Proc. of the European Safety and Reliability Conference (ESREL 2026)
Edited by José C. Matos, Paulo B. Lourenço, Michael Beer, Daniel Oliveira,
Edoardo Patelli, Hélder S. Sousa, Rui A. Silva and Monica Santamaria

doi: 10.3850/ESREL2026061419_esrel26-p26490-cd

A conceptual framework for developing a climate and natural risk index based on Environmental, Social and Governance (ESG) reporting data

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The increasing emphasis on sustainability reporting under the European Sustainability Reporting Standards (ESRS) calls for structured tools to quantify and monitor environmental risks. This paper proposes a conceptual framework for an integrated Climate and Natural Risk Index (CNRI), designed to support large Norwegian oil and gas companies in assessing and reporting physical climate and natural risks in line with ESRS environmental objectives (E1–E5). The proposed framework combines quantitative indicators derived from Environmental, Social and Governance (ESG) data with weighting mechanisms reflecting the relative importance of each ESRS objective. The index integrates both physical and transition risk factors, enabling firms to monitor their environmental performance through a standardized scoring system ranging from "very low risk" to "very high risk." This approach allows for benchmarking within the sector and tracking progress over time. The index provides a practical decision-support tool for sustainability reporting, risk management, and strategic planning. It contributes to the harmonization of ESG disclosure practices and strengthens the interface between corporate accountability, regulatory compliance, and risk science. Grounded in this alignment, the CNRI provides a science-based foundation for understanding and managing risks, while also serving as a risk communication tool that translates complex ESG data into interpretable metrics to support transparent dialogue between corporate actors and stakeholders. The paper outlines the conceptual design, variable selection process, and potential applications, offering a foundation for empirical validation and further integration into corporate sustainability reporting systems.

Keywords:Climate risk assessment, Environmental risk index, ESG data, European Sustainability Reporting Standards, Risk-based decision support, Risk Communication.

1. Introduction

The increasing integration of sustainability considerations into corporate governance and regulatory frameworks has significantly reshaped how companies assess, manage, and disclose climate-related risks. Within the European Union, the introduction of the Corporate Sustainability Reporting Directive (CSRD) and the associated European Sustainability Reporting Standards (ESRS) marks a shift toward more comprehensive, comparable, and decision-relevant sustainability disclosures (European Commission, 2022; EFRAG, 2023). In particular, the ESRS environmental objectives (E1–E5) require companies to identify, assess and report climate- and nature-related risks, including their exposure to physical and transition risks and the measures taken to manage them.

For large Norwegian oil and gas companies, meeting these requirements poses both practical and conceptual challenges. Energy and extractive operations are highly exposed to physical climate and environmental hazards, characterized by long-lived assets and complex ecosystem interactions, while facing increasing regulatory and stakeholder pressures (IPCC, 2023; NGFS, 2020). Although substantial ESG data are disclosed, firms often lack structured methods to translate this information into coherent, risk-oriented assessments aligned with ESRS objectives. Consequently, sustainability reporting may remain fragmented and weakly connected to internal risk management and strategic decision-making

(TCFD,2017; Unerman et al., 2014; Karatzoudi &Mrkai• Kova•evi•, 2025).

These challenges highlight the need for analytical tools that integrate ESG data, regulatory reporting requirements, and risk-based interpretation across multiple environmental objectives. (Berg et al., 2022; Gibson Brandon et al., 2021). Moreover, current approaches tend to underemphasize risk communication, despite its importance for stakeholder engagement and decision-making in complex environments (Renn, 2008; Fischhoff, 2012).

This paper addresses this gap by proposing a conceptual Climate and Natural Risk Index (CNRI) aligned with ESRS objectives E1–E5. Drawing on established approaches in risk assessment and governance that emphasize structured identification and aggregation of multiple risk factors under uncertainty (Aven & Renn, 2010), the CNRI integrates quantitative ESG indicators into a unified, risk-oriented framework consistent with sustainability reporting requirements.

The CNRI combines physical and transition risk factors through a transparent weighting and aggregation mechanism, producing a standardized risk score that supports benchmarking, monitoring over time, and strategic prioritization. Beyond its analytical function, the index facilitates risk-related communication by translating complex ESG information into interpretable metrics that can inform structured stakeholder discussions. This is consistent with risk perception and communication research, which shows that simplified representations can enhance comparison and shared understanding under conditions of uncertainty (Slovic, 1987), while complementing rather than replacing substantive risk analysis (Renn &Benighaus, 2013). Positioned at the intersection of sustainability reporting and risk assessment, the CNRI offers a structured conceptual framework for more transparent and ESRS-aligned climate and natural risk evaluation. Although developed with a focus on large Norwegian oil and gas companies for corporate-level application across their value chain,the framework also provides a basis for further empirical testing and application in other sectors.

The rest of the paper is organized as follows. Section 2 reviews the theoretical background and relevant literature on ESRS environmental objectives, climate and natural risk concepts, existing ESG indices, and key insights from the risk communication literature. Section 3 presents the conceptual development of the CNRI. Section 4 examines the CNRI as a risk communication tool and discusses its role in supporting ESRS-aligned risk assessment, stakeholder communication, and sector benchmarking. Section 5 discusses the implications of the proposed framework, and Section 6 concludes with directions for future research.

2. Theoretical Background

2.1.*ESRS Environmental Objectives, Climate and Natural Risks*

The European Sustainability Reporting Standards (ESRS) provide a framework for identifying, assessing, and disclosing environmental risks and impacts. The environmental objectives E1–E5 cover climate change mitigation and adaptation (E1), pollution (E2), water and marine resources (E3), biodiversity and ecosystems (E4), and resource use and the circular economy (E5) (EFRAG, 2023). Companies must disclose material environmental risks and opportunities, including exposures, potential impacts, business model resilience, and risk management processes. ESRS emphasize a risk-based perspective, linking disclosures to risk identification, assessment, and management rather than isolated indicators.

Under ESRS E1, companies must address both physical and transition climate risks. Physical risks arise from acute events and chronic climatic changes affecting assets and operations (IPCC, 2023; TCFD, 2017), while transition risks result from policy, technological, legal, and market changes related to decarbonization (TCFD, 2017).

ESRS E3 and E4 extend risk identification to water, ecosystems, and biodiversity, commonly framed as nature-related risks reflecting firms' dependencies and impacts on natural systems (Dasgupta, 2021; TNFD, 2023). Climate and natural risks are increasingly recognized as interconnected. However, while ESRS define disclosure requirements, they do not prescribe specific analytical tools for structuring or quantifying environmental risks, leaving companies to operationalize them through existing ESG metrics and indices.

2.2.*ESG Indices, Climate Metrics and Their Limitation*

A growing number of climate, environmental, and ESG indices have been developed to support sustainability assessment, benchmarking, and investment decisions. These include composite ESG ratings, climate risk scores, and thematic indices focusing on specific dimensions such as carbon exposure, water risk, or biodiversity impacts (MSCI, 2022; Sustainalytics, 2023). Regulatory initiatives such as the TCFD and TNFD have further encouraged the use of metrics and indicators to improve transparency around climate- and nature-related risks.

Despite their widespread use, the literature identifies important conceptual and methodological limitations. Composite ESG scores often rely on opaque aggregation and weighting schemes, reducing transparency and interpretability (Berg et al., 2022). Many indices lack sector specificity, limiting their ability to capture risk drivers relevant to asset-intensive sectors such as oil and gas (Krueger et al., 2020). Moreover, most indices are not explicitly aligned with ESRS objectives, creating misalignment between external ESG metrics and regulatory reporting requirements. Integration across physical, natural, and transition risk dimensions also remains limited, as many tools focus on individual categories rather than interdependencies (NGFS, 2020; TNFD, 2023).

These limitations highlight the need for approaches that move beyond isolated or opaque metrics and instead support integrated assessment of environmental risks in a transparent and decision-relevant manner. From a risk governance perspective, such representations should enhance transparency and traceability, enabling users to understand how different risk components contribute to overall assessments (Aven & Renn, 2010). At the same time, developing a more comprehensive framework raises the challenge of communicating complex risk information in ways that remain interpretable and decision relevant.

2.3.*Risk Communication in Complex and Uncertain contexts*

It is important to communicate risks in a straightforward and structured manner that enables audiences to understand key messages without oversimplification (Kasperson, 2014). This need corresponds with the discussions on transparency that have been present for a while in risk communication literature (Löfstedt& Bouder, 2013; Osman et al., 2018; Balog-Way, 2025). While most views of transparency are positive, sceptical ones raise concerns, particularly when dealing with complex data and situations characterized by high levels of uncertainty. Levy& Johns (2016) explain that even though data transparency has beneficial points, it can also backfire and result in unintended negative outcomes. In this case, revealing more information may seem transparent and clear, but it could also cause confusion if audiences struggle to interpret complex data.

Therefore, scholars increasingly emphasize the importance of making uncertainty interpretable rather than simply enclosing raw data to the wide audiences. Löfstedtand Bouder (2021) and Osman (2024) stress the importance of tools when making uncertainty interpretable, especially in energy transition contexts. This perspective aligns with research advocating for improved communication of uncertainties rather than attempts to diminish or eliminate them, which can result in serious consequences for decision-making (van der Bles et al. 2019). However, uncertainty communication should be structured in a way that helps decision-makers understand the implications of the decisions they are about to make. Ideally, the reader's comprehension and the writer's intent should be aligned (Kloprogge et al. 2007).

Extensive risk communication research demonstrates how ambiguous information can be simplified and made understandable without losing the key message. Already, early work by Slovic (1987) shows that individuals rely on cognitive heuristics when interpreting risk information, highlighting the importance of structured and comparative presentation. Wardman (2008) builds on this point by saying that risk communication is not just about sharing information but also making sense of it in different contexts.

Risk research generally supports risk communication tools and indicators that may enhance dialogue among experts, decision-makers, policymakers, and other stakeholders, provided their limitations are clearly communicated (Mrkai•Kova•evi• & Bouder, 2022). Such tools carry the potential of integrating more risk science into governance processes and strengthening the role of risk-informed decision-making. Effective risk communication is therefore central to preparing for complex challenges, including climate change emergencies (Torem et al. 2024). In the context of sustainability, such an approach supports the translation of heterogeneous ESG data into interpretable risk presentations while maintaining the high quality of risk communication.

2.4. *Risk Science for Interpretable ESG-Based Risk Metrics*

Risk science, including risk perception and communication literature, supports the idea of transforming complex ESG inputs into interpretable risk metrics. As discussed in the previous section, risk research highlights the need to simplify the communication messages, be transparent, and align reader comprehension with communication intent. However, translating heterogeneous ESG data into interpretable risk metrics is a challenge that calls for further conceptual clarification.

The Glossary of the Society for Risk Analysis (Aven et al. 2018) provides excellent support for understanding what risks consist of. We can view them as a composite of events, associated uncertainties, and potential consequences. Existing ESG scores, as noted earlier, often focus on single risk dimensions and lack integrated frameworks, limiting their usefulness for science-based and risk-informed decision-making.

Contemporary risk science emphasizes the importance of properly addressing risks to inform decision-making. Instead of using probabilities to describe uncertainty, it proposes the uncertainty-based approach (Aven, 2015a) to provide a more precise description of risk. Using the uncertainty-based perspective to better describe risks leads to more informed, science-based decision-making. This speaks in favour of organizing the collection of ESG information into a risk-focused framework that would connect environmental data to identifying, assessing, and managing risks, as required by ESRS governmental goals E1-E5. Building on this theoretical perspective, the following section translates these risk science insights into a structured conceptual framework, detailing the methodological design of the Climate and Natural Risk Index (CNRI).

3. Conceptual development and structure of the CNRI

3.1. *Overview of the Climate and Natural Risk Index (CNRI)*

This paper proposes a Climate and Natural Risk Index (CNRI) as a conceptual, risk-based tool to support ESRS-aligned environmental risk assessment and reporting for large Norwegian oil and gas companies. The CNRI is constructed as a composite index that aggregates information from ESRS environmental objectives (E1–E5) into a single interpretable risk score ranging from very high to very low risk (Figure 1). ESG data are translated into a standardized scale from 0 to 100, where lower values indicate higher climate and natural risk exposure. This structured scale is consistent with established approaches in risk governance and assessment that represent heterogeneous risk information in interpretable formats (Aven, 2015; Renn, 2008). The scale therefore functions as a normalization and aggregation device rather than a direct measure of absolute risk. The index is grounded in ESRS reporting objectives and reflects a risk-oriented interpretation of ESG variables.

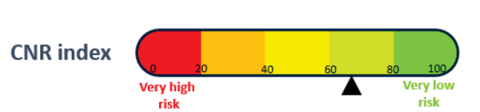

Fig. 1: Standardized scale of the Climate and Natural Risk Index (CNRI), ranging from very high to very low climate and natural risk.

3.2. *Structure of the index and aggregation logic*

The conceptual structure of the CNRI follows a hierarchical aggregation approach, as shown in Figure 2. At the highest level, the index aggregates five sub-indices corresponding to the ESRS environmental objectives: E1: Climate change, E2: Pollution, E3: Water and marine resources, E4: Biodiversity and ecosystems, E5: Resource use and circular economy. Each ESRS objective is represented by a dedicated sub-index (E1 index, E2 index, …, E5 index), constructed from a set of variables derived from the respective ESRS disclosure requirements.

Sub-indices and variables are selected based on alignment with ESRS disclosure requirements, relevance to environmental risks, sector materiality for oil and gas operations, and measurability using ESG data. Anchoring the index in ESRS objectives reduces arbitrariness and ensures transparency between disclosed indicators and the composite risk metric. The linkage between variables and ESRS objectives further reduces discretionary bias in index construction. The overall CNRI can be expressed conceptually as:

$$CNRI = \frac{\sum_{i=1}^{5} w_i \cdot E_i}{\sum_{i=1}^{5} w_i}$$

where *Ei* denotes the sub-index corresponding to ESRS objective*i*, and *wi*represents the relative weight assigned to that objective. The weights reflect the perceived importance or materiality of each ESRS objective and may be informed by stakeholder input, regulatory priorities, or sector-specific considerations, as indicated in Figure 2.

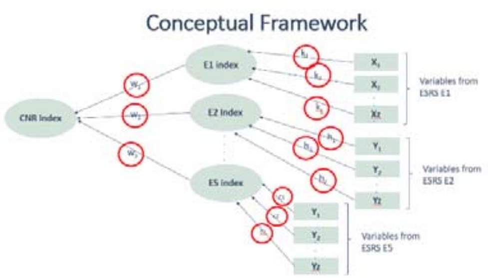

Fig. 2: Conceptual structure of the CNRI. Each ESRS environmental objective (E1–E5) is represented by a dedicated sub-index, which aggregates ESRS-aligned variables and is weighted into the composite CNRI, with weights informed by stakeholder input and materiality considerations.

3.3. *Construction of ESRS sub-indices (E1-E5)*

Each ESRS sub-index is constructed using the same methodological logic already illustrated in Figure 2. Specifically, each sub-index aggregates a set of ESRS-aligned variables representing exposures, impacts, or risk-relevant conditions, for example, the E1 index aggregates variables related to physical climate hazards, transition risks, and climate-related exposures, the E2 index aggregates variables capturing pollution-related risks, such as emissions to air, water, and soil, the E3 index reflects risks associated with water availability, water stress, and marine impacts, the E4 index captures biodiversity- and ecosystem-related pressures and dependencies and the E5 index aggregates indicators related to resource use efficiency, waste generation, and circularity.

Within each sub-index, individual variables (e.g. X1,X2,…,Xz) for E1 (see Table 1), and analogous sets for E2–E5 are weighted using coefficients (e.g. k1,k2,…, h1,h2..) that reflect their relative contribution to the overall risk dimension of the ESRS objective. This mirrors exactly the logic already depicted for E1-E5 in Figure 2 and ensures methodological consistency across all five environmental objectives. The variables chosen for E1 are relevant for high climate impact sectors, such as oil and gas companies and their weights are informed by stakeholder input and materiality considerations.

Table 1: Potential variables for ESRS E1 objectives, (EFRAG, 2022), that will be weighted to reflect their contribution to overall risk dimension of ESRS E1 objectives

Potential E1 variables

Variable (X1, X2,...Xz)	Base Year/baseline 2022	Target Year 2050	Current progress 2026	Score	Normalized values (0-100)
Share of renewable energy in company's overall energy mix	20%	100%	30%	12,5% of target	12,5
Energy intensity based on net revenue (from activities in high climate impact sectors)	Xb monetary unit	Xt monetary unit	Xc monetary unit	x% of target	x
Reduction in GHG emissions	0%	Net Zero	10%	10% of target	10
The monetary amount of assets at material physical risk	Xb monetary unit	Xt monetary unit	Xc monetary unit	X% of target	x
the proportion of assets at material physical risk addressed by the climate change adaptation actions	Xb%	Xt%	Xc%	X% of target	x
The monetary amount of assets at material transition risk	Xb monetary unit	Xt monetary unit	Xc monetary unit	X% of target	x
The proportion of assets at material transition risk addressed by climate change mitigation actions	Xb%	Xt%	Xc%	X% of target	x

3.4. *Weighting, normalization and interpretation*

All variables are assumed to be normalized prior to aggregation to ensure comparability across different units and scales. The weighting structure operates at two levels:

(i) within each ESRS sub-index, and

The resulting CNRI score provides a synthetic and transparent representation of climate and natural risks, enabling benchmarking across companies, tracking changes over time, and supporting internal risk prioritization. Importantly, the framework remains conceptual and flexible: specific variable choices, weighting schemes, and normalization procedures can be adapted to data availability, regulatory guidance, or stakeholder priorities without altering the underlying structure of the index. Beyond its analytical function, the CNRI is designed to support risk communication by translating heterogeneous ESG disclosures into an interpretable risk scale, supporting transparency while acknowledging uncertainty and complexity. In the next section, we discuss the CNRI function as a risk communication tool.

4. The CNRI as a Risk Communication Tool

4.1. *Transparent risk communication of sustainability risks*

The CNRI supports effective communication of risks by translating complex ESG disclosures into a structured risk representation. As we have highlighted in the previous chapters, transparency itself does not guarantee interpretability, especially with heterogeneous types of data and in high-uncertainty contexts. Therefore, the CNRI organizes ESG information into a risk-based framework that provides an understanding of how different risk dimensions contribute to overall climate and natural risk exposure. This way it provides clarity without risking oversimplification.

One of the most important aspects of CNRI is to provide a consistent and traceable risk representation. Instead of offering isolated indicators of sustainability information or not strongly supported scores, the index structures the ESG inputs aligned to ESRS environmental objectives while taking on board the risk science principles. This way it is easy for users to trace how individual variables contribute to the aggregated risk score. Moreover, the CNRI respects transparency, supporting the user's comprehension, while not diminishing

Instead of using probability estimates, the CNRI reflects the uncertainty-based perspective of contemporary risk science, acknowledging the limits of available knowledge and the dynamics of environmental risks. This way it functions as a solid communication support tool. By using this approach, it responds to calls in risk communication literature to not merely disclose large volumes of complex data for the sake of transparency but to make uncertainty interpretable. This strengthens the relationship between sustainability reporting and risk science. It provides solid information to many involved stakeholders in the broader risk governance process, offering a strong basis for science-based decision-making.

4.2. *ESG Metrics adjusted for various audiences*

One of the challenges highlighted in previous chapters is communication to different types of audiences. This means that climate-related risk information is supposed to be understood by various audiences having different levels of expertise, responsibilities, and backgrounds. We know from the literature that there is a difference in risk perceptions of different stakeholder groups, even more so between experts and the lay public (Fischoff et al. 1978). The CNRI addresses this by making the end message simple enough to be understood across different institutional and professional contexts while keeping the needed nuances and not diminishing the quality of the message.

For non-expert audiences, the CNRI provides a simple but, at the same time, robust representation of sustainability risks. The CNRI presents aggregated risk information on a standardized scale while preserving transparency about individual components. This lets non-expert audiences change the level of detail they wish to look at based on their backgrounds or preferences.

For organizations and decision-makers, the CNRI aligns closely with ESRS environmental objectives and risk science principles discussed in the previous chapters. The index enables organizations to identify risk drivers, track changes over time, and detect the strength of knowledge behind them. This supports the integration of sustainability aspects into planning processes. This way the CNRI functions not only as a risk communication support tool but also as a decisionsupport aligned with risk science principles.

5. Discussion

The proposed Climate and Natural Risk Index (CNRI) provides a structured and transparent approach to organizing ESRS-aligned ESG data into a unified environmental risk metric for the oil and gas sector. By aggregating information across ESRS objectives E1–E5 into risk-oriented sub-indices, the framework moves beyond fragmented disclosures and supports a more coherent interpretation of climate and natural risks. This responds directly to regulatory expectations for risk-based sustainability reporting and addresses well-documented challenges related to the comparability and interpretability of ESG disclosures (EFRAG, 2023; Unerman et al., 2014).

The conceptual design of the CNRI allows for methodological flexibility and future development. Rather than relying on a fixed set of indicators, the framework can be adapted as scientific knowledge, data availability, and regulatory guidance evolve. This adaptability is consistent with contemporary risk science, which emphasize uncertainty, learning, and iterative refinement in risk assessment and management processes (Aven, 2015b; Aven & Renn, 2010).

In addition, the standardized structure of the CNRI enables both longitudinal and comparative analysis. Thatexpresses environmental risk on a common scale allows organizations to monitor changes in their overall risk profile over time and to evaluate the effects of risk mitigation measures. At the sector level, the use of a shared conceptual structure facilitates benchmarking across firms, supporting transparency and informed interpretation by regulators, investors, and other stakeholders (TCFD, 2017; NGFS, 2020).Risk exposure varies across oil and gas value-chain segments: upstream operations face greater physical and biodiversity risks, midstream infrastructure transport and storage hazards, and downstream activities stronger transition risks. The CNRI framework allows such variation to be reflected in the interpretation or weighting of sub-indices.

Finally, the explicit role of stakeholder input in the weighting and aggregation process highlights the CNRI's potential as a risk communication and governance tool. Integrating quantitative ESG data with materiality considerations and stakeholder perspectives aligns with established insights from risk governance and risk communication literature, which emphasize that risk evaluation involves both analytical assessment and value-based judgment (Renn, 2008; Slovic, 1987). This comprehensive logic additionally provides strong support in bridging technical risk assessments, regulatory reporting, and stakeholder interpretation.

However, this study proposes a conceptual framework rather than an empirically calibrated index. The selection of variables, weighting schemes, and normalization procedures is illustrative and would require empirical validation, sensitivity analysis, and uncertainty assessment prior to operational use. Moreover, reliance on ESG disclosure data implies sensitivity to reporting quality, consistency, and interpretation, challenges that are widely acknowledged in the sustainability reporting literature (Berg et al., 2022; Christensen et al., 2021). These limitations point to important avenues for future research, including empirical testing, sector-specific calibration, and integration of uncertainty analysis into ESRS-aligned risk metrics.

6. Conclusions and Future work

This paper proposes the Climate and Natural Risk Index (CNRI) as a conceptual framework for transforming ESG data into interpretable and ESRS-aligned risk metrics. It investigates how sustainability indicators can be structured into a risk index that supports decision-making and governance and enhances risk communication in complex and uncertain environments.

Using risk science, especially the literature on risk communication, to support the CNRI index helps make sustainability disclosures stronger from a scientific point of view. This approach strengthens risk-informed decision-making. The index highlights the importance of transparency, uncertainty, and dealing with complexity when developing ESG-based risk metrics that would be aligned with regulatory requirements.

Future work could focus on empirical testing of the CNRI across sectors and different organizational contexts, providing solid feedback for its further refinement and improvement. This would allow for gathering important information on how the CNRI index works in fast-changing situations and finding its weaknesses in tracking changing sustainability risks. Furthermore, it could be adapted to other sectors and regulatory contexts and set a basis for forming a cross-disciplinary framework if successful.

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