risk frameworks and planning;[136]

- From a prudential modelling perspective, the EBA Guidelines on PD/LGD (EBA/GL/2017/16) set technical constraints that determine when and how a driver (including an ESG driver) can become a model variable or a module within the rating system.[137]

Based on the evidence discussed above, the integration of climate and environmental risks into credit parameters remains constrained by a persistent data gap. As already noted in section 3, the ECB 2022 climate stress test showed frequent use of proxies to compensate for incomplete counterparty data and significant heterogeneity in assumptions, affecting the comparability of estimates. This weakness is even more pronounced in the SME segment.

In its operational guidance on climate stress testing, the ECB highlights that the lack of granular and reliable data is particularly material for SMEs, making a progressive approach necessary, grounded in proportionality and strengthened data collection through the bank–firm relationship.[138]

It follows that, for Sicilian SMEs operating in the Blue Economy, the integration of environmental and nature-related drivers should take place along the credit life cycle; first through measurable indicators used in origination and monitoring, useful as early warning signals of deterioration, and only subsequently through incorporation into the rating/PD, in line with prudential constraints.

3.2 Blue Economy materiality: transmission channels to the credit risk profile of accommodation SMEs and coastal food service SMEs

In order to demonstrate that specific environmental and nature-related drivers typical of coastal contexts can translate into a deterioration of repayment capacity and can

[136] European Banking Authority. (2025, January 8). Final report: Guidelines on the management of environmental, social and governance (ESG) risks (EBA/GL/2025/01).
[137] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16).
[138] European Central Bank. (2022, December). ECB report on good practices for climate stress testing.

therefore be considered along the credit life-cycle as determinants of credit risk and, ultimately, of the PD. These drivers are not relevant because they constitute a default event, but because they affect economic and financial variables that precede and fuel credit deterioration, such as the stability and level of revenues, the cost structure, investment needs, and business continuity, thereby influencing creditworthiness throughout the entire life cycle of the exposure.

In this sense, the choice to focus on Sicilian SMEs in the accommodation and coastal food service segments is also consistent with the "operational" definition adopted at EU level: within the perimeter of the European Blue Economy, coastal tourism is the largest sector by size, including accommodation and other services (for example, restaurants)[139]. In 2022, at EU level, coastal tourism accounted for approximately 53% of Blue Economy employment and about 33% of Gross Value Added (GVA), with an employment breakdown showing accommodation at ~44% and other services (e.g., food service) at ~42% of the sector's workforce.[140]

3.2.1 Coastal physical risks and tourism capacity: erosion, sea-level rise, and shocks to revenues and business continuity

For accommodation and food service firms in coastal areas, a significant share of revenue generation is linked to the recreational function of the coast, in relation to factors such as the beach, accessibility, landscape quality, natural amenities, and the continuity of service during the tourist season.

In literature, coastal erosion and sea-level rise are frequently analysed not only as geomorphological phenomena, but as economic drivers that reduce beach usability and tourist beach carrying capacity (BCC), with implications for tourism demand and the economic value of destinations.

A study on Catalan beaches estimates that, by 2050, BCC could decline to around 83% of current levels even in the absence of additional climate effects, due to erosive

[139] European Commission, Directorate-General for Maritime Affairs and Fisheries. (2025). Coastal tourism. In The EU Blue Economy Report 2025
[140] European Commission. (2025). The EU Blue Economy Report 2025 edition. Publications Office of the European Union.

dynamics, and fall further, when incorporating sea-level rise scenarios, within an indicative range of ~74% down to ~53% of current capacity, depending on the scenarios taken into account.[141] A subsequent study in the same context further explores the demand-side dimension, linking the reduction in the recreational function of beaches to measurable economic impacts on tourism.[142]

In the Sicilian context, empirical evidence from individual locations supports the relevance of the causal chain between erosion, loss of attractiveness, and pressure on revenues. Using the case of Lido di Noto as an example, a loss of approximately 53,000 m² of beach is reported over the period 1988–2014, with a shoreline retreat of about 47 metres.[143] Although this is a case study, the figure is useful for the purposes of this research because it makes concrete how a coastal physical driver can translate into:

- a reduction in the natural "base" on which beach tourism is founded;
- the need for interventions such as beach nourishment, coastal protection measures, and maintenance, with impacts on costs and capital needs;
- higher volatility in demand and seasonality.

From a credit perspective, these mechanisms typically operate through "intermediate" variables, such as revenues, margins, extraordinary costs, investment needs, and operational disruptions, which, in banking systems, are frequently observed during monitoring and can anticipate creditworthiness deterioration. Consistently with what was discussed in section 3.1, this is the level at which Blue Economy physical drivers are most readily "integrated" in practice, first as signals and proxies, and only potentially as model variables if supported by robust data.[144]

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[141] López-Dóriga, U., Jiménez, J. A., Valdemoro, H. I., & Nicholls, R. J. (2019). Impact of sea-level rise on the tourist-carrying capacity of Catalan beaches. Ocean & Coastal Management, 170, 40–50.
[142] Garola, A., López-Dóriga, U., & Jiménez, J. A. (2022). The economic impact of sea level rise-induced decrease in the carrying capacity of Catalan beaches (NW Mediterranean, Spain). Ocean & Coastal Management, 218, 106034.
[143] De Salvo, M., Signorello, G., Cucuzza, G., Begalli, D., & Agnoli, L. (2018). Estimating preferences for controlling beach erosion in Sicily. Aestimum, 72, 27–38.
[144] European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06).

3.2.2 “Blue” environmental pressures and transition risks: bathing water quality, discharges/waste, marine litter, and destination reputation

Alongside physical risks, coastal tourism and related services are exposed to environmental pressures that operate through demand, reputation, and compliance channels. In particular, bathing water quality is a highly visible factor for tourism demand and, at the same time, an area subject to public policy oversight.

At EU level, bathing water quality is regulated by Directive 2006/7/EC, which provides for classification into four categories: 1) excellent; 2) good; 3) sufficient; 4) poor, based on defined criteria and parameters.[145] European Environment Agency (EEA) analyses show that, over the period 2010–2024, the share of EU coastal bathing waters classified as “excellent” has remained within an indicative range of approximately 81–89%, based on tests for E. coli and intestinal enterococci.[146] For the purposes of this research, this evidence is not only descriptive, as it indicates that a public monitoring system exists that is comparable over time, and that any deterioration may become a relevant signal for destinations that depend strongly on bathing tourism.

A second typically “blue” channel concerns marine litter and, more broadly, the visible degradation of the shoreline. The scientific literature highlights that the accumulation of litter on beaches can follow seasonal patterns, intensifying during peak tourist season: one study on Mediterranean island beaches reports increases of up to approximately 4.7 times during the high season.[147] From a socio-economic perspective, there are also reports discussing the impacts and costs of marine litter on coastal sectors, including tourism, in Mediterranean macro-regions, reinforcing the

[145] European Parliament and Council of the European Union. (2006). Directive 2006/7/EC concerning the management of bathing water quality and repealing Directive 76/160/EEC (consolidated version, 2009-08-07). Official Journal of the European Union.
[146] European Environment Agency. (2025, July 8). Bathing waters with excellent water quality in Europe.
[147] Grelaud, M., & Ziveri, P. (2020). The generation of marine litter in Mediterranean island beaches as an effect of tourism and its mitigation. Scientific Reports, 10, 20326.

plausibility of a link between environmental degradation and the economic performance of destinations.[148]

On the "transition" side, for coastal accommodation and food service the materiality is not attributable only to the carbon dimension, as it also includes standards and constraints related to water, discharges, waste, management practices, and information requirements along supply chains and within bank–firm relationships.[149][150]

3.2.3 Nature and ecosystem services in coastal tourism: dependencies, impacts, and persistence of economic risk

A distinctive feature of the "coastal blue economy" perimeter is that economic activity not only depends on climate, but also on a set of ecosystem services: shoreline stability, water quality, the integrity of coastal habitats, landscape attractiveness, and the natural capacity to absorb shocks. In this framework, impairment of ecosystem services can constitute a genuine mechanism of "self-harm" for the coastal tourism sector: a scientific synthesis on the Mediterranean highlights how the coastal tourism industry can erode the ecosystem services on which it depends and, conversely, how impacts from other activities can compromise them, with economic repercussions for the destination.[151]

A methodologically important point is that the degradation of ecosystem services can produce persistent effects that are not necessarily captured by short time horizons: loss of scenic quality, biodiversity decline, and increasing environmental degradation can affect the destination's competitive positioning, and therefore occupancy rates and pricing power, in a gradual and cumulative way. The economic and environmental

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[148] Vlachogianni, T. (2017). Understanding the socio-economic implications of marine litter in the Adriatic-Ionian macroregion. MIO-ECSDE; IPA-Adriatic DeFishGear Project.
[149] European Parliament, & Council of the European Union. (2024). Directive (EU) 2024/3019 of the European Parliament and of the Council of 27 November 2024 concerning urban wastewater treatment (recast). Official Journal of the European Union.
[150] European Parliament, & Council of the European Union. (2008). Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (consolidated version 5 July 2018). Official Journal of the European Union.
[151] Drius, M., Bongiorni, L., Depellegrin, D., Menegon, S., Pugnetti, A., & Stifter, S. (2019). Tackling challenges for Mediterranean sustainable coastal tourism: An ecosystem service perspective. Science of the Total Environment, 652, 1302–1317.

valuation literature also supports the idea that beach and coastal-context quality has a measurable perceived value: for instance, one study reports that a significant share of respondents (92%) are willing to pay for beach improvements, with willingness-to-pay estimates on the order of a few euros per visit in the specific contexts analysed.[152] Studies on Italian beaches also use contingent valuation approaches and quantitative methods to estimate the value associated with coastal scenic quality, confirming that the nature/landscape component is an economically relevant asset for seaside destinations.[153]

From a credit perspective, this persistence profile implies that blue/nature risk may initially manifest as a slow but structural deterioration of profitability and cash generation capacity, and only later as arrears events or restructurings. This is consistent with what was discussed in section 3.1 regarding the importance of leading indicators and monitoring processes that capture deterioration before default.

3.2.4 Measurability and traceability of "blue" drivers: information bases usable in credit processes

For the purpose of integration into banking processes, materiality must be assessed against measurability: a driver is more suitable to enter the credit life cycle when reliable, comparable, and auditable proxies and data sources exist. In the Blue Economy domain, several elements suggest that this condition is at least partially met.

On the one hand, as discussed, regulated and regularly updated data sets exist on bathing water quality (Directive 2006/7/EC; EEA reporting), with standardised classifications and clear parameters.

On the second hand, the literature on the water–tourism nexus in the Mediterranean highlights that the use of water-consumption indicators in the tourism sector is

[152] Birdir, S., Ünal, Ö., Birdir, K., & Williams, A. T. (2013). Willingness to pay as an economic instrument for coastal tourism management: Cases from Mersin, Turkey. Tourism Management, 36, 279–283.
[153] Rodella, I., Madau, F. A., & Carboni, D. (2020). The willingness to pay for beach scenery and its preservation in Italy. Sustainability, 12(4), 1604.

recurrent and often expressed in operational metrics, also to assess vulnerabilities and demand-management measures.[154]

Furthermore, a recent review on water-saving measures in hotels systematises the available evidence on adopted practices and their impacts, confirming that, at least for certain dimensions such as water, there is a sufficiently developed research base to support more structured information choices.[155]

Overall, the evidence recalled in the previous sections shows that, in the coastal Blue Economy context, there are physical, environmental, and nature-related drivers that:

- are economically relevant for accommodation and food service SMEs;
- are, at least in part, observable through data sources and proxies with a sufficient degree of standardisation and repeatability.

It follows that these drivers can be treated as informational inputs consistent with the credit risk logic outlined in section 3.1, as they affect variables that precede default and therefore the trajectory of creditworthiness deterioration along the credit life cycle.

3.3 Methodological tools for structuring "Blue Economy" drivers within banking processes

The availability of proxies and data sources on coastal physical and environmental drivers makes it possible to take a further methodological step: transforming "materiality" into structured information for bank risk management. In this respect, two tools are the most relevant and are complementary:

1. **scenario analysis/stress testing:** translates physical and transition shocks into forward-looking pathways and into economic and financial impacts;

[154] Ricart, S., Villar-Navascués, R., Reyes, M., Rico-Amorós, A. M., Hernández-Hernández, M., Toth, E., Bragalli, C., Neri, M., & Amelung, B. (2024). Water–tourism nexus research in the Mediterranean in the past two decades: A systematic literature review. International Journal of Water Resources Development, 40(1), 57–83.
[155] Gabarda-Mallorquí, A., Deyá, B., & Tirado, D. (2024). Exploring research on water-saving measures applied to the hotel sector: A critical systematic review. International Journal of Hospitality Management, 103747.

2. **Nature-related identification and assessment frameworks:** enable a replicable ordering of dependencies, impacts, and transmission channels, which is particularly important in coastal contexts where the "nature" component is a direct driver of demand and business continuity.[156]

3.3.1 Scenario analysis and stress testing: from climate-environmental narratives to economic and credit variables

In the banking context, scenario analysis is used to assess the resilience of the loan portfolio to climate and macro-financial shocks and to introduce a forward-looking dimension consistent with the evolution of physical and transition risks. The climate stress testing literature highlights that the critical point is not only selecting a scenario, but building a credible translation chain: 1) scenario; 2) sectoral variables; 3) firm performance; 4) risk parameters (PD/LGD/EAD, rating migrations, ECL). This must be done while explicitly managing uncertainty and non-linearities.[157]

At EU level, the "one-off Fit-for-55 climate risk scenario analysis", conducted jointly by the EBA, ESMA, EIOPA, ECB, and ESRB, is relevant as a methodological precedent because it adopts a short-term horizon, specifically from 2024 to 2030, and builds transition scenarios combined with macro-financial shocks, with the aim of assessing the financial system's ability to absorb stress during the implementation of the "Fit for 55" package.[158] The methodological message that is useful for this research is that methodologies applied in the European context are converging towards:

- shorter and more actionable horizons;
- higher data granularity;
- integration between transition and macro channels.[159]

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[156] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors.
[157] Acharya, V. V., Berner, R., Engle III, R. F., Jung, H., Stroebel, J., Zeng, X., & Zhao, Y. (2023, April). Climate stress testing (NBER Working Paper No. 31097). National Bureau of Economic Research.
[158] European Banking Authority. (2024, November 19). Report on Fit-for-55 climate scenario analysis.
[159] European Systemic Risk Board. (2023, December 12). Climate-related scenarios for the one-off Fit-for-55 scenario analysis exercise.

In parallel, the most recent regulatory push is not only about developing scenarios, but about doing so with requirements on governance, traceability, and modelling consistency: the EBA "Guidelines on environmental scenario analysis", finalised in 2025, codify an end-to-end approach covering scenario selection, data infrastructure, translation into risk channels, and use within internal processes. This reinforces the idea that, for coastal SME portfolios, scenarios should be understood as tools for progressive integration, initially usable for overlays and monitoring and only subsequently for structured components of rating systems when empirical evidence and data quality make this defensible.[160]

3.3.2 Location-based approaches: why, in the coastal Blue Economy, geography is not a detail

For accommodation and coastal food service firms, a significant share of physical risk, and part of nature risk, is inherently localised: exposure depends on distance from the shoreline, elevation, vulnerability to erosion, the environmental quality of the surrounding area, and seasonal anthropogenic pressure. It follows that adopting location-based approaches is not optional, but a necessary condition to avoid systematic measurement errors, because risk is not only sectoral but also micro-territorial.

The operational relevance of this approach is demonstrated by empirical applications in the Italian context. The work by Meucci and Rinaldi uses granular data (AnaCredit) to estimate banks' exposure to physical risk by taking firms' location into account, showing how georeferencing exposures makes it possible to move from average area-based indicators to measures that better reflect actual risk. Although developed for macroprudential purposes, the approach is transferable to the Blue Economy case because it shows that geographic granularity is technically manageable and can affect both repayment capacity and mitigation-related variables.[161]

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[160] European Banking Authority. (2025, November 5). Final report: Guidelines on environmental scenario analysis (EBA/GL/2025/04).

[161] Meucci, G., & Rinaldi, F. (2022, July). Bank exposure to climate-related physical risk in Italy: An assessment based on AnaCredit data on loans to non-financial corporations (Questioni di Economia e Finanza (Occasional Papers) No. 706). Bank of Italy.

Consistently, standard setters also emphasise that physical risk analysis requires forward-looking hazard data sets and detailed information on exposed assets/activities; the NGFS dedicates a technical note specifically to the structuring and use of physical risk data, highlighting the role of integrated approaches (hazard–exposure–vulnerability) and the need for transparency regarding sources and applications.[162]

3.3.3 Nature-related frameworks and LEAP: organising dependencies and impacts in an auditable way

In coastal contexts, many drivers are not fully explained by the climate dimension alone; a significant portion of risk arises from dependencies and impacts on ecosystems and ecosystem services, as well as systemic risks linked to nature degradation. Here, nature-related frameworks are useful because they provide a common language and a replicable process to:

- identify linkages with nature-related events;
- prioritise areas and value chains;
- assess materiality and transmission channels.

The main operational reference is the LEAP approach of the Taskforce on Nature-related Financial Disclosures (TNFD), designed to guide organisations and financial institutions in identifying and assessing nature-related issues, including an explicitly location-based logic and a progression from descriptive analysis to risk assessment and management responses.[163]

At the same time, the NGFS Conceptual Framework on nature-related financial risks provides a conceptual structure to link impacts and dependencies on nature to economic risks and, consequently, to financial risks, making the adoption of risk taxonomies and transmission channels coherent also in a prudential context. For the purposes of this research, this makes it possible to justify why a nature driver can be

[162] Network for Greening the Financial System. (2025, September). Leveraging physical climate risk data.
[163] Taskforce on Nature-related Financial Disclosures. (2023, September). Guidance on the identification and assessment of nature-related issues: The TNFD LEAP approach.

treated as a determinant of credit risk, avoiding purely reputational or narrative interpretations.[164]

For the coastal accommodation and food service sector, adopting the LEAP methodology therefore makes it possible to:

- identify priority locations, for example coastal areas with high physical vulnerability or environmental pressure;
- make dependencies on critical ecosystem services explicit;
- classify the most relevant economic transmission mechanisms, such as shocks to demand, seasonality, operating costs, adaptation capex, and operational discontinuity;
- produce a set of evidence and proxies that can be subject to data quality controls and internal review.[165]

3.3.4 From methodology to credit use cases

For a bank, the value of scenario analysis and the LEAP approach does not lie only in building a risk narrative, but in producing usable and verifiable outputs: location-based evidence, documented assumptions, the translation of physical and transition drivers into economic shocks and, ultimately, into operational signals that can be embedded in credit controls.

1. **Origination and credit assessment:** location-based outputs and LEAP due diligence make it possible to build an exposure and dependency profile (water, coastline, ecosystems) and to set data requests, covenants, and consistent management measures, progressively closing the data gap that is typical of SMEs.[166]

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[164] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors

[165] Taskforce on Nature-related Financial Disclosures. (2023, March). Nature-related risk and opportunity management and disclosure framework: Beta v0.4 Annex 4.6—Guidance on LEAP: Methods for assessing nature-related risks. TNFD.

[166] European Banking Authority. (2023, November 17). The EBA publishes final templates to collect climate-related data from EU banks. EBA.

2. **Monitoring and early warning:** the periodic updating of external indicators (e.g., bathing water quality, extreme events) and managerial/operational signals supports the definition of early warning indicators and alert thresholds, capturing deterioration before arrears or forbearance emerge.
3. **Integration into risk parameters:** using scenario outputs as a basis for conservatism overlays, internal stress testing, and, where technically defensible, as inputs for modules or variables that improve discriminatory power without undermining calibration. Recent applied research also moves in this direction: for instance, a BIS working paper proposes an extension of standard credit models to parsimoniously incorporate a physical risk component, while preserving properties that are useful for managerial use.[167]

In summary, integrating Blue Economy drivers into banking processes is methodologically supported when an auditable, location-based information base is combined with a scenario approach consistent with emerging EU practices and a nature-related framework that organises dependencies and impacts, making the step from environmental phenomena to economic-financial channels traceable.

3.4 PD-oriented synthesis and methodological requirements for building the framework

What has been discussed in this chapter leads to a methodological conclusion, integrating Blue Economy drivers into credit risk is defensible only if it rests on minimum requirements in terms of traceability, data quality, and process consistency, and if it follows a progressive path, from monitoring to potential model incorporation, consistent with supervisory expectations and with IRB/IFRS 9 constraints.[168]

3.4.1 Minimum requirements for “blue” drivers for use in banking processes

[167] Pozdyshev, V., Lobanov, A., & Ilinsky, K. (2025, July). Incorporating physical climate risks into banks’ credit risk models (BIS Working Papers No. 1274). Bank for International Settlements.
[168] European Central Bank. (2020, November). Guide on climate-related and environmental risks: Supervisory expectations relating to risk management and disclosure. ECB Banking Supervision.

For use in credit processes, a "blue" driver: physical, environmental, or nature-related; must meet requirements that reflect two needs, being measurable and auditable, and being consistent with the risk management architecture. In particular:

- **Unambiguous definition and unit of analysis.** The driver must be defined without ambiguity and linked to the unit of observation relevant for credit risk, at obligor level and/or facility level, avoiding inconsistencies that would contaminate data set construction and subsequent validation.[169]
- **Source traceability and audit trail.** The source must be disclosed and replicable; any transformation steps must be made explicit and data versioning must be managed, in line with governance expectations on climate-environmental data and methods.[170]
- **Granularity and location-based component.** For the coastal Blue Economy, geographic granularity is a substantive requirement; drivers must be linkable to operating locations or, at minimum, to coherent territorial proxies, to avoid measurements that dilute risk.[171]
- **Data quality, coverage, and data gap management.** Where data sets are incomplete or proxies are used, the framework should include ex ante rules such as missing-data treatment, materiality criteria, consistency checks, and, when the driver feeds into prudential estimates, a conservatism mechanism aligned with IRB requirements.[172]
- **Credible causal linkage to economic channels.** Each driver must be mapped to an observable economic-financial channel, avoiding purely descriptive indicators with no link to repayment capacity. This requirement is consistent with the supervisory approach that requires understanding causes and

[169] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16). EBA.
[170] European Banking Authority. (2025, January 8). Final report: Guidelines on the management of environmental, social and governance (ESG) risks (EBA/GL/2025/01).
[171]Network for Greening the Financial System. (2025, September). Leveraging physical climate risk data.
[172] European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06).

transmission channels through which environmental risks affect traditional risk categories.[173]

3.4.2 Positioning blue drivers within the credit life cycle: operational entry points

Blue drivers can be positioned within the credit life cycle through four practical entry points, with increasing methodological intensity: origination (due diligence and baseline setting), where indicators support the initial risk narrative and contractual information; monitoring and early warning, where KRIs act as dynamic signals and trigger-based controls prior to regulatory default[174]; the forward-looking impairment channel (SICR/ECL), where documented indicators can support staging triggers and scenario-consistent assessments[175]; and PD-related incorporation, which remains conditional on IRB robustness, representativeness and validation, and therefore, especially for SMEs, may initially be approached via documented overlays, pricing/limits, or stress testing.[176]

3.4.3 Practical implications for Sicilian SMEs: proportionality, proxies, and non-stationarity

In the case of coastal SMEs, integrating blue drivers faces structural constraints, such as: less granular counterparty data, strong idiosyncratic heterogeneity, seasonality, and dependence on local conditions. As a result, the framework must be designed to operate under data-gap conditions and follow a progressive approach.

Applied evidence on Italian portfolios shows that physical risk can affect both repayment capacity and collateral value, and that the geographic dimension is critical to estimating exposure credibly. An approach based on granular loan-level data and operational-location information provides a methodological reference that can be

[173] European Banking Authority. (2025, January 8). Final report: Guidelines on the management of environmental, social and governance (ESG) risks (EBA/GL/2025/01).
[174] European Banking Authority. (2020, May 29). Final report: Guidelines on loan origination and monitoring (EBA/GL/2020/06).
[175] IFRS Foundation. (2015, September 16). Significant increases in credit risk (Agenda Paper 1, Transition Resource Group for Impairment of Financial Instruments).
[176] European Banking Authority. (2017, November 20). Guidelines on PD estimation, LGD estimation and the treatment of defaulted exposures (EBA/GL/2017/16).

transferred to the Sicilian context, albeit with sector-specific adaptations to the Blue Economy.[177]

From a modelling perspective, recent literature proposes approaches that allow physical risk components to be integrated into credit risk models while preserving properties that are useful for banking and regulatory purposes, but it also implicitly highlights the need for transparent choices regarding proxies, parameters, and assumptions. This reinforces, in the SME segment, the appropriateness of using drivers initially as signals and monitoring levers, with a gradual transition towards more structured integrations when the data base allows it.[178]

Finally, for the nature component, adopting a location-first approach is particularly suited to coastal tourism: the TNFD LEAP approach sets out an operational sequence: 1) Locate, 2) Evaluate, 3) Assess, 4) Prepare, which helps in assessing dependencies and impacts replicablility as well as the production of evidences that can be used in the bank–firm relationship, while maintaining traceability and methodological consistency.[179]

In conclusion, the output of this chapter is a set of "validity conditions" for building the framework, which will be addressed in the next chapter. Specifically, this implies defining an explicit mapping from blue drivers to economic channels and to entry points within the credit life cycle, such as origination, monitoring, SICR, and PD; establishing data quality and traceability rules, including sources, proxies, versioning, and audit trail, consistent with prudential requirements and governance expectations; and clarifying how forward-looking tools, such as scenario analysis, support uncertainty management and documentary consistency, in line with EBA guidance on ESG risk management and scenario analysis.

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[177] Meucci, G., & Rinaldi, F. (2022, July). Bank exposure to climate-related physical risk in Italy: An assessment based on AnaCredit data on loans to non-financial corporations (Questioni di Economia e Finanza (Occasional Papers), No. 706). Bank of Italy.
[178] Pozdyshev, V., Lobanov, A., & Ilinsky, K. (2025, July). Incorporating physical climate risks into banks' credit risk models (BIS Working Papers No. 1274). Bank for International Settlements.
[179] Taskforce on Nature-related Financial Disclosures. (2023, September). Guidance on the identification and assessment of nature-related issues: The TNFD LEAP approach

CHAPTER 4 – OPERATIONAL FRAMEWORK FOR THE TRANSLATION OF "BLUE ECONOMY" AND NATURE-RELATED DRIVERS INTO KPI/KRI USABLE IN CREDIT RISK

This chapter defines an operational framework that enables the integration of environmental, "blue," and nature-related drivers into banks' credit risk management processes for SMEs operating in the hospitality and food service sectors in coastal contexts. The objective is not to redefine default nor to replace prudential/accounting models, but to make observable, measurable, and traceable those factors that affect economic and financial variables antecedent to default (revenues, margins, costs, investment needs, operational continuity) and that, through this channel, can inform origination, monitoring, rating review, and forward-looking assessments (SICR/ECL). The framework takes as its primary basis the Blue Economy Sustainability Framework (BESF) of the European Investment Bank, in particular the Main Report[180], Guidelines[181], and Annexes[182], from which indicators, units of measurement, and the dimension–criteria–indicators structure are adopted. For the methodological ordering of nature-related risks and the traceability of dependencies/impacts, the TNFD is adopted as a conceptual reference (Recommendations[183] and LEAP guidance[184]). For the definition of nature-related risk channels relevant to finance, the NGFS Conceptual Framework[185] is referenced. For alignment with European disclosure requirements and biodiversity taxonomies, reference is made to the ESRS framework adopted through a Commission Delegated Regulation[186].

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[180] European Commission. (2021). Sustainability criteria for the blue economy: Main report. Publications Office of the European Union.
[181] European Commission. (2021). Sustainability criteria for the blue economy: Guidelines. Publications Office of the European Union.
[182] European Commission. (2021). Sustainability criteria for the blue economy: Annexes to the main report. Publications Office of the European Union.
[183] Taskforce on Nature-related Financial Disclosures. (2023). Recommendations of the Taskforce on Nature-related Financial Disclosures
[184] Taskforce on Nature-related Financial Disclosures. (2023). Guidance on the identification and assessment of nature-related issues: The TNFD LEAP approach
[185] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors
[186] European Commission. (2023). Commission Delegated Regulation (EU) 2023/2772 of 31 July 2023 supplementing Directive 2013/34/EU of the European Parliament and of the Council as regards sustainability reporting standards. Official Journal of the European Union, L 2023/2772

4.1 Framework architecture: information layers and "translation layer" toward credit risk

The framework is organized into three information blocks:

A) Territorial context,

B) Firm profile,

C) Managerial capacity,

and into a translation layer that links indicators/KRIs to economic and financial variables and, consequently, to the points of integration within the credit life cycle.

Table 4.1: Logical architecture of the framework

Block	Content	Main Output	Function in credit risk
A. Territorial context (location-specific)	Official proxies on environmental status and ecosystem sensitivity (blue & biodiversity)	Context profile of the area	Geographic screening, portfolio segmentation, territorial risk appetite setting, signal interpretation
B. Firm operational profile (borrower-level)	Consumption/pressure KPIs and operational variables (water, energy, waste, volumes, practices)	Normalized KPIs (per m², guest night, cover, € revenues)	Due diligence in origination; monitoring KRIs; basis for informational covenants
C. Management and adaptive capacity	Governance, supply chain policies, risk plans, investments and mitigation measures	Qualitative/hybrid KRIs	Assessment of resilience, business continuity, non-carbon transition risk, documented judgments (rating review/override)
Translation layer (A→B→C→credit)	Traceability rules "indicator → economic variable → point of integration"	Credit life-cycle integration matrix	From environmental materiality to operational credit risk management

4.2 Information system: data sources, verifiability, and georeferencing requirement

Given that "blue" and nature-related drivers are strongly location-specific, the framework introduces a minimum information requirement: georeferencing of the prevailing operational site (standardized address and/or coordinates). This requirement enables the integration of territorial proxies into the firm's risk profile and ensures consistency between borrower-level indicators and the contextual environment.

Data sources are classified into: (a) official public datasets and (b) verifiable firm-level data, within a data quality framework consistent with auditability and traceability.

Table 4.2: Data sources and verifiability

Data family and sources	Examples	Nature of the data	Verifiability	Primary use
Regulated public "blue" datasets	Bathing water quality (classification and time series)	Territorial	High (EU standards)	Context; reputational - environmental signals
Public biodiversity - ecosystem datasets	Protected areas, sensitive habitats, threatened species proxies (IUCN at area scale)	Territorial	Medium–high (depending on scale and update frequency)	Ecosystem sensitivity; territorial risk appetite
Firm-level data – consumption and costs	Water and energy bills/meters, waste management costs	Borrower-level	High (document-based)	Operational KPIs/KRIs; margin stress
Firm-level data – operations	Guest nights, arrivals, covers, turnover (proxies)	Borrower-level	Medium–high (management records)	Demand/volatility; KPI normalization
Firm-level data – governance	Supply chain policies, risk plans,	Borrower-level (qualitative)	Medium (supporting evidence)	Adaptive capacity; rating review/monitoring

	evidence of interventions			

An example of an official information base for water quality is provided by European Environment Agency (EEA) publications on bathing water quality, which refer to standardized classifications (excellent/good/sufficient/poor) and to reference microbiological parameters[187].

4.3 Indicator set: core (BESF tourism), adaptation to food service, integration of biodiversity and "blue" pressures

4.3.1 Core BESF indicators for the tourism sector (accommodation + related services)

Tourism sector indicators (codes STO.) and their respective units of measurement are drawn from the BESF Annexes.[188]

Table 4.3 – Core indicators (BESF, tourism sector): operational definitions and points of integration into credit risk

Code	Indicator (unit)	Level (A/B/C)	Operational definition	Intermediate economic–financial variable	Point of integration in the credit life cycle
STO.EN.1	Specific energy use (kWh/m²/year)	B	Annual energy consumption of the site / m² (surface area defined unambiguously)	Energy OPEX; efficiency CAPEX needs	Origination (cost/CAPEX due diligence), Monitoring (trend analysis), CAPEX covenants
STO.EN.2	Water consumption per guest night (liters/guest night)	B	Water consumption / guest night	Water OPEX; rationing - interruption risk; consumption-reduction CAPEX	Monitoring (KRI), SICR/ECL (forward-looking), informational covenants

[187] European Environment Agency. (2025, July 8). Bathing waters with excellent water quality in Europe.
[188] European Commission. (2021). Sustainability criteria for the blue economy: Annexes to the main report. Publications Office of the European Union.

STO.EC.1	Number of tourists (no. of tourists/month)	B (or A if territorial)	Monthly flows (firm-level or area-level, depending on data availability)	Revenues; demand volatility	Monitoring (early warning), Rating review (migration)
STO.SO.1	Seasonal jobs (% seasonal employment)	B	Share of seasonal employment over total employment	Cost elasticity; operational risk	Origination (cost structure), Monitoring (operational stability)
STO.SO.2	Tourism density (nights/area surface)	A	Tourism pressure per area	Policy - acceptability risk; congestion	Geographic screening, territorial risk appetite
STO.SO.3	Tourism intensity (nights/resident population)	A	Tourism intensity relative to resident population	Policy/limits risk; contextual volatility	Portfolio segmentation and concentration
STO.GO.1	Planning management incl. tourism (% area)	A	Share of area covered by planning - development management processes	Authorization risk; regulatory predictability	Origination (permitting risk), Monitoring (context changes)
STO.GO.2	Visitor taxes/fees reinvested (yes/no)	A	Presence of taxes/fees with reinvestment for impact mitigation	Destination costs/benefits; reputational stability	Context assessment; qualitative scenario analysis
STO.GO.3	Sustainable sourcing policy (score 1–3)	C	1 absent; 2 existing but not implemented; 3 existing and implemented	Non-carbon transition risk; reputational risk	Origination (due diligence), Monitoring (informational covenants)

4.3.2 Operational adaptation to the food service sector in a coastal context

In the food service sector, some normalizations typically used in hospitality (e.g., guest night) are not applicable. The framework, therefore, provides for a functionally equivalent normalization, maintaining consistency with BESF dimensions (energy, water, waste, supply chain) and prioritizing documentable metrics.

Table 4.4: Operational indicators for food service

Indicator (unit)	Operational definition	Risk rationale	Primary point of integration
Water consumption per cover (liters/cover)	Water consumption / number of covers (or transactions)	Costs + vulnerability to water stress/limitations; operational continuity	Monitoring (KRI), SICR/ECL (forward-looking)
Energy consumption per cover (kWh/cover) o per m²	Energy consumption normalized per covers or per m²	Cost shocks; efficiency investment needs; margins	Origination + Monitoring
Waste generated intensity (kg/year per cover or per € revenues)	Normalized waste generation	Disposal costs; regulatory risk; reputation	Monitoring; covenants on reduction plans
Sustainable sourcing policy (score 1-3)	Purchasing policy and implementation (including "blue" inputs)	Supply chain transition risk; disclosure requirements; reputation	Origination + informational covenants

4.3.3 Biodiversity and "blue" pressures: BESF "common" indicators and minimum territorial proxies

Biodiversity is integrated through: (a) BESF indicators applicable on a cross-cutting basis (common indicators) and (b) minimum territorial proxies based on georeferencing and ecosystem sensitivity. The logic is consistent with the Taskforce on Nature-related Financial Disclosures (dependencies/impacts)[189] and the Network

[189] Taskforce on Nature-related Financial Disclosures. (2023). Recommendations of the Taskforce on Nature-related Financial Disclosures

for Greening the Financial System (nature-related channels toward financial risks)[190], without requiring complex ecological monitoring that would be unrealistic for SMEs.

Table 4.5: Biodiversity and "blue" pressures

Family	Indicator/Proxy	Level (A/B/C)	Unit/Scale	Typical source	Use in credit risk
Biodiversity (sensitivity)	Proximity to areas of high ecosystem sensitivity	A	Classes (low/medium/high)	Official datasets + georeferencing	Territorial screening; concentration limits; engagement prioritization
Biodiversity (pressure)	Extent of habitat impacted	B/C	ha	Permits / projects / interventions; territorial proxy	Authorization / reputational risk; mitigation CAPEX
Biodiversity (area fragility)	Threatened species (IUCN) – sensitivity proxy	A	% / area-level indicator	Public datasets (area scale)	Territorial risk appetite; qualification of nature-related risk
"Blue" pressures (water)	Bathing water quality (classification)	A	Standard classes	Regulated public datasets	Reputational context; destination deterioration signals
"Blue" pressures (waste)	Waste generated (intensity)	B	Normalized kg/year	Contracts/records	Costs + compliance risk; KRI monitoring
Governance / mitigation	Risk management plans	C	yes/no + evidence	Internal documents	Resilience; business continuity; rating review

[190] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors

4.4 Transformation from KPI to KRI: normalization, benchmarks, thresholds, and operational triggers

Indicators are transformed into KRIs through a standardized process that ensures comparability, risk interpretability, and the activation of actions within the credit life cycle. The BESF Guidelines[191] emphasize the importance of clear definitions and information traceability, including distinctions between measured, estimated, and unavailable data.

Table 4.6: KRI transformation procedure

Step	Contenut	Output	Data quality rule
1.Normalization	Selection of the denominator (m², guest night, cover, € revenues) and seasonality rules	Comparable KPI	Unique denominator; outlier management
2.Benchmarking	Comparison with peer group (same type, size, area) and historical trend	Relative positioning	Documented benchmark sources
3.Thresholds	Definition of initial thresholds (percentiles/local limits)	Risk classes (green/yellow/red)	Periodic review of thresholds
4.Triggers / Actions	Linking thresholds to actions (information requests, covenants, rating review, enhanced monitoring)	Operational matrix	Audit trail of decisions/overrides

[191] European Commission. (2021). Sustainability criteria for the blue economy: Guidelines. Publications Office of the European Union.

Example of a causal chain

A persistent increase in water consumption per unit of service (e.g., liters per guest night or liters per cover), especially in territories characterized by water stress or potential usage restrictions[192], tends to be reflected in higher operating costs and/or in a greater likelihood of interruptions or rationing affecting service delivery[193]. Such effects may reduce margins and increase cash flow volatility, translating into observable early warning signals in monitoring (e.g., deterioration in liquidity indicators, increased recourse to payment extensions, or tensions in payment timeliness).[194]

From a forward-looking accounting perspective, the combination of an unfavorable operational trend and territorial vulnerability may constitute relevant information supporting the assessment of a significant increase in credit risk (SICR), in accordance with the intermediary's internal rules.

4.5 Translation toward PD and SICR/ECL: progressive use and maturity pathway

The framework adopts a progressive approach: indicators are initially introduced as information/KRIs and only subsequently, if supported by adequate data quality, may contribute to more structured integrations (e.g., documented overlays or dedicated modules). This approach is consistent with the view that nature-related risks require clarification of transmission channels toward financial risks and a gradual improvement of data foundations.[195]

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[192] Ricart, S., Villar-Navascués, R., Reyes, M., Rico-Amorós, A. M., Hernández-Hernández, M., Toth, E., Bragalli, C., Neri, M., & Amelung, B. (2024). Water–tourism nexus research in the Mediterranean in the past two decades: A systematic literature review. International Journal of Water Resources Development, 40(1), 57–83.

[193] Gabarda-Mallorquí, A., Deyá, B., & Tirado, D. (2024). Exploring research on water-saving measures applied to the hotel sector: A critical systematic review. International Journal of Hospitality Management, 120, 103747.

[194] McCarroll, M. J., LaVanchy, G. T., & Kerwin, M. W. (2024). Tourism resilience to drought and climate shocks: The role of tourist water literacy in hotel management. Annals of Tourism Research Empirical Insights, 5(2), 100147.

[195] Network for Greening the Financial System. (2024). Nature-related financial risks: A conceptual framework to guide action by central banks and supervisors

Table 4.7: Maturity pathway for use in credit risk

Step	Use of indicators	Typical banking tools	Data requirement
1. Informational / managerial	KRIs in origination/monitoring; informational covenants; engagement	Early warning, review of conditions, documentation requests	Minimum data (bills, volumes, policies)
2. Quantitative "add-on"	Documented overlays/scorecards; qualitative/quantitative stress	Pricing, limits, sector/area policies	Historical series, benchmarks, definition stability
3.Advanced integration	Modules/satellites (subject to governance and validation)	Advanced rating systems; more structural use	Robust datasets, backtesting, audit trail

Table 4.8: Credit life-cycle integration matrix

The present Table summarizes how and where the selected indicators (KPI/KRI) operationally enter the credit life-cycle, distinguishing between direct use in decision-making controls and indirect use as an explanatory variable within economic-financial drivers. The "V" marking indicates that the indicator is material and controlled in that phase (i.e., collected/validated and used as a structured assessment element), whereas "indirect" signals a use not as an autonomous default factor, but as a causal signal that impacts revenues, costs, CAPEX and business continuity, and therefore influences the credit assessment through forward-looking projections or the risk narrative. In origination, the matrix privileges a screening and baseline logic, to define the enterprise's and the territorial context's "starting point"; in monitoring, the use becomes dynamic and trigger-based, i.e., guided by thresholds/changes that activate deeper analysis and corrective actions. In rating review/override, "V (documented)" implies that any adjustments or overrides must be justifiable and traceable, with consistent evidence and an explicit link to the observed economic channels. Finally, in the SICR/ECL (forward-looking) component, integration is mainly conditional: some indicators (e.g., water) become relevant only if combined with territorial vulnerability (location-first approach) and with signals of trend persistence, while others primarily feed a qualitative scenario reading. In this sense, the matrix operationalizes a logic of

progressive escalation: from information and screening, to monitoring signals and triggers, to documented support for credit decisions, up to a forward-looking contribution, without conflating the role of environmental drivers with the mechanical determination of the default event.

Indicator / KRI	Origination	Monitoring	Rating review/override	SICR/ECL (forward-looking)
Energy (kWh/m²)	V	V	V (documented)	(indirect)
Water (liters/guest night; liters/cover)	V	V (trigger-based)	V (if persistent trend)	V (if combined with territorial vulnerability)
Waste (intensity)	V (compliance)	V	V	(indirect)
Supply chain policy (score)	V	V (implementation check)	V	(indirect)
Biodiversity proxies (area sensitivity)	V screening	V context	V (sector/area)	V qualitative scenario

In conclusion, this Chapter has translated "blue economy" and nature-related drivers, including biodiversity, into an operational framework consistent with the end-to-end integration of environmental factors within banks' credit risk processes. Building on the sectoral indicators of the European Investment Bank Blue Economy Sustainability Framework and strengthening conceptual traceability through references to recognized nature-related frameworks, the chapter has defined: a) a set of measurable and auditable indicators for accommodation and food service firms operating in coastal contexts; b) a procedure for normalization and transformation into KRIs usable in origination and monitoring; and c) an integration matrix linking these variables to decisions and controls across the credit life cycle, while preserving the distinction between economic signals/drivers and the regulatory definition of default.

In this way, the framework provides the methodological basis for the subsequent empirical phase: the firm-level questionnaire, aimed at verifying the availability, quality, and informational relevance of the proposed indicators and at assessing their

effective usability in the bank–firm dialogue and in credit risk controls across the credit life cycle (origination, monitoring, rating review/override) and in the forward-looking SICR/ECL perspective within the SME segment.

CHAPTER 5 – EMPIRICAL FEASIBILITY ASSESSMENT: DESIGN AND ADMINISTRATION OF THE QUESTIONNAIRE

5.1 Rationale and objective of the questionnaire

After defining in the previous chapters an operational framework capable of "translating" blue economy and nature-related drivers into indicators (KPIs/KRIs) potentially usable in banks' credit risk processes (origination, monitoring, rating review/override, and the SICR/ECL perspective), this chapter develops the empirical phase of the research: administering a questionnaire at the firm level.

The choice of a questionnaire responds to a precise methodological need: to verify whether the proposal developed "upstream" is realistically feasible in the SME segment and, above all, whether it respects the proportionality principle required in bank–company dialogue. Accordingly, this empirical phase is not designed as a full pilot of the framework proposed in Chapter 4, nor as a quantitative validation exercise. Implementing a full pilot would require longitudinal, high-granularity data, stable indicator definitions and sector-/area-specific benchmarks, as well as privileged access to bank-grade governance and validation routines (documentation, controls, auditability) to calibrate thresholds, triggers, and their link to credit outcomes, requirements that fall outside the empirical scope and data access of the present study.

In particular, the questionnaire was designed to validate, from the companies' point of view, three key aspects:

1. **Presence and maturity of monitoring and management practices** on environmental dimensions relevant in the coastal context (e.g., water);
2. **Perceived economic materiality** of environmental and nature-related drivers, i.e., the extent to which these factors affect demand, costs, business continuity, and performance;
3. **Minimum informational feasibility** of a restricted set of information/indicators useful to make dialogue with banks and financiers more transparent and orderly, without requiring sensitive financial data or credit assessments.

Within this scope, the questionnaire primarily supports the first step of the maturity pathway outlined in Chapter 4 (informational readiness and feasibility), as a prerequisite for subsequent and more advanced forms of integration. Consistent with the thesis framework, the objective is not to "measure" PD directly or estimate regulatory parameters, but to test the possibility of making observable, measurable, and traceable those environmental factors that affect economic-financial variables prior to default (revenues, margins, OPEX, CAPEX, business continuity) and that can therefore enter the bank as informational signals and, progressively, as drivers for monitoring and resilience.

5.2 Questionnaire design: structure, logic, and consistency with the framework

The questionnaire consists of 10 closed-ended questions, built using ordinal scales (frequency, intensity, level of agreement, feasibility) in order to enable quick and comparable answers, minimizing the informational burden on companies.

Table 5.1: Questionnaire

Question N.	Title and Description	Answers
1	**Water consumption monitoring** Does your company systematically monitor water consumption related to its activity (e.g. by facility, period, or level of service)?	☐ Yes, in a regular and structured way; ☐ Yes, but only occasionally; ☐ No, but we believe it would be feasible; ☐ No, and we believe it is not currently feasible.
2	**Water stress and business continuity** In recent years, have you experienced **limitations, constraints or risks related to water availability** (e.g. rationing, increasing costs, service interruptions)?	☐ Never; ☐ Rarely; ☐ With some frequency; ☐ Frequently and in a significant way.
3	**Environmental quality and destination attractiveness** To what extent do you believe that **coastal environmental quality** (bathing water quality, beach cleanliness, ecosystem conditions) affects customer demand for your business?	(1: Not at all; 5: It is a key determining factor) ☐ 1; ☐ 2; ☐ 3; ☐ 4; ☐ 5.
4	**Environmental events and economic performance** In recent years, has your business experienced **economic impacts** (e.g. revenue losses, cost increases, operational disruptions) due to environmental or climate-related	☐ No, never; ☐ Yes, with marginal impacts; ☐ Yes, with significant impacts; ☐ Yes, with structural impacts on the business.

	events (e.g. heatwaves, storms, coastal erosion, pollution)?	
5	**Environmental investments and adaptation** Has your company undertaken or planned **investments** aimed at reducing environmental impacts or adapting to environmental constraints (e.g. water, waste, energy, ecosystems)?	☐ Yes, already implemented; ☐ Yes, planned; ☐ No, but under consideration; ☐ No, not considered.
6	**Biodiversity and business sustainability** To what extent do you believe that the **condition of coastal ecosystems and biodiversity** (sea, beaches, natural habitats) affects the medium- to long-term economic sustainability of your business?	☐ Not at all; ☐ To a limited extent; ☐ To a significant extent; ☐ To a decisive extent.
7	**Availability of environmental information** Are environmental data relevant to your activity (e.g. water, waste, energy, territorial impacts) **easily available** within your company?	☐ Yes, already available; ☐ Partially available; ☐ Retrievable with limited effort; ☐ Difficult to retrieve.
8	**Dialogue with banks and sustainability** Have banks or other financial institutions ever requested **environmental or sustainability-related information** in the context of loans or credit relationships?	☐ No, never; ☐ Yes, informally; ☐ Yes, through questionnaires or documents; ☐ Yes, in a structured and recurring manner.
9	**Usefulness of standardized environmental indicators** Do you believe that a **limited set of standardized environmental indicators**, specifically designed for coastal tourism and food services, could facilitate dialogue with banks?	☐ Not at all; ☐ To a limited extent; ☐ To a moderate extent; ☐ To a large extent.
10	**Feasibility of environmental information sharing** Overall, how feasible would it be for your company to **collect and periodically share a limited amount of environmental information** (e.g. water use, waste management, impacts on the local environment) requested by banks or other financial institutions?	☐ Not feasible; ☐ Slightly feasible; ☐ Moderately feasible; ☐ Fully feasible.

The structure of the questions directly reflects the dimensions of the framework and the "translation layer" toward economic channels relevant for credit risk (costs, demand, volatility, business continuity, investment needs). In summary, the 10 questions cover:

- **Water – monitoring and management:** presence of systematic monitoring of consumption (Q1) and perception of critical issues/constraints linked to water availability (Q2);
- **Environmental quality and economic attractiveness:** impact of coastal environmental quality on demand (Q3);
- **Environmental shocks and economic impacts:** experience of impacts on revenues/costs/operations due to environmental or climate events (Q4);
- **Adaptation and investments:** investments made or planned (or under assessment) in environmental areas (Q5);
- **Ecosystems and biodiversity:** perception of the role of ecosystems and biodiversity for medium- to long-term economic sustainability (Q6);
- **Internal data availability:** accessibility/retrievability of environmental information within the company (Q7);
- **Relationship with banks/financiers:** any requests for environmental/ESG information in lending or credit line contexts (Q8);
- **Usefulness and feasibility of standardized indicators:** usefulness of a limited set of indicators for dialogue with the bank (Q9) and overall feasibility of collecting/sharing periodically a minimum set (Q10).

A central methodological element is the non-invasiveness of the instrument: the questions are designed to collect evidence on practices, perceptions, and availability of documentable data (e.g., bills, meters, management logs, internal policies), without entering into strictly credit-related or proprietary information. This approach is consistent with the logic of auditability and traceability recalled in the framework.

5.3 Sample, selection criteria, and sharing method

The questionnaire was administered to a targeted sample of Sicilian SMEs operating in the **accommodation** (hospitality/lodging facilities) and **food service** (restaurants/catering services) sectors, consistently with the scope of the thesis and with the high exposure of these activities to constraints and dependencies typical of coastal contexts (water, environmental quality, extreme events, pressures on ecosystems).

In line with the "location-first" approach and with the strongly territorial nature of blue and nature-related drivers, selection prioritized companies:

- operating in **coastal areas** or with a strong link to the environmental quality of the territory;
- belonging to the **two target sectors**, to allow a minimum comparison between accommodation and food service, also in light of different KPI normalization logics;
- with **typical SME characteristics**, where data availability is often more limited and informational proportionality is particularly relevant in the relationship with intermediaries.

The questionnaire was shared directly with the selected companies and completed with reference to practices actually adopted and to perceptions developed in recent years regarding environmental constraints and shocks. For reasons of operational simplicity and clarity for respondents (reducing possible linguistic ambiguities), administration took place in Italian; subsequently, for drafting purposes and for the usability of the work in the academic context, the content was reproduced in a faithful English translation of the questionnaire. The results, presented in the second part of the chapter, allow a comparative reading of monitoring maturity, perceived materiality, and informational readiness toward banking requests.

5.4 Criteria for interpreting responses and limitations

The analysis of responses is aimed at producing a reading of operational feasibility and informational relevance of the minimum set of information, aggregating evidence according to three interpretive blocks:

- **Monitoring and informational availability:** (Q1, Q7, Q10) → what is already measured, what is retrievable, what is realistically shareable on a periodic basis;
- **Perceived economic materiality:** (Q2–Q4, Q6) → the extent to which water, environmental quality, events, and biodiversity are perceived as factors affecting demand, costs, continuity, and sustainability;

- **Banks' information demand and usefulness of standardization:** (Q8–Q9) → to what extent the financial system already requests this information and how much a standardized set would facilitate dialogue.

This reading supports the principle of progressive integration of indicators: from simple collection and standardization (as a basis for transparency and comparability) up to a more structured use as monitoring and resilience signals along the credit cycle, consistently with the "maturity pathway" outlined in the framework.

The empirical phase focuses on three Sicilian SMEs selected as case studies, consistent with the sectoral scope of the research (accommodation and food service) and with the "coastal-dependent" logic of the framework: **Hotel Nettuno** (lodging facility), **Ristorante Andrew's Faro** (restaurant/food services), and **Lido Verde** (coastal/beach tourism services). This choice makes it possible to observe how the same environmental dimensions (water, coastal quality, shocks, investments, biodiversity, and data availability) are perceived and managed across different operating models, united by dependence on the coastal context.

Finally, it is appropriate to clarify an inherent limitation of the empirical phase: since this is a small sample and based on self-assessments, the results are not intended for statistical generalization, but as a proof-of-concept regarding informational feasibility and the coherence between the theoretical-operational framework and business reality, especially in the SME segment.

5.5 Case study 1: Lido Verde

Company overview and sector framing

Lido Verde is a beach resort located in the coastal area of Playa di Catania, offering services focused on seaside tourism and including integrated restaurant services. The company therefore operates within the perimeter of coastal tourism services, with features that relate both to the "coastal tourism" segment and to "food service" due to the restaurant component. The business has deep historical roots in the local area, having been founded in 1954.

Location and georeferencing requirement

Address: Viale Presidente Kennedy, 33, 95121 Catania (CT).

Figure 5.1: Georeference Lido Verde

Commentary on the responses

Table 5.2: Lido Verde Questionnaire

Question N.	Title and Description	Answers
1	**Water consumption monitoring** Does your company systematically monitor water consumption related to its activity (e.g. by facility, period, or level of service)?	**X Yes, in a regular and structured way;** ☐ Yes, but only occasionally; ☐ No, but we believe it would be feasible; ☐ No, and we believe it is not currently feasible.
2	**Water stress and business continuity** In recent years, have you experienced **limitations, constraints or risks related to water availability** (e.g. rationing, increasing costs, service interruptions)?	☐ Never; **X Rarely;** ☐ With some frequency; ☐ Frequently and in a significant way.
3	**Environmental quality and destination attractiveness** To what extent do you believe that **coastal environmental quality** (bathing water quality, beach cleanliness, ecosystem	(1: Not at all; 5: It is a key determining factor) ☐ 1; ☐ 2; ☐ 3;

	conditions) affects customer demand for your business?	**X 4;** ☐ 5.
4	**Environmental events and economic performance** In recent years, has your business experienced **economic impacts** (e.g. revenue losses, cost increases, operational disruptions) due to environmental or climate-related events (e.g. heatwaves, storms, coastal erosion, pollution)?	☐ No, never; ☐ Yes, with marginal impacts; **X Yes, with significant impacts;** ☐ Yes, with structural impacts on the business.
5	**Environmental investments and adaptation** Has your company undertaken or planned **investments** aimed at reducing environmental impacts or adapting to environmental constraints (e.g. water, waste, energy, ecosystems)?	**X Yes, already implemented;** ☐ Yes, planned; ☐ No, but under consideration; ☐ No, not considered.
6	**Biodiversity and business sustainability** To what extent do you believe that the **condition of coastal ecosystems and biodiversity** (sea, beaches, natural habitats) affects the medium- to long-term economic sustainability of your business?	☐ Not at all; **X To a limited extent;** ☐ To a significant extent; ☐ To a decisive extent.
7	**Availability of environmental information** Are environmental data relevant to your activity (e.g. water, waste, energy, territorial impacts) **easily available** within your company?	☐ Yes, already available; **X Partially available;** ☐ Retrievable with limited effort; ☐ Difficult to retrieve.
8	**Dialogue with banks and sustainability** Have banks or other financial institutions ever requested **environmental or sustainability-related information** in the context of loans or credit relationships?	**X No, never;** ☐ Yes, informally; ☐ Yes, through questionnaires or documents; ☐ Yes, in a structured and recurring manner.
9	**Usefulness of standardized environmental indicators** Do you believe that a **limited set of standardized environmental indicators**, specifically designed for coastal tourism and food services, could facilitate dialogue with banks?	☐ Not at all; **X To a limited extent;** ☐ To a moderate extent; ☐ To a large extent.
10	**Feasibility of environmental information sharing** Overall, how feasible would it be for your company to **collect and periodically share a limited amount of environmental information** (e.g. water use, waste management, impacts on the local environment) requested by banks or other financial institutions?	☐ Not feasible; ☐ Slightly feasible; **X Moderately feasible;** ☐ Fully feasible.

Monitoring and availability of information (Q1, Q7, Q10)

The company reports regular and structured monitoring of water consumption (Q1), which signals an initial level of managerial maturity regarding a variable directly

linked to OPEX and operational vulnerability in coastal contexts. However, the overall availability of environmental data is described as **Partially available** (Q7), suggesting that not all information (e.g., waste, energy, territorial impacts) is already organized in a systematic way or is immediately extractable.

Consistently, the feasibility of collecting and periodically sharing a limited set of information is assessed as **Moderately feasible** (Q10): a level compatible with the "maturity pathway" approach, in which integration starts from documentable data and progressively standardized information, before evolving toward more advanced uses in a monitoring perspective.

Perceived economic materiality of environmental and nature-related drivers (Q2–Q4, Q6)

Regarding "water stress," Lido Verde reports having experienced issues/constraints related to water availability **Rarely** (Q2). This does not exclude a forward-looking risk, especially under scenarios of increasing water stress, but it indicates that the company's recent experience has not been characterized by recurring or particularly intense water constraints.

By contrast, the "demand–reputation" channel emerges clearly: coastal environmental quality (bathing water quality, cleanliness, ecosystem conditions) is considered to affect demand to a high extent (Q3). This result is fully consistent with the framework, which recognizes environmental quality as an economic asset for seaside tourism and as a potentially relevant driver for revenue volatility and competitive positioning.

In addition, the company states that it has experienced **Yes, with significant impacts** (Q4) due to environmental or climate-related events. From a credit-risk perspective, this evidence supports the centrality of the "business continuity/extra-cost" channel and the relevance of indicators/KRIs capable of capturing shocks that translate into margins and cash flows.

Conversely, the "biodiversity/ecosystems" dimension is assessed as affecting medium- to long-term economic sustainability only **To a limited extent** (Q6). This is useful because it highlights a potential perceptual gap: while environmental quality is

immediately recognized as a key determinant of demand, more "structural" dependencies on ecosystems (ecosystem services, habitat integrity, shoreline stability) may be less visible in day-to-day management, despite being relevant within the nature-related framework.

Investments and adaptive capacity (Q5)

Lido Verde indicates **Yes, already implemented** (Q5). Even without detailing the nature of the measures, this evidence points to an operational orientation toward mitigation/adaptation actions, which may be leveraged in bank–company dialogue as a resilience element, especially if supported by documentation and a minimum level of ex post traceability.

Relationship with the financial system and perception of standardization (Q8–Q9)

The company reports **No, never** (Q8), meaning that banks or intermediaries have never requested environmental or sustainability-related information within credit relationships. Consistently, the potential usefulness of a limited set of standardized indicators to facilitate dialogue with banks is assessed only **To a limited extent** (Q9).

This outcome is relevant in two respects:

1. it confirms that, at least in this case, information pressure "from the bank side" is not yet perceived as a concrete driver;
2. it suggests that adopting minimum standards may require a clearer articulation of benefits (e.g., transparency, reduced information asymmetries, document simplification, access to more proportionate terms), consistent with the idea of progressive and non-punitive integration of indicators.

5.6 Case study 2: Andrew's Faro

Company overview and sector framing

Andrew's Faro is a company operating in the food service sector, with positioning oriented toward a customer base connected to the use and enjoyment of the coastal context. From an operational standpoint, the company's informational materials

highlight year-round continuity of operations, with 365-day opening and significant service volumes, with over 30,000 lunches as stated by the company.

Location and georeferencing requirement

Address: Via San Giovanni Licuti 36/38, Catania (Italy).

San Giovanni li Cuti is a small seaside borough in the eastern part of the city of Catania and is characterized by the presence of one of the best-known beaches in the urban context. This location strengthens the consistency of the case study with the research's coastal-dependent approach, since the attractiveness and quality of the coastline represent potentially relevant elements for demand and for the business continuity of restaurant activities close to the sea.

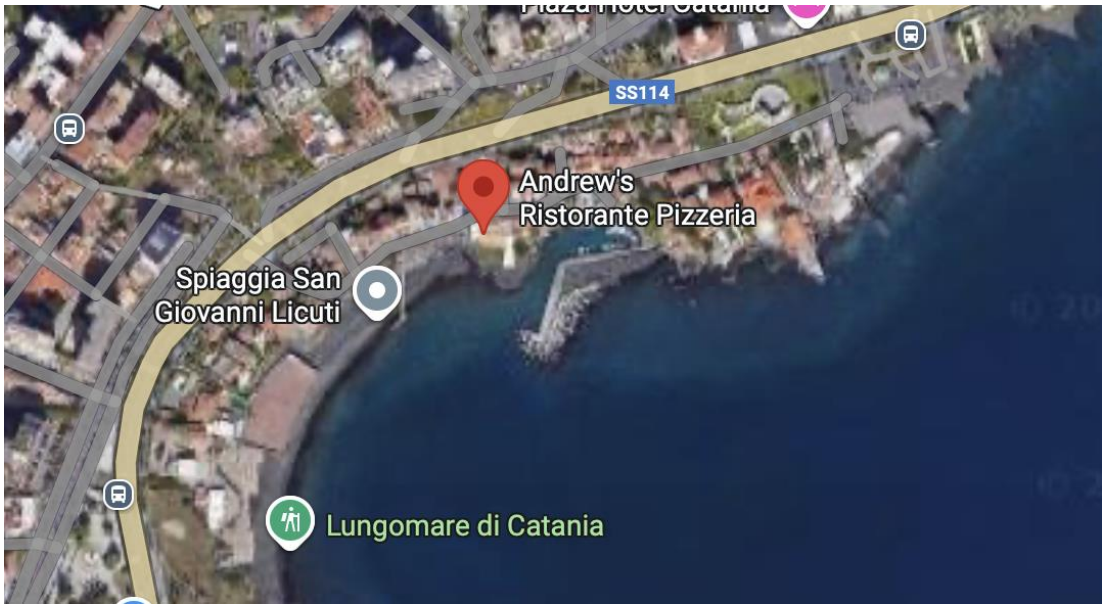

Figure 5.2: Georeference Andrew's Faro

Commentary on the responses

Table 5.3:Andrew's Faro Questionnaire

Question N.	Title and Description	Answers
1	**Water consumption monitoring** Does your company systematically monitor water consumption related to its activity (e.g. by facility, period, or level of service)?	☐ Yes, in a regular and structured way; **X Yes, but only occasionally;** ☐ No, but we believe it would be feasible; ☐ No, and we believe it is not currently feasible.

2	**Water stress and business continuity** In recent years, have you experienced **limitations, constraints or risks related to water availability** (e.g. rationing, increasing costs, service interruptions)?	**X Never;** ☐ Rarely; ☐ With some frequency; ☐ Frequently and in a significant way.
3	**Environmental quality and destination attractiveness** To what extent do you believe that **coastal environmental quality** (bathing water quality, beach cleanliness, ecosystem conditions) affects customer demand for your business?	(1: Not at all; 5: It is a key determining factor) ☐ 1; ☐ 2; ☐ 3; ☐ 4; **X 5.**
4	**Environmental events and economic performance** In recent years, has your business experienced **economic impacts** (e.g. revenue losses, cost increases, operational disruptions) due to environmental or climate-related events (e.g. heatwaves, storms, coastal erosion, pollution)?	☐ No, never; **X Yes, with marginal impacts;** ☐ Yes, with significant impacts; ☐ Yes, with structural impacts on the business.
5	**Environmental investments and adaptation** Has your company undertaken or planned **investments** aimed at reducing environmental impacts or adapting to environmental constraints (e.g. water, waste, energy, ecosystems)?	☐ Yes, already implemented; ☐ Yes, planned; **X No, but under consideration;** ☐ No, not considered.
6	**Biodiversity and business sustainability** To what extent do you believe that the **condition of coastal ecosystems and biodiversity** (sea, beaches, natural habitats) affects the medium- to long-term economic sustainability of your business?	☐ Not at all; **X To a limited extent;** ☐ To a significant extent; ☐ To a decisive extent.
7	**Availability of environmental information** Are environmental data relevant to your activity (e.g. water, waste, energy, territorial impacts) **easily available** within your company?	☐ Yes, already available; **X Partially available;** ☐ Retrievable with limited effort; ☐ Difficult to retrieve.
8	**Dialogue with banks and sustainability** Have banks or other financial institutions ever requested **environmental or sustainability-related information** in the context of loans or credit relationships?	**X No, never;** ☐ Yes, informally; ☐ Yes, through questionnaires or documents; ☐ Yes, in a structured and recurring manner.
9	**Usefulness of standardized environmental indicators** Do you believe that a **limited set of standardized environmental indicators**, specifically designed for coastal tourism and food services, could facilitate dialogue with banks?	☐ Not at all; **X To a limited extent;** ☐ To a moderate extent; ☐ To a large extent.
10	**Feasibility of environmental information sharing** Overall, how feasible would it be for your company to **collect and periodically share a limited amount of environmental**	☐ Not feasible; **X Slightly feasible;** ☐ Moderately feasible; ☐ Fully feasible.

	information (e.g. water use, waste management, impacts on the local environment) requested by banks or other financial institutions?	

Monitoring and availability of information (Q1, Q7, Q10)

The company reports that water consumption monitoring occurs **Yes, but only occasionally** (Q1), indicating the presence of spot data rather than a structured process. This is consistent with what is often observable in the SME segment of food service, where environmental traceability is frequently secondary to operational priorities and is not always organized into continuous systems. In parallel, the company indicates that relevant environmental data are **Partially available** (Q7) and that the periodic sharing of a minimum set of information would be **Moderately feasible** (Q10).

Overall, an intermediate level of informational readiness emerges, compatible with a progressive integration pathway based on documentable evidence and simple normalizations.

Perceived economic materiality of environmental and nature-related drivers (Q2–Q4, Q6)

On "water stress," Andrew's Faro reports no limitations or risks related to water availability in recent years (Q2). At the same time, coastal environmental quality is considered a decisive driver of demand: the company assigns the maximum influence level (Q3). This result reinforces, for food service in a coastal area, the economic channel "attractiveness/reputation → demand → revenues," which in the framework constitutes one of the main transmission pathways of blue drivers into credit risk, through revenue volatility and cash flow resilience.

As for environmental and climate shocks, the company reports **Yes, with marginal impacts** (Q4). This evidence is useful because it indicates that, despite a high dependence of demand on the quality of the context, the economic effects of recent events have not been perceived as significantly disruptive, at least over the observed period.

Finally, as already found in the first case study, the "ecosystems and biodiversity" dimension is assessed as relevant only **To a limited extent** (Q6). This suggests a potential misalignment between structural ecosystem dependencies, which are less "visible" in day-to-day management, and drivers immediately perceived by the market, namely environmental quality as a determinant of demand.

Investments and adaptive capacity (Q5)

The company indicates **No, but under consideration** (Q5), with no evidence of implementation already completed or formally planned. From a banking perspective, this positioning is consistent with an adaptation profile that is not yet consolidated: translation into resilience signals would require, at a later stage, documentary evidence and a minimum level of ex post monitoring of effects (reduced consumption/costs, mitigation of vulnerabilities).

Relationship with the financial system and usefulness of standardization (Q8–Q9)

Andrew's Faro reports **No, never** (Q8), meaning that banks or intermediaries have never requested environmental or sustainability-related information in financing contexts. Consistently, the potential usefulness of a limited set of standardized indicators is assessed as **To a limited extent** (Q9).

A relevant methodological point emerges for the research: if information demand, from the bank side, is not yet perceived as concrete, the adoption of minimum indicators risks being interpreted as an additional compliance burden. It therefore becomes central to adopt a proportionate and progressive approach, linking such information to operational benefits in the dialogue (clarity, reduced information asymmetries, documental standardization, traceability).

5.7 Case study 3: Hotel Nettuno

Company overview and sector framing

Hotel Nettuno is a 4-star accommodation facility located along the Ionian coast of Catania. The declared capacity is 101 units, including rooms and suites. The offer

includes typical seaside hospitality services, including a swimming pool and direct access to the sea via a Beach Club, as well as ancillary services, with restaurant areas and bars. The facility also integrates a conference center with 6 meeting rooms of variable capacity, approximately 10–300 seats, for a total overall capacity indicated at around 600 participants. This configuration makes it possible to frame the case both within the "accommodation" segment with direct exposure to the coastal context and within the MICE perimeter (Meetings, Incentives, Conferences, Exhibitions), where business continuity and destination attractiveness affect demand and seasonality.

Location and georeferencing requirement

Address: Viale Ruggero di Lauria, 121, 95127 Catania CT (Italy).

The facility is located on Catania's seafront, close to the urban center, approximately 500 meters, and with accessibility to Catania–Fontanarossa International Airport, elements that are relevant for the usability and attractiveness of the destination.

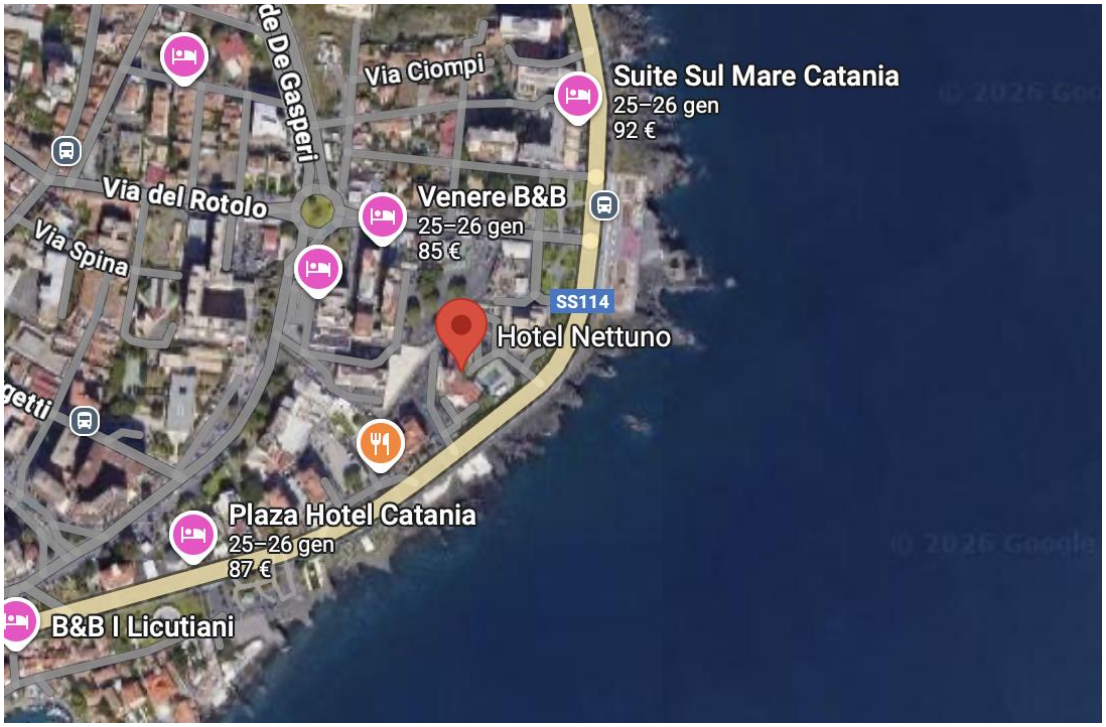

Figure 5.3: Georeference Hotel Nettuno

Commentary on the responses

Table 5.4: Hotel Nettuno Questionnaire

Question N.	Title and Description	Answers
1	**Water consumption monitoring** Does your company systematically monitor water consumption related to its activity (e.g. by facility, period, or level of service)?	**X Yes, in a regular and structured way;** ☐ Yes, but only occasionally; ☐ No, but we believe it would be feasible; ☐ No, and we believe it is not currently feasible.
2	**Water stress and business continuity** In recent years, have you experienced **limitations, constraints or risks related to water availability** (e.g. rationing, increasing costs, service interruptions)?	☐ Never; ☐ Rarely; ☐ With some frequency; **X Frequently and in a significant way.**
3	**Environmental quality and destination attractiveness** To what extent do you believe that **coastal environmental quality** (bathing water quality, beach cleanliness, ecosystem conditions) affects customer demand for your business?	(1: Not at all; 5: It is a key determining factor) ☐ 1; ☐ 2; ☐ 3; ☐ 4; **X 5.**
4	**Environmental events and economic performance** In recent years, has your business experienced **economic impacts** (e.g. revenue losses, cost increases, operational disruptions) due to environmental or climate-related events (e.g. heatwaves, storms, coastal erosion, pollution)?	☐ No, never; ☐ Yes, with marginal impacts; **X Yes, with significant impacts;** ☐ Yes, with structural impacts on the business.
5	**Environmental investments and adaptation** Has your company undertaken or planned **investments** aimed at reducing environmental impacts or adapting to environmental constraints (e.g. water, waste, energy, ecosystems)?	**X Yes, already implemented;** ☐ Yes, planned; ☐ No, but under consideration; ☐ No, not considered.
6	**Biodiversity and business sustainability** To what extent do you believe that the **condition of coastal ecosystems and biodiversity** (sea, beaches, natural habitats) affects the medium- to long-term economic sustainability of your business?	☐ Not at all; ☐ To a limited extent; **X To a significant extent;** ☐ To a decisive extent.
7	**Availability of environmental information** Are environmental data relevant to your activity (e.g. water, waste, energy, territorial impacts) **easily available** within your company?	**X Yes, already available;** ☐ Partially available; ☐ Retrievable with limited effort; ☐ Difficult to retrieve.
8	**Dialogue with banks and sustainability** Have banks or other financial institutions ever requested **environmental or sustainability-related information** in the context of loans or credit relationships?	☐ No, never; ☐ Yes, informally; **X Yes, through questionnaires or documents;** ☐ Yes, in a structured and recurring manner.
9	**Usefulness of standardized environmental indicators**	☐ Not at all; **X To a limited extent;**

	Do you believe that a **limited set of standardized environmental indicators**, specifically designed for coastal tourism and food services, could facilitate dialogue with banks?	☐ To a moderate extent; ☐ To a large extent.
10	**Feasibility of environmental information sharing** Overall, how feasible would it be for your company to **collect and periodically share a limited amount of environmental information** (e.g. water use, waste management, impacts on the local environment) requested by banks or other financial institutions?	☐ Not feasible; ☐ Slightly feasible; **X Moderately feasible;** ☐ Fully feasible.

Monitoring and availability of information (Q1, Q7, Q10)

Hotel Nettuno reports monitoring water consumption **Yes, in a regular and structured way** (Q1), and indicates that relevant environmental data are **Yes, already available** (Q7). Overall, the feasibility of collecting and periodically sharing a limited set of information is assessed as **Moderately feasible** (Q10).

This combination suggests a more advanced level of informational readiness compared to firms with only occasional tracking processes, while also indicating that the operational requirements of periodic "bank-ready" sharing still call for organizational consolidation (standardization, internal responsibilities, periodicity).

Perceived economic materiality of environmental and nature-related drivers (Q2–Q4, Q6)

Unlike the other cases, the company reports having experienced water availability constraints/issues **Frequently and in a significant way** (Q2).

In parallel, coastal environmental quality is considered a key driver of demand (Q3). Regarding environmental and climate shocks, Hotel Nettuno indicates **Yes, with significant impacts** (Q4). Finally, the condition of ecosystems and biodiversity is considered to affect medium- to long-term economic sustainability **To a significant extent** (Q6).

Within the research's interpretive framework, this profile indicates high materiality across multiple channels:

- OPEX and business continuity (water constraints);
- Demand/attractiveness (environmental quality as a driver);
- Resilience to climate/environmental events that may generate additional costs and service disruptions.

Investments and adaptive capacity (Q5)

The company reports **Yes, already implemented** (Q5). From a maturity pathway perspective, this strengthens the coherence between perceived materiality and actions undertaken: the presence of investments can be a useful element in bank–company dialogue if supported by documentary evidence and a minimum level of traceability of effects (e.g., reduced consumption, mitigated vulnerabilities, management procedures).

Relationship with the financial system and usefulness of standardization (Q8–Q9)

Hotel Nettuno reports that banks or intermediaries have requested environmental/sustainability information **Yes, through questionnaires or documents** (Q8). However, the usefulness of a limited set of standardized indicators, specifically designed for coastal tourism and food services, is assessed only **To a limited extent** (Q9).

This result is particularly informative: it suggests that, even in the presence of formal requests, companies may perceive standardization as of limited usefulness if requests are episodic, not fully comparable across counterparties, or not accompanied by tangible benefits. In other words, the mere existence of requests does not automatically guarantee a perceived value of standardization; this reinforces the research approach based on proportionality and progressive integration, aimed at making indicators useful first and foremost at the operational and informational level, and only subsequently as structured signals within the credit cycle.

5.8 Emerging evidence and implications for progressive integration

On the first axis (**monitoring and availability of information**), the results show a heterogeneous picture that is nevertheless overall consistent with expectations for the SME segment. In all cases, however, the availability of environmental data does not appear to be "fully ready" for a systematic information flow toward third parties: even where data are **Yes, already available** or **Partially available**, the feasibility of periodic sharing is assessed as **Moderately feasible**. This evidence supports the research's approach according to which, in the transition toward more structured reporting practices and in the relationship with banks, a gradual and proportionate approach is essential, based on documentable, standardizable, and low-burden information.

On the second axis (**perceived economic materiality**), the most robust and cross-cutting signal concerns the importance of coastal environmental quality as a demand driver: all companies assign a high or determining role to this dimension. In other words, the channel "destination attractiveness/reputation → demand → revenues" is clearly recognized by operators and constitutes the most immediate entry point for translating environmental drivers into economically relevant variables. Alongside this, water constraints and environmental shocks show heterogenous exposure profiles, consistent with transmission through the "business continuity/extra-cost" channel. With respect to biodiversity/ecosystems, perception is weaker or in any case less immediate. This element is relevant because it suggests a potential "gap" between structural ecosystem dependencies, less observable in the short term, and drivers perceived as directly affecting the business; such a gap reinforces the usefulness of a "translation layer" that makes the connection between nature, tourism services, and economic sustainability more understandable and measurable.

On the third axis (**dialogue with banks and usefulness of standardization**), the cases show that requests for environmental information by intermediaries are not yet systematic. In parallel, the assessment of the usefulness of standardized indicators is overall limited, even where requests exist. The evidence suggests that standardization is perceived as truly enabling only if accompanied by a clear framework of operational benefits: reduced documentary burden, greater comparability, transparency of

informational expectations, and improved quality of bank–company dialogue. In the absence of these conditions, even formal requests risk being interpreted as episodic compliance obligations rather than as an orderly and proportionate process.

Overall, the results reinforce the thesis that an effective approach should not immediately aim at sophisticated measurement, but at a **progressive integration** of indicators: starting from a minimum core of highly traceable and low-sensitivity information, consolidating collection and standardization, and only subsequently using them as monitoring and resilience signals along the credit cycle. In this logic, the empirical phase shows that informational feasibility exists, but requires gradualism; economic materiality is strongly perceived above all through the demand channel; and the relationship with the banking system can be improved more effectively through simple, transparent, and sector-calibrated tools. These findings therefore provide empirical support for the proposed framework.

CONCLUSIONS

This research addressed a circumscribed yet operationally relevant problem: how to make the environmental, "blue", and nature-related drivers that characterize coastal economic activities "bankable", with reference to Sicilian SMEs in the accommodation and food service sectors. The starting point is deliberately prudent: such drivers are not default events, but they can affect the economic-financial variables that precede default, thereby changing repayment capacity over time and, consequently, the credit risk profile.

Within the European context, which is converging toward increasing integration of ESG and nature-related factors into disclosure and risk management, the main contribution of this work lies in having built a methodological bridge between environmental/ecosystem phenomena that are often complex and strongly location-specific, and the typical decision nodes of the credit life cycle. Within this perimeter, the reference to PD remains prospective: the research does not aim to estimate regulatory parameters, but clarifies how, only with adequate maturity, signals can support PD-related logics without conflating them with the concept of default. The answer to the research question is that this "translation" is possible provided that certain validity conditions are respected and a progressive integration is adopted. Concretely, drivers become "bank-ready" information only if: they are uniquely defined, anchored to geography, grounded in a verifiable information architecture, and transformed from descriptive KPIs into interpretable KRIs.

The core of the work is an operational framework built starting from the BESF of the European Investment Bank and reinforced, for the "nature" component, by the LEAP logic of the Taskforce on Nature-related Financial Disclosures. The framework is articulated into three blocks:

- territorial for geographic screening and risk appetite;
- the firm's operational profile with normalized metrics for comparability;
- managerial/adaptive capacity to assess resilience and business continuity.

The translation layer makes explicit the pathway "indicator → economic-financial channel → control point in the credit life cycle", making the architecture usable in the

SME context thanks to two pragmatic choices: georeferencing as a minimum requirement and the adoption of low-burden metrics that are traceable and documentable. The research therefore defines a KPI→KRI procedure and an integration matrix that make indicators actionable within banking processes. The guiding idea is that an indicator has credit relevance only if it is comparable, readable in risk terms (trends/thresholds), and associated with operational responses, with an audit trail and without forcing deterministic linkages to default.

The empirical phase was designed consistently with this approach: a firm-level questionnaire to test informational feasibility and perceived materiality, in line with the proportionality principle in the bank–firm dialogue. Evidence from the three case studies indicates: heterogeneous maturity and data availability, with periodic sharing perceived as only moderately feasible even when data exist; a robust signal on coastal environmental quality as a demand driver; a gap between ecosystem dependencies and short-term perception, reinforcing the usefulness of the translation layer in making the nature–economy link more "visible". In addition, the informational dialogue with intermediaries does not yet appear systematic: standardization is enabling only if it produces tangible benefits; otherwise, it risks being perceived as mere compliance.

The limitations are inherent, but they clearly orient future developments: expanding the empirical base and segmenting by territorial exposure; strengthening benchmarks/thresholds with comparative and geospatial data; testing more rigorously the ability of KRIs to anticipate deterioration, and only subsequently exploring more structured linkages with PD-related logics, supported by adequate data foundations.

In sum, the work concludes that translating "blue" and nature-related drivers into information useful for credit risk is feasible, but it requires gradual and proportionate integration. In a coastal context such as Sicily, where competitiveness and resilience depend closely on environmental quality, making these linkages measurable is not only about transparency: it is a condition for managing risk in a more orderly way and for steering capital and decisions toward economically robust sustainability trajectories.

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