### **Devising Nature-Aligned Finance**

#### Abstract

This paper presents a novel approach, Natural-Aligned Finance, to foster Natural Capital Accounting (NCA) adoption in decision-making, driving financial flows towards nature recovery targets following NCA standards. Addressing obstacles and research gaps in NCA implementation in the financial sector, the study assesses public and private institutions' readiness via a comprehensive global expert survey on nature-related impacts, dependencies, and data analytics experience. A total of 613 responses were gathered, and we utilized a sample selection model in the survey design to correct self-selection bias and mitigate potential disparities in opinion between respondents and non-respondents. Findings indicate stakeholder willingness to adopt this approach, particularly with regional or national nature-positive target support. Three critical factors for promoting Natural-Aligned Finance adoption are identified: government stewardship of public and private data provision, corporate nature recovery plans, and increased sustainability-linked finance issuance. This research provides valuable insights for policymakers, financial institutions, and corporations aiming to incorporate environmental sustainability in their decision-making processes.

JEL Codes E01, O44, G23 Keywords: natural capital, nature-related risk, nature finance, nature positive, sustainability transition, sustainable finance

#### **1. Introduction**

Natural Capital<sup>1</sup> Accounting (NCA) encompasses methods for quantifying and monitoring natural resources not captured by conventional economic indicators such as Gross Domestic Product (GDP).<sup>2</sup> Recently, NCA has gained attention in the financial sector (NGFS, 2022; UNEP-FI & UNDP, 2021; World Bank, 2022) due to dramatic nature loss (IPBES, 2019) and the recognition that over half of the global economic output depends on natural assets (WEF, 2020). However, NCA's integration into decision-making remains limited as primarily focus on addressing greenhouse gas emissions, rather than other planetary boundaries or the protection of critical natural capital. Sustainable development requires fully accounting for natural wealth (Arrow et al., 2010; World Bank, 2021b), but political, technological, and budgetary restrictions have impeded the development of comprehensive environmental measurements for policy use (Brandon et al., 2021; Recuero Virto et al., 2018). As a result, existing approaches have failed to safeguard critical natural resources and prevent irreversible ecological harm beyond tipping points.

Our research examines governments and financial institutions' engagement with nature-related metrics and risks related to natural capital. Although many countries have adopted NCA to measure natural capital assets and inform policy, its influence on macroeconomic and financial decisions remains limited. Amid the emergence of nature recovery targets and a global framework supported by the United Nations to advance NCA, we explore how public and private financial institutions can advocate for a more comprehensive integration of natural capital into decision-making. We propose Nature-Aligned Finance (NAF) as an approach that applies NCA standards to align financial flows with natural capital recovery. This approach enhances the conventional objective of NCA to measure natural wealth by guiding the selection of indicators and targets that can be integrated into innovative financial products, services, and policies.

Our proposal is supported by a stakeholder readiness assessment for adopting an NAF approach, derived from an extensive expert survey. We obtained 613 responses from specialists across various sectors, including over 200 from the financial sector and its regulation.<sup>3</sup> Our findings indicate sufficient readiness within the financial system to engage with NAF, particularly supported by the emerging

<sup>&</sup>lt;sup>1</sup> Natural capital refers elements of nature that directly and indirectly produce value or benefits to people, including ecosystems, species, freshwater, land, minerals, the air and oceans, as well as natural processes and functions (NCC, 2019). These resources fall under the nature category of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) conceptual framework and are viewed from an economic and utilitarian perspective, as they are resources that people use or expect to use in the future (IPBES, 2019). Further, in terms of natural capital assets, from the SEEA perspective, ecosystem assets as spatial areas containing a combination of biotic and abiotic components and other characteristics that function together (SEEA, 2014).

<sup>&</sup>lt;sup>2</sup> Although gross domestic product (GDP) is commonly utilised in economic decision making, it is deemed insufficient as an indicator of overall welfare or sustainable development (e.g. Stiglitz et al., 2018).

<sup>&</sup>lt;sup>3</sup> Experts in the financial sector and its regulation include people working in banks, asset owners, asset managers as well as professionals in central banks, ministries of finance and financial supervisors.

national or regional nature recovery targets. This paper contributes to the literature by proposing a new pathway for the broader use of NCA to achieve nature-positive goals. Previous research has extensively focused on developing accurate metrics and valuation techniques (Brandon et al., 2021; World Bank, 2021b), but substantial barriers to NCA adoption involve insufficient institutional capacity (Recuero Virto et al., 2018), lack of political support (Vardon et al., 2017; Veeman & Politylo, 2003), stringent budgetary constraints (Milligan et al., 2014), and fiscal policy misalignment with nature recovery (OECD, 2021; Vardon et al., 2023). As a result, limited progress has being made in using NCA to guide macroeconomic and financial decisions (e.g., Boerema et al. 2017; Hime, Sharman, and Cranston 2017), and the financial system's role in advancing NCA has been largely overlooked. The current emphasis is on managing natural capital risks and opportunities (CISL, 2022; Maclet & Chandellier, 2022; UNDP, 2022), but with insufficient focus on a systemic approach for NCA to support nature recovery objectives. To address this gap, we discuss the challenges and barriers to integrating NCA into decision making, such as data scarcity, inconsistent methodologies, and limited understanding of natural capital concepts among decision-makers. We also provide specific recommendations and examples of how governments can act as data stewards and promote the use of NCA in financial decision-making, such as by implementing mandatory reporting requirements, providing financial incentives for NCA adoption, and supporting the development of standardized methodologies. As sustainable finance and investment continue to gain traction, making it increasingly important for the financial system to be prepared for the wider adoption of financial instruments aligned with NCA. This is not only crucial for the preservation of critical natural resources, but also for long-term financial stability and prosperity.

Our expert surveys constitute a significant contribution to the existing literature in the field by assessing the use of natural capital metrics and the challenges and potential for further advancement for both public and private actors. To our knowledge, this is the first survey of its kind. The data confirms significant stakeholder awareness of the necessity of accounting for nature-related risks and dependencies yet reveals a lack of integration in policy and financial decision-making. Our findings support the importance for scaling up sustainability-linked finance, fostering the public stewardship of data, and increasing the credibility of corporate nature recovery plans. Such initiatives require more active collaboration between stakeholders and the use of emerging technologies to produce better metrics and integrate nature-positive goals into corporate, regional, and national transition plans.

We also acknowledge the potential negative consequences and drawbacks of implementing naturealigned finance and NCA, such as the risk of misallocating resources or the potential for companies to exploit the system for their own benefit. We suggest possible mitigation measures to minimize these risks, including rigorous monitoring and evaluation processes, transparency requirements, and stakeholder engagement.

Finally, we address the issue of sample selection bias in our expert surveys. While we acknowledge that sample selection bias is a prevalent issue in online surveys, we incorporated sample selection models

in the survey design, providing a more rigorous approach to evaluating survey results. This approach helps to mitigate potential disparities in opinion between respondents and non-respondents. We identified that governments could take a more active role in acting as data stewards and promoting the use of NCA in financial decision-making. Further, the surveys highlight the importance of addressing the risk of greenwashing by improving the standards for evaluating natural capital.

The rest of this paper is organized as follows. Section 2 describes the problem of the uneven uptake of natural capital accounting. As there is a lack of stakeholder demand for NCA, Section 3 explores the potential of nature-aligned finance to scale up its adoption. Section 4 assesses the financial sector readiness for nature-aligned finance with the results of our expert survey. Section 5 examines potential avenues for advancing the implementation of NAF. Section 6 concludes.

#### 2. The uneven uptake of natural capital accounting

Over the past three decades, the principles, systems and tools of NCA have developed significantly (Brandon et al., 2021). In 1993, the United Nations led the first initiative to harmonize these approaches by establishing the System of Environmental-Economic Accounting (SEEA), which evolved to measure the relationship between the environment and the economy in 2012 (UN et al., 2014).<sup>4</sup> Almost one decade after, the United Nations Statistical Commission officially adopted the SEEA in 2021 (UN, 2021). The SEEA implements standard terms and definitions to describe a comprehensive set of environmental stocks and flows, such as natural resources, physical flows, land and ecosystems, ecosystem services, and biodiversity (IDEEA, 2017). The SEEA's compatibility with the System of National Accounts (SNA) is a significant advantage, as both systems follow the same accounting rules and principles. This compatibility allows to study the impact of macroeconomic decisions on environmental flows and the risk of depletion of environmental assets. By accounting for physical and monetary losses in environmental assets, NCA can measure wealth better than the SNA alone.

The progress in building natural capital accounts has been uneven across countries (Green Economy Coalition, 2022).<sup>5</sup> As of 2021, over 90 national governments had compiled at least one NCA for a given

<sup>&</sup>lt;sup>4</sup> The Central Framework focuses on environmental assets, which include the individual components of the environment that provide materials and space to all economic activities. It distinguishes between two types of assets: flows and stocks. Environmental stocks refer to all living and non-living natural components, while environmental flows include all natural inputs to the economy and natural inputs absorbed by the economy. The information on environmental flows and stocks is compiled in supply and use tables, functional accounts, and asset accounts for natural resources. The different physical flows to and from the economy are represented in physical supply and use tables. Functional accounts record economic activities undertaken for environmental purposes, while asset accounts focus on recording stocks and flows associated with environmental assets to track depletion (UN et al., 2014).

<sup>&</sup>lt;sup>5</sup> Sweden and the UK are leaders in developing environmental and economic accounts. Since 1993, Sweden has been compiling CO<sub>2</sub> emissions accounts, which now include energy, air emissions, and material flow accounts, as well as information about environmental goods, services, and taxes. The Swedish system is cited as an example of good governance around NCA as the CO<sub>2</sub> emissions accounts are used to monitor the government's tax on CO<sub>2</sub> (WAVES, 2014; Statistics Sweden, 2022). The UK Office for National Statistics estimates natural capital to be worth GBP 1.2 trillion in 2021, covering a wide range of assets,

class of assets (UNSC, 2022), and 69% of them publish them regularly (see **Figure 1**). Europe and Northern America have the highest proportion of countries, while Africa has the lowest percentage. The complexity and diversity of natural capital, which encompasses a wide range of resources such as energy, minerals, land, water, timber, soil, aquatic resources, and ecosystem services, partially cause this disparity in progress.



Figure 1. Global SSEA implementation by country, 2021

Source: SEEA, 2021. 90 countries have implemented the SEEA. Of these 90 countries, 62 (69 per cent) publish at least one account on a regular basis (stage III); 15 (17 per cent) publish their accounts on an ad-hoc basis (stage II); while 13 countries (14 per cent) compile, but do not yet publish their accounts (stage I).

National Statistical Organizations (NSOs) face several technical challenges (discussed in Appendix A) in producing consistent accounts. These challenges include biophysical quantification of natural capital, its monetary valuation; and the integration of benefits from ecosystem services. Addressing these issues requires identifying or classifying critical natural capital assets, assessing their preservation thresholds, and analyzing the benefits from their yields. Natural assets may perform essential and irreplaceable functions, which means losing them could have a value much greater than losing other types of assets. To effectively protect natural capital, NCA must account for the complementarity and substitutability between natural assets and provide economic values considering asset criticality.<sup>6</sup> Furthermore, various

including agriculture, fossil fuels, renewables, and the value of recreation and tourism, among others (ONS, 2022). Other countries, such as China and the United States, have fewer comprehensive accounts but are taking steps towards developing them further. For example, China completed its first National Ecosystem Assessment in 2014, involving more than 3,000 scientists, and has launched a national effort to compile "natural resource balance sheets." (SEEA, 2022; Song et al., 2019). n August 2022, the U.S. published a strategy to produce comprehensive NCAs in a phased approach over 15 years, which recommends tracking changes in natural asset wealth to provide a more complete view of economic progress than GDP alone. The U.S. NCA would be embedded in the broader U.S. economic statistical system, allowing policy-relevant analyses at different levels. (White House, 2022).

<sup>&</sup>lt;sup>6</sup> Natural capital accounting does not necessarily lead to identifying those forms of "critical natural capital". The distinction between natural assets may require creating separate categories within a specific NCA exercise to make sure that non-critical

public agencies and ministries provide the information NSOs rely on, which may not adhere to the accounting systems' classification or definition (UNSC, 2021).

Due to the inherent complexity of NCA, experts agree that countries should build natural capital accounts progressively, allowing them to focus on specific assets, particularly those constituting the largest share of their natural wealth (World Bank, 2012; UN et al., 2014). This approach enables countries to gradually develop comprehensive natural capital accounts, as demonstrated in the UK (ONS, 2018). However, the widespread adoption of NCA requires strong political will, which has raised concerns among some scholars in the field (Guerry et al. 2015; Vardon, Burnett and Dovers 2016; Vardon et al. 2017; Recuero Virto, Weber and Jeantil 2018; Fairbass et al. 2020; Brandon et al., 2021). A survey of policymakers revealed that NCA often lacks the necessary "policy pull" for rapid and comprehensive implementation (Recuero Virto, Weber and Jeantil 2018).

As it has been demonstrated over the past three decades, the mere existence of NCA does not guarantee their utilization in policymaking. Typically, NSOs are responsible for compiling information from different sources inside and outside the public sector, which may result in ineffective communication of the outputs to sectoral policymakers (Feger et al. 2019). Furthermore, even when government representatives are aware of such information, they may need technical assistance to understand how to best utilize them (UNEP-WCMC and UNSD 2019). Despite the versatility of NCA in terms of potential applications, inadequate engagement of policymakers remains a persistent issue, leading to the underutilization of NCA information for policy design and evaluation. Thus, there is a need for enhanced collaboration between policymakers and statisticians working within the SEEA framework to ensure the success of NCA. Capacity building, provision of successful examples of NCA implementation and use in policymaking may be important facilitators of future uptake. Multilateral agencies have been promoting the development of NCA by upgrading the capacities of National Statistical Offices (NSOs) and other public agencies. For instance, the Wealth Accounting and the Valuation of Ecosystem Services (WAVES) initiative has backed NCA development in 24 data-poor, middle-income countries, backing over 50 policies and strategies, and training 260 policymakers (World Bank, 2021a).

While sectoral engagement is a viable pathway for NCA adoption, this approach may not guarantee that NCA delivers on its promise of a new statistical paradigm beyond the use of GDP in financial decisionmaking. Research to date suggests that NCA has had little policy impact at the national level (Fairbrass

and critical natural assets are not bundled together but reported separately. Ekins et al. (2003) defines three criteria that can be used to define critical capital: either (1) they cannot be substituted, in terms of welfare generation, by any other form of capital, whether natural or not (e.g., physical capital or human capital); or (2) their loss is irreversible; or (3) their loss would risk, or entail, immoderate losses. Critical natural capital would be any form of natural capital that fulfils at least one of these three criteria. In the case of renewable resources, for example, there may be a "critical zone" below which exhaustion reaches a point of no-return (Ciriacy-Wantrup, 1968), leading to irreversible loss.

et al. 2020). For this to happen, higher levels of government would have to use NCA and environmental metrics before taking policy decisions. In that regard, the G20 Bali Leaders' Declaration acknowledged the utility of the SEEA as a cohesive system of statistics that integrates the economy-nature nexus and can provide decision-useful information to formulate policies promoting a sustainable and robust economy with low carbon emissions (IMF, 2022).

However, several barriers may impede the uptake of NCA at such a high policymaking level. GDP, which has tracked economic progress for decades, relies on well-established methodologies. In contrast, natural capital and ecosystem services' frameworks requires further development. For instance, the conversion of some physical accounts into monetary accounts remains incomplete, constraining their applicability in economic decision-making beyond natural resource management (Boerema et al. 2017; Hime, Sharman, and Cranston 2017). In addition, while managing natural resources effectively is crucial for sustained economic growth, finance ministries must address diverse policy needs competing for resources. Policymakers have debated the implementation of NCA sensitively, as NCA benefits often appear to indirectly impact key economic indicators like employment and economic growth compared to other policy interventions. This situation presents a challenge for advocates of comprehensive wealth measurement, as they struggle to demonstrate how NCA can effectively indicate improvements in well-being compared to the typical use of GDP as an economic performance indicator, especially in the short term when politicians face greater accountability.

### **3.** Integrating natural capital info financial decisions: the concept of nature-aligned finance

A decisive policy pull for NCA is lacking, suggesting the private sector should increase its advocate for comprehensive environmental performance measures. Financial institutions are increasingly conscious of imminent financial risks from natural resource depletion (Bolton et al., 2020; UNEP-FI & UNDP, 2021). The potential role of the financial sector in internalizing environmental risks is creating renewed interest in NCA among financial actors (NGFS, 2021). However, this momentum also comes with the risk of misleading communication on sustainability, also known as greenwashing. Addressing such risk requires more than a harmonized NCA framework with rigorous monitoring, reporting and verification; it also demands the alignment of measurable targets to halt the loss of nature by 2030 (IPBES, 2019; World Bank, 2022). This highlights the need for a *Nature-Aligned Finance* approach that promotes NCA as a tool guiding financial decisions in line with emerging regional or national nature recovery targets.

From a financial perspective, the recently launched Taskforce on Nature-related Financial Disclosures (TNFD) provides a comprehensive framework for assessing nature-related financial risks arising from

dependencies and impacts.<sup>7, 8</sup> The TNFD demonstrates a growing recognition of material risks associated with natural capital depletion, driven by physical risks such as climate change and resource scarcity and transition risks associated with the transition to a low-carbon, nature-positive economy (TNFD, 2022a). In turn, factors such as regulatory changes, exposure to high-impact sectors or regions, business opportunities, and reputational benefits drive these risks and their increasing assessment (Maclet & Chandellier, 2022). However, few financial institutions have effectively mainstreamed nature into their decision-making processes, with only a small number of early movers leading the way (*ibid*.). Initiatives such as ENCORE<sup>9</sup> and CBF<sup>10</sup> have provided guidance to these institutions by filling data gaps and identifying critical natural capital assets from a financial perspective.

In parallel, Central Banks and Financial Supervisors (CBFS) recognize challenges in fully incorporating nature into their operations, including limited internal resources, capacity, understanding of the business case for nature-related risks and impacts, and standardization in reporting (NGFS, 2022). As a result, discourse among CBFS focuses on addressing nature-related financial instability risks (NGFS, 2021). This marks a paradigm shift, as nature and biodiversity were not previously considered essential by most financial system participants. Traditionally prioritizing pricing and financial stability, CBFS now recognize the impact of nature-related risks and begin incorporating them into their policies (Kedward et al., 2020; Mongelli et al., 2022; NGFS & INSPIRE, 2022; van Toor et al., 2020).

Developments in financial regulation and supervision, coupled with the growing focus on sustainable finance, create a favorable environment for implementing Nature-Aligned Finance. This approach, which uses NCA standards to guide financial flows alignment with natural capital restoration, complements NCA's traditional objective of measuring natural wealth. NCA can be used to select metrics and calibrate targets that can be integrated into various financial products, services, and policies. Aligning financial institutions with nature-positive outcomes requires investing in or financing assets or companies committed to follow emerging nature recovery goals at regional or national scale. Measuring and tracking such commitments requires an accelerated uptake of NCA. To align with a nature-positive economy, we argue that financial institutions must meet at least two conditions:

<sup>&</sup>lt;sup>7</sup> Impacts on natural capital refer to the external forces that affect a business's impact on the environment. Business dependencies refer to the external factors that affect a business's dependence on natural resources. Impacts can provide a better understanding of the direct effects of business operation on the environment. Dependencies can help understand the indirect effects of external factors on the availability of resources that a business requires for its operation (TNFD, 2022b).

<sup>&</sup>lt;sup>8</sup> The real economy sectors have been addressing such risks using a common framework, the Natural Capital Protocol (2016), albeit not from a systemic perspective.

<sup>&</sup>lt;sup>9</sup> Exploring Natural Capital Opportunities, Risks and Exposure (ENCORE) is a database that enables users to visualise how the economy potentially depends on and impacts nature and how environmental change creates risks for businesses.

<sup>&</sup>lt;sup>10</sup> Corporate biodiversity footprint (CBF) assesses the annual impact of companies, financial institutions and sovereign entities on global and local biodiversity.

positively impact real economy sectors by driving business model transformation to nature loss by 2030, and developing a transition plan compatible with a nature-positive economy.

How can Nature-Aligned Finance employ NCA outcomes to direct financial flows towards a naturepositive economy? Firstly, NCA has effectively measured natural capital assets and environmental services at local and regional levels, but frameworks developed under the System of National Accounts have occasionally been inconsistent with those at firm-level. However, the recent SEEA's recognition as the international standard and its acceptance from private-led initiatives reduced the possibility of disconnected frameworks. Thus, the ongoing process of harmonizing NCA frameworks lays the foundation for connecting financial decisions guided by NCA development. Secondly, NCA can help keep track of the condition and extent of natural resources. Although there are challenges to doing this, a harmonized NCA framework would contribute to improving the assessment of a company's environmental performance against regional nature recovery. Lastly, NCA can serve as technical support for calibrating nature recovery targets, strategically important for a financial sector interested in holding stakeholders, including governments, financially liable and accountable for sustainable development. This approach would reduce exposure to nature-related risks and enhance financial stability. Furthermore, nature recovery targets can will help to regulate sustainable financial services, ensuring the fulfillment of environmental promises.

An advantage of Nature-Aligned Finance is that it can be operationalized through existing products, services and policies in the sustainable finance and investing field, especially in relation to impactaligned approaches, following Busch et al.'s (2021) typology on sustainable finance practices' evolution (see **Table 1**). Ethical approaches focus on financing a subset of investments based on ethical principles (e.g., socially responsible). So far, they have been the dominant practice in sustainable finance. Examples include green bonds, which establish use-of-proceeds for sustainable activities in the debt capital markets (ICMA, 2021). However, ethical approaches do not systematically factor financial risks, as instruments are limited to identifying sustainable activities. For instance, there are mixed results about the risk levels or premia of green bonds compared with conventional bonds (MacAskill et al., 2021; Zerbib, 2019).<sup>11</sup>

<sup>&</sup>lt;sup>11</sup> Even though it may not be their primary intent, ethical approaches are likely to foster investments with lower nature-related risks.

**Table 1.** Typology of financial decisions (products, services, and policies) to address nature-related risks and opportunities, and the scope of natural capital accounting frameworks needed.

Approaches	Focus	Scope	Main uses of natural capital data
Ethical	Exclusion criteria and avoidance of unethical behavior	Asset- and entity- focused	Label sustainable investments and estimate their impact
Risk-based	Nature-related impacts and dependencies	Asset-focused and Market-focused	Identify and track nature-related impacts and dependencies
Impact-aligned	Nature-positive outcomes	System-focused beyond the market	Calibrate nature-related targets and support incentive structures.

Source: typology based on Busch et al. (2021).

Risk-based approaches tackle the shortfall in internalizing nature-related risks in the financial sector by assessing, mitigating, and disclosing decision-useful information related to these risks. In this regard, the NGFS, in collaboration with the TNFD, is developing a framework for organizations to report and address evolving nature-related risks (TNFD, 2022a). Such type of efforts aim to guide financial institutions to assess their environmental impact, including outside-in effects.<sup>12</sup> Mitigating identified risks may involve diversifying investments (ESMA, 2020), setting nature-positive targets (UNEP-FI & Global Canopy, 2020), and implementing sustainable procurement policies (WEF, 2022). Disclosing natural capital risk assessments and mitigation measures enables investors to allocate capital where is most needed. Over 330 corporations, with combined revenues of USD 1.5 trillion, are urging governments to mandate disclosure of nature-related impacts and dependencies (Business for Nature et al., 2022). his heightened awareness presents an opportunity for the financial sector to collaborate with stakeholders, such as clients, regulators, and civil society organizations, to develop and implement policies and initiatives that support managing natural capital risk management. Notably, a correlation exists between the level of disclosure and the extent of engagement between financial institutions and the real economy sectors, emphasizing the importance of transparency in fostering collaboration (CDP, 2021).

The third approach to sustainable finance and investing is focused on achieving specific objectives through various means, such as sustainability-linked finance, environmental impact verification (i.e., CBI, 2021), and sustainable labelling standards (i.e., FCA, 2021). From a macroeconomic perspective, performance-based innovations at the national level can address issues related to nature loss, climate change, and debt sustainability. An example is the use of sovereign sustainability-linked bonds (SLBs),

<sup>&</sup>lt;sup>12</sup> Pioneering research conducted by the Dutch and French central banks verifies the hypothesis that natural capital degradation triggers financial risks for their respective financial institutions. For instance, the Dutch financial sector has EUR 96 billion of investments in environmental controversies with negative impacts on natural capital (van Toor et al., 2020). Moreover, the central bank of France estimates that 42% of French financial institutions' securities come from issuers that are highly or very dependent on one or more natural capital assets (Svartzman et al., 2021).

which tie borrowing costs to predetermined sustainability performance targets at the national level (Cheng et al., 2022). Such financial incentives signal strong commitment to high-level sustainability policy objectives and hold stakeholders accountable for meeting nature recovery goals. The debt swap market can also utilize performance-based incentives (Landers & Lee, 2021), such as debt forgiveness, in exchange for investing in natural capital restoration (Egolf, 2001). This approach can benefit nature finance, including nature-conditional grants, nature-conditional official lending, and sustainability-linked bond issuance (Chamon et al., 2022).

#### **3.** Stakeholder readiness for nature-aligned finance

Nature-aligned finance has shown some progress in the development of financial products, services, and policies, although it is still in the early stages of maturity. Successful implementation of financial innovations is dependent on institutional and stakeholder readiness, as well as a willingness to adopt NCA as a standard tool. In order to evaluate stakeholder readiness for engaging in nature-aligned finance, we conducted three parallel online surveys targeting experts from various sectors, including financial institutions and central banks. The purpose of these surveys was to collect information on the use of natural capital data and to assess the operationalization, scalability, and reliability of nature-aligned finance.

The surveys were conducted concurrently, with Survey A directed towards financial institution experts, Survey B towards public officers involved in financial regulation, and Survey C towards stakeholders representing non-financial institutions. After the survey introduction and data privacy policy pages, participants self-selected their profession and were directed to the appropriate survey (see **Appendix Table B2.a** on which professions were directed to which survey). The surveys aimed to explore the perceived importance of natural assets, current engagement with natural capital accounting, potential challenges and barriers, and opportunities related to nature-aligned finance (see **Table 3**).

The surveys were available in English, French, and Spanish and were hosted on the Typeform platform. We sent survey links and reminders to 5,507 email addresses between October 26th, 2022, and November 5th, 2022, resulting in a total of 613 responses, which represents a response rate of 11 percent (see **Appendix Table B2.b** for details on the mailing lists).<sup>13</sup> Survey A received 122 responses, survey B received 88 responses, and survey C received 403 responses. The primary concern regarding the low response rate is that experts with more positive opinions about natural capital accounting may have been more likely to respond to the surveys, which is a common issue in online surveys that is often

<sup>&</sup>lt;sup>13</sup> About two thirds of experts were contacted through the World Bank GPS (3,260 emails). Due to the characteristics of this programme, a larger share of responses came from people working on Africa, and experts in the GPS list necessary had had some contact with the World Bank before. We widened the scope of respondents by directly searching for email addresses of professionals in the finance sector and the public sector related to the regulation of financial activities.

overlooked. To address this problem, we implemented a sample selection model (Heckman, 1976) in our survey methodology. This model necessitates at least one variable that explains the decision to respond to the surveys without influencing respondents' opinions about survey questions. To achieve this, we randomly assigned each potential respondent on our mailing lists to a group, allocating a 20-percent probability for group 1, a 30-percent probability for group 2, and a 50-percent probability for group 3. We then sent a maximum of one email reminder to group 1, two reminders to group 2, and three reminders to group 3.<sup>14</sup> This approach ensured different response probabilities for each group, independent of respondents' characteristics due to random group assignment. <sup>15</sup> Detailed information about the methodology and statistical analysis employed for these surveys can be found in **Appendices B1-B5**.

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Elements	Key insights	Example questions*	А	В	С
Importance of	Asset criticality	How important are the following natural capital assets for your organization/country's financial decision-making?	•	•	•
natural assets	Risk exposure	What is the level of exposure to nature-related risks in areas/asset classes of your country/organization?	•	•	
Engagement	Natural Capital Accounting uptake	How important is natural capital accounting in your organization?	•	•	•
	Actions undertaken	To what extent has your organization progressed in the following actions to mitigate nature-related financial risks?	•	•	
Challenges	Financial regulation	Do you agree that the following factors may inhibit the adoption of financial instruments that integrate natural capital metrics?	•	•	
and barriers	Data quality	Have you encountered any of the following challenges regarding natural capital data?	•	•	•
	Nature finance potential	How would you rate the potential of the following finance instruments to promote nature preservation and recovery?	•	•	
Opportunities	Metrics and targets	Which of the following changes are most significant to improve the natural capital data?	•	•	•

Table 3. Conceptual framework for the survey design to assess readiness for Nature-Aligned Finance.

Notes: Data for this study was collected from three groups of experts from private financial corporations (Sample A), public financial institutions (Sample B), and non-financial institutions (Sample C). The questionnaire and summary statistics of all responses can be found in **Appendix B4**.

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<sup>&</sup>lt;sup>14</sup> Typically, reminders are not sent to respondents who have already finished a survey. This group can be readily identified by their provision of email addresses to receive updates on the project, a requirement which was satisfied by the majority of respondents.

<sup>&</sup>lt;sup>15</sup> After randomization, we collected answers using different links for each group but noticed low response rates after the first wave of emails. To assign groups retroactively, we used email addresses provided by respondents, but 59 respondents lacked email addresses or provided ambiguous ones. We then used a multiple imputation method to randomly assign these respondents to a group, accounting for the uncertainty of unknown allocations. This approach ensured proper identification of the impact of group allocation on survey response probability when running the sample selection model, with detailed methodology provided in **Appendices B1-B3**.

The sample selection model (fully described in **Appendix B3**) can estimate the average response values for each question while accounting for the likeliness that non-respondents would have had a different opinion from respondents. The intuition is as follows. Suppose people are more inclined to respond because they have a favorable opinion about NCA. In that case, the nature of responses will be more positive in group 1 compared with groups 2 and 3. This is because we insisted that groups 2 and 3 provide an answer. However, this econometric model relies on assumptions about the distribution of responses. Therefore, we are more interested in the direction of the bias than in the exact numbers obtained with the sample selection model.

Hereafter, we present survey results following the four building blocks of our survey design (Table 3).

**Importance of natural assets** The significance of natural assets is evidenced by survey results, which indicate that experts perceive natural capital assets to be important for their business or country and that there are associated risks with inadequate natural capital management. Specifically, we surveyed experts on the relevance of a list of natural capital assets in financial decision-making for their organization or country and analyzed responses based on whether they were from the private or public sector (see **Figure 2**).<sup>16</sup>





<sup>&</sup>lt;sup>16</sup> The list of assets was based on the SEEA and TNFD frameworks. Factors that determine the importance of natural capital assets from a financial perspective include the extent to which the asset is used or consumed (Islam et al., 2019), the valuation of the asset based on available data (NCC, 2013), the risk of loss of the asset (Caldecott et al., 2013), the irreplaceability of the asset (Anielski & Wilson, 2009), and the ecosystem services provided by the asset. For instance, an economy that relies heavily on minerals or oil may prioritize these resources even if they threaten marine ecosystems. On the other hand, rare assets that are irreplaceable, such as coral reefs, may be considered highly important even if their economic benefits are not yet accurately estimated. However, these assets can still provide valuable ecosystem services, such as protecting coastlines from tropical storms (Beck et al., 2018).

Notes: for sample A, the question was "How important are the following natural capital assets for your organization's financial decision-making?" and for sample B, the question 2 was "How important are the following natural capital assets for your country's financial decision-making. Number of responses to each item in brackets. Test for sample selection in **Appendix B5** (**Table B5.a**).

Both groups agreed that mineral and energy resources were very important assets for financial decisionmaking, possibly due to the increasing importance of the energy transition globally. After energy and minerals, we found that cultivated biological resources, terrestrial systems, and atmospheric systems were considered important for financial decision-making by both sectors, which may be influenced by the relevance of climate change and the role of terrestrial ecosystems in carbon sequestration (The Nature Conservancy & EF, 2019). In contrast, both sectors saw marine ecosystems as the least important asset.

Respondents working in the financial sector (survey A) also seem especially aware of climate change and resource use risks, with about 70 percent declaring that their businesses were either highly or very highly exposed (see responses to question 17 in **Appendix B4**). Nonetheless, the general perception of nature-related risks exposure in the financial sector and among central bankers is likely lower because of sample selection. In **Table 4**, we report analyses of several types of risks among financial stakeholders and regulators. Survey results may overestimate risk perception among the wider pool of stakeholders (by about 30 percent on our Linkert scale).<sup>17</sup>

Table 4. Opinion about exposure to nature-related risks.

Question	Sample	Sample mean	Corrected mean
1. Exposure of own country to five nature-related risks	В	3.66	2.72
		(0.07)	(0.89)
2. Exposure of six public budget areas	В	3.41	3.48
		(0.07)	(1.10)
3. Exposure of own organization to five nature-related risks	А	3.49	2.79
		(0.08)	(0.73)
4. Exposure of five asset classes in portfolios	А	3.09	2.72
		(0.06)	(1.32)
5. Overall country/business score	A and B	3.40	2.60
		(0.04)	(0.73)

Notes: Standard errors in brackets. Sample A is financial sector and sample B is public related to financial sector. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. Question 1 was "How would you rate the exposure of your national economy to the following factors?", the factors being climate change; invasive species and other biological alterations; land/marine ecosystem use; pollution (air, water, soil); and resource use (e.g., water). Question 2 was "In your opinion, what is the level of exposure to nature-related risks in these areas of the public budget of your country?", the areas being debt service; environmental protection; infrastructure investment; public health; security; and social assistance. Question 3 was "How would you rate your organization's business exposure to the following factors?", and the factors were the same as question 1. Question 4 was "In your opinion, what is the level of exposure) to 5 (very high exposure), with a rank of 3 given to "Don't know". We then calculated the mean across all answers. Overall score is calculated as the mean between the answers to question 1 and 2 in sample B, and 3 and 4 in sample A. Methodological details in **Appendices B1-B4**.

<sup>&</sup>lt;sup>17</sup> Ratio of 3.4 over 2.6 taken from comparing the sample mean with the corrected mean of row 5.

**Engagement.** The surveys confirm that NCA has a relatively low take-up, even among a selected list of experts. Looking at the "sample mean" in **Table 5**, we find that a third of the experts were not familiar with SEEA, and many were not using natural capital data for their work or did not consider natural capital data to be important for their organization. When accounting for sample selection, we found that, most likely, even lower shares of contacted experts would have known about SEEA, worked on natural capital data, or considered it important in their workplace.

Table 5. Familiarity,	data use and	importance of	natural capital	accounting and	data
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Question	Sample	Sample mean	Corrected mean
1. Familiar with SEEA	A, B and C	0.67 (0.02)	0.49 (0.13)
2. Worked with natural capital data	С	0.61 (0.02)	0.48 (0.13)
3. Natural capita important at workplace	A and B	0.52 (0.04)	0.17 (0.41)

Notes: Standard errors in brackets. Sample A is private sector, sample B is public sector, and sample C non-financial institutions. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. Question 1 was "Are you familiar with any of the following natural capital metrics?". Coding is 1 if familiar with SEEA and ecosystem services accounting, 0 otherwise. Question 2 was "Have you worked with any natural capital data in your job?". Coding is 1 if yes, frequently, 0.5 if yes, rarely, and 0 otherwise. Question 3 was "How important is natural capital accounting in your organization?". Coding is one if important or more, 0 otherwise. Methodological details in **Appendices B1-B4**.

Organizations are, however, starting to account for nature-related risks more systematically. In **Table 6**, survey results indicate that private sector experts (Sample A) have made the most progress in incorporating environmental, social, and governance (ESG) factors into investment decision-making. Typically, ESG investments provide a detailed description of their appraisal process and are externally verified through an audit or label (Busch et al., 2021). This investment approach contributes mainly to the avoidance and reduction of risks related to natural capital and may also contribute to risk transfer in the case of insurance and reinsurance underwriting (CISL, 2022; SIF, 2021). It is estimated that the total assets under management oriented towards ESG criteria will reach at least USD 24 trillion by 2026, nearly equivalent to the current size of the United States economy (PwC, 2022). ESG investing usually includes exclusionary screening criteria for unsustainable assets or projects, as well as engagement and stewardship practices, which likely explains the similar progress reported in these areas.

However, progress seems to be much higher among respondents than non-respondents. While we observe some progress among respondents, the sample selection model suggests little progress among non-respondents. Moreover, our findings regarding the lack of disclosure of nature-related financial risks are consistent with a recent evaluation that concluded that disclosure of this type is in the early

stages and that further progress is necessary for effectively integrating nature into business practices (Maclet & Chandellier, 2022).

	Sample A:	Private Sector	Sample B:	Public Sector
Risk mitigation actions	Sample mean	Corrected mean	Sample mean	Corrected mean
Use of sustainable finance	3.74 (0.11)	2.41 (0.68)	2.67 (0.13)	2.04 (1.77)
ESG integration: risk/return assumptions	4.00 (0.09)	3.28 (0.85)	2.87 (0.12)	2.27 (1.33)
Engagement/stewardship	3.96 (0.10)	3.04 (0.65)		
Exclusionary screening	3.79 (0.12)	3.21 (0.94)		
Nature-related financial risks disclosure	2.94 (0.14)	-0.02* (2.33)		
Average score over 5 items	3.64 (0.08)	2.76 (0.83)		
Average score over 2 items			2.87 (0.12)	2.27 (1.33)

#### **Table 6.** Progress to mitigate nature-related financial risks.

Notes: Standard errors in brackets. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. The variables are obtained from the question: "To what extent has your organization progressed in the following actions to mitigate nature-related financial risks?". Five actions were specified in survey A (use of sustainable finance, ESG integration: risk/return assumptions, engagement/stewardship; exclusionary screening; and nature-related financial risks disclosure). Only two were specified in survey B (use of sustainable finance and nature-related financial risks disclosure). We coded variables as follows: 1 for "not at all", 2 for "to small extent", 3 for "to some extent", 4 for "to moderate extent" and 5 for "to large extent". We coded "Don't know" as equal to 3 when computing average scores. Methodological details in **Appendices B1-B4**.

Respondents reported lower progress in integrating ESG factors and using sustainable finance in the public sector compared to the private sector (see **Table 6**). However, it is important to note that the governance challenges faced by public and private financial institutions regarding these issues are not easily comparable. Central banks in advanced and emerging market economies have recently begun incorporating ESG assessment and investing practices into their reserve management and stress testing processes (Boffo & Patalano, 2020). National development banks (NDBs) in regions such as Latin America have also considered ESG factors, particularly considering the COVID-19 pandemic and the push for a green recovery (Netto et al., 2021). In the European Union, regulatory changes require that the financial decisions of NDBs be aligned with sustainable taxonomy (Nyikos & Kondor, 2022). Further, finance ministries have been at the forefront of the issuance of sovereign green bonds since 2016 (EF, 2022). They have recently begun to innovate using performance-based bonds linked to natural capital recovery (MEF, 2022). The share of sovereign issuers in total outstanding green, social and sustainability bonds has significantly increased since the COVID-19 pandemic. At the end of 2019, this figure was 4.2%, but it had risen to 7.5% by June 2022 (Cheng et al., 2022).

Altogether, and as presented in **Table 7**, experts believe that not enough has been done to adequately integrate impacts and dependencies in sovereign risk assessment or into country-level financial and economic risk assessments. Results from the sample selection model suggest that non-respondents were likely to have a very negative opinion about progress made compared to respondents. These findings match historical patterns of voluntary financial disclosure, which can sometimes result in the insufficient provision of information, such as that seen in climate-related disclosure (FCA, 2022; Janssen et al., 2022). Currently, as a subsequent phase, we are observing a greater involvement of public authorities in evaluating the actions of the private sector and creating mandatory disclosure frameworks, mainly related to climate change, to preserve market integrity (i.e., EFRAG, 2022; SEC, 2022).

	Sample A: Private Sector		Sample B: Public Sector	
Question: Do you agree with the following statements?	Sample mean	Corrected mean	Sample mean	Corrected mean
"Economic impacts on nature are adequately integrated into the sovereign risk assessment of my organization"	2.92 (0.12)	1.5 (1.71)		
"The exposure to nature-related risks is adequately integrated into the sovereign risk assessment of my organization"	3.01 (0.11)	2.13 (1.15)		
"Economic impacts on nature are adequately integrated into my country's financial or economic risk assessment"			2.48 (0.11)	-0.99 (1.31)
"The exposure to nature-related risks is adequately integrated into my country's financial or economic risk assessment"			2.7 (0.11)	-0.03 (1.21)

**Table 7.** Integration impacts and dependencies in financial decisions

Notes: Standard errors in brackets. Sample A is private sector, sample B is public sector. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. The variables are obtained from the question: "Do you agree with the following statements?". Coding is 1 for strongly disagree, 2 for disagree, 3 for neutral, 4 for agree, and 5 for strongly agree. Please note that the sample selection models are not bounded, so negative values are possible if the model estimates substantial downward bias. In this case, confidence intervals are wide but suggest a statistically significant difference and downward bias compared to the sample mean. Methodological details in **Appendices B1-B4**.

**Challenges and barriers.** We asked experts about the factors that inhibit the adoption of financial instruments that integrate natural capital metrics (see **Figure 3**). They overwhelmingly agreed that insufficient knowledge about such instruments, insufficient demand from investors, lack of financial sector interest, lack of reliable data and risks and greenwashing were strong concerns for the uptake of this type of financial instruments.

The lack of reliable nature-related data came first on the list of potential barriers, with 90 percent of respondents agreeing or strongly agreeing on this potentially inhibiting factor. Experts mentioned experiencing many issues with natural capital data, including problems of insufficient capacity or resources to compile data, infrequent updates, or a lack of granularity (see **Figure 3**). Likewise, the opinion about natural capital data among the financial sector and its regulators is far too low to warrant

systematic use and sustain macroeconomic policies. When asked to evaluate natural capital data against seven criteria, 30-50 percent of those respondents found the data to be either very low or low quality (depending on the criterion).<sup>18</sup> As a response, various initiatives from the financial sector are currently working to develop methods for measuring and tracking natural capital and filling data gaps (e.g., ARIES, 2023; InVEST, 2019). Additionally, natural capital accounting (NCA) can also provide opportunities for both "greening finance" and "financing green" efforts (HMG UK, 2021).<sup>19</sup>



#### Figure 3. Natural capital data quality challenges

Notes: **Question 1** was "Do you agree that the following factors may inhibit the adoption of financial instruments that integrate natural capital metrics?" Responses from surveys A and B. In **Appendix B4**, we find no evidence of sample selection bias in the answers collected on this question, especially no evidence that respondents would be less likely to identify barriers to adoption compared to non-respondents. In a test that is not reported for concision, we found no difference in answers from people mostly working on Africa either. **Question 2** was "Have you encountered any of the following challenges regarding natural capital data?" This question was included in all surveys. Number of responses to each item in brackets. Analysis for African respondents and test for sample selection in **Appendix B5** (**Tables B5.b and B5.c**). Findings remain with a sample selection model. Respondents working in Africa reported problems with a slightly higher frequency (+6 percent), but the difference is not statistically significant.

According to our survey results, greenwashing is another significant obstacle hindering the expansion of investments in nature restoration and integrating natural capital information into financial decision-making. While including natural capital risk reporting and disclosures will be a crucial aspect of the sustainability transition, more than simply increasing transparency is needed to address this issue (Ameli et al., 2020). Greenwashing remains a significant risk without mandatory reporting requirements and harmonizing sustainability reporting practices. Further, greenwashing threaten financial stability,

<sup>&</sup>lt;sup>18</sup> See **Appendix B4** and question 34 for full results. The criteria are accessibility; comparability; frequency of updates; geospatial resolution and scalability; relevance for financial decision making; temporality; and traceability. Results accounting for sample selection in **Appendix B5** (**Table B5.b**) suggest that non-respondents would have an even more negative view of the available data. Separate results for respondents mostly working on Africa are not reported for concision: they were not statistically different from other responses.

<sup>&</sup>lt;sup>19</sup> "Greening finance" refers to reducing impacts and dependencies from natural capital risks, while "financing green" refers to providing financial products, services, and policies to stop the depletion of natural capital.

as it may result in the undervaluation of transition risk and potential financial distress (ECB, 2022). Our survey results suggest that regulatory bodies, including central banks and financial supervisors (CBFS), may need to devote more attention to defining nature-positive transition planning and benchmarks, implementing mandatory disclosure requirements, and promoting the responsible use of green finance to enhance market integrity.

**Opportunities.** Despite substantial challenges, our expert surveys confirm that there is wide support for using financial instruments further to promote nature presentation and recovery (see **Table 8** below). The belief in the potential of sustainable finance is not limited to specific instruments such as carbon credits but includes a much broader range of instruments. Especially, experts agreed that de-risking instruments such as blended finance,<sup>20</sup> grants, guarantees, and insurance products could effectively promote investment in nature. In **Appendix B5 (Table B5.d)**, we compared the perspectives of public authorities and private practitioners about the viability of those instruments. We found that public authorities were more cautious about carbon credits as a reliable market-based solution than private practitioners.<sup>21</sup>

Financial instruments	Sample mean	Corrected mean	Financial instruments	Sample mean	Corrected mean
Blended finance	3.92 (0.07)	3.45 (0.53)	Grants or guarantees	3.96 (0.07)	3.04 (0.52)
Bonds	3.72 (0.06)	6.59 (1.44)	Insurance	3.97 (0.08)	N/A*
Carbon credits	3.57 (0.08)	3.02 (0.86)	Loans	3.67 (0.07)	6.13 (1.95)
Equity	3.43 (0.07)	4.09 (1.89)	Average score across 7 items	3.67 (0.04)	4.11 (1.16)

Table 8. Financial instrument potential to promote nature preservation and recovery

Notes: Standard errors in brackets. Sample A is private sector, sample B is public sector. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. The results for responses to the question: "How would you rate the potential of the following financial instruments to promote nature preservation and recovery?". For each financial instruments, we coded answers as follows: 1 for "very low", 2 for "low", 3 for "moderate", 4 for "high" and 5 for "very high". The average score was obtained by averaging values across all items. For the average score, we gave a value of 3 to "Unsure/Don't know" to avoid reducing the sample of exploitable answers. (\*) Probably due to small sample size, the sample selection model did not converge for "insurance". Methodological details in **Appendices B1-B4**.

<sup>&</sup>lt;sup>20</sup> Blended finance is a kind of financing that combines private and public funding to support development initiatives, particularly in developing countries that seek to have a positive social or environmental impact. This sort of financing is often employed for projects that may not be financially viable with only private investment. The objective of blended finance is to leverage more private investment and generate beneficial outcomes for natural capital assets.

<sup>&</sup>lt;sup>21</sup> Concerns about the integrity of voluntary carbon markets could be based on three factors (IOSCO, 2022). First, the environmental integrity of the credits at the project level. Second, the integrity of trading conditions and market participants' behavior. Lastly, the transparency of buyers' communication and use of carbon credits to prevent greenwashing. Further, using NbS as carbon offsets while continuing to rely on fossil fuels does not address the root cause of climate change. It may divert attention from the need for transformative, nature-positive economic practices (NbSI, 2021).

Finally, experts overwhelmingly agreed that to overcome the reported challenges in our survey, financial innovations that establish incentives around emerging nature-positive<sup>22</sup> commitments should be explored (see the first row of **Table 9**). National statistics offices have been involved in developing natural capital accounting frameworks. Although progress has been limited, they are still trusted by financial system participants (see **Table 9** – even though levels of trust may differ across respondents and non-respondents). Similarly, multilateral organizations have extensively collaborated with governments to improve technical and institutional capacities for natural capital accounting, such as through the NCAVES project, which aims to advance knowledge, as well as policy and business (Lammerant, 2019) applications of environmental-economic and ecosystem accounting and has initiated pilot testing of SEEA EA in several countries (SEEA, 2023a). According to our survey, levels of trust for the private sector and NGOs may greatly vary between respondents and non-respondents. This inconsistency may be due to the recent nature of these initiatives, which have yet to produce tangible results. However, this presents an opportunity for governments to collaborate with the private sector to harmonize natural capital accounting frameworks rather than standardize them. Early efforts towards this goal can be seen in the TNFD's inclusion of public sector participants in its framework development (TNFD, 2023), as well as the work of national statistics offices to create national accounting frameworks that can be useful to the private sector (SEEA, 2023b).

Question		Sample	Sample mean	Corrected mean
Would include nature data to p	produce KPIs	С	0.86 (0.02)	0.73 (0.05)
	Governments	A and B	0.63 (0.04)	0.39 (0.45)
Would rely on data from following organizations to Produce KPIs on economic sustainability	Multilateral organizations	A and B	0.87 (0.03)	0.70 (0.18)
	Non-governmental organization	A and B	0.45 (0.04)	1.27 (0.35)
	Private sector	A and B	0.37 (0.04)	1.14 (0.28)

Table 9. Use of natural capital for KPIs, and opinion of different providers.

Notes: Standard errors in brackets. Sample A is financial sector, sample B is public related to financial sector, and sample C is all other professions. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. Question 1 was "Would you include natural capital data when producing key performance indicators on economic sustainability? Coding for yes is 1, and unsure and no are coded as 0. Question 2 was "Would you rely on natural capital data provided by the following organizations to produce key performance indicators on economic sustainability?". It was followed with a list of four types of organizations. Coding is 1 for yes, and 0 for no or unsure. Methodological details in **Appendices B1-B4**.

<sup>&</sup>lt;sup>22</sup> Nature-positive is defined as a strategy that aims to stop and reverse the loss of nature, measured from 2020 levels, through increasing the well-being, abundance, variety, and robustness of species, populations, and ecosystems, with the goal of achieving visible and quantifiable recovery of nature by 2030 (WWF, 2022a).

#### 4. Scaling up nature-aligned finance

The survey results indicate that the financial sector is aware of the importance of natural capital assets and the risks associated with poor natural capital management. However, the survey also suggests that engagement in NCA could be higher among experts, with a third of them not familiar with SEEA and many not using natural capital data or considering it essential in their workplace. Despite this, organizations are starting to account for nature-related risks more systematically, with private sector experts making the most progress in incorporating ESG factors into investment decision-making. However, progress is likely higher among survey respondents than non-respondents, suggesting that there are early movers and late adopters. The disclosure of nature-related financial risks is still at an early stage. Overall, the survey suggests that the financial sector is still at an early stage of development for a nature-aligned finance approach and that further progress is necessary for effectively integrating nature into business practices.

Hereafter, we outline three key strategies for promoting the implementation of a nature-aligned finance approach. These include (1) scaling-up sustainability-linked finance; (2) fostering the public stewardship of data; and (3) increasing the credibility of corporate nature recovery plans. These strategies should be spearheaded by the financial, public, and private sectors, respectively, and are rooted in the recognition that there are already several existing and promising initiatives in place that can act as a foundation for more ambitious efforts to enhance the use of natural capital accounting for nature recovery goals.

Scaling up sustainability-linked finance. The financial sector is instrumental in promoting sustainability by incentivizing real economy businesses to adopt sustainable practices. Our survey results reveal a great opportunity for both public and private sectors to scale up the use of sustainability-linked finance in the debt capital markets and beyond. To realize this opportunity, adopting a nature-aligned finance approach can allow for the selection of material key performance indicators based on transition taxonomies and aligning regional nature recovery targets with corporate ones. To date, sustainability-linked finance has primarily been limited to fixed-income instruments. However, there may be opportunities of incorporating sustainability-linked rewards into other products, services, and policies. For example, linking executive bonuses to natural capital through an NAF approach could support the selection of KPIs and adjust targets based on the regions in which corporations operate. Another potential application of sustainability-linked finance in portfolio management is using an equity ratchet, which allows management to earn additional returns if specific nature recovery targets are met. Such an approach could be tailored based on financial corporations' specific natural capital risk exposures.

From a macroeconomic approach, the emerging issuance of sovereign sustainability-linked bonds represent an opportunity to close the financial gap in resources committed to climate finance by developed countries with emerging economies that has been outstanding since 2015. NAF can direct the financial flows towards the critical natural capital of developing nations. The governments of Chile and Uruguay were among the first to structure SLBs in 2022 (MEF, 2022; MFC, 2022), providing strong precedents for the use of SLBs by governments. In particular, the Uruguayan government included an indicator related to the recovery of native forests, which is tied to its commitment to achieving net zero deforestation by 2030. This demonstrates how SLBs can hold stakeholders responsible for meeting nature recovery goals and increase the financial support flowing from developed to emerging markets. In 2021, 145 countries, representing nearly 95% of the world's forests, endorsed the Glasgow Leaders Declaration on Forest and Land Use, which aims to halt and reverse forest loss and land degradation by 2030 while promoting sustainable development and inclusive rural transformation (UNFCC, 2021). However, lack of government incentives may partly explain nature loss, for instance the 2019 Amazon rainforest fires. Governments such as the Brazilian, which manages approximately 12% of the world's forests, could be rewarded with SLBs based on their performance in safeguarding critical natural capital, according to recent asset pricing models (Stewart et al., 2022). There are initiatives underway to develop taxonomies of key performance indicators that can be incorporated into sovereign SLBs or used by financial institutions to analyze sovereign risk (Flugge et al., 2021; IBRD & World Bank, 2022; Wang et al., 2022).

Governments as data stewards. The concept of governments as stewards of natural capital data emphasizes the vital role that they play in safeguarding and improving natural capital through the oversight of natural capital accounting standards, the encouragement of data provision by various stakeholders, the maintenance of data integrity as a public good that shape the actions of economic actors. This role also includes measuring and valuing natural resources, setting targets for nature recovery, implementing policies and regulations to achieve those targets. Public institutions can enhance the reliability of natural capital data, particularly for critical assets, through measures that improve the usability of data products for time-series analysis and decision-making (Bagstad et al., 2021). Ensuring data consistency and regular updates can increase trust in the data, supporting informed decision-making and effective resource management. For instance, the US government has recently recognized that an SEEA EA-based accounting system can improve the quality and reliability of environmental claims made by businesses (US Government, 2022). A harmonized framework can help firms clarify expectations and reduce risk, and a government-led defined framework for environmentaleconomic data can ensure audits of these claims. In this way, it can serve as the basis for the transition taxonomy required by private businesses and assure their reliance on and impacts on natural capital. It is also worth noting that the recent update from the International Sustainability Standards Board, which includes the inclusion of biodiversity in the scope of upcoming global reporting sustainability standards, should be considered in efforts to integrate public and private natural capital accounting frameworks (IFRS, 2022). Through their national statistics offices, governments can assume the responsibility of data stewardship and move beyond their traditional function of simply producing statistics to providing a collaborative and facilitative approach to data and statistics across diverse communities whilst ensuring the implementation of appropriate oversight and governance implementation measures (UNSC, 2021).

Another critical support required by governments acting as data stewards is to promote the production and use of new technologies that enable accurate, granular, and decision-useful metrics of natural capital. For instance, in 2018, the UK government established an independent expert committee, the Geospatial Commission (2020), responsible for setting the UK's geospatial strategy. One of its objectives is to invest in data projects to accelerate innovation and adoption of geospatial data applications. Several survey participants recognize such technologies as critical for overcoming barriers to integrating nature into financial decisions (see **Table 10**). In practice, this technology has relevant implications. For instance, the NCAVES project chooses which ecosystem accounts to pilot based on environmental pressures on natural capital assets, the availability of mapping data, and the ability to link such maps with other economic factors (IBGE, 2021). Geospatial technology could support the scaling up of emerging financial innovations that require high-quality performance indicators by improving data accuracy and resolution, enhancing data visualization for better communication, providing greater spatial context with other socioeconomic factors, and improving monitoring and tracking over time (Caldecott et al., 2022).

	Financia		
Factors	Sample A Private sector	Sample B Public sector	Sample C Experts
Better accessibility	0.69	0.73	0.76
Easier traceability	0.32	0.21	0.31
Improving comparability	0.57	0.47	0.54
More frequent updates	0.36	0.26	0.54
Larger geographical coverage	0.36	0.38	0.40
Finer geospatial resolution and scalability	0.48	0.26	0.54
Longer time span	0.26	0.12	0.41
Other	0.07	0.07	0.05
Number of observations	52	42	398

Table 10. Factors for upgrading natural capital data

Notes: The question was "Which of the following changes are most significant to improve the natural capital data?" This question was included in all surveys (sample A is private sector, sample B is public sector, and sample C refers to experts). The respondents could choose as many reasons as they liked.

**Credibility of corporate nature recovery plans.** The growing trend among financial and non-financial corporations to develop climate transition plans has recently included incorporating nature-related metrics and targets. As a result, frameworks currently in development, such as those of the UK

Transition Plan Taskforce (2022) or GFANZ (2022), have announced the inclusion of nature-related material interdependencies in their transition plan disclosure frameworks. WWF (2022a) has proposed a hierarchical commitment framework for future transition plans that focuses on nature-positive goals consistent with these emerging proposals. This framework includes lower levels that involve avoiding and eliminating harmful corporate practices, followed by mitigating negative impacts on nature. The highest level of this framework aims for a net-positive impact on biodiversity, people, and climate. Additionally, investors have started to call for the inclusion of the benefits and risks associated with nature in mandatory disclosure regimes for the private sector and government transition plans. One of the key challenges to expanding nature-positive transition plans is the requirement for better metrics and targets. This is where nature-aligned finance can play a pivotal role in driving systemic change by promoting the widespread adoption of KPIs that enable credible disclosure and assessment of transition plans.

Halting nature loss by 2030 should be the foundation for central banks' goals, with a full recovery of biodiversity serving as a nominal anchor for those goals (WWF, 2022b). Achieving this goal could support the development of regional benchmarks that hold the private sector accountable when preparing their transition plans (WBA, 2022). This can address the third most significant limitation to increasing nature-themed investments identified by our survey participants: comparability (see Table **10**). To advance on this matter, CBFS should require regulated financial institutions to disclose annual, comprehensive plans outlining their efforts to align investing, lending, and underwriting processes with this objective, recognizing that this is part of their mandate (Dikau & Volz, 2021). Recent efforts have been concentrated on international policy coordination and adjusting the financial architecture (i.e., reporting standards, taxonomies, and indicators), followed by non-monetary policy portfolio management and financial market conduct focused on greenwashing (NGFS & INSPIRE, 2022). Enhancing capacity-building through CBFS collaboration could effectively utilize better natural capital data, a significant challenge that respondents report facing (see Figure 3). The financial architecture aspects are critical to sufficient data and creating a basis for biodiversity impacts and risk assessment, such as stress-testing and scenario analysis, giving due consideration to consistency within and across jurisdictions and in international value chains (Stampe, 2021). Another effective mechanism to incentivize nature-positive transition plans based on an NAF approach is the transition taxonomies, in which CBFS in the European Union, China, Malaysia, and Mongolia have established such classification systems to promote green fixed-income issuance, such as green bonds (Central Bank of Malaysia, 2021; European Commission, 2023; FSCM, 2019; PBOC, 2021). These initiatives represent a relevant step before considering a microprudential framework for banking and insurance supervision that consider nature-positive transition planning into capital or liquidity requirements (Baer et al., 2021). Together, these efforts could address the risk of greenwashing by improving the standards for evaluating natural capital.

#### 5. Conclusion

The readiness of the financial system to adopt natural capital accounting is crucial for unlocking the necessary financial resources to achieve the growing nature recovery targets set by governments worldwide. Evidence suggests a growing awareness of nature's role in maintaining long-term financial stability (NGFS & INSPIRE, 2022; UNEP-FI, 2021; World Bank, 2021b). However, a significant concern is the slow pace at which nature is being integrated into mainstream financial decisions (UNDP, 2022). As a result, the potential of natural capital accounting (NCA) to guide restoration targets and track key performance indicators is currently being underutilized (Farrell et al., 2022).

Our study is the first to undertake a readiness assessment for the uptake of natural capital accounting for financial decision-making. In contrast to previous studies, which have primarily focused on the challenges of integrating NCA into policymaking (e.g., Recuero Virto et al., 2018; Vardon et al., 2017), our research considers financial decision-making processes aligned with nature recovery targets. This was possible by defining NAF as the application of NCA standards to guide the alignment of financial flows with the recovery of natural capital. This approach complements the conventional objective of NCA to measure natural wealth. It enables us to identify three critical strategies for nature recovery efforts: (1) scaling-up sustainability-linked finance; (2) fostering the public stewardship of data; and (3) increasing the credibility of corporate nature recovery plans. The financial, public, and private sectors should spearhead these strategies. They can act as a foundation for more ambitious efforts to enhance the use of NCA for nature recovery goals.

The survey results indicate that the financial sector recognizes the significance of natural capital assets and the dangers associated with inadequate natural capital management. Respondents working in the financial sector appear to be particularly aware of climate change and resource utilization risks, with 70% stating that their businesses were highly or very highly exposed. However, the survey also implies that engagement in NCA could be higher among experts, with a third not familiar with the SEEA and many not using natural capital data or considering it crucial in their workplace. Despite this, organizations are beginning to systematically address nature-related risks, with private sector experts making the most progress in incorporating ESG factors into investment decision-making. Nonetheless, progress is likely higher among survey respondents than non-respondents, and disclosure of naturerelated financial risks is still in its early stages. Overall, the survey suggests that the financial sector is still at an early stage of development for an NAF approach, and that further progress is needed to integrate nature effectively into business practices. Future research should delve deeper into factors influencing the adoption of NCA among real economy sectors and analyze how short-term business objectives align with long-term nature recovery goals set by different jurisdictions.

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### Supplementary Materials

#### Appendix A: Technical challenges of natural capital accounting

Quantifying natural resources can be very difficult. For biodiversity, for instance, there are large uncertainties: globally, the number of species is estimated to be between 8 and 20 million (Dasgupta, 2021). Data gathering and scientific methods to process the data at hand are likely to play a crucial role to improve natural capital accounts, for instance aerial surveys can allow analysing land cover and soil composition, while sonar technologies can be used to estimate fish populations. The policy relevance of NCAs may also depend on the level of disaggregation or the frequency at which the data is available since the management of natural resources may require decisions to be taken locally and indicators to be monitored with regularity. Using geospatial methods, the United Nations Environment Programme (UNEP) provided one of the first maps of natural capital (Dickson et al., 2014) at global level. Likewise, the UK has been working of a layered approach to develop spatial data on natural capital, first using land cover to trace back environmental conditions such as land and soil conditions, and then build up maps of services (e.g., timber extraction, pollution removal) that could ultimately be linked to social and demographic statistics (of ownership, for instance) (ONS, 2018).

Assuming that all environmental assets could be properly monitored, another challenge consists in giving a dollar value to those assets. To maintain full comparability, the preferred approach to value environmental assets is the use of market values. This aspect of SEEA is often criticised because market values often underestimate the economic value of environmental goods due to market failures such as externalities. Most of the environmental valuation literature (see Knights et al., 2013, for a review of methods) is based on appraisal values of changes in economic welfare (i.e., the overall value of a shift in the demand curve from an environmental change), and the difference between market values and economic values after accounting for social benefits from environmental goods could be very large. Furthermore, many environmental assets are either non-excludable (it is not possible to prevent access to them) or non-rivalrous (consumption from one person does not prevent consumption from another), which limits the feasibility of organizing markets to buy and sell them. In the absence of a market, determining an asset's economic value is difficult, and analysists may have to use different approaches to build monetary accounts from physical accounts.<sup>18</sup>

The full valuation of environmental assets and flows beyond market values remains an outstanding issue. For instance, in the absence of a carbon tax or emissions trading scheme, the market value to emit CO2 emissions into the atmosphere is zero, whereas its social cost is expected to be much higher. Due to differences in valuation methods and the estimation of climate change impacts, much uncertainty remains regarding the social cost of carbon, from USD 20 dollars per ton by 2030 in Frankhauser (1994) to up to USD 1,550 per ton by 2050 in Ackerman and Stanton's (2012) worst climate change scenario.

Science is currently evolving to empirically estimate the social cost of carbon, with initiatives such as the ones conducted by the Climate Impact Lab in the United States to determine the social cost of carbon from the observed damages caused by climate change.<sup>19</sup>

Ultimately, natural capital accounting would need to be complemented with ecosystems accounting to properly value all forms of natural capital, and possibly identify adequately critical natural capital in a unified accounting framework. This is because the central framework of SEEA focuses on the material benefits from the direct use of environmental assets and does not consider non-material benefits from indirect use, especially benefits from ecosystem services such as water purification, carbon storage or environmental risk mitigation, for instance flood risks (UN et al., 2014). This aspect is currently covered in the SEEA experimental ecosystem accounting system, which encompasses the same environmental assets but focus on their interactions within ecosystems, and on the material and non-material benefits derived from ecosystem services.<sup>20</sup> However, the experimental ecosystem accounting is not a statistical standard, but provides an overview of current knowledge to measure ecosystem services in a way that complements the SEEA and SNA.

Ecosystem services accounting is at an earlier stage of development and take-up worldwide. Hein et al. (2020) found that 24 experimental ecosystem accounts had been developed by January 2020. The UK and the Netherlands had published the most comprehensive ones to date (ONS, 2022; Horlings et al. 2019). Other countries, such as Australia, Spain and South Africa also published several accounts. The European Union also produced an integrated system of ecosystem accounts for the EU covering crop provision, timber provision, crop pollination, carbon sequestration, flood control, water purification and nature-based recreation in a large variety of ecosystems (such as croplands, grasslands, forests as well as urban areas or rivers and lakes) (Vysna et al. 2021).

#### Appendix B. Survey methodology and results

**B1. Data access.** An anonymized dataset of survey answers is publicly accessible here: **[Link will be included in published article]**. It includes all responses apart from the email address willingly provided by respondents, the date and time of response, as well as the exact country of origin of responses. We provide the region / continent of respondents instead to ensure full anonymity. We also excluded respondents who did not consent to have their data used in such a way.

**B2. Data collection.** We prepared three online surveys on the use of natural capital data in decisionmaking in partnership with the World Bank. The surveys were first prepared in English and then translated into French and Spanish, allowing respondents to choose between English, French and Spanish to fill the surveys. Each survey was targeting different professions. Survey A targeted the financial sector, survey B the public sector related to the regulation of the financial sector, and survey C focused on other stakeholders using natural capital data.

The authors were responsible for surveys A and B, while the World Bank designed survey C. All surveys were aligned and harmonized so that we use the same wording on some questions, even though a few questions differed between each survey.

The surveys ran in parallel. After the survey introduction and data privacy policy pages, respondents would self-select their profession among a list of professions, and then be directed to one of the surveys. Table A2 summarizes which profession was directed to which survey, and how many responses were gathered for each profession.

We used the same platform and same survey links to send to the same mailing lists. In total, the survey links were sent to 5,507 email addresses, from the mailing lists described in Table A2.

We used different links for three different segments of our mailing lists. The World Bank split answers in two separate lists (World Bank 1 and World Bank 2). The "World Bank 1" list included only the respondents from the GPS list for which we knew the affiliation and profession. The "World Bank 2" list included all other respondents from the GPS, GGKP, World Bank media and government expert self-collected list, and World Bank referrals. The other segment included the two complementary lists collated.

Survey responses were collected between 26<sup>th</sup> October 2022 and 28<sup>th</sup> November 2022. After sending a first email to respondents, we realized that the final response rate could be around 10-15 percent. This caught our attention since it implied that responses could be vulnerable to sample selection bias: those experts with a more positive opinion about natural capital accounting could be more inclined to answer our survey.

Table B2.a. Professions assigned to each survey, and number of responses by profession.

Sample	Profession	Number of respondents
	Asset manager	16
	Asset owner	11
	Bank	30
A	Insurance firm	14
	Multilateral financial institution	50
	Pension fund	1
	Central bank	30
В	Financial regulator	25
	Ministry of finance	24
	National development bank	9
	Academia	67
	Bilateral development agency/donor	27
	Civil society organization	49
	Consultancy	20
	Environmental protection agency	21
C	Ministries of natural resource management / environment	63
C	Ministries of planning/development	30
	Ministry of agriculture	14
	Ministry of economy	13
	Ministry of energy/extractives	4
	Multilateral agency	29
	Statistics office	42
	Think tank	24

Notes: respondents self-selected a profession when asked the question: "What is the category of your current place of work?". Multilateral financial institutions (e.g., IMF) were included in survey A rather than survey B considering that they tend to invest in projects rather that oversee the regulation of financial systems.

We adjusted the survey methodology accordingly to be able to run a sample selection model based on Heckman (1976). Sample selection model requires a least one variable that can explain selection and does not explain outcome variables of interest. We created such a variable through survey design.

Table B2.b. Description of mailing lists.

Name	Description	Number of email addresses
GPS	List of experts who attended the events organized by the Global Program on Sustainability (GPS) of the World Bank, including those of the global partnership led by the World Bank on Wealth Accounting and the Valuation of Ecosystem Services (WAVES).	3,260 of which we had information about affiliation and profession for 1,700 emails.
GGKP	List of experts provided by the Green Growth Knowledge Platform	13
World Bank media and government expert self-collected list	The World Bank also collected a list of contacts from economic correspondents for major newspapers (e.g. Financial Times, WSJ, WP, The guardian, The straits times, the globe and mail, Bloomberg), and government experts (based on their titles: chief economist or above) from the central banks (mainly The Federal Reserve). This list was collected through online searches.	201
Complementary list of financial experts collected by the authors	<ul> <li>Senior practitioners from financial institutions were identified through comprehensive desktop searches of public data for relevant Level 1 - Level 4 employees at financial institutions with a membership in the Glasgow Financial Alliance for Net Zero (GFANZ) and the major Multilateral Development Banks. GFANZ members were identified through the following initiatives: <ul> <li>Net-Zero Asset Owner Alliance</li> <li>Net-Zero Asset Managers initiative</li> <li>Net-Zero Banking Alliance</li> <li>Net-Zero Insurance Alliance</li> </ul> </li> <li>Among those, we selected 91 major organizations, trying to balance out potential respondents by geography to cover all continents.</li> </ul>	A total of 1048 practitioners and their corresponding email addresses from 91 organizations.

Name	Description	Number of email addresses
	Within these institutions, employees were recognized using corporate organograms. Relevant personnel were individuals whose job titles implied that they had a significant role in formulating or advising financial decisions. Included were: Associate Director of Sustainable Investing, Board Committee Sustainability, Chief Financial Officer, Corporate Sustainability Manager, Head of Responsible Investment, Global Head of Sustainable Finance, and Vice President Climate & ESG Risk. We identified a range of public transparency and website openness among the financial institutions. We were able to find at least ten names for each institution. Through internet searches, email addresses were found.	
Complementary list of public experts relevant to financial sector regulation collected by the authors	Senior policymakers in central banks, national development institutions, financial regulators and ministries of finance were identified in a similar manner to private sector practitioners. The relevant Level 1 - Level 4 personnel were identified by manual, exhaustive Internet searches of public data. To identify public institutions with a public commitment to addressing sustainability-related risks and opportunities, we selected leading organizations from the following networks and alliances: The Network of Central Banks and Supervisors for Greening the Financial System. Coalition of Finance Ministers for Climate Action. The International Development Finance Club. We selected 90 large organizations covering all continents. Similar to the private sector, most personnel were identified using organizational charts. Further, relevant personnel were those with job titles indicating a key role in making financial decisions related to sustainability officer, <i>Chief Financial Officer, Climate Risk Specialist, Director of Financial Stability, Head of Private Finance for Nature, Senior Economist</i> , and <i>Senior Policy Advisor</i> .	A total of 1079 senior officials were identified with their respective email addresses from 90 organizations.
World Bank Referrals	Some respondents that voluntarily helped the World Bank circulate the survey to experts within their company/organization.	33

Notes: To avoid unintended use of emails, all mailing lists are kept confidential. The authors did not have access to the mailing lists collected by the World Bank, and vice-versa.

We randomly assigned a group to each potential respondent in our mailing lists, with a 20-percent probability for respondents to belong to group 1, a 30-percent probability for respondents to belong to group 2, and a 50-percent probability for respondents to belong to group 3. We assigned this group number to all potential respondents, including those who had already answered our survey. We would then send a maximum of one reminder email to respondents in group 1, two reminder emails to respondents in group 2 and three reminder email to respondents in group 3. We would naturally not send reminders to those respondents that already answered our survey.<sup>23</sup> All in all, respondents in each group would have a different probability of response considering that they would be sent a different number of reminders, with experts in group 1 having a lower probability of respondents or expendents in groups 2 and 3. This probability of response would be independent on respondents' characteristics because of the random group allocation.

After randomization, we collected answers separately with different links for each group, allowing us to know which answer belonged to which group of experts. Answers were also collected separately by

<sup>&</sup>lt;sup>23</sup> We could identify many of those since we asked respondents to provide us with their email address to receive news about the progress of this project, which most respondents did.

segment of survey list (World Bank 1, World Bank 2, and the authors). This allowed us to know the group to which each answer belonged.

Since randomization occurred after we sent emails to respondents, we had to assign their group back to the experts that responded to our first waves of emails. We call these experts "early respondents". This operation concerned 256 early respondents (out of 613 respondents) and could be performed easily for the great majority of these. This is because respondents were asked if they wanted to receive news from the development of this project and leave us their email address at the end of the survey. 214 early respondents (out of 256) provided an email address. We therefore used the email address that respondents provided to assign them back to their group. We could assign their group back to 197 respondents (17 email addresses were ambiguous). For the remainder of early respondents (59 respondents), we unfortunately had no mean to trace back to which group these respondents belonged.

We used a multiple imputation method to randomly reassign these respondents to a group. The multiple imputation method uses an ordered probit model with no explanatory variable, providing chances to belong to group 1, 2 or 3 that match sample proportions (of 20, 30 and 50 percent). We randomly imputed 10 group values for each respondent with unknown group value. We ran all statistical analyses that relied on the group to which respondents belonged with multiple imputation methods that corrected for the uncertainty surrounding the initial group allocation of these 59 early respondents. This method allows for the correct identification of the impact of group allocation on the variables of interest.

Finally, our first email to respondents included the following subject and formulation: "Invitation to contribute to natural capital study".

Dear << Test First Name >>,

You have been identified as a relevant professional for our survey on natural capital. This survey, available in English, French and Spanish, takes no more than 10 minutes to complete.

- English / Español / Français

Many thanks for your time and cooperation.

We adapted this email to audiences in reminders to possibly increase response rates. The email subjects used in the reminders were: "Invitation to participate in a natural capital project" (World Bank 1 and World Bank 2 segments) and "Consultation on natural capital uses" (The authorssegment). Emails were sent from Richard Damiana's chief economist email on the World Bank side to increase the response rate. Emails for the The authorssegments were sent from the author's email address.

**B3.** Sample selection model. Low response rates are an issue if people decide whether to respond based on the opinion they have about the issues at stake. In this case, we could expect people with a more

positive view about a capitals approach to be more likely to respond. To correct for sample selection, we use the model of Heckman (1976), such as:

$$y^* = \bar{y} + v$$
$$s^* = a.Z + u$$

In this model, y is the variable of interest (for instance an answer to a survey question).  $y^*$  is a latent variable which is equal to y but only observed if s = 1, a condition that is fulfilled if  $s^* \ge 0$ , where  $s^*$ is a latent variable for responding to the survey. In our specifications, Z is equal to the group number assigned to each respondent. v and u are error terms. a is a parameter to be estimated.  $\bar{y}$  is a constant, to be estimated as well, equal to the mean of y after correcting for sample selection. Later, we use several answers to our survey as the dependent variable y to estimate expected average responses after correcting for sample selection. We use robust standard errors to account for heteroskedasticity.

This model is consistent if variable Z as no impact on  $y^*$ . This is the case by design since we have randomly assigned a group number to potential survey respondents. The group number should not correlate with their answers other than through its impact on the probability of response. This design allows eliciting the correlation between the probability of response and the opinion of respondents. If people are more inclined to respond because they have a positive opinion about natural capital statistics, then the nature of responses will be more positive in group 1 compared with groups 2 and 3. This is because we will have insisted for groups 2 and 3 to provide us with answers with reminders, while we only sent one reminder to group 1 respondents. To remain concise, we do not report first-stage results for the impact of the group number on the probability of response. However, the correlation between the probability of response and the group number always positive and statistically significant with tstatistics between 2 and 4.

The model also assumes that v and u follow a bivariate normal distribution. This is a strong assumption and results should be read with caution. Ultimately, we are more interested in the potential direction of the bias than the exact number obtained with this process. The assumption of normality of errors is known to potentially have an impact on estimated coefficients. Moreover, while our expert surveys are relatively large, the number of observations is still rather small to perform econometric analyses. Therefore, confidence intervals for corrected means are relatively wide.

Furthermore, as explained in **Appendix B2**, we could not allocate their group number to 59 answers. For these answers, we used a multiple imputation method to reallocation a group number and run econometric analyses later down the line. Therefore, we run the Heckman sample selection model after multiple imputation, run as many runs of the model as multiple imputations (10) and average estimates and standard errors across imputations. This method provides consistent estimates that account for the uncertainty regarding group allocation for these 59 answers (out of 613).

The Heckman sample selection model naturally needs to know how many people did not respond to each question. For questions common to all surveys, we have a pool of potential respondents equal to the number of emails in our lists (5,507). However, the number of non-responses needs to be estimated when a question was only asked in some surveys. This is because people can self-select into one survey, and therefore the potential number of non-respondents depends on the proportion of non-respondents that would have self-selected either into survey A, B or C. For the self-collected list of professionals in the finance sector (1,048 emails collected by the authors), we make the simplifying assumption that all would self-select into survey A. We make a similar assumption for the self-collected list of public sector professionals relevant to the regulation of this sector (1,079 emails that we assign to survey B). For the remainder, we do not know which proportions. Results indicated that about 20.5 percent would have been directed to survey A, about 6.6 percent to survey B, and the rest to survey C. We use these proportions to estimate the total pool of respondents from each survey to be 1,766 for survey A, 1,310 for survey B, and 2,252 for survey C. Robustness checks where we changed the number of missing responses is not reported for concision. They implied that this assumption had little impact on results.

We know how many of these respondents would pertain to which group since we have randomly assigned group numbers beforehand. However, because we do not know the group of 59 respondents, this has a small impact on the potential number of non-respondents assigned to each survey and pertaining to a group. When reassigning group numbers to non-respondents, we simply assume that 20, 30 and 50 percent of those 59 emails belong to each group (hence 12, 18 and 29 emails), and work on a homogenous database of respondents and non-respondents with a consistent number of non-respondents belonging to each group and survey. This can only have a negligible impact on results considering that the total pool is of 5,507 emails.

**B4:** Survey questions and summary statistics. Hereafter, we provide details to all questions and calculate and provide summary statistics for all closed questions. We specify if answers come from survey A, B and C or a combination of surveys (since the same questions were often used).

#### Welcome address (front page of all surveys):

This survey is part of a project to better understand how the financial and public sectors use natural capital in their decision making processes. This survey takes between 10 and 15 minutes to complete.

Thank you very much in advance for your time and insights. Your responses will be kept anonymous.

The World Bank Group | University of Oxford | University of Barcelona



#### Question 1: I consent to having my information collected and shared.

Notes: Surveys A, B and C. We informed respondents that responses would be kept in the strictest confidence. University of Oxford CUREC Ethics Approval: SOGE1A2021-238. View Privacy Policy.



Question 2: Which country or region do you spend most of your time working on?

Notes: Surveys A, B and C. To maintain anonymity, we aggregated the data at regional level. We present this information separately by survey to show over-representation of the African continent in survey C.

Question 3: What is the category of your current place of work?



Notes: This question was used to separate respondents across surveys A, B and C. Consultancy was added as a possible answer during survey rollout to respond to a comment from respondents wishing to answer "consultancy".



#### Question 4: What is your role in this agency?

Notes: Surveys A, B and C. Note that "Consultancy" was added as a possible answer during survey rollout to respond to a comment from respondents wishing to answer "consultancy".

#### Question 5: Other roles different from those in question 4, specified

Open ended question – summary statistics not reported.



#### Question 6: Which sectors are you mainly working on?

Notes: Survey C only.



#### Question 7: Are you familiar with any of the following natural capital metrics?

Notes: Survey C only.



Question 8: Have you worked with any natural capital data in your job?

Notes: Survey C only.



#### Question 9: For which type of issues did you use this data?

Notes: Survey C only.

#### Question 10: What data sources did you use

Open ended question – summary statistics not reported. Survey C only.

## Questions 11 and 35: Have you encountered any of the following challenges regarding natural capital data?



Note: Responses from surveys A, B (question 35) and C (question 11).

Questions 12 and 37: How important are the following criteria for natural capital data to be effectively used in the decision-making process?



Notes: Responses from Survey C (question 12)



Notes: Responses from Surveys A and B (question 37)



Questions 13 and 39: What is the main reason for not using natural capital data in your work?

Notes: Responses from surveys A, B (question 39) and C (question 13). Respondents could choose as many reasons as they liked.

Questions 14 and 36: What are the main constraints to integrating environmental and naturerelated risks and concerns into decision making?



Notes: Survey C (question 14)



Notes: Surveys A and B (question 36)

Question 15: Would you include natural capital data when producing key performance indicators on economic sustainability?



Note: Responses from survey C.

Questions 16 and 40: Which of the following changes are most significant to improve the natural capital data?



Note: Responses from surveys A, B (question 40) and C (question 16).



#### Question 17: How would you rate your organization's business exposure to the following factors?

Note: Responses from survey A.

#### Question 18: How would you rate the exposure of your national economy to the following factors?



Note: Responses from survey B.

Question 19: In your opinion, what is the level of exposure to nature-related risks in these areas of the public budget of your country?



Note: Responses from survey B.

Question 20: In your opinion, what is the level of exposure to nature-related risks of these asset classes of your organization?



Note: Responses from survey A.

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Question 21: How important are the following natural capital assets for your country's financial decision-making?



Note: Responses from survey B.





Note: Responses from survey A.

Question 23: To what extent has your organisation progressed in the following actions to mitigate nature-related financial risks?



Note: Responses from survey A.

Question 23 bis: To what extent has your organization progressed in the following actions to mitigate nature-related financial risks?



Note: Responses from survey B.





Note: Responses from survey B (questions 24 and 26) and A (questions 25 and 27). The first and third questions were asked in survey B, and the second and fourth in survey A.

#### Question 28: What are the most significant limitations to boosting capital allocations to naturethemed investments?



Question 29: How would you rate the potential of the following finance instruments to promote nature preservation and recovery?



Note: Responses from surveys A and B.

Question 30: Do you agree that the following factors may inhibit the adoption of financial instruments that integrate natural capital metrics?



Note: Responses from surveys A and B.



Question 31: How important is natural capital accounting in your organization?

Note: Responses from surveys A and B.

Question 32: In the last 2 years, within your work, has natural capital accounting become more or less important?







Note: Responses from surveys A and B.

# Question 34: How would you rate natural capital data of the country you work on the most against the following criteria?





Question 38: Would you rely on natural capital data provided by the following organisations to produce key performance indicators on economic sustainability?

#### **B5:** Additional results

	Sample A: Financial sector		Sample B: Public sector related to finance	
Natural Capital Assets	Sample mean	Corrected mean	Sample mean	Corrected mean
Atmospheric systems	3.62	3.08	3.62	6.79
	(0.11)	(1.21)	(0.10)	(2.29)
Cultivated biological resources	3.84 (0.10)	4.00 (2.11)	3.86 (0.11)	N/A*
Marine (ocean) ecosystems	3.27	2.30	3.23	3.16
	(0.12)	(1.26)	(0.13)	(2.02)
Mineral and energy resources	4.18 (0.09)	3.92 (0.7)	4.57 (0.09)	N/A*
Renewable energy resources	4.37 (0.08)	3.99 (0.39)	4.43 (0.08)	N/A*
Terrestrial ecosystems	3.84	3.52	3.67	2.63
	(0.09)	(1.07)	(0.11)	(0.84)
Water resources and ecosystems	3.77	2.38	3.82	2.78
	(0.11)	(0.54)	(0.11)	(0.82)
Average across all assets	3.81	3.65	3.87	3.99
	(0.07)	(0.98)	(0.07)	(1.91)

 Table B5.a Importance of natural capital assets before and after correcting for sample selection

Notes: Standard errors in brackets. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. Each variable was constructed from the question: "How important are the following natural capital assets for your organization's (sample A) / country's (sample B) financial decision marking?" We coded ratings from 1 (very unimportant) to 5 (very important), giving a missing value to "Unsure/Don't know". We also took the average across all assets, then giving a value of 3 to "Unsure/Don't know" to compute an average even when respondents were unsure about a few items. (\*) N/A stands for not available. For some entries, and probably due to the small sample size, the sample selection model did not converge.

Table B5.b Natural capital data quality before and after correcting for sample selection

Question	Sample	Sample mean	Corrected mean
1. Number of challenges with natural capital data (0 to 6)	A, B, C	4.31	4.03
		(0.08)	(2.53)
2. Average rating of natural capital data against 7 criteria	A and B	2.56	1.07
(from 1, very low, to 5, very high)		(0.07)	(2.05)

Notes: Standard errors in brackets. Sample A is financial sector, sample B is public related to financial sector, and sample C is all other professions. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. The variable "number of challenges" was constructed from the question "Have you encountered any of the following challenges regarding natural capital data?". Six potential challenges were listed: lack of capacity or resources to compile natural capital data; poor data management and infrequent updates; lack of granularity; lack of policies to use data; lack of tools to analyse data; unreliable data. We created a variable for the number of challenges encountered. For each challenge, we added a value of 1 to the number of challenges when respondents said "yes, frequently", and 0.5 when they responded "yes, rarely". The variable "average rating" was obtained from the question: "How would you rate natural capital data of the country you work on the most against the following criteria?". The criteria were accessibility; comparability; frequency of updates; geospatial resolution and scalability; relevance for financial decision making; temporality; and traceability. We coded ratings from 1 (very low) to 5 (very high), giving a value of 3 to "Unsure/Don't know", and took the average across the seven criteria.

Number of chanenges with natural capital data (0 to 6)	Number of chanenges (0 to 6)
Works on Africa	0.27
	(0.17)
Constant	4.21
	(0.11)

**Table B5.c.** Number of data challenges for respondents working mostly on Africa, vs. other continentsNumber of challenges with natural capital data (0 to 6)Number of challenges (0 to 6)

Notes: Standard errors in brackets. Results of linear regression with robust standard errors. The variable "Works on Africa" was obtained from responses to the question: "Which country or region do you spend most of your time working on?". Responses were aggregated into the following categories: Africa; Asia; Central and South America; Europe; North America; Oceania; and no specific region. Works on Africa equals 1 for Africa, and 0 otherwise. The variable "number of challenges" was constructed from the question "Have you encountered any of the following challenges regarding natural capital data?". Six potential challenges were listed: lack of capacity or resources to compile natural capital data; poor data management and infrequent updates; lack of granularity; lack of policies to use data; lack of tools to analyse data; unreliable data. We created a variable for the number of challenges were data; variable for the number of challenges were data; so it to the number of 1 to the number of challenges when respondents said "yes, frequently", and 0.5 when they responded "yes, rarely".

**Table B5.d.** Potential of different financial instruments to promote nature preservation and recovery, before and after correcting for sample selection.

	Sample A: Financial sector		Sample B: Public sector related to finance	
Financial instruments	Sample mean	Corrected mean	Sample mean	Corrected mean
Blended finance	3.96	3.77	3.88	2.87
	(0.1)	(1.39)	(0.09)	(0.53)
Bonds	3.7	4.32	3.73	6.92
	(0.09)	(2.12)	(0.09)	(0.53)
Carbon credits	3.78	3.34	3.28	2.54
	(0.1)	(1.17)	(0.12)	(1.72)
Equity	3.35	4.76	3.53	3.73
	(0.1)	(2.53)	(0.09)	(1.7)
Grants or guarantees	3.96	2.95	3.95	3.18
	(0.09)	(0.73)	(0.1)	(0.75)
Insurance	3.89 (0.1)	3.93 (1.62)	4.09 (0.12)	N/A*
Loans	3.62	4.51	3.72	5.69
	(0.1)	(5.42)	(0.1)	(1.89)

Notes: The question was "How would you rate the potential of the following financial instruments to promote nature preservation and recovery?" Standard errors in brackets. Sample A is private sector, sample B is public sector. Sample mean is directly obtained from the sample. Corrected mean is obtained after using multiple imputation on observations with missing groups, determining the number of emails with missing information in each survey sample, and running a Heckman sample selection model using group assignment to determine the probability of response. Methodological details in **Appendices A1 and A3**. The list of financial instruments was obtained from the UNEP-FI (2021).