A Systematic Approach to Quantifying Nature as an Investible Asset Class

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Abstract

We introduce an innovative approach to incorporating nature-related risks into investment decisions, based on two key measures of company behaviour: materiality assessment and forward-looking assessment. The materiality assessment estimates the direct and indirect impacts of companies on five major drivers of nature change (climate change, land, freshwater and ocean use, pollution, resource use, and invasive species) by utilizing data from the Encore and Exiobase datasets (Encore 2021; Stadler et al., 2018). Building on the principles of the Net Zero Investment Framework NZIF 2.0 for climate change investment guidance (IIGCC 2021), we develop a robust forward-looking assessment framework that evaluates the quality of company responses to nature-related risks.

Our methodology identifies industry leaders and laggards with significant exposure to nature-related risks, drawing parallels with multi-factor investing. We design a strategy around the five drivers of nature change, recognizing the varying availability, quality, and maturity of data across different drivers. These differences guide our risk budgeting process.

We also present some results obtained using our framework. Specifically, we empirically justify the use of an exponential distribution to map qualitative ENCORE assessments of impact intensity; we analyse the distribution of our materiality assessment on the MSCI World benchmark; and we use our framework to compare leaders and laggards in two equity sectors.

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1. Introduction

The Taskforce on Nature-related Financial Disclosures (TNFD) recommends that companies disclose information on five key drivers of nature change (DNCs): climate change, land, freshwater and ocean use, pollution, resource use, and invasive species (TNFD, 2023). These recommendations aim to provide investors with comparable and consistent nature-related information. DNCs can significantly impact the stability and sustainability of ecosystems, which in turn affect economic activities and financial markets. By incorporating these risks into investment strategies, investors can better anticipate and mitigate potential disruptions to their portfolios caused by environmental degradation (Bosch et al., 2022). Investments that consider environmental impacts are more likely to support companies that engage in sustainable practices, thereby contributing to the preservation and restoration of natural ecosystems (CISL and Aon, 2022). This approach not only enhances the overall health of the planet but also aligns with the growing demand for responsible and ethical investment options among stakeholders (Elbaz et al., 2023). Additionally, integrating nature-related risks into investment decisions can lead to more informed and strategic allocation of capital. By evaluating the direct and indirect impacts of companies on nature, investors can identify leaders and laggards in terms of environmental performance (Impax Asset Management, 2024). This enables the development of investment strategies that prioritize companies with robust responses to nature-related risks, ultimately driving positive environmental outcomes and fostering a transition to a more sustainable economy (Finance for Biodiversity Foundation, 2024).

Current research has primarily focused on reporting aspects, such as computing portfolio footprints, rather than integrating nature risks into the investment process using the TNFD recommendations (see Literature review below). In this work, we introduce an innovative approach to incorporating nature-related risks into investment decisions, emphasizing the need for comprehensive investment strategies that address all dimensions of nature change. Our approach is based on two key measures of company behaviour: materiality assessment and forward-looking assessment. The materiality assessment estimates the direct and indirect impacts of companies on each driver of nature change, utilizing data from Encore and Exiobase datasets (ENCORE, 2021; Stadler et al., 2018).

Building on the principles of the Net Zero Investment Framework NZIF 2.0 for climate change investment guidance (IIGCC, 2021), we develop a robust forward-looking assessment framework that evaluates the quality of company responses to nature-related risks. Most investment frameworks for nature risk assessment rely on materiality mapping —quantifying a firm's direct and indirect environmental impact. While materiality assessment is an essential first step, it suffers from four critical limitations when used in isolation:

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1. **It is backward-looking.** Materiality scores are based on historical environmental footprints but fail to capture whether a firm is actively mitigating or worsening its nature-related risks. For example, two firms in the agricultural sector might have equivalent materiality scores, yet one is investing in regenerative farming while the other continues unsustainable land-use practices. Without a forward-looking governance metric, investment decisions risk misallocating capital.

2. It does not distinguish between nature-dependent and nature-transitioning firms. Sectors such as forestry, food production, and textiles have inherently high nature dependencies, but firms within these industries may have fundamentally different risk trajectories. A forestry company investing in reforestation and biodiversity offsets may represent a lower long-term risk than a firm with static high deforestation exposure. Without a forward-looking component, materiality-based strategies risk punishing nature-positive transitioners.

3. Materiality does not reflect regulatory adaptation risk. The financial materiality of biodiversity loss is increasing due to regulatory intervention, such as the EU Corporate Sustainability Due Diligence Directive (CSDDD, 2024), among others. A firm may not yet be highly exposed to biodiversity transition risks, but if it lacks adequate governance structures, it could be at higher financial risk as regulations tighten. Static materiality models fail to anticipate regulatory compliance risks.

4. **Nature Risks Are Systemic and Non-Linear.** Unlike carbon pricing, which follows a linear, market-driven pricing mechanism, nature-related risks do not exhibit continuous, incremental financial impacts. Instead, nature degradation occurs in step changes — a fishery collapse, a tropical forest tipping point, a groundwater depletion event, etc. (see, e.g., D'Amato et al., 2019; Newbold et al., 2020). These changes have disproportionate financial consequences, and materiality-based models cannot account for these non-linear ecosystem threshold effects.

For these reasons, this paper introduces a forward-looking dimension to complement materiality scores, ensuring that investment decisions are based on both a company's exposure and its concrete actions towards integrating nature to its operations. Our work includes integrating nature-related risks into investment decisions, which is crucial for several reasons. Firstly, nature-related risks encompass a broad range of environmental factors, including climate change, land, freshwater and ocean use, pollution, resource use, and invasive species (TNFD, 2023).

To summarize, our contributions are three-fold:

(i) we propose a unified, generic framework to guide the implementation of systematic nature-positive investment strategies.

(ii) Taking the Net-Zero (climate change) factor investing as our starting point, we generalize this approach to all DNCs, including land, freshwater and ocean use, pollution, resource use, and invasive species.

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(iii) We provide empirical evidence of the soundness of our approach via quantitative and qualitative results. Specifically, we empirically justify the use of an exponential distribution to map qualitative ENCORE assessments of impact intensity; we analyse the distribution of our materiality assessment on the MSCI World benchmark; and we use our framework to compare leaders and laggards in two equity sectors.
The literary review, our methodology, results, and discussion are offered in the next Sections.

2. Literature review

The journey towards integrating nature and biodiversity into investment portfolios has evolved significantly over the years, driven by both regulations and industry initiatives. Various government and non-profit organizations offer guidance on integrating environmental considerations into financial decision-making processes through a conceptual framework for nature risks and recommendations for nature scenarios (The Network for Greening the Financial System, 2023; OECD, 2023; The Financial Conduct Authority, 2024; Capitals Coalition DNB Report, 2024; The Finance for Biodiversity Foundation, 2024; European Commission JRC Science for Policy Report, 2025).

The Taskforce on Nature-related Financial Disclosures (TNFD, 2023) has produced a series of comprehensive documents aimed at guiding companies in disclosing nature-related information. The TNFD recommendations focus on five key DNCs: climate change, land, freshwater and ocean use, pollution, resource use, and invasive species. The TNFD documents emphasize the importance of transparency and accountability in corporate reporting, encouraging companies to disclose their environmental impacts and strategies for mitigating nature-related risks. They provide detailed methodologies for assessing and managing nature-related risks. These include the proposed approach to value chains, sector disclosure metrics, and scenario analysis. The TNFD also offers a glossary of key terms and guidance on the identification and assessment of nature-related issues, known as the TNFD LEAP Approach. These resources are designed to help companies systematically integrate nature-related considerations into their financial decision-making processes. By adopting the TNFD recommendations, companies can enhance their environmental disclosures, providing investors with valuable insights into their nature-related risks and opportunities. Materiality assessments are the cornerstone of this methodology, providing a detailed understanding of a company's environmental footprint. Investors can utilize comprehensive datasets like Encore and Exiobase to estimate the direct and indirect impacts of companies on each driver of nature change (ENCORE, 2021; Stadler et al., 2018).

Oliver Wyman & WWF (2020) provided early insights into the integration of climate and nature-related factors into the investment process, emphasizing the importance of

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environmental considerations in financial decision-making. Building on these early efforts, Nature Action 100 advocated for greater corporate ambition and action on reversing nature and biodiversity loss (Nature Action 100, 2021). Svartzman et al. (2021) highlighted the importance of integrating environmental considerations into financial decision-making processes by exploring biodiversity-related financial risks in France. IIGCC (2021) described forward-looking assessments built on the principles of NZIF 2.0 that evaluate the quality of company responses to nature-related risks. CISL and Aon (2022) mapped exposure to nature-related risks across financial indices, underscoring the need for comprehensive risk assessment frameworks that incorporate environmental factors. Further elaboration of the critical issues of biodiversity loss and land degradation and stressing the necessity for financial institutions to address these challenges in their investment strategies is given in (CISL, 2023).

Robeco's Bosch et al. (2022) emphasized the importance of incorporating biodiversity considerations into financial decision-making, highlighting the potential risks and opportunities associated with nature-related impacts. This approach allows investors to identify leaders and laggards in terms of nature-related risks, drawing parallels with multi-factor investing. Amundi Asset Management has proposed a bespoke framework for integrating biodiversity into investment portfolios, utilizing tailored materiality assessments to estimate the direct and indirect impacts of companies on biodiversity (Elbaz et al., 2023). Pictet Asset Management (2023) has made significant strides in measuring corporations' impact on biodiversity loss (see also Kulionis et al., 2024). Their comprehensive assessment framework evaluates the environmental impacts of corporate activities, providing investors with critical insights into the sustainability of their portfolios. Nordea Asset Management (2024) highlights the integration of environmental considerations into their investment strategies in their white paper on biodiversity and nature. Impax Asset Management (2024) outlined their strategy for addressing nature, biodiversity, and deforestation, showcasing the integration of environmental considerations into their investment processes. Their approach involved identifying leaders and laggards with significant exposure to nature-related risks, drawing parallels with multi-factor investing and supporting the design of strategies around the five drivers of nature change. Lewis et al. (2024) emphasize the need for enhanced transparency and education in the financial sector to improve investor understanding of nature-related risks.

Recently, Garel et al. (2024) introduced a new measure of biodiversity and discussed an impact on biodiversity of a wide range of firms in different countries (Garel et al., 2025). Giglio et al. (2025) explore the twin crises of nature loss and climate change, emphasizing the multiplier effect of these interconnected issues on financial stability and the importance of addressing both in investment strategies.

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As we indicated in Introduction, this paper's approach expands the strategies of integrating nature-related risks into investment decisions described in the known literature by actively incorporating nature-related risks into investment strategies through both materiality and forward-looking assessments, ensuring that these risks are managed and mitigated effectively.

3. Methodology

3.1 Overview

Our methodology for evaluating nature-related risks relies on the same principles as those used in Net-Zero investing, which emphasizes the reduction of greenhouse gas emissions to achieve net-zero carbon emissions by a specified date (IIGCC, 2021). This approach is closely related to factor investing, an investment strategy that involves targeting quantifiable firm characteristics or "factors" that can explain differences in stock returns (Bessler et al., 2021). Specifically, we distinguish for each DNC the materiality of DNC-specific impacts in different geographies and economic sectors, and company-specific forward-looking signals.

In Net-Zero investing, materiality is assessed as the carbon intensity of certain business activities in specific geographies. From an investment point of view, the carbon intensity of a company provides absolute sizing information. This is motivated by the necessity to promote the decarbonization of companies that currently contribute the most to global warming and avoid “low-carbon investing” (Campos et al., 2025). We generalize this approach to all DNCs by defining a specific impact factor for each DNC.

The forward-looking part of a Net-Zero investment strategy can be constructed using different metrics such as the Implied Temperature Rise (ITR) of a company (see, e.g., Hohne-Sparborth et al., 2021, and references therein). A low ITR signals a company that is committed to decarbonize in the future, while a high ITR shows the opposite. In the investment strategy, the forward-looking metric defines whether a company should be overweighed (low ITR) or underweighted (high ITR). Our investment framework extends this procedure by defining a generic framework that constructs forward-looking signals for each DNC independently. Moreover, our approach ensures that forward-looking signals are company-specific as this part is the direction of the investment strategy. In the remaining of this section, we further detail our approach for both dimensions of our investment framework.

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3.2 Materiality Assessment

3.2.1 Data sources

To compute the materiality assessment, two main data sources are required:

1. A dataset of footprints related to all nature DNCs for sectors and regions
2. An Input-Output model that allows to translate direct impacts into indirect impacts.

Two data sources are commonly used jointly for this purpose (Svartsman et al., 2021; Kulionis et al., 2024): Exiobase (Stadler, et al., 2018) and ENCORE (ENCORE, 2021). Exiobase is commonly used to compute indirect impacts. Indeed, Exiobase models the economic relationships between sectors and regions at high granularity. ENCORE is used to assess the materiality of different sectors across all DNCs in a standardized fashion.

3.2.2 Conversion of ENCORE ratings to absolute impact values

In the case of ENCORE data, a footprint intensity by DNC is provided as ratings from "very low" to "very high". Since these ratings are not numerical and are not compatible with the absolute impact metric that Exiobase provides, we perform a mapping of each rating to a numerical exponential scale as shown in Table 1.

ENCORE Rating	Quantitative Footprint Intensity Value
Very Low	1
Low	10
Medium	100
High	1000
Very High	10000

Table 1: Mapping of ENCORE ratings to quantitative indicators. The mapping follows an exponential low to match empirical observations conducted on Exiobase data.

This design choice comes from the observation that impacts provided by Exiobase are exponentially distributed. It constitutes the main difference between our approach and (Svartzman, et al., 2021). We expand on this analysis in Sect. 4.

3.2.3 Aggregation of impacts for each DNC

Multiple impacts can correspond to a single DNC. For instance, biotic resource use and abiotic resource use are both related to the "Resource Use" DNC. Let r, s be a region and sector respectively, let $\{F^d_{r,s,k}\}_{k=1,\dots,n}$ be the set of n impact values related to DNC d. We define the impact value for d in r, s as $F_{r,s,d}$:

$$F_{r,s,d} = \max_k F^d_{r,s,k}$$

This method allows to take into account the most harmful impact in each DNC.

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3.2.4 Company-specific total impact computation

We follow the same approach as (Svartzman, et al., 2021) to compute company-specific impacts by DNC.

3.2.4.1 Direct impact intensity by region and sector computation

Let r, s be a region and sector respectively and let $F_{r,s,d}$ be the absolute impact for DNC d in r, s. Let $R_{r,s}$ be the total production in r, s as provided by Exiobase. We define the direct impact intensity in r, s for DNC d as $f_{r,s,d}^{direct}$:

$$f_{r,s,d}^{direct} = \frac{F_{r,s,d}}{R_{r,s}}$$

3.2.4.2 Indirect impact intensity by region and sector computation

The indirect impact intensity is computed following standard environmentally-extended multi-region input-output manipulations to compute upstream impacts from direct impacts.

Let Z be the transaction flow matrix and let x be the vector of total production provided by Exiobase. Let f_d^{direct} be the vector containing $f_{r,s,d}^{direct}$ for all regions and sectors r, s.

Let A be the direct requirements matrix defined as:

$$A = Z\widehat{x^{-1}}$$

where we use the standard shorthand of $\hat{X}$ to designate the square matrix with diagonal entries equal to the elements in vector X.

Let L be the Leontief inverse matrix computed as:

$$L = (I - A)^{-1}$$

Where I is the identity matrix with the same dimensions as A.

The indirect (upstream) intensity for DNC d is computed as:

$$f_d^{indirect} = (L - I)^T \cdot f_d^{direct}$$

3.2.5 Company absolute impact from intensities

Let $f_{r,s,d}$ be an impact intensity (direct or indirect) for region r and sector s. Let $R_{c,r,s}$ be the revenue generated by company c in region r and sector s. The absolute, company-specific impact for DNC d is defined as $F_{c,d}$:

$$F_{c,d} = \sum_{r,s} f_{r,s,d} \times R_{c,r,s}$$

By combining the company-specific direct and indirect impacts $F_{c,d}^{direct}$ and $F_{c,d}^{indirect}$, we obtain the total company-specific impact for DNC d:

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$$F_{c,d}^{total} = F_{c,d}^{indirect} + F_{c,d}^{direct}$$

3.2.6 Nature Driver Investment Ratio

The company absolute intensity is sensitive to the size of the company. To incorporate this information, an investment framework equivalent to owned emissions of a portfolio is required. Specifically, let $EVIC_c$ be the enterprise value including cash of company c. We compute the Nature Driver Investment Ratio of company c for DNC d $NaDIR_c^d$ as:

$$NaDIR_c^d = \frac{F_{c,d}^{total}}{EVIC_c}$$

It can also be useful to compute separately the $NaDIR_c^d$ for direct and indirect impact separately. This computation is easily derived from the previous formula by substituting the total impact with the direct and indirect impacts, respectively.

3.2.7 Final company-specific materiality assessment

To determine the final materiality score of company c for DNC d, we compute the percent rank of $NaDIR_c^d$. This quantity provides a standardized comparison of companies for each DNC.

From a practical perspective, the materiality assessment of a company c for direct, indirect and total impacts related to the DNC d leads to the scores $NaDIR_{c,d,direct}$, $NaDIR_{c,d,indirect}$ and $NaDIR_{c,d,total}$, respectively, expressed as a percentage. A score of 100% indicates a highly material impact, whereas 0% indicates no impact. This information can be summarized in a table as illustrated in Table 2 for a mock company. Note that since the weight of direct and indirect impact is different for each DNC, the total score is not a simple average of the direct and indirect score (see below).

Type	DNC				
	Climate	Land and Ocean Use	Waste and Pollution	Resource Use	Invasive Species
Direct	50%	95%	0%	27%	10%
Indirect	96%	10%	10%	47%	99%
Total	53%	37%	9%	31%	93%

Table 2: Mock example of materiality impact scores

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3.3 Forward-looking Indicator

3.3.1 Data sources

To compute forward-looking indicators that are idiosyncratic to companies, leveraging a broad range of data sources is key. For our implementation, we use about 95 different data points that we source from the established data providers: S&P Trucost, Factset, Bloomberg, Sustainalytics, CDP and SBTi. Each provide a broad range of quantitative indicators that ca be used as input of the methodology described in this section.

3.3.2. Category construction

Our forward-looking framework takes inspiration from the NZIF 2.0 framework for net-zero alignment. We generalize the NZIF 2.0 approach by proposing more generic categories that are summarized in Table 3. Each category in Table 3 applies to any DNC. Each category belongs to three sub-categories: (1) categories that are related to the current state of the company's consideration of a DNC, (2) categories that relate to the ambition of the company to address its DNC issues and (3) categories that demonstrate tangible results achieved by the company.

Category name	**Description**
Aware (1)	The company acknowledges the DNC in its annual report. This can be materialized by the mention of policies related to the DNC.
Committed (2)	The company has set a quantitative commitment to reduce its footprint regarding the DNC.
Highly Committed (2)	The company's commitment can be counterfactually verified.
On Track (2) (3)	The company is on track with its commitments.
Taking Action (3)	The company invests to mitigate its impact on the DNC.
Objectives Attained (3)	The company is already neutral to the DNC.

Table 3: Forward-looking categories applying to any DNC. (1) designate categories that are related to the current state of the company's consideration of a DNC, (2) signals categories that relate to the ambition of the company to address its DNC issues and (3) applies to categories that demonstrate tangible results achieved by the company.

In order to clarify the relationship between our framework and NZIF 2.0, Table 4 summarizes the correspondence between our categories and their NZIF 2.0 equivalents.

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All entries have an equivalent category form the NZIF 2.0 framework and are computed for all DNCs independently.

Category name	NZIF 2.0 equivalent
Aware	Aligning to a net zero pathway
Committed	Committed to aligning
Highly Committed	Aligning to a net zero pathway
On Track	Aligned to a net zero pathway
Taking Action	Aligned to a net zero pathway
Objectives Attained	Achieving net zero

Table 4: Relationship between NZIF 2.0 and our categories.

To allow the computation of a score, we rank the categories from 1 to 6, 1 being the lowest score and 6 the highest score. Categories that are harder to achieve are given a higher score. For instance, it is more difficult to be on track with one's target than to only commit to it. Therefore, the "On Track" category is ranked higher than "Committed" and "Highly Committed".

Category name	Score
Aware	1
Committed	2
Highly Committed	3
On Track	4
Taking Action	5
Objectives Attained	6

Table 5: score assigned to each category. 1 is the lowest score, and 6 the highest.

In practice, for a given company, we determine independently for each category within each DNC whether the company fulfils the criteria required to belong to the category or not. Therefore, 30 separate assignments are conducted.

The computation is done according to three steps described below.

1. Gather available data points that are relevant to the considered Category-DNC entry. Note that each Category-DNC entry can have multiple data points to determine its value.
2. Harmonize each data point into a Boolean fulfilment criterion that depends on the data point, the category and the DNC.
3. Determine the company's score for each DNC based on the harmonized Boolean indicators.

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Gathering of available data points. Depending on available data, practitioner can select multiple data points to each Category-DNC entry. These can come in a variety of forms (footprint values, disclosure information, policy guidance, etc).

Data point harmonization. The diverse data points are harmonized into Boolean values. The kth harmonized data point is set to "True" if data point k contains an information allowing to assign the Category to the company for the considered DNC. In all other cases, including when no data is available, the harmonized data point's value is set to "False". For instance, when considering the category "Committed" for the DNC "Waste and Pollution", a data point indicating that a company has a pollution reduction target will be converted to "True".

DNC overall score computation. Let $d_1^k, \dots, d_n^k$ be the n_k harmonized data points available for the company in the considered DNC and for the Category corresponding to the score k (see *Table 5*). The overall DNC score S_{DNC} is obtained by computing:

$$S_{DNC} = \max\left\{ k \times \left[\left(\sum_{j=1}^{n_k} d_j^k \right) > 0 \right] \right\}$$

Intuitively, this formulation means that we perform an "or" operation on the harmonized data point for each Category of the DNC and take the largest score to which the company belongs as the overall DNC score.

To illustrate our approach, Table 5 presents the application of our forward-looking framework to a mock company. In this example, the final forward-looking score would be highest in the "Resource use" dimension (6) and lowest for the "Climate" dimension (1).

Category name	Score	DNC				
		Climate	Land and Ocean Use	Waste and Pollution	Resource Use	Invasive Species
Aware	1	yes				
Committed	2			yes	yes	yes
Highly Committed	3		yes			yes
On Track	4					
Taking Action	5					
Objectives Attained	6				yes	
Company's Overall Score		1	3	2	6	3

Table 6: Example of our forward-looking framework for a mock company. The label "yes" designates cells where the data points meet the category's requirements.

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4. Results

In this section, we present some results using our framework. Specifically, we empirically justify the use of an exponential distribution to map qualitative ENCORE assessments of impact intensity; we analyse the distribution of our materiality assessment on the MSCI World benchmark; and we use our framework to compare leaders and laggards in two equity sectors.

4.1 Exponential distribution of ENCORE qualitative indicators

In this section, we justify our exponential scaling of ENCORE ratings by conducting a simple experiment. For three footprint indicators that have a one to one correspondence between Exiobase and ENCORE, namely "Emissions of GHG", "Volume of Water use" and "Area of land use", we construct a mapping between ENCORE ratings and Exiobase footprint values as follows.

First, we compute Exiobase footprints aggregated at the sector level, leading to 163 different value for each footprint indicator.

Second, we assign to each Exiobase sector the associated ENCORE rating. Encore ratings are given as letter ratings: VL stands for "Very Low", L for "Low", M for "Medium", H for "High" and VH for "Very High" in increasing order of footprint.

By aggregating Exiobase footprints sharing the same ENCORE rating, we obtain 5 Exiobase footprints that are directly mapped to an ENCORE rating. The outcome of this computation is presented in Figure 1. All three footprint are measures of different DNCs display an exponential behavior, which justify our exponential scaling of ENCORE scores.

From a qualitative point of view, this exponential scaling is also satisfying as it models the well-documented non-linearity of the impacts on nature (see, e.g., D'Amato et al., 2019; Newbold et al., 2020).

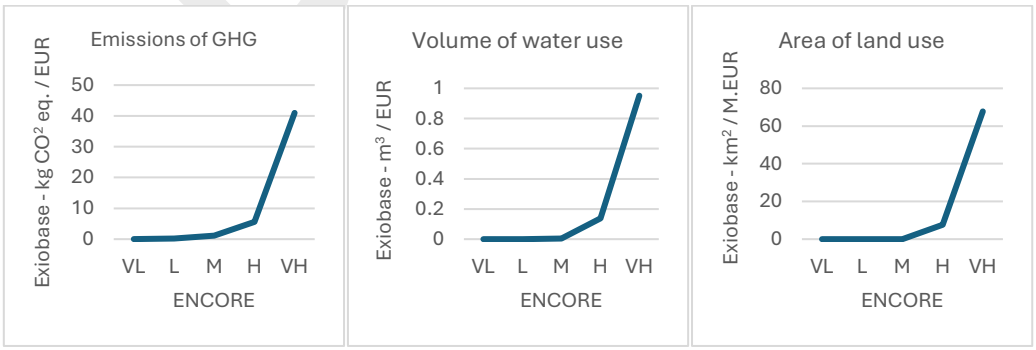


Figure 1: Mapping of ENCORE ratings to Exiobase footprint measures.

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4.2 Materiality assessment distribution

In this section, we analyse our footprint scores by DNCs on all companies in the MSCI World benchmark. For each company, we compute their direct and total materiality footprint by the DNC. Resulting footprints are aggregated at the GICS 1 level to provide summary statistics. The outcome of this computation is shown in Figure 2.

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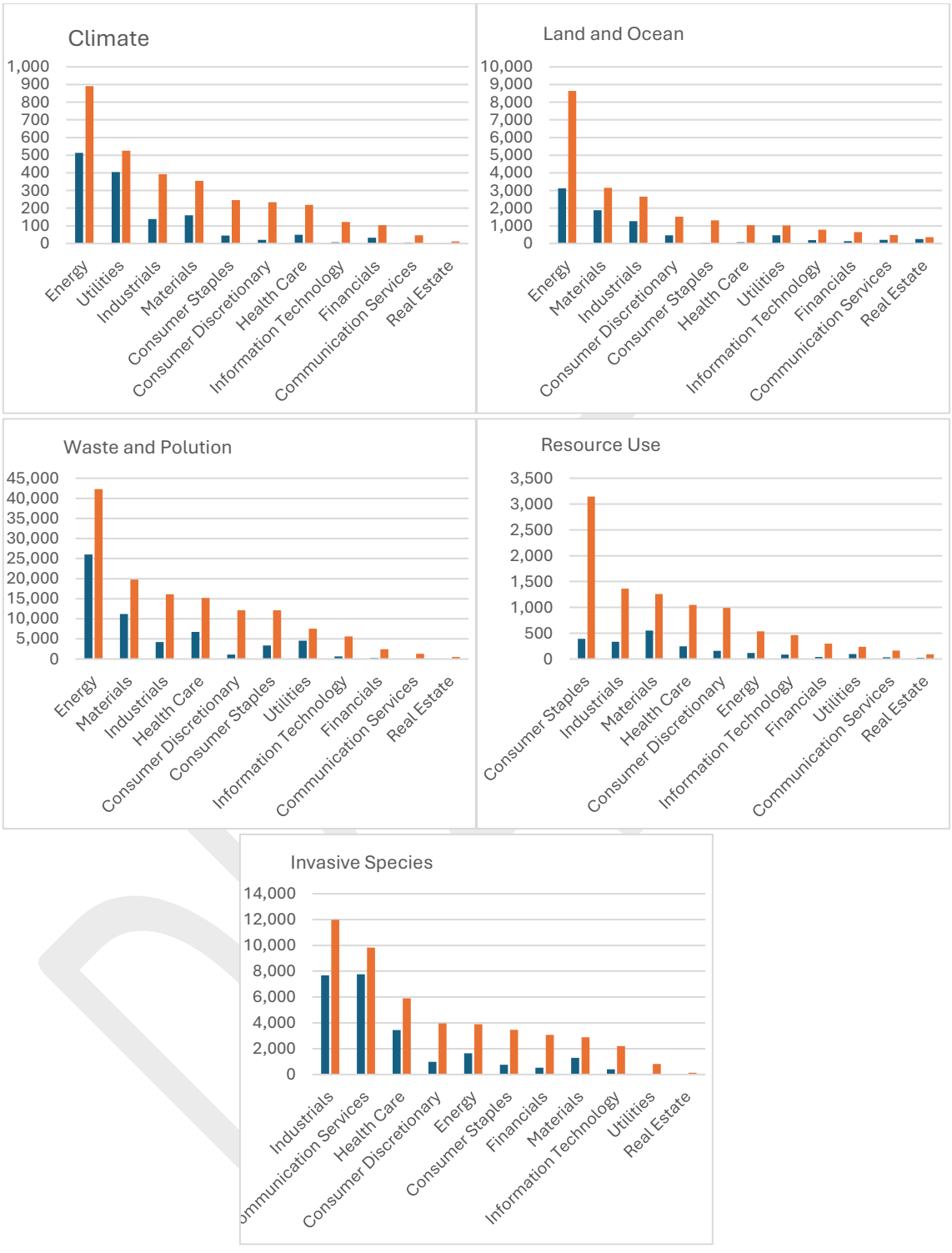


Figure 2: Direct (in blue) and total (in orange) materiality assessment of the GICS 1 sectors for all DNCs

Overall, energy and utilities are the most impactful sectors in the "Climate" DNC. In the "Land and Ocean" and "Waste and Pollution" DNCs, Energy and Materials are most impactful. In "Resource Use", Consumer Staples and Industrials have the highest footprint. Finally, Industrials and Communication Services have the highest impact in the

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"Invasive Species" DNC. Real Estate is consistently the lowest impact sector across all DNCs.

4.3 Application of our framework

In this section, we apply our complete framework on two pairs of companies from MSCI World, one "leader" and one "laggard", in each pair.

The first pair belongs to the GICS 1 "Consumer Staples" sector. The output of our method is shown in Table 6.

The similarity of the materiality assessments is expected: both companies from the same GICS 1 sector, they therefore largely share comparable revenue breakdown and hence also comparable materiality assessments. From a materiality assessment, the large weight of "Resource Use" and the overall larger share of indirect impact corresponds well to the business practice of companies in the "Consumer Staples" GICS 1 sector.

On the other hand, due to differences of results in our forward-looking assessment, both companies are easily distinguishable: one company performs much better in terms of "Climate" and "Resource Use" DNCs compared to the other. This company can be classified as a "leader" regarding nature issues, whereas the other company can be labelled as a "laggard".

	Category name	Score	DNC									
			Climate		Land and Ocean Use		Waste and Pollution		Resource Use		Invasive Species	
Forward Looking Framework	Aware	1	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Committed	2	yes	yes	yes	yes	yes	yes	yes	yes		
	Highly Committed	3	yes	yes	yes	yes						
	On Track	4	yes						yes			
	Taking Action	5										
	Objectives Attained	6										
	Forward Looking Assessment		**4**	3	3	3	2	2	**4**	2	1	1
Materiality Framework	Direct		67%	53%	16%	16%	69%	40%	71%	72%	22%	22%
	Indirect		77%	75%	81%	78%	75%	72%	95%	97%	65%	65%
	Materiality Assessment		71%	67%	75%	72%	69%	64%	94%	95%	59%	60%

Table 7: Application of our full framework to a pair of companies from the MSCI World "Consumer Staples" GICS 1 sector. The "leader" company is displayed in blue, while the "laggard" company is shown in (orange).

The second pair belongs to the GICS 1 "Materials" sector. The output of all computations is shown in Table 7.

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For this comparison, we also see similar materiality assessment for the same reasons as in our previous example. The materiality of all DNCs for both direct and indirect impacts is high in the "Materials" sector, which is in line with the business practice of this economic activity.

Moreover, as in our previous example, a company appears as a clear "leader", by ranking higher in three DNCs: "Climate", "Land and Ocean Use" and "Resource Use".

	Category name	Score	DNC									
			Climate		Land and Ocean Use		Waste and Pollution		Resource Use		Invasive Species	
Forward Looking Framework	Aware	1	yes	yes	yes	yes	yes	yes	yes	yes	yes	yes
	Committed	2	yes	yes			yes		yes			
	Highly Committed	3										
	On Track	4	yes									
	Taking Action	5										
	Objectives Attained	6										
	Forward Looking Assessment		**4**	2	1	1	**2**	1	**2**	1	1	1
Materiality Framework	Direct		95%	97%	99%	99%	95%	95%	98%	99%	72%	100%
	Indirect		93%	96%	94%	97%	84%	92%	85%	90%	80%	98%
	Materiality Assessment		95%	98%	99%	99%	93%	95%	92%	96%	74%	99%

Table 8: Application of our full framework to a pair of companies from the MSCI World "Materials" GICS 1 sector. The "leader" company is displayed in blue, while the "laggard" company is shown in orange .

From an investment perspective, the "leader" company would be overweighed, while the "laggard" company would be underweighted.

5. Discussion

Data Issues Related to Materiality Assessment

The materiality assessment framework faces several data-related challenges that impact its accuracy and reliability. One significant issue is the use of different types of units across various datasets. For instance, biodiversity-related metrics such as Potentially Disappeared Fraction (PDF) and Mean Species Abundance (MSA) are often expressed in units that are not directly comparable to other environmental impact metrics. This discrepancy can complicate the integration of biodiversity data into a unified materiality assessment framework (Kulionis et al., 2024).Moreover, the limitations of biodiversity-related metrics themselves pose challenges. Metrics like PDF and MSA are designed to capture specific aspects of biodiversity loss, but they may not

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fully represent the broader ecological impacts of economic activities. These metrics often rely on assumptions and models that can introduce uncertainties into the assessment (Svartzman et al., 2021). Additionally, the availability and quality of biodiversity data can vary significantly across regions and sectors, further complicating the materiality assessment (ENCORE, 2021).

Nature Solution Providers and Materiality

Our framework does not explicitly account for NZIF 2.0's "nature solution providers" for nature-related issues, i.e., companies that actively restore nature. However, from a forward-looking perspective, such companies are naturally classified under the "Taking Action" category. This classification captures the allocation of a company's resources towards nature-related issues (IIGCC, 2021). From the materiality point-of-view, "nature solution providers" would typically report a negative materiality for any DNC. This concept is well understood for the "Climate" dimension, where it can be captured by Scope 4 (avoided) emissions. However, data for such negative materiality is still at a nascent stage, even for the Climate dimension. Consequently, a computation similar to our materiality assessment is not yet feasible for nature restoration activities (Bosch et al., 2022).

Approximations for Nature Restoration

To address the current limitations, we propose two potential approximations to capture nature restoration activities within the materiality assessment framework:

Median Materiality. One option is to choose a median materiality value for nature solution providers. This approach would avoid penalizing these companies in terms of investment weight, ensuring that their positive contributions to nature restoration are recognized without skewing the overall assessment (Elbaz et al., 2023).

Turnover Percentage. Another option is to use the percentage of a company's turnover that is dedicated to nature restoration activities. This figure can serve as a proxy for the standard impact materiality assessment, reflecting the company's commitment to restoring nature and mitigating environmental impacts (Finance for Biodiversity Foundation, 2024).

By exploring these approximations, we aim to enhance the integration of nature restoration activities into the materiality assessment framework, promoting a more comprehensive and forward-looking approach to evaluating nature-related risks and opportunities.

Comprehensive Strategy for Managing Nature-Related Financial Risks

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A comprehensive strategy for managing nature-related financial risks involves several key components:

1. Data-Driven Risk Assessment: Utilizing high-quality datasets such as Encore and Exiobase to conduct detailed materiality assessments and forward-looking evaluations (ENCORE, 2021; Stadler et al., 2018). This approach ensures that investment decisions are based on reliable and up-to-date information (Bosch et al., 2022).
2. Risk Budgeting: Allocating resources and investment weights based on the availability, quality, and maturity of data across different DNCs (Evison & JRC Science for Policy Report, 2025). This process helps balance the need for comprehensive risk assessments with the limitations of available data (Svartzman et al., 2021).
3. Positive Impact Data: Incorporating positive impact data—such as Scope 4 (avoided) emissions—into the assessment framework to recognize and reward companies that actively contribute to nature restoration (Kulionis et al., 2024; Lewis et al., 2024). This approach aligns financial flows with sustainability goals and promotes the preservation of natural ecosystems (Finance for Biodiversity Foundation, 2024).
4. Regular Monitoring and Reporting: Providing updates on biodiversity impact assessments and the integration of nature-related risks into investment portfolios. Regular monitoring and reporting help build trust with stakeholders and demonstrate a commitment to sustainable investment practices (Nature Action 100, 2021).
5. Stakeholder Engagement: Actively engaging with companies and stakeholders to promote transparency and accountability in environmental disclosures (Svartzman et al., 2021). This engagement supports the broader goal of integrating nature-related risks into financial decision-making processes (TNFD, 2023).

By implementing these components, investors can develop a comprehensive strategy for managing nature-related financial risks, ensuring that their portfolios are resilient to environmental challenges and contribute to the preservation of natural ecosystems.

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