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SDG-Aligned Environmental Resilience Impact Index (ERII): Quantifying and Mitigating Corporate and Sovereign Ecological Footprints

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Abstract: The growing tension between economic development and environmental sustainability has highlighted the need for analytical tools capable of measuring and guiding the environmental performance of economic systems. This article proposes the development of the Environmental Resilience Impact Index (ERII) designed to support both states and private companies in assessing and minimizing the ecological footprint of their productive activities. The index integrates environmental, resource-efficiency, and governance indicators aligned with the framework of the United Nations Sustainable Development Goals. By combining multiple environmental dimensions - such as water use, energy efficiency, pollution control, circular resource management, and ecological resilience - the ERII offers a composite metric capable of guiding strategic planning and sustainable investment decisions. The proposed index aims to function not only as a measurement instrument but also as a strategic policy tool promoting environmentally responsible economic development.

Keywords: *Resilience Index, SDG metrics, corporate footprints, planetary limits, policy analytics*

1. Introduction

Over the past decades, the global economic system has undergone an unprecedented expansion in scale, technological complexity, and resource consumption. While this transformation has contributed significantly to economic growth and improvements in human well-being, it has also intensified pressures on natural ecosystems, leading to widespread environmental degradation, resource depletion, and growing ecological instability. Industrial production, urbanization, and globalized supply chains increasingly interact with fragile environmental systems, generating complex challenges for governments, companies, and international institutions seeking to reconcile economic development with environmental sustainability. The urgency of these challenges has been widely recognized within the international policy community. In this respect, it is relevant to consider that in 2015, the United Nations adopted the Sustainable Development Goals, a comprehensive global framework aimed at guiding economic and social development toward environmentally sustainable pathways. The SDGs represent an integrated agenda addressing a broad spectrum of sustainability concerns, including climate change, natural resource management, responsible production, and ecosystem protection. Within this framework, several goals explicitly emphasize the need to transform economic systems in order to reduce environmental pressures, including SDG 6 (Clean Water and Sanitation), SDG 12 (Responsible Consumption and Production), SDG 13 (Climate Action), and SDG 15 (Life on Land).

Despite the growing institutional commitment to sustainability, translating the principles of the SDGs into operational strategies remains a significant challenge. Governments and private sector actors are increasingly required to evaluate the environmental implications of their economic activities, yet the tools available for measuring environmental performance often remain fragmented, sector-specific, or insufficiently integrated. Existing environmental metrics - such as carbon emissions indicators, water footprint measurements, or pollution indices - typically focus on single dimensions of sustainability (Wadhwani & Malpani. 2023; Langford, 2016). While these indicators provide valuable insights into specific environmental pressures, they rarely capture the broader systemic interactions between economic activity and ecological resilience. The complexity of modern production systems further complicates environmental assessment. Global supply chains, technological innovation, and resource interdependencies create multidimensional environmental impacts that cannot be adequately understood through isolated indicators. Industrial production, for example, may simultaneously affect water resources, energy consumption, land use, biodiversity, and atmospheric emissions. Assessing such interconnected impacts requires analytical frameworks capable of integrating diverse environmental variables into coherent evaluation systems.

In response to these limitations, the development of composite environmental indices has gained increasing attention within both academic research and policy practice. Specifically, composite indicators allow the aggregation of multiple environmental variables into a unified metric capable of providing a more comprehensive representation of environmental performance. By synthesizing diverse indicators into a single analytical framework, such indices facilitate comparison across sectors, regions, and economic actors while supporting strategic decision-making processes. However, many existing environmental indices remain primarily descriptive, focusing on retrospective assessments of environmental performance rather than providing forward-looking strategic guidance. In the context of accelerating environmental change and growing sustainability commitments, there is a growing need for analytical tools capable not only of measuring environmental impact but also of supporting strategic environmental governance.

This article proposes the development of the Environmental Resilience Impact Index (ERII), a multidimensional composite indicator designed to evaluate and guide the environmental performance of economic systems in alignment with the Sustainable Development Goals. The proposed index aims to provide both states and private sector actors with a systematic framework for assessing the environmental implications of economic and productive activities, while simultaneously identifying opportunities for reducing ecological pressures and enhancing sustainability. Unlike conventional environmental metrics that focus primarily on isolated environmental variables, the ERII adopts an integrated approach combining indicators related to resource efficiency, environmental resilience, pollution control, and sustainability governance. By incorporating multiple dimensions of environmental impact, the index seeks to capture the complex interactions between economic production systems and natural ecosystems. The goal is not merely to quantify environmental pressures but also to provide a strategic instrument capable of informing policy design, corporate sustainability strategies, and environmentally responsible investment decisions.

From a policy perspective, such a framework can assist governments in identifying sectors characterized by high environmental vulnerability and in designing targeted regulatory or incentive mechanisms aimed at improving sustainability performance. For corporations, the index can serve as a strategic management tool supporting the transition toward more sustainable production models and facilitating compliance with emerging environmental reporting standards. In the context of sustainable finance, composite environmental indicators may also contribute to improving the transparency and reliability of environmental performance assessments within ESG-oriented investment frameworks. More broadly, the development of integrated environmental indices reflects a growing recognition that sustainable development cannot be achieved solely through regulatory frameworks or technological innovation. Instead, it requires the creation of analytical tools capable of linking environmental sustainability with economic decision-making processes. By embedding sustainability considerations directly into strategic planning and performance evaluation systems, such tools can contribute to aligning economic incentives with long-term ecological resilience.

Within this context, the present study aims to contribute to the emerging literature on environmental performance measurement by proposing a structured methodological framework for constructing the Environmental Resilience Impact Index. The article first reviews the theoretical foundations underlying composite environmental indicators and their relevance for sustainability governance. It then outlines the methodological structure of the proposed index, including the selection of indicators, normalization procedures, and weighting mechanisms. Finally, the study discusses potential applications of the ERII for policy design, corporate sustainability strategies, and environmental risk assessment. By providing a multidimensional framework capable of translating sustainability principles into measurable and operational metrics, the proposed index seeks to support a more strategic and coordinated approach to environmental governance in an increasingly resource-constrained global economy.

2. Methodology

This study adopts a composite index approach to develop the Environmental Resilience Impact Index (ERII), conceived as a multidimensional tool for assessing the environmental performance of economic and productive systems in alignment with the Sustainable Development Goals of the United Nations. The methodological framework is grounded in the assumption that environmental resilience emerges from the interaction between resource efficiency, pollution control, and governance capacity, and therefore requires an integrated analytical structure capable of capturing these interdependencies. The construction of the ERII begins with the selection of indicators that are both empirically measurable and conceptually linked to the environmental implications of productive activity. Particular attention is given to the ability of indicators to reflect not only operational performance, such as resource use efficiency and emissions intensity, but also the strategic dimension of environmental management, including regulatory compliance and sustainability integration. The selected variables are organized into five core dimensions - water sustainability, energy and emissions, circular resource management, pollution control, and environmental governance - which together provide a systemic representation of environmental impact. Given the heterogeneity of the selected indicators, expressed in different units and scales, a normalization procedure is applied to ensure comparability. The model employs a min–max normalization method, transforming all variables into a standardized range between zero and one. This allows for the consistent interpretation of results, with higher values indicating better environmental performance across all indicators, regardless of their original measurement scale. The normalization process also enables the index to remain adaptable over time, facilitating updates as new data become available.

Following normalization, the indicators are aggregated within each dimension through an averaging process, generating dimension-specific scores that capture the relative performance of the evaluated unit in each environmental domain. These dimension scores are then combined into the overall ERII through a weighted linear aggregation model. In its baseline formulation, the index assigns equal weights to each dimension, reflecting a neutral assumption regarding their relative importance. However, the weighting structure is designed to remain flexible, allowing adjustments in response to sectoral characteristics or policy priorities, thereby enhancing the applicability of the index across different economic contexts. The methodological robustness of the ERII is supported through basic validation procedures, including sensitivity analysis of weighting schemes and consistency checks across different units of analysis. This ensures that the index maintains stability under varying assumptions and can be applied at multiple scales, from national systems to individual firms or industrial sectors. In this sense, the ERII is conceived not only as a descriptive metric but as a flexible and scalable analytical tool capable of supporting both comparative assessment and strategic decision-making. In essence, the proposed methodology seeks to bridge the gap between environmental measurement and strategic governance by providing a coherent framework that integrates diverse environmental dimensions into a single, operational index. In doing so, it offers a practical instrument for evaluating and guiding the transition toward more sustainable and resilient economic systems.

3. Theoretical Framework

The development of the Environmental Resilience Impact Index (ERII) is grounded in an interdisciplinary theoretical framework that integrates insights from sustainability science, environmental economics, and governance theory. At its core, the index builds on the premise that environmental sustainability cannot be adequately understood through isolated ecological variables, but rather emerges from the dynamic interaction between resource use, environmental pressures, and institutional capacity. A first conceptual pillar of the framework is the notion of environmental sustainability as a systemic condition. Traditional approaches to environmental assessment have often focused on single dimensions - such as emissions, water use, or land degradation - treating them as independent variables. However, contemporary sustainability literature emphasizes that environmental systems are inherently interconnected, with feedback loops linking resource extraction, pollution, and ecological resilience. This systemic perspective implies that the environmental impact of economic activity must be assessed through integrated models capable of capturing cross-sectoral and cross-resource interdependencies.

Closely related to this is the concept of resilience, which plays a central role in the ERII framework. Resilience is understood not merely as the capacity of ecological systems to absorb shocks, but as the broader ability of socio-environmental systems to adapt, reorganize, and maintain functionality under conditions of stress. In the context of economic production, environmental resilience reflects the extent to which productive systems can operate without generating irreversible ecological damage or triggering resource scarcity. This perspective shifts the analytical focus from static measurements of environmental degradation to the long-term sustainability and adaptability of economic systems (Ferranti, 2018). In addition, a second pillar of the framework is derived from resource efficiency theory, which highlights the importance of optimizing the use of natural resources within production processes. From this perspective, environmental sustainability is closely linked to the capacity of economic actors to minimize inputs - such as water, energy, and raw materials - while maximizing output and reducing waste. This approach is particularly relevant in the context of circular economy models, which seek to decouple economic growth from resource consumption by promoting reuse, recycling, and the valorization of industrial by-products. The ERII incorporates this logic by evaluating not only the level of environmental pressure generated by economic activities, but also the efficiency with which resources are utilized (Domingo-Posada et al., 2024; Willis, 2016).

A third key component of the theoretical framework concerns environmental governance and institutional capacity. A growing body of literature demonstrates that environmental outcomes are not determined solely by technological or economic factors, but are also strongly influenced by governance structures, regulatory frameworks, and strategic decision-making processes. Effective environmental governance includes elements such as regulatory enforcement, transparency, long-term planning, and the integration of sustainability into policy and corporate strategies. By incorporating governance as a core dimension, the ERII acknowledges that environmental performance is as much a function of institutional quality as it is of operational efficiency (Abidoye et al., 2024).

The framework is further informed by the global normative architecture established by the United Nations through the Sustainable Development Goals. The SDGs provide a comprehensive and internationally recognized set of objectives that link environmental sustainability with economic development and social well-being. In particular, goals related to water management, energy transition, responsible production, climate action, and ecosystem protection form the conceptual backbone of the ERII. By aligning its dimensions with these goals, the index ensures both conceptual coherence and policy relevance.

Importantly, the ERII framework also reflects a shift from descriptive to strategic environmental assessment. While many existing indicators focus on measuring environmental conditions or past performance, the ERII is designed to function as a tool for decision-making and forward-looking planning. This implies that environmental assessment should not only identify current levels of impact, but also support the identification of vulnerabilities, trade-offs, and opportunities for improvement within economic systems (Pájaro et al., 2022). In this sense, the ERII can be understood as a synthesis of three theoretical dimensions: environmental sustainability as a systemic condition, resilience as adaptive capacity, and governance as a strategic enabler of sustainable outcomes. By integrating these elements into a single analytical framework, the index seeks to provide a more comprehensive and operational understanding of the relationship between economic activity and environmental impact (Sharma et al., 2025). Ultimately, the theoretical contribution of the ERII lies in its attempt to bridge the gap between environmental measurement and strategic governance. It moves beyond fragmented indicators and static assessments, offering instead a multidimensional perspective that captures the complexity of sustainability challenges in contemporary economic systems.

4. Literature Review

The development of analytical tools capable of measuring the environmental implications of economic activity has become a central concern in sustainability research. Over the past three decades, scholars and international institutions have produced a wide range of environmental indicators and composite indices designed to assess the relationship between economic development and ecological sustainability. These tools aim to support decision-making processes by translating complex environmental dynamics into measurable indicators capable of guiding policy and corporate strategies.

Early attempts to quantify environmental impact primarily focused on single-variable indicators, such as carbon emissions, pollution levels, or resource extraction rates. While these measures provided important insights into specific environmental pressures, they often failed to capture the broader systemic interactions between economic activity and ecological resilience (Parotto & Pablos-Méndez, 2023). The need for more comprehensive analytical frameworks led to the development of composite environmental indices, which integrate multiple indicators into a unified metric capable of providing a broader assessment of environmental performance. One of the most influential examples is the Environmental Performance Index (EPI) developed by researchers at Yale University and Columbia University. The EPI evaluates national environmental performance across several categories, including ecosystem vitality, climate change mitigation, and environmental health. By aggregating multiple indicators into a standardized framework, the index enables cross-country comparisons and highlights policy areas requiring improvement (Senger, 2024).

Figure 1. Overview of the United Nations Sustainable Development Goals (SDGs)

Similarly, the Ecological Footprint methodology developed by the Global Footprint Network measures the ecological demand placed on planetary resources by human activities. The ecological footprint approach evaluates the extent to which consumption patterns exceed the regenerative capacity of ecosystems. Although widely used in sustainability assessments, this methodology primarily focuses on resource consumption and does not fully account for governance mechanisms or sector-specific environmental strategies (Adiyoso, 2022). Another influential framework is the Environmental Sustainability Index (ESI), which preceded the EPI and attempted to capture the broader institutional, environmental, and socio-economic dimensions of sustainability. The ESI incorporated indicators related to environmental systems, environmental stress, human vulnerability, and institutional capacity, reflecting the growing recognition that environmental sustainability depends not only on ecological conditions but also on governance structures and policy frameworks (Fukuda-Parr, 2018). Despite the contributions of these indices, scholars have increasingly emphasized the limitations of existing measurement tools. Many indices operate primarily at the national level and therefore provide limited insights into corporate or sectoral environmental performance. Furthermore, the aggregation of environmental indicators often involves methodological challenges related to weighting schemes, data comparability, and indicator selection (Domingo-Posada, et al., 2024).

As anticipated, the adoption of the Sustainable Development Goals by the United Nations in 2015 marked a major milestone in global sustainability governance. The SDGs introduced a comprehensive framework integrating economic development, social inclusion, and environmental protection. Unlike previous development agendas, the SDGs explicitly recognize the interconnected nature of sustainability challenges and emphasize the need for integrated policy approaches (Wynn & Jones, 2021; Fukuda-Parr, 2018). Several SDGs directly address environmental sustainability and resource management. SDG 6 focuses on sustainable water management, SDG 7 promotes clean and affordable energy, SDG 12 emphasizes responsible consumption and production patterns, SDG 13 addresses climate change mitigation and adaptation, and SDG 15 seeks to protect terrestrial ecosystems and biodiversity (Gigliotti et al., 2018). In response to the SDGs, researchers have increasingly explored methods for translating these global goals into measurable sustainability indicators applicable at national, regional, and corporate levels. Various organizations have developed SDG monitoring frameworks designed to track progress toward the goals through quantitative indicators. However, these frameworks often function primarily as reporting mechanisms, rather than as operational tools capable of guiding strategic decision-making (Langford, 2016).

In parallel with global sustainability frameworks, corporate environmental governance has emerged as a major area of research and policy development. Companies are increasingly expected to integrate environmental considerations into their operational strategies, driven by regulatory pressures, investor expectations, and growing public awareness of sustainability issues (Hegde, 2025). One of the most prominent developments in this area has been the rise of Environmental, Social, and Governance (ESG) frameworks used by investors and financial institutions to assess corporate sustainability performance. ESG metrics evaluate corporate practices across multiple dimensions, including environmental impact, social responsibility, and governance transparency (Sharma et al., 2025; Wynn & Jones, 2021).

It is relevant to consider that although ESG frameworks have contributed significantly to the integration of sustainability considerations within financial markets, critics argue that ESG metrics often lack standardization and methodological consistency. Different rating agencies may produce divergent assessments of the same company, reflecting variations in indicator selection, weighting methodologies, and data sources (Parotto & Pablos-Méndez, 2023). Furthermore, many ESG indicators remain primarily focused on disclosure and reporting practices, rather than on the underlying environmental performance of productive activities. As a result, there is growing interest in developing more robust analytical tools capable of linking corporate environmental performance with measurable ecological outcomes (Amato, 2020).

Within the academic literature, composite environmental indices have increasingly been recognized as valuable tools for integrating diverse sustainability indicators into coherent analytical frameworks. Scholars argue that such indices can facilitate strategic environmental assessment by providing simplified representations of complex environmental systems (Willis, 2016). However, the design of composite indices raises several methodological challenges. Indicator selection must ensure that the chosen variables adequately capture the multidimensional nature of environmental sustainability. Data normalization procedures must allow comparisons across different scales and measurement units. Weighting schemes must balance the relative importance of different environmental dimensions without introducing excessive subjectivity (Jones et al., 2016). In this respect, recent studies have therefore emphasized the importance of developing transparent and adaptable index architectures, capable of integrating environmental, economic, and governance indicators while remaining flexible enough to accommodate sector-specific characteristics (Senger, 2024).

Despite the growing body of literature on environmental performance measurement, several gaps remain. Many existing indices focus primarily on national-level environmental performance, offering limited guidance for companies or industrial sectors seeking to evaluate their environmental impact. Additionally, while the SDGs provide a comprehensive normative framework for sustainable development, the operational translation of these goals into measurable indicators remains incomplete (Gehringer & Kowalski, 2023). This study seeks to address these limitations by proposing the Environmental Resilience Impact Index (ERII), a composite analytical framework designed to support both states and companies in assessing and reducing the environmental impact of economic activities. By integrating indicators related to resource efficiency, environmental resilience, pollution control, and sustainability governance, the proposed index aims to provide a strategic tool capable of linking environmental sustainability with economic decision-making processes (Huck, 2022). In doing so, the ERII contributes to the ongoing effort within sustainability research to develop integrated analytical frameworks capable of supporting the transition toward environmentally responsible economic systems.

Table 1. Comparative Overview of Existing Environmental Indices and Frameworks and Their Relevance to the Environmental Resilience Impact Index (ERII)

Framework / Index	Main Focus	Strengths	Limitations	Relevance for ERII
Environmental Performance Index (EPI) (Yale University, Columbia University)	National environmental performance across health and ecosystems	Comprehensive, cross-country comparability, policy relevance	Limited applicability to firms and sectors; mostly descriptive	Provides structural inspiration but lacks micro-level applicability
Ecological Footprint (Global Footprint Network)	Resource consumption vs. planetary capacity	Intuitive concept, strong communication power	Focused mainly on resource demand; limited governance dimension	Highlights resource pressure but lacks strategic and governance components
Environmental Sustainability Index (ESI)	Broad sustainability including environmental, social, and institutional factors	Multidimensional approach; includes governance variables	Methodological complexity; limited operational use	Supports integration of governance into ERII
ESG Frameworks	Corporate sustainability (environmental, social, governance)	Widely used in finance; promotes corporate accountability	Lack of standardization; often disclosure-based rather than impact-based	ERII improves by focusing on measurable environmental impact
SDG Monitoring Framework (United Nations)	Global progress toward sustainability goals	Comprehensive and globally recognized; normative strength	Primarily reporting-oriented; limited operational application	ERII translates SDGs into a decision-making tool
Carbon Footprint Metrics	Greenhouse gas emissions measurement	Precise and widely standardized	Single-dimension focus; ignores broader environmental dynamics	ERII expands beyond carbon to systemic environmental impact
Water Footprint Assessment	Water use and consumption patterns	Sector-specific applicability; strong relevance for resource management	Narrow scope; limited integration with other environmental factors	Integrated into ERII as one key dimension (water sustainability)

5. Scientific Elaboration of the Environmental Resilience Impact Index (ERII)

As anticipated in the previous sections, the Environmental Resilience Impact Index is designed as a multidimensional analytical tool aimed at evaluating the environmental performance of economic and productive systems through a structured and integrated approach. The index is built upon five core dimensions - water sustainability, energy and emissions, circular resource management, pollution control, and environmental governance and strategy - which together capture the systemic relationship between economic activity and environmental resilience. Each dimension reflects a key domain in which productive processes interact with natural systems, and collectively they provide a comprehensive framework aligned with the sustainability principles promoted by the Sustainable Development Goals of the United Nations.

The first dimension, Water Sustainability, evaluates the extent to which economic activities utilize water resources in an efficient and sustainable manner. Water represents a critical input in many productive systems, particularly in agriculture, manufacturing, and energy production (Bai, 2024). This dimension assesses not only the volume of water consumed but also the efficiency of its use, the degree of water recycling and reuse, and the effectiveness of wastewater treatment processes. By incorporating these elements, the ERII captures both the pressure exerted on water resources and the capacity of systems to mitigate water-related risks, which is particularly relevant in contexts characterized by increasing water scarcity and climate variability (Ferranti, 2018).

In addition to measuring efficiency and reuse, the Water Sustainability dimension within the ERII incorporates a broader hydro-strategic perspective, recognizing water not only as a resource but as a critical determinant of environmental resilience and economic stability. This implies evaluating the exposure of productive systems to water-related risks, including scarcity, variability, and regulatory constraints. Indicators such as water stress levels, dependency on freshwater withdrawals, and vulnerability to climatic fluctuations are essential in capturing the long-term sustainability of water use. By integrating these elements, the ERII moves beyond static assessments of consumption and incorporates the dynamic nature of water systems, particularly in regions affected by climate change or competing demands across sectors (Caballero, 2019).

Furthermore, the water dimension reflects the growing importance of integrated water resource management (IWRM) principles, which emphasize coordination between different users, sectors, and governance levels. In this context, environmental resilience is closely linked to the ability of economic actors to operate within broader watershed and basin-level constraints (Gulseven, 2020). The ERII therefore considers not only firm- or sector-level performance but also the alignment of water use practices with regional sustainability thresholds and policy frameworks. This approach reinforces the idea that water sustainability is inherently relational and systemic, requiring coordination between industrial activity, environmental protection, and public governance. By embedding these considerations, the index captures both the operational and strategic dimensions of water management, making it particularly relevant in contexts where water scarcity, transboundary dynamics, or resource competition represent critical challenges (Gulseven, 2020).

The second dimension, Energy and Emissions, focuses on the relationship between production processes and energy use, as well as the environmental impact associated with greenhouse gas emissions. Energy consumption remains one of the primary drivers of environmental degradation, particularly when reliant on fossil fuels. This dimension evaluates the energy intensity of production, the share of renewable energy within the energy mix, and the level of emissions generated per unit of output. In doing so, it reflects both the efficiency of energy use and the transition toward low-carbon production systems, in line with global efforts to mitigate climate change and promote sustainable energy pathways (Jayasooria, 2023).

The Energy and Emissions dimension of the ERII extends beyond the measurement of energy intensity and carbon output by incorporating the concept of energy transition pathways. In this perspective, environmental resilience is closely linked to the ability of economic systems to progressively decouple production from fossil fuel dependency and move toward low-carbon and renewable energy sources (Wynn & Jones, 2021). This includes not only the share of renewables in the energy mix, but also investments in energy efficiency technologies, electrification processes, and innovation in clean energy systems. By capturing these dynamics, the ERII evaluates not only current environmental performance but also the trajectory of transformation, recognizing that resilience depends on the capacity to adapt to future regulatory, technological, and climatic constraints (Huck, 2022).

Moreover, this dimension integrates a broader understanding of emissions that goes beyond direct greenhouse gases to include indirect and embedded emissions across value chains. Modern production systems are increasingly characterized by complex supply networks, where environmental impact is distributed across multiple stages of production and geographical areas (Gigliotti et al., 2018). The ERII therefore considers the importance of scope-based emissions accounting, encouraging the inclusion of indirect emissions linked to energy procurement, logistics, and upstream production processes. This systemic approach allows the index to better reflect the true environmental footprint of economic activity and to incentivize more comprehensive mitigation strategies. In doing so, the Energy and Emissions dimension reinforces the role of strategic planning and innovation in achieving long-term environmental resilience within increasingly interconnected and carbon-constrained global economies (Sharma et al., 2025).

The third dimension, Circular Resource Management, captures the extent to which economic systems adopt circular economy principles. Traditional linear production models - based on extraction, use, and disposal - generate significant environmental pressures through resource depletion and waste generation (Parotto & Pablos-Méndez, 2023). In contrast, circular models aim to extend the lifecycle of materials by promoting reuse, recycling, and the recovery of industrial by-products. This dimension evaluates indicators such as material efficiency, recycling rates, and the degree to which waste is reintegrated into production processes. By doing so, it provides insight into the capacity of economic systems to reduce their dependence on virgin resources and minimize environmental externalities (Gigliotti et al., 2018).

The Circular Resource Management dimension of the ERII is grounded in the transition from linear to circular production systems, where the objective is not only to reduce waste but to redefine waste as a resource within continuous production cycles. This implies a shift in how materials are sourced, used, and reintegrated, emphasizing durability, reparability, and the extension of product life cycles (Senger, 2024). Within this framework, environmental resilience is closely linked to the capacity of economic systems to minimize dependence on virgin raw materials and to reduce exposure to supply chain disruptions and resource scarcity. By incorporating indicators such as material productivity, secondary raw material usage, and industrial symbiosis, the ERII captures the extent to which production processes are structurally aligned with circular economy principles (Amato, 2020).

In addition, this dimension reflects the increasing relevance of system-wide resource optimization, which goes beyond individual firms and requires coordination across entire value chains and industrial ecosystems (Adiyoso, 2022). Circularity is not achieved solely at the level of a single production unit but emerges from the interaction between producers, consumers, and waste management systems. The ERII therefore implicitly accounts for the degree of integration between different stages of production and the capacity to create closed-loop systems at a regional or sectoral level. This perspective highlights the strategic importance of innovation, regulatory frameworks, and cross-sector collaboration in enabling circular transitions. By embedding these elements, the index captures both the operational efficiency of resource use and the broader structural transformation required to achieve long-term environmental sustainability (Gehringer & Kowalski, 2023).

The fourth dimension, Pollution Control, assesses the extent to which productive activities generate and manage environmental pollutants. Pollution represents one of the most immediate and visible impacts of economic activity, affecting air quality, soil integrity, and water systems. This dimension includes indicators related to the emission of air pollutants, the management of hazardous waste, and the control of industrial discharge into natural environments. The inclusion of pollution control within the ERII ensures that the index captures not only resource efficiency but also the broader environmental consequences of production processes (Sharma et al., 2025).

The Pollution Control dimension of the ERII expands beyond the mere quantification of emissions by incorporating the capacity of systems to prevent, monitor, and mitigate environmental contamination across multiple media - air, water, and soil. This perspective emphasizes that pollution is not only an output of inefficient production processes but also a reflection of technological choices and management practices (Caballero, 2019). Accordingly, the ERII considers indicators related to the adoption of cleaner production technologies, the implementation of emission abatement systems, and the effectiveness of monitoring mechanisms. By doing so, it captures the degree to which economic actors actively reduce the environmental externalities associated with their operations, rather than simply complying with minimum regulatory thresholds (Bai, 2024).

Furthermore, this dimension integrates the concept of cumulative and cross-sectoral pollution impacts, recognizing that environmental degradation often results from the interaction of multiple sources over time. Industrial emissions, agricultural runoff, and urban waste streams frequently converge, amplifying ecological stress and undermining ecosystem resilience (Huck, 2022). The ERII therefore reflects not only the level of pollutants generated but also the broader capacity of systems to manage and contain their long-term effects, including remediation efforts and environmental restoration initiatives. This approach reinforces the importance of adopting a preventive and systemic view of pollution control, where the objective is not only to limit immediate damage but also to preserve the regenerative capacity of ecosystems in the face of ongoing economic activity (Jayasooria, 2023).

The fifth dimension, Environmental Governance and Strategy, reflects the institutional and strategic capacity of economic actors to integrate sustainability into decision-making processes. Environmental performance is not solely determined by technical or operational factors, but also by governance structures, regulatory compliance, and long-term planning. This dimension evaluates the presence of environmental policies, the level of transparency in sustainability reporting, adherence to regulatory frameworks, and the integration of environmental considerations into corporate or public strategies. By incorporating governance as a core component, the ERII acknowledges that sustainable outcomes depend on both measurable performance and the strategic orientation of economic actors (Langford, 2016).

The Environmental Governance and Strategy dimension of the ERII emphasizes the role of institutional quality and strategic orientation in shaping environmental outcomes. Environmental performance is not solely determined by technological efficiency or resource availability, but also by the ability of organizations and governments to design, implement, and enforce coherent sustainability policies (Parotto & Pablos-Méndez, 2023). This dimension therefore considers the presence of structured environmental management systems, the integration of sustainability objectives into long-term planning, and the alignment of operational practices with regulatory frameworks. By doing so, it captures the extent to which environmental considerations are embedded within decision-making processes rather than treated as peripheral or compliance-driven obligations (Amato, 2020).

Moreover, this dimension reflects the increasing importance of transparency, accountability, and adaptive governance in achieving environmental resilience. Effective environmental governance requires not only formal policies but also mechanisms for monitoring, reporting, and continuous improvement. The ERII, therefore, accounts for practices such as sustainability reporting, stakeholder engagement, and the adoption of internationally recognized standards, which enhance the credibility and effectiveness of environmental strategies (Bai, 2024). At the same time, it recognizes the need for adaptability in the face of evolving environmental challenges, including climate change, regulatory shifts, and technological innovation. By incorporating these elements, the index captures the dynamic and forward-looking nature of governance, highlighting its central role as an enabler of sustainable and resilient economic systems (Pájaro et al., 2022).

Table 2. Core Dimensions of the Environmental Resilience Impact Index (ERII)

Dimension	Description	Key Focus	Related SDGs
Water Sustainability	Evaluates efficient and sustainable use of water resources	Water use efficiency, reuse, risk exposure	SDG 6
Energy and Emissions	Assesses energy consumption patterns and emission intensity	Energy efficiency, renewables, carbon reduction	SDG 7, SDG 13
Circular Resource Management	Measures the adoption of circular economy principles	Recycling, material efficiency, waste reduction	SDG 12

Pollution Control	Examines the generation and management of pollutants	Emissions control, waste treatment, and environmental protection	SDG 3, SDG 15
Environmental Governance and Strategy	Evaluates institutional and strategic commitment to sustainability	Policy integration, compliance, transparency	SDG 16, SDG 17

6. Mathematical Model of the ERII

The Environmental Resilience Impact Index is constructed as a composite indicator designed to evaluate the environmental performance of economic and productive systems. It aggregates multiple sustainability dimensions into a single standardized score, allowing comparison across states, companies, or industrial sectors.
Formally, the ERII is defined as:

$$ERII_j = \sum_{d=1}^{m} w_d \cdot D_{dj}$$

where:

- $ERII_j$represents the index score for unit j
- $D_{dj}$is the score of dimension d
- $w_d$is the weight assigned to each dimension, with $\sum_{d=1}^{m} w_d = 1$

The index is structured around five core dimensions: **water sustainability, energy and emissions, circular resource management, pollution control, and environmental governance**. Each dimension captures a specific aspect of environmental impact linked to productive activity.
Each dimension score is calculated as the arithmetic mean of its normalized indicators:

$$D_{dj} = \frac{1}{n_d} \sum_{i=1}^{n_d} S_{idj}$$

where:

- $n_d$is the number of indicators within dimension d
- $S_{idj}$is the normalized value of indicator i

To ensure comparability across heterogeneous variables, all indicators are standardized using a min–max normalization approach. For positive indicators:

$$S_{idj} = \frac{X_{idj} - X_{id}^{\min}}{X_{id}^{\max} - X_{id}^{\min}}$$

and, for negative indicators:

$$S_{idj} = \frac{X_{id}^{\max} - X_{idj}}{X_{id}^{\max} - X_{id}^{\min}}$$

This transformation converts all values into a range between 0 and 1, where higher scores indicate better environmental performance.
The final ERII score can be rescaled to improve interpretability:

$$ERII_j^* = 100 \cdot ERII_j$$

Thus, the index ranges from 0 (low environmental sustainability) to 100 (high environmental sustainability).

The weighting structure can be adapted depending on sectoral characteristics or policy priorities, making the model flexible and applicable across different economic contexts.

7. Economic and Strategic Implications of Environmental Measurement for SDG Achievement

The adoption of composite measurement tools such as the Environmental Resilience Impact Index (ERII) generates significant economic and strategic benefits for both states and companies, particularly in the context of assessing and advancing progress toward the Sustainable Development Goals defined by the United Nations. By translating complex environmental dynamics into structured and comparable metrics, such indices enable economic actors to move from abstract sustainability commitments to concrete, data-driven decision-making processes (Abidoye et al., 2024). From an economic perspective, the ERII supports a more efficient allocation of resources by identifying areas where environmental inefficiencies generate hidden costs. Excessive water use, high energy intensity, or poor waste management are not only environmental issues but also sources of economic loss. By making these inefficiencies measurable, the index allows companies and governments to optimize production processes, reduce operational costs, and improve resource productivity. In this sense, environmental measurement becomes directly linked to economic performance, reinforcing the idea that sustainability and competitiveness are not mutually exclusive but increasingly interdependent (Hegde, 2025).

In addition, the ERII enhances the capacity of economic actors to anticipate regulatory and market transformations associated with the global sustainability transition. As environmental standards become more stringent and climate-related policies more pervasive, companies and states that lack robust measurement frameworks risk facing regulatory penalties, stranded assets, or reduced market access. By providing a forward-looking assessment of environmental performance, the index enables actors to align their strategies with evolving policy frameworks, thereby reducing transition risks and strengthening long-term economic resilience (Fukuda-Parr, 2018). From a strategic standpoint, the ERII plays a crucial role in bridging the gap between global sustainability objectives and operational implementation. While the Sustainable Development Goals offer a comprehensive normative framework, their translation into actionable strategies remains a major challenge. The ERII contributes to addressing this gap by operationalizing key SDG-related targets into measurable indicators that can be directly integrated into planning, monitoring, and evaluation processes. This allows both public and private actors to assess their contribution to sustainability goals in a more systematic and transparent manner (Gigliotti et al., 2018).

Furthermore, it is relevant to consider that the index enhances comparability and benchmarking, enabling states and companies to evaluate their performance relative to peers. This creates incentives for improvement through competition and reputational dynamics, particularly in sectors where sustainability performance is increasingly scrutinized by investors, regulators, and consumers. In financial markets, for instance, the availability of robust environmental metrics supports more informed investment decisions, facilitating the allocation of capital toward actors that demonstrate higher levels of environmental resilience and SDG alignment (Jones et al., 2016). Another key strategic advantage lies in the ability of the ERII to support risk assessment and long-term planning. Environmental risks - such as water scarcity, energy transition pressures, and pollution-related liabilities - are becoming central determinants of economic stability. By integrating multiple environmental dimensions into a single analytical framework, the index enables a more comprehensive assessment of these risks, allowing decision-makers to identify vulnerabilities and design mitigation strategies. This is particularly relevant in sectors exposed to climate change, resource constraints, or geopolitical tensions linked to environmental factors (Wynn & Jones, 2021).

At the policy level, the ERII provides governments with a tool for evidence-based governance, supporting the design of targeted interventions aimed at improving sustainability performance across sectors. By identifying areas of weakness and strength, the index can inform regulatory measures, incentive structures, and investment priorities. This contributes to more effective and coherent policy frameworks, reducing fragmentation and enhancing the overall impact of sustainability initiatives. Finally, the strategic value of environmental measurement lies in its capacity to transform sustainability from a normative aspiration into a measurable and manageable objective. By embedding environmental considerations into performance evaluation systems, the ERII encourages a shift toward more integrated and forward-looking models of economic governance. In doing so, it supports the alignment of economic activity with the broader objectives of sustainable development, reinforcing the role of measurement as a key enabler of the transition toward resilient and environmentally responsible economic systems (Gigliotti et al., 2018).

8. Conclusions

This study has proposed the Environmental Resilience Impact Index (ERII) as an integrated analytical framework designed to assess the environmental performance of economic and productive systems in alignment with the Sustainable Development Goals of the United Nations. By combining five core dimensions - water sustainability, energy and emissions, circular resource management, pollution control, and environmental governance - the index offers a multidimensional perspective capable of capturing the complex interactions between economic activity and environmental systems. The ERII addresses a key limitation in existing environmental assessment tools, namely their tendency to remain fragmented, descriptive, or insufficiently connected to the operational realities of states and companies. In contrast, the proposed index provides a structured and scalable methodology that integrates environmental measurement with strategic decision-making. Its composite nature allows for both an overall assessment of environmental performance and a disaggregated analysis of specific dimensions, enabling the identification of critical vulnerabilities and areas for improvement.

From a methodological standpoint, the ERII demonstrates how heterogeneous environmental indicators can be harmonized through normalization and aggregation processes to produce a coherent and comparable metric. The flexibility of the weighting system further enhances its applicability across different sectors and geographical contexts, making it a versatile tool for both policy and corporate use. At the same time, its explicit alignment with the Sustainable Development Goals ensures that the index remains anchored to a globally recognized framework for sustainable development. Beyond its analytical contribution, the ERII carries important economic and strategic implications. By making environmental performance measurable and comparable, it enables more efficient resource allocation, supports risk assessment, and facilitates the integration of sustainability into long-term planning processes. For companies, the index can serve as a tool to improve operational efficiency and align production models with emerging environmental standards. For governments, it provides a basis for evidence-based policy-making and the design of targeted interventions aimed at enhancing sustainability performance across sectors.

Importantly, the ERII contributes to shifting the role of environmental assessment from a purely descriptive exercise to a strategic instrument for guiding transformation. In a context characterized by increasing environmental pressures, regulatory evolution, and growing demand for sustainable practices, the ability to measure and manage environmental impact becomes a central component of economic resilience. The index thus supports the transition toward more sustainable and adaptive systems by embedding environmental considerations within the core of decision-making processes. Future research should focus on the empirical application of the ERII across different sectors and regions, as well as on the refinement of indicator selection and weighting schemes. The integration of real-time data, advanced modeling techniques, and scenario analysis could further enhance the predictive and strategic capabilities of the index. In addition, testing the ERII within specific industrial contexts would provide valuable insights into its practical applicability and potential for supporting sustainability transitions. In conclusion, the Environmental Resilience Impact Index represents a step forward in the development of integrated environmental assessment tools. By linking environmental performance, resource efficiency, and governance within a single framework, it offers a practical and policy-relevant approach to evaluating and advancing progress toward sustainable development.

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10. Conflict of Interests

The author declares that there are no known financial or personal relationships that could have appeared to influence the work reported in this paper. The author has no competing interests to disclose.

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