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SAFE White Paper No. 95 | August 2023

Leibniz Institute for Financial Research SAFE
Sustainable Architecture for Finance in Europe

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Mind the Gap?! The Current State of Biodiversity Reporting*

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August 2023

Abstract

Biodiversity loss poses a significant threat to the global economy and affects ecosystem services on which most large companies rely heavily. The severe financial implications of such a reduced species diversity have attracted the attention of companies and stakeholders, with numerous calls to increase corporate transparency. Using textual analysis, this study thus investigates the current state of voluntary biodiversity reporting of 359 European blue-chip companies and assesses the extent to which it aligns with the upcoming disclosure framework of the Task Force on Nature-related Financial Disclosures (TNFD). The descriptive results suggest a substantial gap between current reporting practices and the proposed TNFD framework, with disclosures largely lacking quantification, details and clear targets. In addition, the disclosures appear to be relatively unstandardized. Companies in sectors or regions exposed to higher nature-related risks as well as larger companies are more likely to report on aspects of biodiversity. This study contributes to the emerging literature on nature-related risks and provides detailed insights on the extent of the reporting gap in light of the upcoming standards.

1. Introduction

Biodiversity loss is proceeding at an alarming rate, leading to species extinction and significant ecosystem degradation. This not only exacerbates the impacts of climate change, but also undermines the value of ecosystem services on which the global economy relies heavily (IPBES 2019; IPCC 2022; S&P 2023). The loss of species diversity therefore poses significant nature-related risks to companies (NGFS and INSPIRE 2022; ECB 2023).² Accordingly, companies and their stakeholders are increasingly recognizing the financial relevance of biodiversity loss and their own dependencies and impacts (BIS

* SAFE policy papers represent the authors' personal opinions and do not necessarily reflect the views of the Leibniz Institute for Financial Research SAFE or its staff.

¹ I thank the researchers at the SAFE Policy Center and the University of Mannheim for the helpful comments and suggestions received throughout the development of this project. In particular, I thank Giulia Aliprandi, Jannis Bischof, Tatiana Farina, Angelina Hackmann, Jan Krahnert, Maximilian Müller and Stefan Weck. I also thank the participants of the SAFE brown bag seminar. Also, I gratefully acknowledge funding from the Deutsche Forschungsgemeinschaft (DFG, German Research Foundation) – Project-ID 403041268 – TRR 266 and from the Graduate School of Economic and Social Sciences of the University of Mannheim.

² The terms biodiversity risk and nature-related risk are used interchangeably.

2023; Giglio et al. 2023; WEF 2023). However, mitigating nature-related risks is different from mitigating climate risks, as the two have different triggers. Moreover, policies, targets and regulations are far less developed for biodiversity than for climate (Garel et al. 2023). Although some progress has been made with the United Nations Global Biodiversity Framework 2022, many observers call for further action, including increasing corporate transparency (Business for Nature et al. 2022; Gambetta 2022; Kenway 2022). Higher transparency seeks to spur information production, bridge information gaps and increase accountability for nature-related risks (EFRAG 2022; ISSB 2022; TNFD 2023). However, the current extent of voluntary biodiversity reporting of European companies remains largely unexplored. Hence, this study aims to fill this gap by systematically investigating the current extent of biodiversity reporting and assessing the extent to which it aligns with the upcoming disclosure standards.

The reporting gap is likely to be large. Peter Harrison, CEO of the British asset manager Schroders, suggests that “[...] reporting on biodiversity is where reporting on climate change was five to 10 years ago” (Agnew 2022). While the extent to which companies have access to raw data for assessing nature-related risks remains unclear, they currently largely lack guidance on how to use the data (S&P 2022; TNFD 2022a; Sustainalytics 2023). The lack of progress in developing sound measures, clear targets and metrics likely affects both internal risk measurement and subsequent reporting on it (Abdelli 2023; Garel et al. 2023). In addition, even if the information is available internally, companies may be reluctant to share it publicly with stakeholders. Biodiversity information is, for example, typically associated with highly detailed and therefore sensitive site data (Mollod and Balaisyte 2023; RepRisk 2023). While the provision of useful information may enable the reduction of nature-related risks, such risks also likely vary by sector, country and company (IPBES 2019; Giglio et al. 2023). Companies with higher nature-related risks may therefore systematically disclose more information, for example, to allay stakeholder concerns or to legitimize operations (Cho and Pattern 2007; Griffin et al. 2021). This would also be consistent with prior literature showing that voluntary disclosures are tailored to company-specific demands for disclosures (Christensen et al. 2021 for a review). If high-risk companies already report much more than others, this may largely reduce the relevance of the reporting gap.

To explore the current state of biodiversity reporting, a textual analysis based on a dictionary method and the 2021 corporate reports of 359 European non-financial blue-chip companies is conducted. Moreover, this current state of reporting is compared to the proposed risk and disclosure framework of the Task Force on Nature-related Financial Disclosures (TNFD). The TNFD has emerged as one of the most important initiatives in this area, backed by supporters with combined assets of \$20 trillion USD and engaging with a wide range of stakeholders (Stone 2023). In addition, the proposed TNFD framework is already serving as the basis for future reporting standards (e.g., ESRS E4 or ISSB 2022). Observers predict that the TNFD framework will have a similar success as its sister initiative, the Task

Force on Climate-Related Financial Disclosures (TCFD) framework, which is already directly or indirectly mandatory in major jurisdictions worldwide (Accounting for Sustainability 2022; Chirnside 2022).

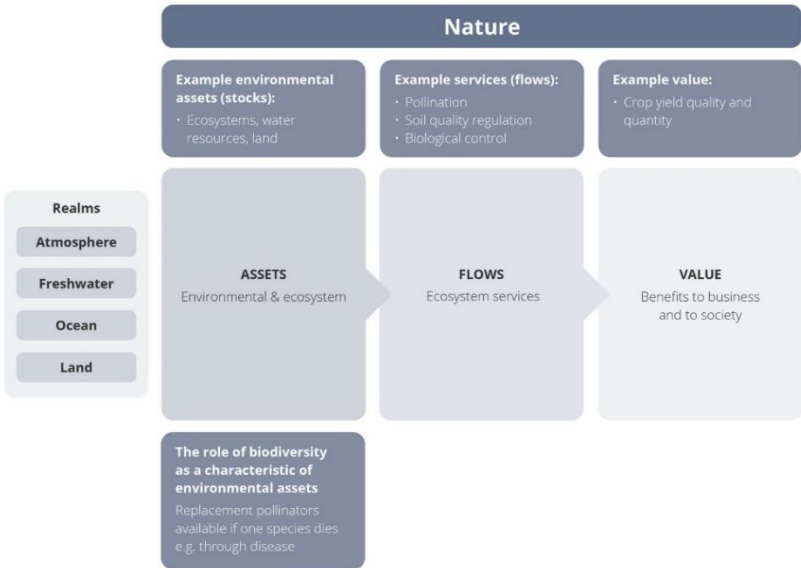
The remainder of this study is organized as follows: Section 2 provides the institutional background on the implications of biodiversity loss, including nature-related risks, for companies. It also provides an overview of corporate reporting and the proposed TNFD framework as an approach to enable the management of such risks. Section 3 provides a description of the research design and the sample and Section 4 presents the results. Section 5 provides concluding remarks and policy implications.

2. Institutional Background

2.1. Biodiversity Loss

According to the global biodiversity council IPBES, nature is defined as “[...] the natural world [...] with emphasis on the diversity of living organisms and their interactions among themselves and with their environment” (Díaz et al. 2015). It can also be viewed as a set of different environmental assets (Figure 1). Environmental assets include, for example, renewable energy resources such as solar energy or cultivated biological resources such as crops. Together they form ecosystems (Dasgupta 2021). Ecosystems, in turn, give rise to ecosystem services (e.g., the provision of food) that benefit the economy and society (Figure 1). Biodiversity or the variability in species, is a key feature of all these environmental assets (UN 1992). It enhances nature's productivity, resilience and adaptive capacity and is therefore critical to nature's provision of ecosystem services (Díaz et al. 2015; TNFD 2023).

Figure 1: TNFD’s Building Blocks for Understanding Nature



Source: TNFD (2023).

However, economy and society impact the provision of ecosystem services by affecting nature and biodiversity. While produced capital and human capital have increased in recent decades, natural capital has declined significantly: Biodiversity is in a global crisis (IPBES 2019; Dasgupta 2021). The current rate of biodiversity decline is surpassing any previous instances in human history (IPBES 2019). One million plants and species are at risk of extinction (NGFS and INSPIRE 2022). The main drivers of biodiversity loss are land and sea use change, overexploitation of environmental assets, climate change, pollution and invasive species (IPBES 2019). With respect to overexploitation, humanity currently needs 1.75 Earths to maintain the current standard of living. August 2 marks the date in 2023 on which annual human consumption of natural resources exceeds the Earth's corresponding regenerative capacity (Global Footprint Network 2023). As a consequence of this biodiversity loss, 14 out of 18 ecosystem services have significantly declined since 1970 (IPBES 2019) and another planetary boundary, one of Earth's safe zones, has been crossed (NGFS and INSPIRE 2022). This crossing of planetary boundaries might “[...] trigger non-linear, abrupt environmental change within continental- to planetary-scale systems” (Rockström et al. 2009).

Economy and society are, however, largely dependent on these ecosystem services and thus on nature and biodiversity. A study conducted by the World Economic Forum, for example, suggests that a staggering economic value of 44 trillion USD, which accounts for over half of the global gross domestic product (GDP), is moderately or highly reliant on the services provided by nature (WEF 2020). Recent estimates suggest that 85% of the world's 1,200 largest companies rely significantly on nature within their direct operations (S&P 2023). Hence, biodiversity loss has severe financial consequences for the economy and society (Dasgupta 2021).

2.2. Nature-Related Risks due to Biodiversity Loss

Similar to climate change, biodiversity loss poses physical and transition risks to the economy and society (BCBS 2021; Figure A1). Physical risk is shaped by acute and chronic physical risk drivers. Acute physical risk drivers are biodiversity-related events ranging from environmental accidents (e.g., an oil spill) to an increased likelihood of zoological pandemics. Chronical physical risk drivers are gradual changes in biodiversity, such as declines in pollinator species. Reduced pollinator diversity, for example, can lead to a significant long-term decline in agricultural yields. This may, in turn, affect agricultural companies but also global food prices (Ricketts et al. 2008; Wurz et al. 2021).

Biodiversity loss can also lead to changes in the economy and society. Transition risk can therefore be triggered by changes in government policy and regulatory frameworks, technology or investor and customer sentiment (TNFD 2023). More stringent environmental regulations, for example, may require adaptation costs for high-risk companies, which in turn may reduce their profitability. Changes in sentiment may translate into changes in investor and consumer financing or consumption behavior.

The exact extent and timing of when these changes will occur remain highly uncertain – particularly due to their unprecedented nature. Moreover, not all of the consequences of biodiversity loss are yet known (NGFS and INSPIRE 2022). For example, not all species and their interactions within ecosystems are yet identified. Mora et al. (2011) suggest that “[...] 86% of existing species on Earth and 91% of species in the ocean still await description” (Mora et al. 2011). Thus, the consequences of physical and transition risk drivers may be difficult to assess. In addition, biodiversity changes are not expected to be linear, but may have tipping points (NGFS and INSPIRE 2022).³

As the economy and society are highly dependent on ecosystem services, nature-related risks are likely to be large in scope and scale. Consistent with this, nature-related risks are considered by companies and experts to be among the greatest global risks for the next decade (WEF 2023). Hence, investors perceive nature-related risks to be material (e.g., Fronda 2023). For example, they respond to nature-related risk events and assess risks in equity markets (Garel et al. 2023; Giglio et al. 2023). Several regulators have also begun to assess the impact of nature-related risks (EIOPA 2023; EPA 2023; Svartzman et al. 2021). However, prior literature suggests that underlying dependencies and impacts vary by country, sector and company (CDSB 2021; Garel et al. 2023; Giglio et al. 2023). For example, the TNFD indicates that certain sectors, such as basic materials, utilities or energy, are likely to have greater dependencies and impacts than other sectors (TNFD 2023). Therefore, companies, e.g., in different countries or sectors, are likely to face different levels of nature-related physical and transition risks.

Nature-related risks and risks due to climate change are interrelated. Climate change is one of the five drivers of biodiversity loss. Biodiversity loss, on the other hand, exacerbates the physical impacts of climate change. Biodiversity is therefore critical for climate change adaptation and resilience, including disaster risk prevention (IBPES 2019; Menéndez et al. 2020; NGFS and INSPIRE 2022). Although both constructs share commonalities, they are triggered by different events. Giglio et al. (2023), for example, show that their nature-related risk measures behave differently than their climate risk measures. Hedging strategies built on dealing with climate risk do not perform well for dealing with nature-related risks. Moreover, measurements, targets and regulations for biodiversity are far less developed than their counterparts for climate (Garel et al. 2023; Giglio et al. 2023). Due to the multidimensionality of biodiversity and the interdependencies in nature, there is currently no consensus on the measurement methods and the targeted level of nature-related risks (Karolyi and Tobin-de la Puente 2022). Similar to climate change, mitigating nature-related risks is difficult because they have a global dimension. Many risks are transmitted through the supply chain, as developing countries such as Brazil or Malaysia can be both biodiversity hotspots and source countries for many

³ In addition, companies may be subject to systemic risk. Physical and transition risks may turn into systemic risks as an entire ecosystem may collapse, risks may aggregate or risks may spill over to other entities (Figure A1).

natural resources (Lenzen et al. 2012; Steffen et al. 2015). Political instability, market failures and lack of public funding in such developing countries can hinder risk mitigation (NGFS and INSPIRE 2022).

Due to the physical consequences of biodiversity loss, scientists are increasingly calling for system-wide ecological change (IPBES 2019). At the end of 2022, nearly 200 countries committed to limit global biodiversity loss through the Kunming and Montreal Global Framework Agreements, the Paris Agreement on biodiversity. One of the 23 targets for 2030 is to conserve at least 30% of the Earth's land, coastal areas and oceans and restore 30% of ecosystems. In addition, the framework emphasizes the need to allocate at least \$200 billion USD annually for biodiversity management and to channel \$30 billion USD in international financial flows to developing countries. It also calls for large companies to be required to monitor, assess and disclose these nature-related risks (UN 2022).

2.3. Corporate Reporting on Nature-Related Risks

Companies can play a critical role in managing nature-related risks globally, as their operations both rely on and affect biodiversity (Svartzman et al. 2021; EIOPA 2023; EPA 2023). While it remains unclear whether companies possess sufficient raw data to adequately assess their nature-related risks, in any case companies lack guidance to make use of the data (TNFD 2022a; S&P 2022; Sustainalytics 2023). Even when sufficient internal information is available, it may be asymmetrically distributed. Managers, for example, typically know their operations (e.g., the location of their production sites) better than their stakeholders. Combined with differing incentives of managers and stakeholders, this lack of information and asymmetric distribution of information may cause information problems in capital markets (Healy and Palepu 2001). Higher corporate transparency may, in turn, spur information acquisition incentives and level the playing field by resolving information asymmetries (Verrecchia 2001).

Currently, corporate biodiversity reporting is primarily voluntary.⁴ Companies may choose to voluntarily disclose information about nature-related risks due to a variety of economic and sociopolitical incentives (Müller et al. 2020; Christensen et al. 2021). For example, companies may choose to disclose to showcase their positive practices and legitimize their operations (e.g., Dowling and Pfeffer 1975 or Deegan 2002). However, voluntary reporting, in particular sustainability reporting, is often not standardized, incomplete and lacks credibility (Lang and Stice-Lawrence 2015; Bernow et al. 2019; BlackRock 2020). This makes the information disclosed less useful for decision-making by users of corporate reporting.⁵ Companies may, for instance, not provide high-quality voluntary reporting due to the high cost of reporting. They may face high direct costs, if the information is not available internally (Abdelli 2023; Agnew 2022). In addition, high-quality reporting may include detailed information on

⁴ Currently, there are only few biodiversity disclosure requirements (e.g., in the telecommunications sector related to birds). However, this seems to be changing rapidly (e.g., ESRS E4 and ISSB 2022).

⁵ FASB (2018), QC4-QC32 and IASB (2018), 2.4-2.36.

the supply chain, including specific locations of business activities (Mollod and Balaisyte 2023; RepRisk 2023). This information may be used by competitors and thereby provide a competitive disadvantage (Badia et al. 2021; Müller et al. 2021). Finally, detailed disclosure may impose compliance costs by attracting regulatory attention or increasing litigation by stakeholders (Christensen et al. 2021).

Currently, there are several important voluntary frameworks and standards that promote biodiversity reporting.⁶ One of these frameworks is provided by the TNFD. The TNFD was founded in 2020 and is a business-oriented initiative. Its goal is to provide a risk and disclosure framework for nature-related risks that follows a dynamic materiality perspective. The framework is expected to be completed in September 2023.⁷ It is designed to enable the provision of useful information that supports a shift in global financial flows from nature-damaging to nature-enhancing outcomes. This includes substantiating and standardizing the information provided and ensuring its credibility. Corporate biodiversity reporting should thereby enable investors, regulators and other stakeholders to understand and account for a company's nature-related risks and opportunities (TNFD 2023).

The TNFD is currently one of the most important biodiversity reporting initiatives for several reasons. First, it has received wide recognition and support from various stakeholders (Stone 2023). Second, the framework serves as a basis for future regulations and standards. For example, in 2024, the EU Directive on Corporate Sustainability Reporting will significantly expand the reporting requirements for large companies on sustainability issues through the European Sustainability Reporting Standards (ESRS). One of these standards, ESRS E4, focuses on biodiversity, which itself builds on several important concepts of the proposed TNFD framework. Third, the head of the UN Convention on Biological Diversity, politicians, companies and non-governmental organizations have called for TNFD reporting to be made mandatory (Business for Nature et al. 2022; Forests and Finance 2022; Gambetta 2022; Kenway 2022). Finally, the TNFD has many parallels with the Task Force on Climate-Related Financial Disclosures (TCFD). This interrelated task force has published a climate disclosure framework that has become mandatory in several major jurisdictions around the world (Caswell 2021; Rajendran 2023). The TNFD is expected to follow a similar path (Chirnside 2022; Accounting for Sustainability 2022).

Besides an approach to assess nature-related issues, the current draft of the TNFD framework mainly provides disclosure recommendations to guide companies in reporting their nature-related dependencies, impacts, risks and opportunities. As described in more detail in Figure 2, the disclosure

⁶ A detailed description of the other frameworks is provided in Appendix C. They follow a single, dynamic or double materiality perspective (TNFD 2022b). Single materiality aims to cover only those biodiversity-related issues that are decision-relevant for investors. Dynamic materiality also includes issues that likely become relevant for investors over time. Double materiality also considers issues that are relevant for others (TNFD 2022b).

⁷ This study primarily relies on the final draft of the proposed TNFD framework (TNFD 2023).

recommendations cover various aspects, including biodiversity-focused disclosures related to corporate governance, strategy, risk and impact measurement and biodiversity metrics and targets.

Figure 2: TNFD Draft Disclosure Recommendations

Governance	Strategy	Risk & Impact Management	Metrics & Targets
Disclose the organisation's governance around nature-related dependencies, impacts, risks and opportunities.	Disclose the actual and potential impacts of nature-related dependencies, impacts, risks and opportunities on the organisation's businesses, strategy and financial planning where such information is material.	Disclose how the organisation identifies, assesses and manages nature-related dependencies, impacts, risks and opportunities.	Disclose the metrics and targets used to assess and manage relevant nature-related dependencies, impacts, risks and opportunities where such information is material.

Source: TNFD (2023).

While there is an emerging literature on the global shift in disclosure regulation to provide more sustainability information (e.g., Bauer et al. 2021, Gutiérrez-Ponce et al. 2022 or Kopetzki et al. 2023), there is currently no such study specifically related to corporate biodiversity reporting.⁸ Hence, it is still largely unclear how many companies report on biodiversity and how large the reporting gap is in light of the upcoming standards. The purpose of this study is therefore to highlight the current state of biodiversity reporting and evaluate how it aligns with the proposed TNFD framework.

3. Sample and Research Design

The main sample (*Europe*) consists of all listed non-financial blue-chip companies in the 19 largest EU countries by GDP with machine-readable English reports being available (i.e., 359 companies).⁹ Another sample (*Germany*) is used for robustness checks, holding the institutional characteristics of one country constant. Similar to the main sample, it consists of all listed non-financial companies of the German prime standard market (i.e., DAX, MDAX and SDAX). The listing status of the companies in the respective indices is determined for both samples using S&P Global Capital IQ. Companies from the financial sector (e.g., banks, insurers, or asset managers) are excluded in line with previous sustainability reporting literature, as they are only indirectly affected by sustainability risks (BCBS 2021). The company reports are retrieved from S&P Global Capital IQ and collected by hand from the company websites to ensure their completeness. They mainly include annual reports, sustainability reports and GRI indices from the end of 2021. Some companies also prepare integrated reports combining

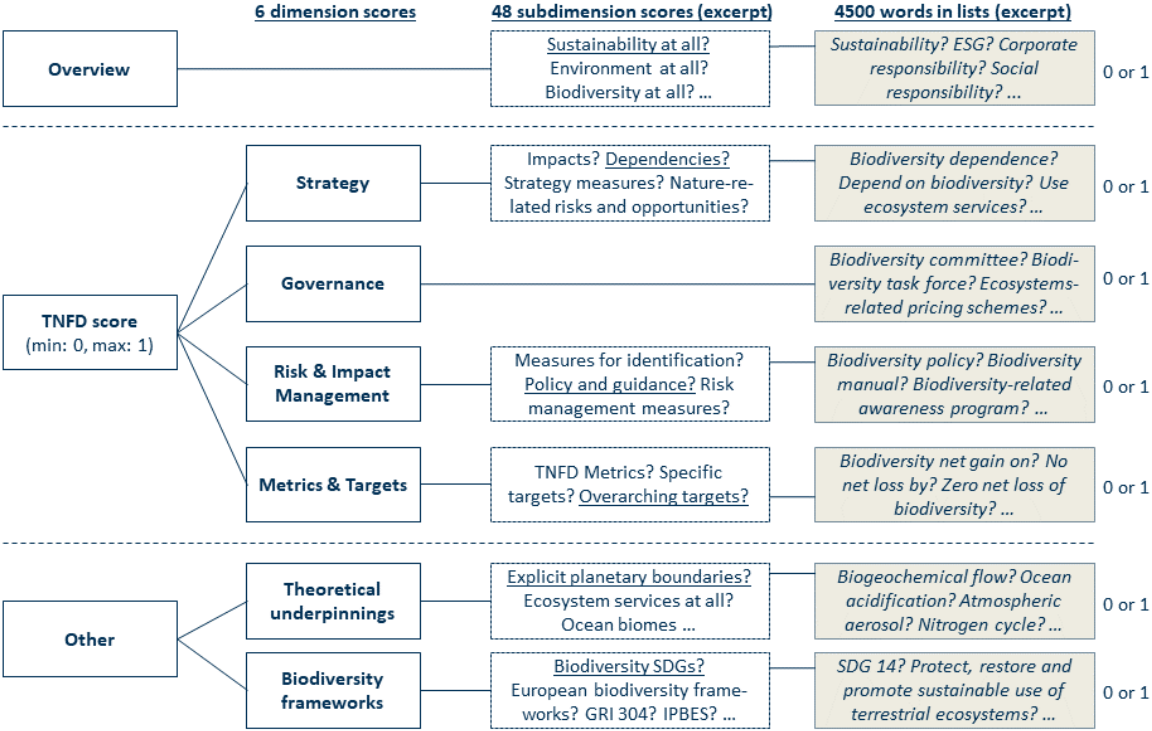
⁸ This stream of literature likely just started. The [Sustainability Reporting Navigator](#), for instance, began to conduct large-scale systematic analyses to assess the reporting gap to the upcoming sustainability standards.

⁹ English machine-readable reports are particularly rare in Eastern European and smaller countries. Thus, the *Europe* sample is restricted to the 19 largest EU countries. The German prime standard market is chosen as an additional sample as English reports are also available for smaller public companies in Germany. The coverage of the samples is shown in Table A1 and A2. On average, 88.53% of the respective index constituents are covered.

annual and sustainability reports. For most companies, the reports are available for 2021.¹⁰ Both samples are supplemented by company-level information (e.g., on company size, sector or headquarter country) from Thomson Reuters DataStream. Observations with missing information are removed.

Reporting on biodiversity-related topics is identified using textual analysis, as there is currently no database that captures biodiversity-related content of corporate reports. The design of the textual analysis follows a bag-of-words approach based on a dictionary method, similar to previous research on disclosure (e.g., Loughran & McDonald 2016 or Bochkay et al. 2022 for a review). The three main inputs of this approach are the dimensions, the words used for each dimension and the score construction (Figure 3). In this design, there are four core dimensions like in the proposed TNFD framework: strategy, governance, risk and impact management and metrics and targets. Similar to the proposed

Figure 3: Research Design



Source: Own depiction.

TNFD framework, each dimension typically has several subdimensions to capture different aspects of the core dimensions. However, some subdimensions (e.g., risk identification measures for a company’s direct operations and such measures for its upstream and downstream value chains) have been combined in this study as it is difficult to separately identify them based on a bag-of-words approach. A bag-of-words approach is, for instance, not suitable to detect the context of the words used (Brown et al. 2020). Three additional dimensions supplement the analysis with company-level information on

¹⁰ In the *Europe* sample, 13 sustainability reports are only available from 2020. Two annual reports are only available from 2020. In the *Germany* sample, two reports are only available from 2020.

sustainability reporting in general, reported technical terms and referenced biodiversity frameworks. All dimensions and its subdimensions are depicted in Table A3.

The second input is the words used for each dimension. Since biodiversity reporting is a relatively new topic, there are no bag-of-words specifically related to biodiversity reporting and the proposed TNFD framework. Therefore, it was self-generated, but closely follows the proposed TNFD framework (i.e., the drafts and the glossary). The lists are supplemented with terms from several other sources to account for potential heterogeneity in corporate reporting: a) other biodiversity reporting frameworks and standards (e.g., the ESRS exposure drafts), b) underlying biodiversity frameworks (e.g., by the IPBES) and the natural science literature, c) academic literature that connects natural sciences, business and economics (e.g., Dasgupta 2021), d) academic literature and frameworks related to climate-related risks (e.g., by the BCBS or the TCFD) and e) available lists of words for certain dimensions of biodiversity reporting (e.g., the elements of the periodic table or statistics on the most produced agricultural products). In addition, synonyms, examples and common expressions from online dictionaries are added for the identified words. After the initial collection of words, all company reports were manually reviewed to determine if all relevant biodiversity-related topics are captured. Furthermore, the most frequently counted word per subdimension was examined in subsequent control analyses. Last, ambiguous words such as “land”, “ecosystem” or “nature” were excluded to avoid overlaps with other subdimensions or traditional financial reporting. The list of words contains around 4,500 words.

The third input is how the score is determined. There are several ways to consider the words identified per subdimension and report of a company (Loughran & McDonald 2016 or Ash & Hansen 2023 for a review). This study applies a simple averaging method for including at least one word per subdimension across all reports of a company to avoid complex weighting methods or spurious relationships due to the length of the report. Therefore, each subdimension of each company is coded with a 1 if at least one word per subdimension occurs in any of the company's reports. The subdimension is coded with a 0 if none of these words occur in any of the reports. These scores are averaged for each dimension. The TNFD score is the average of the four TNFD dimension scores. Thus, a TNFD score of 1 means that all subdimensions are mentioned in one of the company's reports in that year.¹¹

An exception to this procedure is the TNFD Metrics subdimension. Metrics are difficult to classify based on a bag-of-words approach because they are often inserted as images. However, since metrics are an essential part of corporate reporting, a metrics inclusion score is created based on a manual review

¹¹ The validity of the TNFD score is assessed by comparison with established ESG scores of the companies in the sample. These scores were retrieved from Thomson Reuters DataStream. Unfortunately, a biodiversity score is not available, which underlines the importance of this study. Similar to other studies, disclosure scores are weakly correlated with overall ESG score, environmental pillar score and emissions score.

(Christensen et al. 2023).¹² According to the proposed TNFD reporting framework, there are four main types of disclosure metrics: risk and opportunity metrics, impact metrics, dependency metrics and response metrics (TNFD 2023). Sometimes multiple subtypes of these metric types were identified in the reports. These subtypes are depicted in Table A4. Similar to the general procedure, each subtype dimension of each company is coded with a 1 if at least one of these metrics occurs in one of the company's reports and 0 otherwise. The next step is to average the subtype scores for each metric type. The TNFD Metrics score is the average of the four metric-type scores. A TNFD Metrics score of 1 indicates that all subtypes of metrics are included in one of the company's reports.

The summary statistics for the main sample (*Europe*) are depicted in Table A5. The median company has a market capitalization of 6.99 billion USD (mean: 19.38 billion USD).¹³ Table A6 depicts the differences in median and mean company size across countries. On average, public blue-chip companies appear to be larger in Western and Northern Europe than in Eastern and Southern Europe.

4. Results

4.1. Who Reports?

Almost all companies in the sample mention sustainability or the environmental pillar of sustainability in their reports (Figure A2). But while 96.10% of the companies refer to climate change in their reports, only 74.93% of them mention “biodiversity”. The average score is even lower for the TNFD reporting dimensions. The median TNFD score of companies in the *Europe* sample is only 0.33 (mean: 0.35).¹⁴ Hence, the median company only mentions one-third of the TNFD-related dimensions.

In addition, there seems to be substantial cross-sectional variation depending on the headquarters country, the economic sector and the company size. First, the mean TNFD score is higher for companies headquartered in Germany, Spain and Portugal. It is lower for companies based in Hungary, Poland and Slovakia. In general, companies based in Western and Southern Europe tend to have a higher mean TNFD score than companies headquartered in Eastern and Northern Europe (Figure 4).

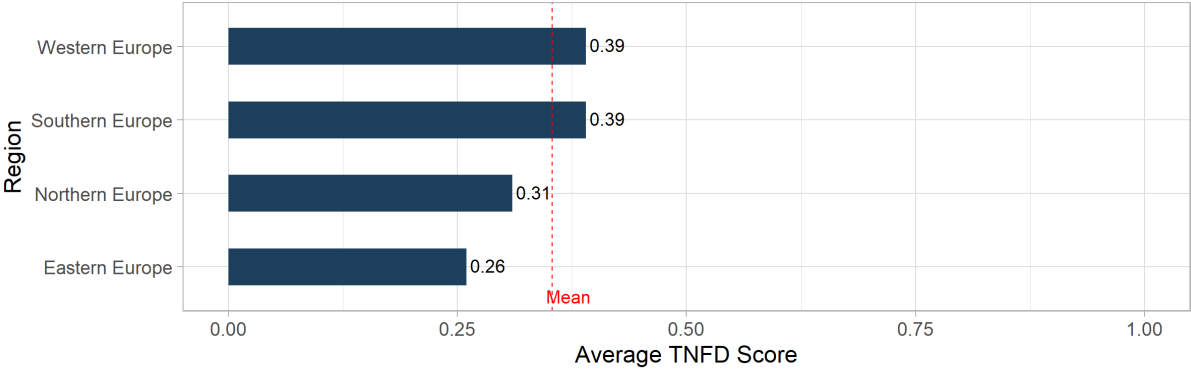
Second, the mean TNFD score is higher for companies in the utilities, energy and basic materials sector (Figure 5). The high score of the basic materials companies is mainly driven by companies in the applied resources sector (e.g., paper and forest) and mineral resources industry (e.g., metals and mining). The

¹² The manual review has been validated by two research assistants.

¹³ The other sample (*Germany*) includes 142 companies. The median company in this sample has a market capitalization of 3.12 billion USD (mean: 11.90 billion USD).

¹⁴ The median company in the *Germany* sample has a TNFD score of 0.31 (mean: 0.35).

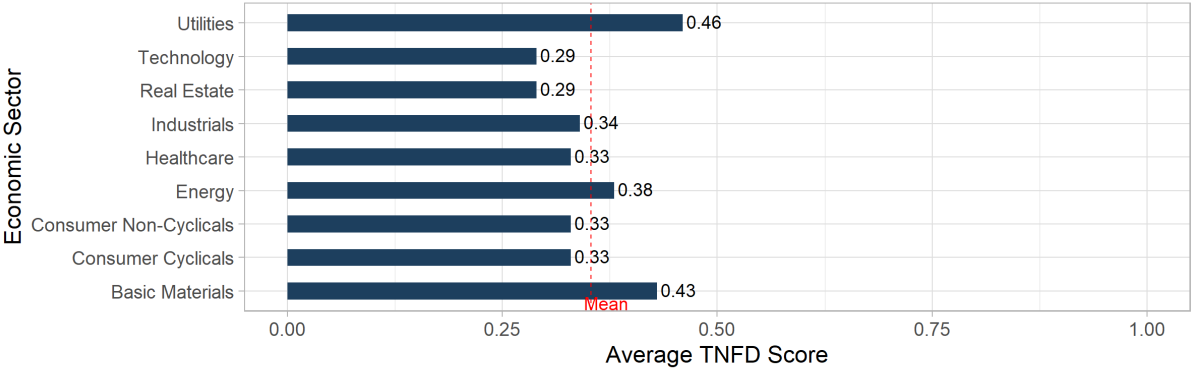
Figure 4: Average TNFD Score per Region (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, S&P Global Capital IQ.

energy companies are primarily associated with fossil fuels (e.g., coal, oil, or gas). The mean TNFD score is lower for companies in real estate, technology (e.g., software and IT services or technology equipment) and health care (e.g., medical research).¹⁵

Figure 5: Average TNFD Score per Sector (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, S&P Global Capital IQ.

Third, larger companies tend to have a higher mean TNFD score than smaller companies (Figure A3). These results are obtained when company size is measured using size quartiles and size deciles based on market capitalization in June 2022. For the *Germany* sample, the results also suggest a positive relationship between company size and the TNFD score (Figure A4). The reporting gap between small and large companies seems to be particularly large for governance measures, metrics, risk identification and strategy measures, both in the *Europe* and *Germany* sample.

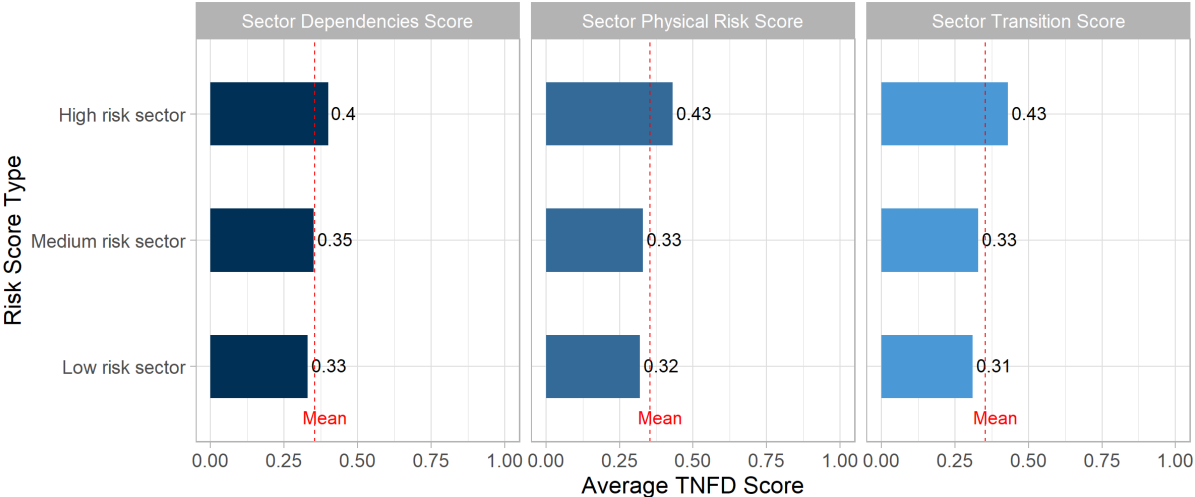
To analyze the cross-sectional variation across sectors and countries in more detail, the sample is combined with various measures of nature-related risk, which are described in more detail in Appendix B. All measures are normalized as values between 0 and 1, with a value of 1 indicating high nature-related risk. Three measures are used to rank economic sectors according to their relative nature-

¹⁵ Similar cross-sectional results are obtained for the *Germany* sample.

related risks: a sector dependencies score based on the work of the UN-based sustainability network of global insurance regulators (Sustainable Insurance Forum 2021), a sector physical risk score based on calculations of the World Economic Forum (WEF 2022) and a sector transition risk score based on the TNFD priority sectors (TNFD 2023). After ordering companies into high, medium, and low-risk sectors according to their relative dependence on nature, physical risk and transition risk, the average TNFD score is calculated for each of these subgroups. Figure 6 shows that companies in sectors with higher dependencies and nature-related risks, tend to have, on average, a higher TNFD score.¹⁶ This means that these companies appear to report more TNFD-related dimensions on average.

For nature-related country-level risks, two measures are used to rank EU countries according to their relative nature-related risks: a country physical risk score based on the IUCN Red List (OECD 2023) and a country transition risk score based on the Yale Environmental Performance Index sub score related to biodiversity (EPI 2023). In addition, a country climate risk score based on the Germanwatch Climate Risk Index (Eckstein et al. 2021) is employed to account for interactions between climate change and biodiversity loss. Based on these risk scores, countries are sorted into quintiles.¹⁷ For each of these groups, the mean TNFD score is calculated. Figure A5 shows that companies that are headquartered in countries with higher nature-related and climate risks tend to have, on average, a higher TNFD score.

Figure 6: Average TNFD Score per Sector Risk Tercile (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, S&P Global Capital IQ and the author's calculation.

¹⁶ The results are similar for the *Germany* sample.

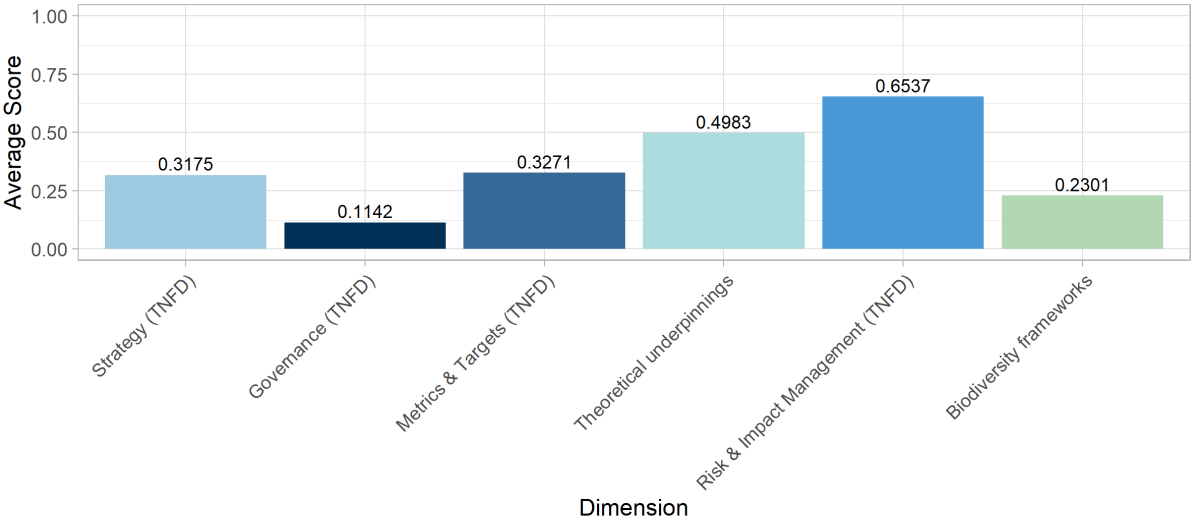
¹⁷ Since there are more countries than economic sectors, quintiles are used to provide a more detailed analysis. However, the results are robust even when using terciles.

4.2. What is Reported?

4.2.1. Correspondence of Current Disclosures with the TNFD Dimensions

The average score of the individual TNFD dimensions varies considerably (Figure 7). While 65.37% of companies disclose information on nature-related risk and impact management, only 11.42% of the companies describe how nature-related risks are internally governed. 31.75% of the companies publicly share their biodiversity strategy efforts, while 32.71% report on biodiversity metrics and targets. The results also suggest heterogeneity within the TNFD dimensions (Figure A6).¹⁸ With respect to the strategy dimension, for example, most companies disclose information on their biodiversity impacts (i.e., 91.92%), while very few companies report that they are dependent on biodiversity and nature (i.e., 5.29%). The analysis also suggests that only a small share of companies (i.e., 8.64%) appear to publicly acknowledge nature-related risks or opportunities based on identified nature-related company impacts and dependencies. According to the manual review, only a few companies that publicly acknowledge nature-related risks and opportunities describe them in detail. One of the exceptions is Stellantis, a Dutch cyclical consumer goods company, which describes in detail how new taxes, higher

Figure 7: Average Score per Dimension (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

insurance premiums and new subsidies create nature-related transition risks for the company. In addition, 21.17% of the companies disclose that they implemented strategy-related actions like a biodiversity action plan or a biodiversity strategy. Regarding climate change, 29.81% of the companies in the sample use expressions that underline the interaction between climate change and biodiversity.

¹⁸ With respect to the theoretical underpinnings, there is also substantial heterogeneity. While more than half of the companies mention basic biodiversity concepts, drivers of biodiversity loss and the environmental asset concept, less than 10% refer to planetary boundaries, ecosystem services and existing measurement concepts.

In addition to strategy-related disclosures, the proposed TNFD framework also recommends reporting on biodiversity-related governance measures taken by the company. Governance measures can support the institutional integration of nature-related risk management into the company. However, only 11.42% of companies refer to governance measures such as a biodiversity task force or ecosystem-based pricing systems. In addition, several frameworks recommend a joint monitoring approach for climate and nature-related risks to account for the interdependencies. The manual review suggests that at least some companies are taking such an integrated approach by monitoring climate- and nature-related risks together. For example, the French consumer cyclical company Hermes or the Italian consumer cyclical company Moncler mention such an approach.

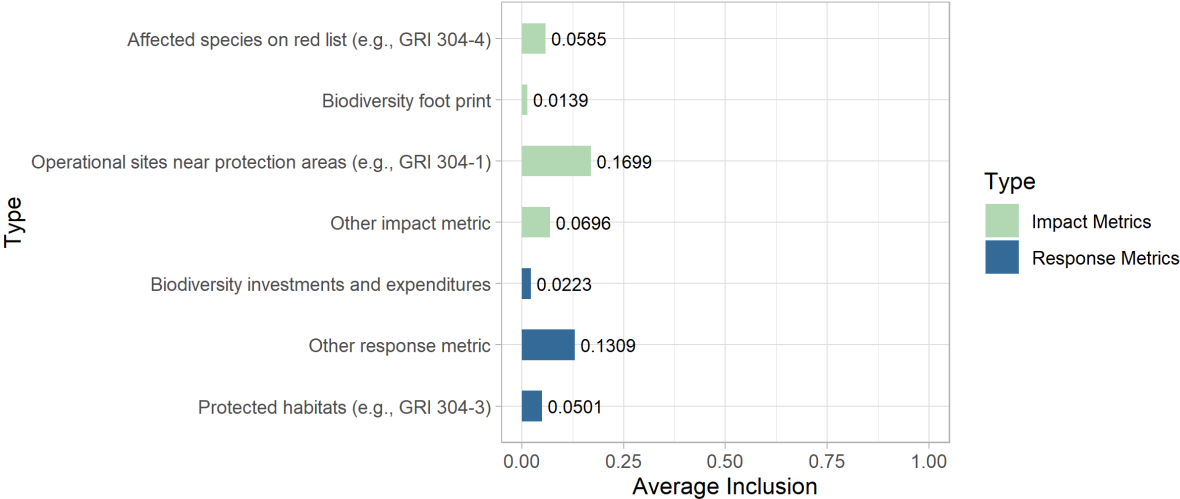
With respect to the proposed risk and impact management measures, 54.87% of the companies describe how they identify their nature-related impacts and dependencies. They use, for instance, an environmental impact assessment or a vegetation analysis. In addition, 69.08% of the companies mention policy- and guidance-related actions such as a biodiversity handbook or a no-deforestation-policy. Measures to curb nature-related risks, which can range from general tools like a biodiversity loss management to topic-specific tools such as a bird monitoring program or an integrated pest management are mentioned by 72.14% of the companies. When specifying their risk management measures, companies often report on specific projects to explain their nature-related risk management. The Belgium utilities company Elia, for example, describes how it manages biodiversity impacts by describing a project on green corridors under overhead electrical lines in forests. Other companies mention more simpler measures, such as installing a bee hotel.

Finally, the proposed TNFD framework recommends the disclosure of targets and metrics. Targets can be very general (e.g., promoting or restoring biodiversity) or more specific (e.g., targets related to the drivers of biodiversity loss such as halting habitat loss or reducing invasive species). Many companies disclose such general biodiversity-related targets (i.e., 78.55%). Overarching targets have already been used prominently for climate change mitigation. Targets like "net zero" or "1.5C" aggregate several sub-targets into one main target. Similar overarching targets also exist for biodiversity: "nature-positive", "net gain of biodiversity" or "no net loss of biodiversity". There is, however, no consensus how such constructs are defined. Currently, only 7.52% of the companies mention such overarching targets. These are mostly energy companies, large companies and companies from France and Portugal.

The proposed TNFD framework sets out four types of metrics: risk and opportunity metrics, impact metrics, dependency metrics and response metrics (TNFD 2023). While almost one-third of the companies report risk and opportunity metrics, a much smaller share includes the other three types (Figure A7). Furthermore, many companies do not refer to a specific standard when reporting on metrics. However, if a standard is referred to, it is often the standards of the Global Reporting Initiative (GRI).

If companies report a risk and opportunity metric, it is always a materiality matrix as recommended by the GRI Materiality Standard 101. Figure A8 shows an example of such a materiality matrix, which is usually spanned by two axes: the importance of biodiversity to stakeholders and the impact of biodiversity on the company. Both are assessed by the company in relation to other sustainability risks. 31.48% of the companies report biodiversity separately from climate in their materiality matrix. 43.36% (16.81%) of the companies disclosing such a matrix report that they perceive the relative importance of biodiversity for stakeholders as low (high). 43.36% (15.93%) of the companies disclosing such a matrix indicate that they rate the relative impact of the company on biodiversity as low (high). Impact metrics are reported by 7.80% of the companies. There are different types of impact metrics: the biodiversity footprint of the company, affected species on the IUCN red list (e.g., following GRI 304-4), the operational sites near protection areas (e.g., following GRI 304-1) or others (Figure 8). Overall, only 1.39% of the companies quantify (parts of) their overall biodiversity footprint. The French industrial company Schneider Electric, for instance, calculates its biodiversity footprint and outlines the drivers of this footprint. Similarly, the French cyclical consumer goods company Kering quantifies its impact on nature along its value chain. Furthermore, only 5.85% of companies indicate which threatened species are affected by their activities and 16.99% of companies describe the operational sites (e.g., in terms of size or location) that are located in protected areas or areas of high biodiversity. Only 1.67% of the companies disclose dependency metrics. These companies mostly quantify how

Figure 8: Average Inclusion of Impact and Response Metrics Subtypes (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

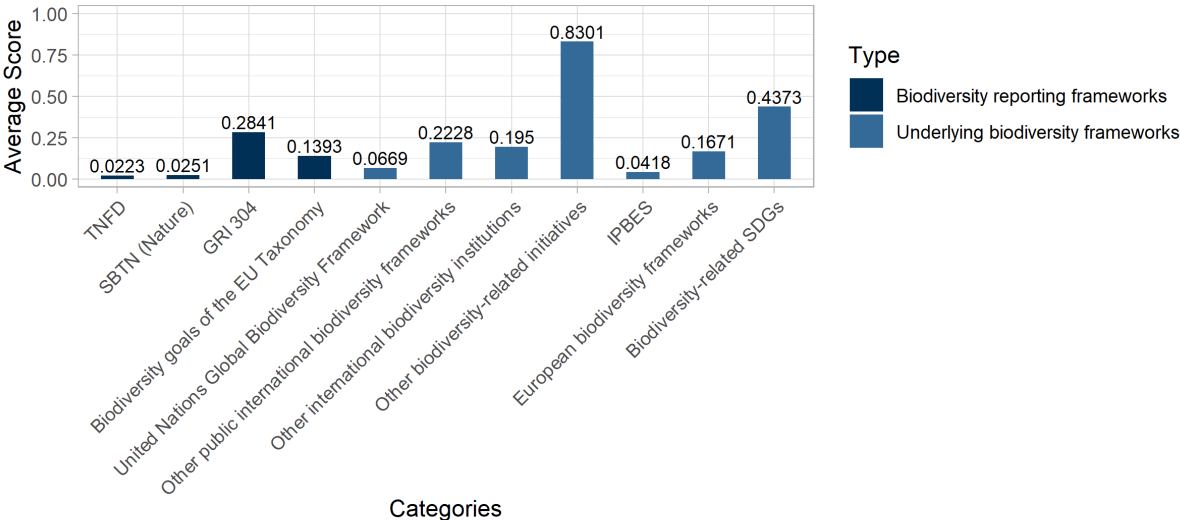
much revenue depends on activities sensitive to declines in biodiversity. Finally, 6.78% of the companies disclose a response metric. These include metrics on biodiversity investments and expenditures, protection measures in protected habitats (e.g., following GRI 304-3) or other company responses (Figure 8). Overall, only 2.23% of the companies outline their biodiversity-related investments and

expenditures. In addition, 5.01% of the companies disclose at least one metric on protection measures in protected habitats. The Spanish utilities company Naturgy Energy Group, for instance, provides a description of habitats that are protected or restored, including their location, the activity associated with the site and the size of the protected area.

4.2.2. Level of Standardization of Current Disclosures

The dimension on biodiversity frameworks is used to examine which companies refer to such frameworks in their corporate reports (Figure 9). Overall, companies refer to a wide range of frameworks, which are described in Appendix C. As TNFD is a relatively new initiative, only 2.23% of the companies mention it in their reports. In contrast, the longer established topic standard GRI 304 is cited by 28.41% of the companies in the sample. This is in line with estimates by the GRI (CDSB 2021). However, this figure is likely overstated, as the manual review also shows that several companies refer to this standard but simply state that they currently do not report anything under it. In addition, while more than half of the companies in the sample generally refers to SBTN, very few companies explicitly mention the SBTN’s guidance for businesses on nature-related goals (i.e., 2.51%). 13.93% of the companies mention the biodiversity-related goals of the EU taxonomy. Moreover, many companies disclose their involvement in various private biodiversity initiatives such as "Entreprises pour l'Environnement", "Transforming Fashion for Nature" or "We Value Nature". Some of these initiatives are initiated or led by public agencies, such as the "Spanish Company and Biodiversity Initiative", which is led by the Spanish Federal Ministry of Environment. In addition to such initiatives, companies disclose their membership in various product-specific associations and initiatives like the "Fur Free Alliance", the "Roundtable on Responsible Soy" or the "Sustainable Palm Oil Forum".

Figure 9: Average Reference of Frameworks (Europe Sample)



Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

5. Conclusion and Implications

This study explores the current state of biodiversity reporting through textual analysis of the 2021 corporate reports of 359 European blue-chip companies. It further assesses the extent to which current reporting aligns with the proposed disclosure framework of the TNFD.

Although the topic biodiversity is mentioned by three-quarters of the companies at least once in their reports, the results of the text analysis show that current biodiversity reporting deviates substantially from the recommendations of the proposed TNFD framework. Currently, companies focus primarily on reporting biodiversity impacts. Less than 9%, on the other hand, publicly acknowledge nature-related dependencies or risks. Similarly, companies rarely describe the strategy and governance measures they employ. Only risk management measures and broad targets are reported relatively often. Moreover, current biodiversity disclosures often lack quantification, details and specific targets. While, for instance, more than 30% of the companies report a risk and opportunity metric, less than 8% include response or impact metrics. Only five companies in the sample provide a dependency metric. This lack of substantiation suggests that there are barriers and high costs to more robust disclosures. In addition to the aforementioned variety of metrics, companies that provide biodiversity information also use a wide range of reporting frameworks. The forthcoming TNFD framework, which aims to provide a standardized framework and guidance on how to report on biodiversity matters, may help to overcome this lack of standardization.

Substance, credibility and standardization are important prerequisites for making disclosed information more useful to the users of corporate reporting. The provision of useful information, in turn, may be a necessary condition to affect decision-making and enable a shift in financial flows from nature-negative to nature-positive outcomes. Mandatory disclosure requirements may, in addition, help to speed up the process of disclosure and extend it to a larger group of companies. For European companies, such reporting is already in sight, as the first companies within the scope of the CSRD will have to apply the European Sustainability Reporting Standards (ESRS) as of January 2024. These standards also cover the topics biodiversity and ecosystems (i.e., ESRS E4). Similarly, the ISSB is planning to integrate biodiversity reporting in their new set of standards (ISSB 2023). While the introduction of such reporting standards may help overcome the current lack of substantiation and standardization, it may also entail further efforts and costs for companies, given the current low level of reporting.

However, the results also suggest that companies with higher risks are currently reporting more than others. This descriptive evidence on biodiversity reporting is broadly consistent with a large strand of literature stating that voluntary reporting, in particular sustainability reporting, follows a risk-driven approach (Christensen et al. 2021). In particular, this study shows that companies headquartered in

countries with higher nature-related risks as well as companies belonging to sectors with higher dependencies and nature-related risks are, on average, more likely to report on biodiversity. Similar results are obtained for both nature-related physical and transition risks. While this risk-based reporting may reduce the impact of the introduction of the TNFD framework and other upcoming standards, the overall level of current biodiversity reporting is still relatively low and largely not aligned with them.

It, however, should be noted that the findings are descriptive, not necessarily causal. In addition, the research method and the country- and sector-based risk measures are rather simple given the early state of the literature. Nonetheless, this exploratory study is one of the first highlighting the current low level of biodiversity reporting and the substantial gap with upcoming standards. Future research could shed more light on the internal availability of such information, develop sound measures to assess company-level risks and evaluate the usefulness of the required disclosures.

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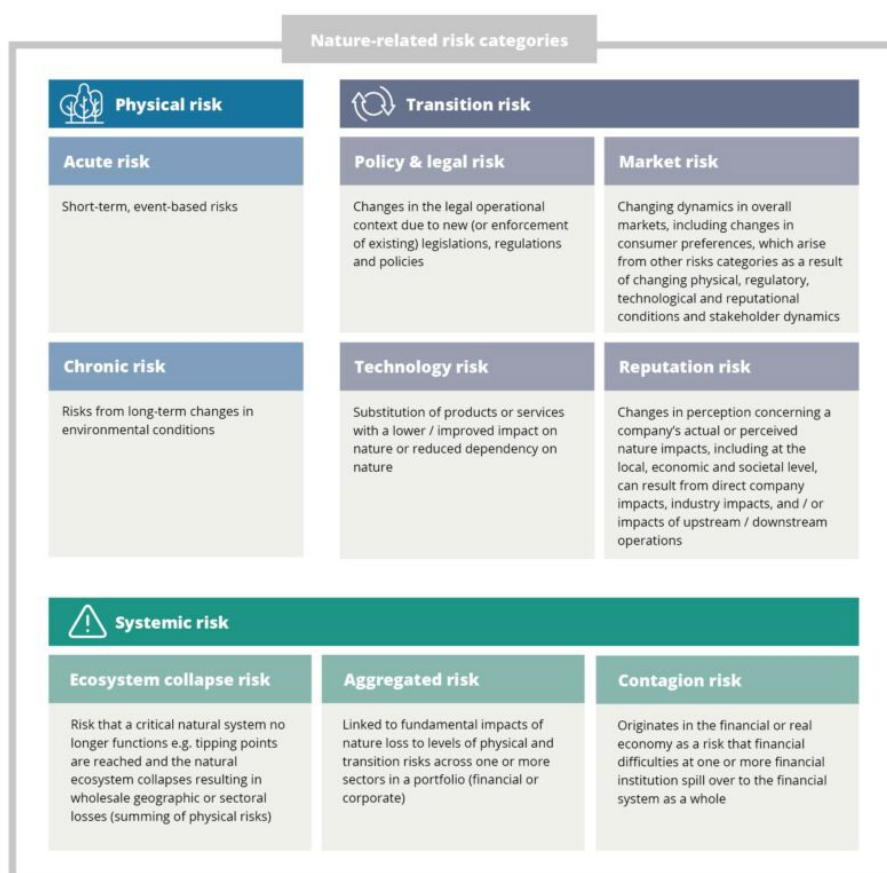
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Appendix A: Further Tables and Figures

Figure A1: TNFD's Definitions of Nature-Related Risks



Source: TNFD (2023).

Table A1: Coverage for the *Europe* Sample

Country	Index	Non-financial companies	In sample	Coverage
Austria	ATI	15	15	100%
Belgium	BEL 20	16	15	93%
Czech Republic	PX Index	6	4	67%
Denmark	OMX 20	18	16	89%
Finland	S&P Finland BMI Index (First 40 by market capitalization)	36	35	97%
France	CAC40	35	34	97%
Germany	DAX	35	35	100%
Greece	Athex Composite Share Price Ind (First 40 by market capitalization)	35	30	86%
Hungary	BUX	14	11	79%
Ireland	ISEQ All Share Index	16	15	94%
Italy	S&P Italy BMI Index (First 40 by market capitalization)	33	31	94%

Luxembourg	LuxX	6	4	67%
Netherlands	Amsterdam Exchange Index	20	18	90%
Poland	S&P Poland LargeMidCap Index	16	15	93%
Portugal	PSI 20	15	13	87%
Romania	Bucharest Exchange Trading	17	16	94%
Slovakia	SAX	3	2	67%
Spain	IBEX 35	29	27	93%
Sweden	OMX 30 Stockholm	24	23	96%

Source: S&P Global Capital IQ.

Table A2: Coverage for the *Germany* Sample

Country	Index	Non-financial companies	In sample	Coverage
Germany	DAX	34	32	94%
Germany	MDAX	48	46	96%
Germany	SDAX	65	61	94%

Source: S&P Global Capital IQ.

Table A3: Dimensions of Biodiversity Reporting

Dimension	Subdimension	Score	Exemplary word(s)
Overview	Sustainability at all?	0 or 1	<i>Sustainability</i>
Overview	Environment at all?	0 or 1	<i>Environment</i>
Overview	Biodiversity at all?	0 or 1	<i>Biodiversity</i>
Overview	Climate at all?	0 or 1	<i>Climate</i>
Strategy (TNFD)	Impacts	0 or 1	<i>Biodiversity footprint</i>
Strategy (TNFD)	Dependencies	0 or 1	<i>Depend on biodiversity</i>
Strategy (TNFD)	Nature-related risks and opportunities	0 or 1	<i>Nature-related risk</i>
Strategy (TNFD)	Strategy measures	0 or 1	<i>Action plan on biodiversity</i>
Governance (TNFD)	Governance	0 or 1	<i>Biodiversity task force</i>
Risk and Impact Management (TNFD)	Measures for identification	0 or 1	<i>Biodiversity assessment</i>
Risk and Impact Management (TNFD)	Policy and guidance	0 or 1	<i>Biodiversity policy</i>
Risk and Impact Management (TNFD)	Risk management measures	0 or 1	<i>Bird monitoring program</i>
Metrics and Targets (TNFD)	TNFD Metrics ¹⁹	0 to 1	→ <i>Table A4</i>
Metrics and Targets (TNFD)	Specific targets	0 or 1	<i>Protect biodiversity</i>
Metrics and Targets (TNFD)	Overarching targets	0 or 1	<i>No net loss by</i>
Theoretical underpinnings	Basic biodiversity definitions	0 or 1	<i>Endangered species</i>
Theoretical underpinnings	Planetary boundaries at all?	0 or 1	<i>Planetary boundaries</i>
Theoretical underpinnings	Explicit planetary boundaries	0 or 1	<i>Biogeochemical flow</i>
Theoretical underpinnings	Negative effects on biodiversity	0 or 1	<i>Biodiversity loss</i>

¹⁹ As indicated in the text, this subdimension was manually checked by two research assistants and myself for validation purposes. The sub-subdimensions of this subdimension are shown in Table A4.

Theoretical underpinnings	Drivers of biodiversity loss	0 or 1	<i>Degrade habitat</i>
Theoretical underpinnings	Realms	0 or 1	<i>Freshwater</i>
Theoretical underpinnings	Land biomes	0 or 1	<i>Grassland</i>
Theoretical underpinnings	Freshwater biomes	0 or 1	<i>Lagoon</i>
Theoretical underpinnings	Ocean biomes	0 or 1	<i>Marine shelf</i>
Theoretical underpinnings	Environmental assets	0 or 1	<i>Environmental asset</i>
Theoretical underpinnings	Ecosystem services at all?	0 or 1	<i>Ecosystem services</i>
Theoretical underpinnings	Ecosystem – Overview of types	0 or 1	<i>Regulating and maintenance services</i>
Theoretical underpinnings	Ecosystem services – Provisioning services	0 or 1	<i>Biomass</i>
Theoretical underpinnings	Ecosystem services – Cultural services	0 or 1	<i>Hiking</i>
Theoretical underpinnings	Ecosystem services – Regulating and maintenance services	0 or 1	<i>Detoxification</i>
Theoretical underpinnings	Ecosystem services – ENCORE and IPBES	0 or 1	<i>Pollination</i>
Theoretical underpinnings	Connection with climate change	0 or 1	<i>Biodiversity loss and climate change</i>
Theoretical underpinnings	Mitigation hierarchy	0 or 1	<i>Mitigation Hierarchy</i>
Theoretical underpinnings	Measurement concepts – NGFS and INSPIRE	0 or 1	<i>ENCORE</i>
Theoretical underpinnings	Measurement concepts – Dasgupta	0 or 1	<i>Living planet index</i>
Biodiversity frameworks	Biodiversity SDGs	0 or 1	<i>SDG 14</i>
Biodiversity frameworks	IPBES	0 or 1	<i>IPBES</i>
Biodiversity frameworks	Other international biodiversity institutions	0 or 1	<i>Wildlife Habitat Council</i>
Biodiversity frameworks	United Nations Global Biodiversity Framework	0 or 1	<i>Global Biodiversity Framework</i>
Biodiversity frameworks	Other public international biodiversity frameworks	0 or 1	<i>Aichi</i>
Biodiversity frameworks	European biodiversity frameworks	0 or 1	<i>Habitats Directive</i>
Biodiversity frameworks	Biodiversity goals of the EU Taxonomy	0 or 1	<i>Protection and restoration of biodiversity and ecosystems</i>
Biodiversity frameworks	Science Based Targets Network – Nature	0 or 1	<i>Science Based Targets for Nature</i>
Biodiversity frameworks	TNFD	0 or 1	<i>Taskforce on Nature-related Financial Disclosures</i>
Biodiversity frameworks	GRI 304	0 or 1	<i>304-4</i>
Biodiversity frameworks	Other biodiversity-related initiatives	0 or 1	<i>Act4Nature</i>
Biodiversity frameworks	Product-specific associations and initiatives	0 or 1	<i>Roundtable on Sustainable Palm Oil</i>
Biodiversity frameworks	Cooperation with biodiversity NGOs and institutes	0 or 1	<i>BirdLife Europe</i>

Source: Own depiction.

Table A4: Biodiversity Metrics in Reporting (TNFD Metrics)

Dimension	Subdimension	Score
Risk and Opportunity (TNFD)	Biodiversity in materiality matrix?	0 or 1
Risk and Opportunity (TNFD)	Materiality matrix – Relative relevance for stakeholders	1 to 3 ²⁰
Risk and Opportunity (TNFD)	Materiality matrix – Relative company impact	1 to 3 ²¹
Impact (TNFD)	Biodiversity footprint	0 or 1
Impact (TNFD)	Affected protected species on red list (e.g., GRI 304-4)	0 or 1
Impact (TNFD)	Operational sites near protection areas (e.g., GRI 304-1)	0 or 1
Impact (TNFD)	Other impact metric	0 or 1
Dependency (TNFD)	Strategy measures	0 or 1
Response (TNFD)	Biodiversity investments and expenditures	0 or 1
Response (TNFD)	Protected habitats (e.g., GRI 304-3)	0 or 1
Response (TNFD)	Other response metric	0 or 1

Source: Own depiction.

Table A5: Summary Statistics (Europe Sample)

Variables	N	Mean	Min	Median	Max	SD
TNFD Score	359	0.35	0.00	0.33	0.88	0.19
Dimension Score - Strategy (TNFD)	359	0.32	0.00	0.25	1.00	0.18
Dimension Score - Risk and Impact Management (TNFD)	359	0.65	0.00	0.67	1.00	0.36
Dimension Score - Governance (TNFD)	359	0.11	0.00	0.00	1.00	0.32
Dimension Score - Metrics and Targets (TNFD)	359	0.33	0.00	0.33	0.88	0.19
Dimension Score – Theo- retical Underpinnings	359	0.50	0.00	0.50	0.80	0.14
Dimension Score – Biodiversity Frameworks	359	0.23	0.00	0.23	0.85	0.17
Market Capitalization (Million USD) in 2022	359	19,375.68	22.16	6,994.61	347,315.81	37,187.71

Source: Own depiction.

²⁰ A score of 1, 2 or 3 indicates a low, medium or high positioning of biodiversity in the materiality matrix on the relative stakeholder relevance axis, respectively.

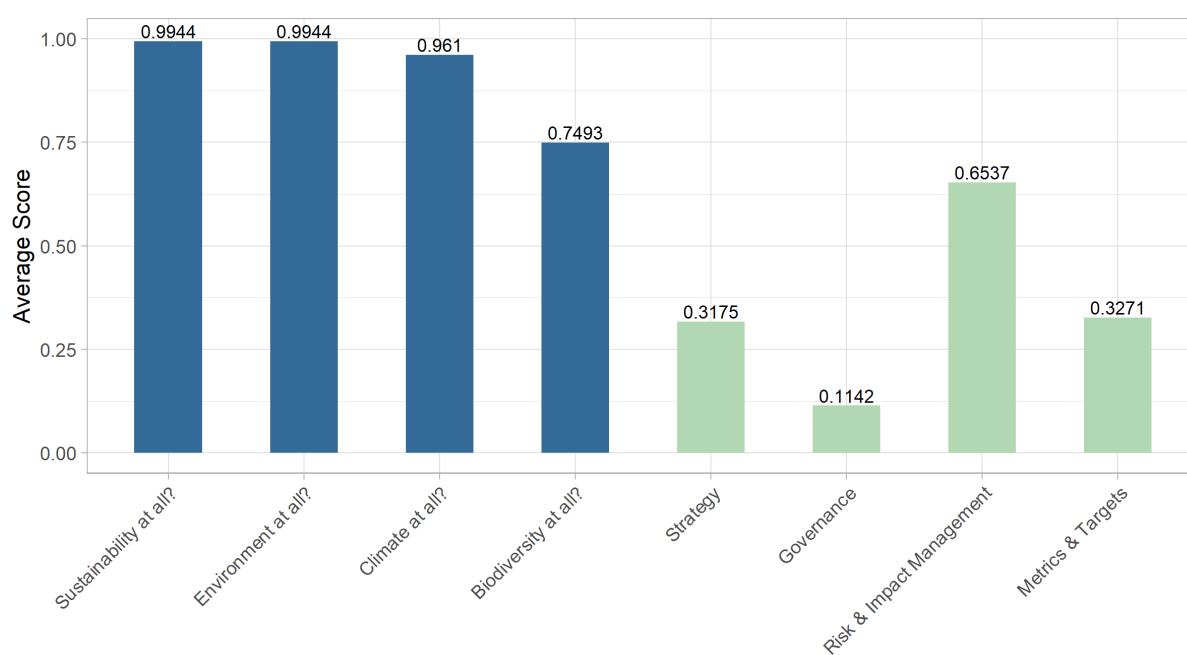
²¹ A score of 1, 2 or 3 indicates a low, medium or high positioning of biodiversity in the materiality matrix on the relative company impact axis, respectively.

Table A6: Selected Summary Statistics across Countries (Europe Sample)

Country of Issuer	N	Mean Market Capitalization (Million USD) in 2022	Median Capitalization (Million USD) in 2022	Mean TNFD Score	Median TNFD Score
Austria	15	4,368.51	2,538.23	0.35	0.33
Belgium	15	12,828.73	4,729.02	0.34	0.32
Czech Republic	4	7,548.72	3,686.97	0.32	0.28
Denmark	16	30,357.10	17,073.64	0.30	0.23
Finland	35	5,878.10	2,045.24	0.30	0.31
France	34	55,095.60	31,729.11	0.41	0.42
Germany	35	38,630.79	26,125.55	0.44	0.40
Greece	30	1,481.06	554.33	0.37	0.36
Hungary	11	1,067.81	149.45	0.24	0.23
Ireland	15	7,231.05	922.66	0.40	0.40
Italy	31	12,694.95	9,071.84	0.35	0.33
Luxembourg	4	2,554.21	1,925.37	0.26	0.24
Netherlands	18	56,027.87	24,411.12	0.37	0.31
Poland	15	3,826.51	3,147.63	0.24	0.31
Portugal	13	6,219.04	1,936.31	0.42	0.42
Romania	16	1,120.93	403.26	0.28	0.24
Slovakia	2	98.00	98.00	0.15	0.15
Spain	27	15,295.02	7,866.47	0.46	0.43
Sweden	23	26,291.00	15,843.23	0.25	0.25

Source: Thomson Reuters Datastream and S&P Global Capital IQ.

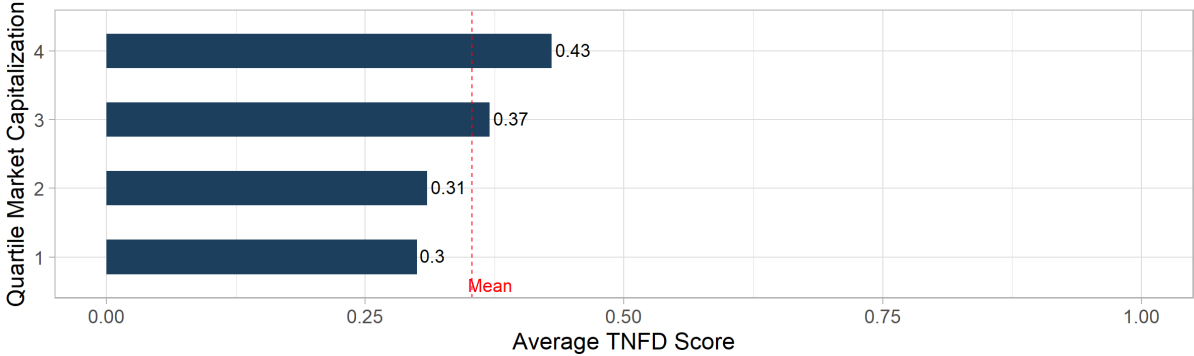
Figure A2: Average Score across Overview Categories and TNFD Dimensions (Europe Sample)



Overview Categories (Blue) and TNFD Dimensions (Green)

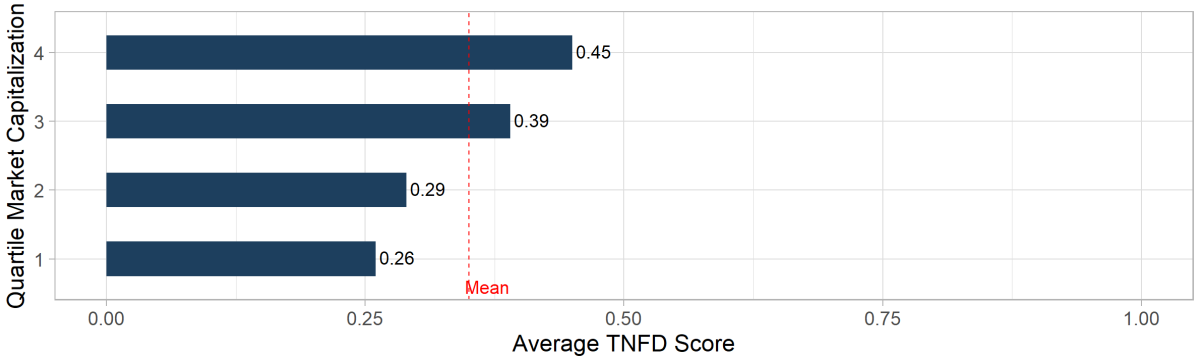
Source: the 2021 financial statements of companies, Thomson Reuters Datastream, S&P Global Capital IQ and the author's calculation.

Figure A3: Average TNFD Score per Company Size Quartile (Europe Sample)



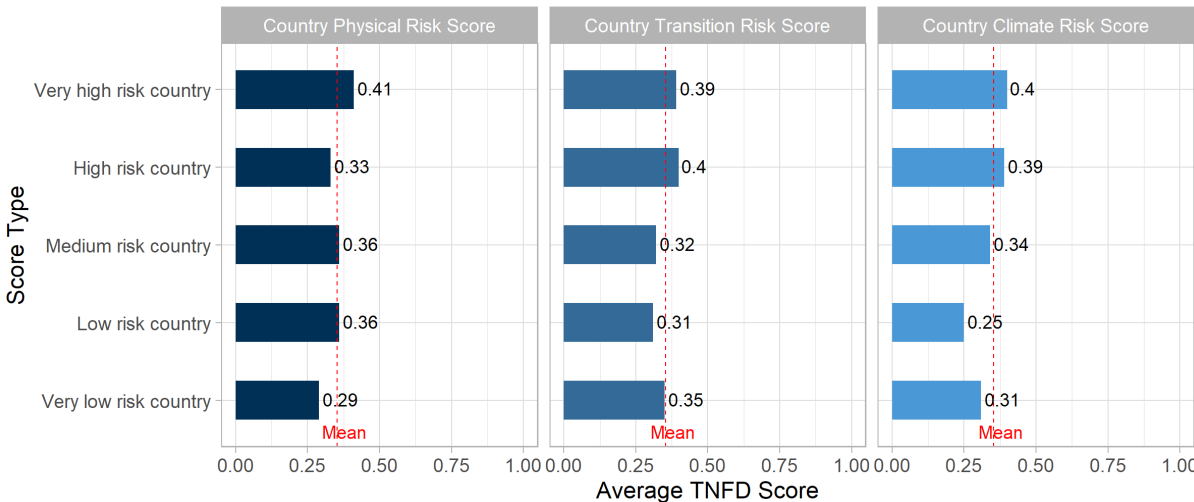
Note: Company size is determined by market capitalization as of June 2022. 1 is the smallest company. 4 is the largest company. Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

Figure A4: Average TNFD Score per Company Size Quartile (Germany Sample)



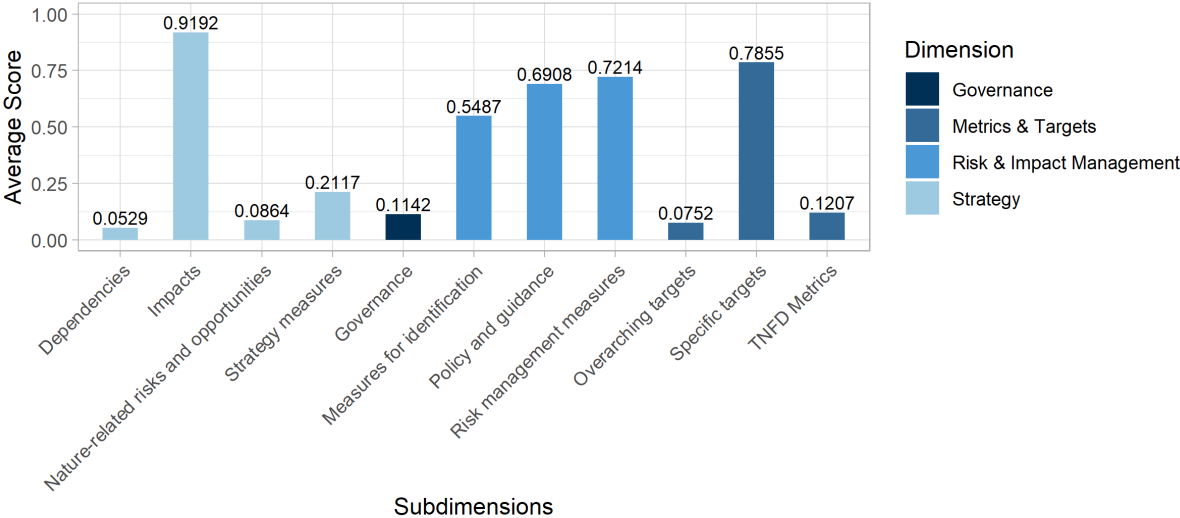
Note: Company size is determined by market capitalization as of June 2022. 1 is the smallest company. 4 is the largest company. Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

Figure A5: Average TNFD Score per Country Risk Quintile (Europe Sample)



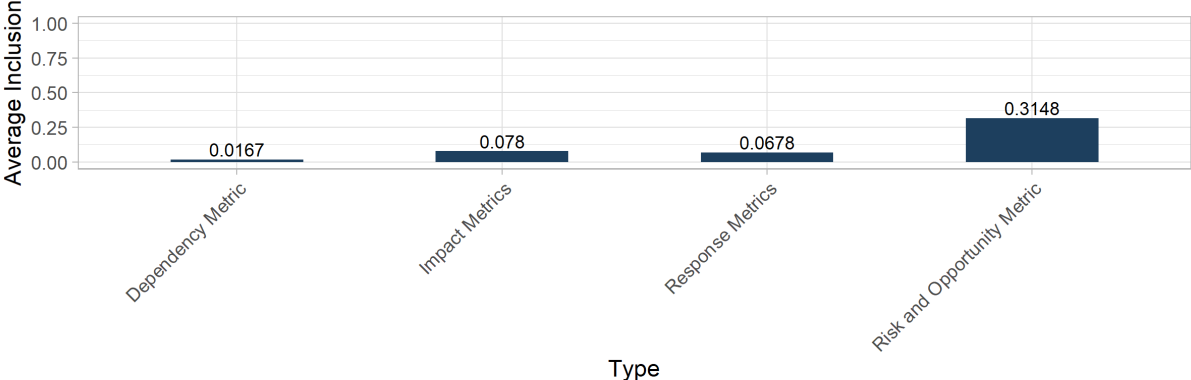
Source: the 2021 financial statements of companies, Thomson Reuters Datastream, S&P Global Capital IQ and the author's calculation.

Figure A6: Average Score Within the TNFD Dimensions (Europe Sample)



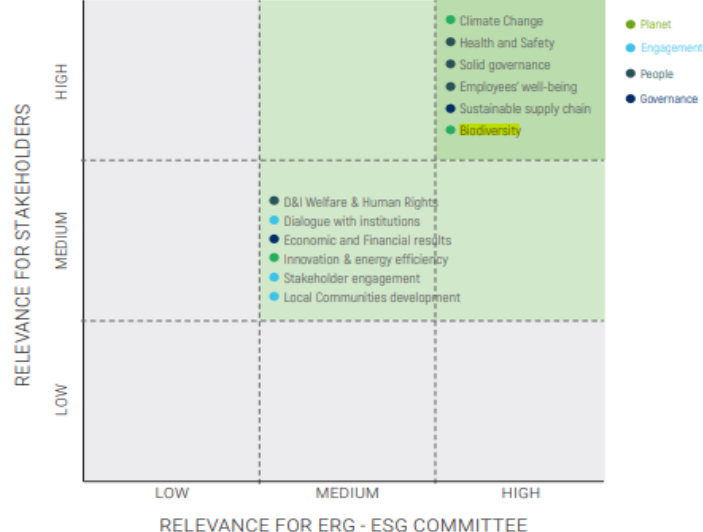
Source: the 2021 financial statements of companies, Thomson Reuters Datastream, and S&P Global Capital IQ.

Figure A7: Average Inclusion of Metrics per Type (Europe Sample)



Source: the 2021 financial statements of companies, and S&P Global Capital IQ.

Figure A8: Materiality Matrix Disclosed by the Italian Utilities Company ERG



Source: 2021 annual report of ERG.

Appendix B: Nature-related Risk Measures

Given the limitations in measuring the impact of biodiversity loss and biodiversity dependence as well as the early state of the literature, it is challenging to directly measure company-level nature-related risks (Karolyi and Tobin-de la Puente 2022; NGFS and INSPIRE 2022). Hence, country- and sector-level proxies are used to capture these risks. In addition, different proxies are employed to capture different types of risk factors (e.g., nature-related transition and physical risks).²²

For the nature-related sector-level risks, three measures are used: a sector dependencies score, a sector physical risk score and a sector transition risk score. First, the sector dependencies score is derived from a relative sector classification in a scoping study conducted by the Sustainable Insurance Forum (SIF). SIF is a global network of insurance supervisors and regulators focusing on sustainability issues in the insurance sector (Sustainable Insurance Forum 2021). An insurance-based sector classification might be particularly suited as insurance regulators likely have – due to the business model of the companies they supervise – high competence in assessing nature-related risks in all sectors of an economy. It is also used as an input by individual regulators like the EU insurance regulator EIOPA (e.g., EIOPA 2023). The sector classification is based on expert consultations, qualitative research and estimations using data from McKinsey & Company's Global Insurance Pools database and publicly available property and casualty insurance premium data.²³ The economic sectors with the highest dependencies on nature are utilities and consumer non-cyclicals (i.e., food & beverage). Health care (i.e., pharmaceutical) and consumer cyclicals (e.g., media & entertainment) have the lowest dependencies. Second and closely related, the sector physical risk score is derived from the relative sector classification of the World Economic Forum (WEF 2022). The WEF is based on the evaluation of the disruption risk of 19 industry sectors by considering their economic contributions (i.e., GDP) to cities. Each sector was assigned a disruption risk score out of 100, which was determined by analyzing the average number of business operations affected by different environmental change factors and their impact on natural capital assets and ecosystem services. If a sector experienced more than 80% disruption in its production processes, it was classified as having a high risk. The data sources for this assessment include – among others – the ENCORE database and estimations of the consultancy Alphabeta. The economic sector with the highest nature-related physical risks is the utilities sector. Health care, technology (e.g., electronics), industrials (e.g., advanced manufacturing) and consumer cyclicals face the lowest nature-related physical risks. Third, the TNFD outlined a list of priority sectors (TNFD 2023). These are sectors that are more likely to face financial impacts due to their significant dependencies

²² Non-firm-level measures, however, may also introduce measurement error. Globally operating companies may, for example, be less dependent on the beliefs of the home country population.

²³ However, it should be noted that the classification does not account for risks cascading between sectors, which could have significant implications for sectors like chemicals and automobiles that rely heavily on other sectors.

and impacts on nature. Mapping the TNFD priority sector list directly on the Refinitiv economic sectors, however, is not feasible, as almost all economic sectors would be considered priority sectors. However, mapping can be done on a lower level (i.e., on the industry group level) due to the relatively detailed nature of the TNFD's priority sector list. Priority industry groups are, for instance, chemicals or electrical utilities. Non-priority industry groups are, for example, media & publishing or financial technology. In a second step, the prioritization of the industry groups is then used to rank the sectors on the broader level based on the relative prioritization of their industry groups. According to this, high priority sectors are utilities, energy and basic materials. Overall, the relative sector classification appears similar across all three measures. This is consistent with the notion that sectors with high physical risks are also the sectors primarily targeted by regulation. In addition, the relative sector classification is largely in line with Garel et al. (2023) and Giglio et al. (2023). Giglio et al. (2023), for instance, suggest that energy, utilities and basic materials companies have the highest nature-related risks. Technology and consumer non-cyclical companies face lower nature-related risks. Interestingly, real estate and health care companies appear to be ranked differently. While my proxies suggest that real estate and health care companies face rather low nature-related risks, Giglio et al. (2023) suggest the opposite.

For nature-related country-level risks, two measures are used: a country physical risk score and a country transition risk score. First, the country physical risk score is derived from the IUCN Red List (OECD 2023), which is the most comprehensive inventory of global species conservation status. It evaluates the extinction risk of thousands of species based on precise criteria. This list is often used as a key indicator for country physical risk (e.g., by the OECD). A country-level value of 1 is defined as that all species in a country are categorized as "Least Concern", while a value of 0 indicates the extinction of all species. In the latest available data from 2021, countries such as France, Greece and Spain have been identified as having high extinction rates (and thus high physical risk), while countries like Belgium, Finland, Luxembourg and Sweden have been classified as having low extinction rates (and thus low physical risk). Second, the country transition risk score is based on the Environmental Performance Index (EPI) of the Yale University for 2022 (EPI 2022), which provides a quantitative assessment of environmental actions of 180 countries. The Biodiversity and Habitat category within the EPI evaluates countries' efforts in preserving natural ecosystems and protecting biodiversity within their borders. It includes indicators such as terrestrial biome protection efforts, the extent of marine protected areas and various indices related to species and habitat conservation. The EPI is also used by Garel et al. (2023). According to the index, France, Germany and Poland are identified as having high transition risk due to high efforts in biodiversity protection, while Greece, Ireland, Portugal and Sweden exhibit lower transition risk. Interestingly, the two country-level measures for nature-related risks appear to display some different patterns. Countries with the highest species extinctions are, for instance, not

necessarily those that also take the most action against biodiversity loss. Countries such as Greece, Hungary, Italy or Portugal, for example, appear to face high physical risk but low transition risk.

In addition, a country climate risk score is used to examine whether interactions between climate change and reductions in biodiversity loss also play a role. The country physical climate risk score is assessed using the Global Climate Risk Index 2019, developed by Germanwatch, a non-governmental organization working for sustainable global development (Eckstein et al. 2019). The index relies on the impacts of past extreme weather events and associated socio-economic factors. It considers indicators such as the number of deaths, deaths per 100,000 inhabitants or losses in US dollars (adjusted for purchasing power parity). According to the index, Germany, Italy and Poland exhibit high physical climate risk, while Denmark, Finland, Ireland and Sweden face low physical climate risk.

Appendix C: Other Private Reporting Frameworks that Recommend Biodiversity Reporting

Besides TNFD, there are several other voluntary biodiversity reporting frameworks and standards. They are provided by the Global Reporting Initiative (GRI), the Climate Disclosure Standards Board (CDSB), the Sustainability Accounting Standards Board (SASB), the Science Based Target Network (SBTN) and the International Sustainability Standards Board (ISSB) (NGFS and INSPIRE 2022).

The GRI was founded in 1997 and is a multi-stakeholder-oriented initiative. It provides universal, sector and topic sustainability standards. The standards follow a double materiality perspective. The topic standard 304 is on biodiversity (GRI 2018). It was published in July 2018 and prescribes disclosures in four areas of reporting: Information on the location of corporate activities relevant for biodiversity (304-1), information on impacts of activities, products and services on biodiversity (304-2), information on habitats protected or restored (304-3) and information on affected threatened species (304-4). Threatened species are defined by the IUCN Red List species and national conservation lists. The standard is currently being revised (GRI 2022; NGFS and INSPIRE 2022).

The CDSB was founded in 2007 and is a business-oriented initiative. It provides a framework for reporting biodiversity-related information, which was published in November 2021. The framework prescribes the reporting of biodiversity-related information in six areas of reporting: Governance (e.g., to explain the delegation of issues to the management), management's environmental policies, strategies and targets (e.g., to summarize biodiversity policies), risks and opportunities (e.g., to describe the processes for assessing risks), sources of environmental impact (e.g., to provide impact indicators), performance and comparative analysis (e.g., to contextualize performance with baselines) as well as a managerial outlook (e.g., to explain likely future effects of biodiversity-related dependencies). The CDSB was consolidated with the ISSB in 2022 (NGFS and INSPIRE 2022).

The SASB was founded in 2011 and is a business-oriented initiative by the Value Reporting Foundation. It provides sector sustainability standards for 77 industries and follows a single materiality approach. Some of these standards also require the reporting of biodiversity-related information like ecological impacts and pollution. The SASB was consolidated with the ISSB in 2022 (NGFS and INSPIRE 2022).

The SBTN is a multi-stakeholder-oriented initiative by the Science Based Targets initiative (SBTi). It was founded in 2015 and is supported – among others – by the Carbon Disclosure Project, United Nations Global Compact, the World Resources Institute and the WWF (Rekker et al. 2022). Following the successful development of a climate targets framework, the latest efforts aim to create an integrated framework for setting and disclosing biodiversity and climate targets. A central concept within the framework is the mitigation hierarchy (i.e., AR³T Framework) which prescribes the order of the actions

a company should take: Avoid, reduce, restore and regenerate and transform. The framework has just been published in May 2023 (SBTN 2020; Quantis 2023).

The ISSB was founded in 2021 and is a business-oriented initiative. It plans to provide sustainability reporting standards which follow a dynamic materiality perspective. The ISSB already published the drafts of a general standard on sustainability reporting and a climate reporting standard. Both standards are expected to be applicable from 2024 onwards. It also plans to issue drafts related to biodiversity reporting in the future (IFRS 2023).