



Research Article

# The future of economic reporting: ecosystem services and biodiversity in government and corporate accounting

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## Abstract

An intact, species-rich natural environment forms the basis for human life. It provides clean water, nourishment and sufficient space for a wide variety of activities and experiences. However, while the services provided by functioning ecosystems are recognised in environmental reports, the factor of natural capital has to date hardly played any role in economic calculations and company balance sheets.

It is vital that public and corporate reporting systems take account of natural assets and ecosystem services because this is the only way to ensure that they are given sufficient consideration in political and economic decision-making processes. The introduction of this new and transparent form of economic reporting is also being called for and supported internationally by the United Nations, the World Bank and the European Commission.

Against this background, our article looks at the question of how biodiversity and ecosystem services can be incorporated into economic reporting at governmental and corporate level. It was written as part of the project “Appreciating biodiversity –

modernising economic accounting in Germany” (Bio-Mo-D), whose aim is to provide a range of actors from business, politics and society at large with information to enable them to make integrated, ecologically sustainable decisions – and thus to demand and support a greater appreciation of nature, measurable via key indicators on biological diversity and ecosystem services.

In the following, we first provide an overview of information sources and data products for ecosystem accounts available at national level in Germany. We focus on Germany, but in an EU and global context. The results of these accounting systems, which can be integrated into political and economic decision-making, should be easily understood by the general public and provide a basis for scientific analyses. As “flow” variables, information on ecosystem services contributes to societal well-being by improving decision-making processes, in particular, by demanding and supporting a greater appreciation of nature, measurable via biodiversity and ecosystem service indicators.

A new paradigm is emerging both in companies globally and within European regulations, namely the explicit consideration of nature and its services as the basis for holistic corporate reporting, management and financing. As impacts on biodiversity and ecosystems, as well as interdependencies between ecosystem services, can be highly specific, depending on the sector, company activity and location, more detailed, sector-specific information will be needed in the future – ideally also from national accounting. Finally, we look at which institutions and actors can influence the field of action and discuss how the process of expanding economic reporting to include natural capital can be viewed as a “social innovation”.

We postulate that ecosystem data and indicators are relevant to economic policy because they open up room for manoeuvre and can be used to identify solution pathways. They help national authorities and institutions as well as lower tier authorities identify potential conflicts of interest when planning areas relevant to nature conservation, to justify decisions on the conservation of natural capital and to communicate these to stakeholders and the wider public.

## **Keywords**

biodiversity, corporate accounting, ecosystem accounting, ecosystem services, national statistics, sustainability reporting

## **Bringing nature into business reporting**

### **Accounting for the future**

With the now undeniable repercussions of global climate change, the increasing use and strain on natural ecosystems and a dramatic decline in the number of species, there is clearly an urgent need to radically change our environmental policies (MEA – Millennium

Ecosystem Assessment 2005). In many countries, but especially in Germany, nature conservation has a long tradition. At the same time, a number of international and national strategies to protect biodiversity have been introduced in recent years. In March 2021, the UN Statistical Commission adopted the System of Environmental-Economic Accounting - Ecosystem Accounting as a milestone (Edens et al. 2022). The SEEA EA provides detailed guidance measuring the extent and condition of ecosystems and how to quantify ecosystem services. Nevertheless, there do not seem to have been any major improvements, for instance in avoiding species extinction and the loss of landscape diversity (CBD – Convention on Biological Biodiversity 2022a, OECD 2023).

The focus of interest is now on political decision-making as well as entrepreneurial action. On the one hand, many social groups are increasingly voicing criticism, demanding that we show a high level of ecological responsibility. On the other hand, there is an emerging resistance to supposedly rigid “environmental-only” policy programmes, not only in the agricultural sector.

In view of this situation, it is important to make some serious “calculations”. What repercussions do diverse economic activities have on the quality of ecosystems and their biodiversity? What form of growth is still possible without simultaneously undermining the basis of life? A closer look reveals our double ignorance here because, firstly, outside individual cases, we simply do not know what risks the loss of biodiversity brings to the economy and society across all areas; and secondly, the preservation and improvement of social well-being and prosperity through nature’s services are usually underestimated, both in terms of their importance and in monetary value (examples in Naturkapital Deutschland – TEEB DE (2018)).

One central and essential lever of transformative change, we believe, is the modernisation of economic reporting. A new system of ecological-economic reporting at the national and corporate level would not only provide important information for decision-making processes, but also open up intellectual space and greater social acceptance for a new understanding of social prosperity.

It may sound self-evident, but it needs pointing out that only those companies which record the impact of their actions on ecosystem services and biodiversity in their balance sheets can maintain the trust of their customers and cooperation partners as well as improve their financial position – apart from the fact that many companies are, of course, themselves directly dependent on clean water, renewable raw materials and intact landscapes. To record this impact, ecological values must be recorded and reported in a standardised and comparable form. The same applies to economic reporting at the national level (Zieschank and Diefenbacher 2019, Dasgupta 2021, Grunewald et al. 2022a, Förster et al. 2023).

## **The driving forces of modernisation**

Whether we consider Germany’s national accounts, the annual economic reports of the federal government, the annual reports of the German Council of Economic Experts or

the opinions of the vast majority of economic modelling experts, all have so far largely ignored the issue of ecosystems and their services for society. Here, of course, we are specifically talking about ecological functions or services and not classic resources or raw materials.

The closer you look at these forms of reporting, the more astonishing this neglect of induced environmental damages and (still) existing ecosystem services seems, especially in view of the loss of economic prosperity that is otherwise a frequently voiced fear in politics and business. In industrialised countries, up to 50% of the GDP relies on biodiversity and intact ecosystems (WEF – World Economic Forum 2020), along with other services that help secure people's livelihoods and well-being, as well as their cultural development.

However, there is also a positive countermovement that advocates the inclusion of nature in economic reports. The main drivers of such enhanced national and business reporting are:

- alternative growth and prosperity discourses (keyword "Beyond GDP");
- biodiversity strategies of international actors and institutions;
- further developments within the environmental economic accounting community (keyword: SEEA – Systems of Economic and Environmental Accounting, see <https://seea.un.org/>);
- business (nature) reporting.

In the following, we point out some important factors behind these recent developments:

### **Understanding prosperity in transition**

At the international level, there is increasing awareness of the need to view productive capital, natural capital and social capital as all part of a coherent economic system. An important keyword here is the "Wellbeing Society" (Brandt et al. 2022). The United Nations (UN), the Organisation for Economic Cooperation and Development (OECD), the World Bank as the European Commission and other influential organisations are all striving for the closer integration of ecosystem services and biodiversity into economic and sustainability reporting. Politicians in Germany are also sending signals that they want to measure and evaluate prosperity differently in the future (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023; JWB - Jahreswirtschaftsbericht der Bundesregierung 2024).

One of the milestones on this path was the international conference "Beyond GDP" in 2007, initiated by the European Commission, the results of which were embraced – with some delays – by international institutions. After the World Bank published a report in 2011 under the heading "The Wealth of Nations", they had fundamentally changed their position by 2018, detailed in the study "The Changing Wealth of Nations". This was accompanied by a new understanding of how prosperity can be measured using additional indicators for a green economy. Such indicators were developed, for example,

as part of the OECD initiatives on the green economy or the UN environmental programme UNEP under the keywords “Green Performance Indicators”<sup>\*1</sup>.

### **International biodiversity strategies**

The key advocates for the inclusion of biodiversity and ecosystem services in societal reporting systems are the scientific and political actors of the Convention on Biological Diversity (CBD – Convention on Biological Biodiversity 2022b). The Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) recognises the need for more comprehensive monitoring of biodiversity. Since 2015, in addition to the German IPBES coordination office, other national actors, including in particular the dialogue and action platform “Biodiversity in Good Company”, have been discussing the role of business in the IPBES process.

Overall, recognition of the vital importance of preserving biodiversity has motivated a number of further initiatives: at international and EU level, there have long been concrete proposals by various political actors to include ecosystems in public accounting and reporting systems (e.g. the SDGs for 2030). These have also been taken up in the new Post-2020 goals of the CBD Framework (CBD – Convention on Biological Biodiversity 2022b) and are being promoted by various organisations such as the UN, the International Union for Conservation of Nature (IUCN) and at EU level.

### **Further development of economic and environmental accounting (SEEA)**

In Germany, there are encouraging signs that information on ecosystem services will be incorporated as part of an expanded system of national accounts. This can be viewed as part of wider international trends in this direction, all rooted in the UN statistical system for ecosystem accounting (United Nations 2021, Chapter 3). The SEEA EA (Edens et al. 2022) is crucially important for the further development and design of ecosystem assessments in Germany. To supply the additional appendices demanded by the expansion of EU Regulation 691/2011 (statistical reporting obligations for EU Member States), the accounting systems of Member States have to be adjusted to reflect additional data collection and documentation as well as its standardised processing. This also includes innovative data from forest accounting, environmentally-related subsidies and similar transfer payments as well as – important for our discussion – the ecosystem accounts of Germany’s Federal Statistical Office, which will be published from 2026.

These processes spotlight the expanded understanding within the professional community of statistical organisations; at the same time, the new regulations underline the importance with which the Federal Statistical Office views this topic. Through its membership of the UN Committee of Experts on Environmental-Economic Accounting (UNCEEAA) and the London Group on Environmental Accounting, as well as intensive cooperation with Eurostat, we clearly see the international collaborative work of the Federal Statistical Office.

## **Business accounting**

Corporate sustainability reports aim to gain clarity about a company's social-environmental footprint and align it with sustainability goals. As many firms have now begun to combine their sustainability and business reports into one integrated report, there are extensive opportunities to transparently identify the interactions between economic performance and a company's use of natural and social resources.

In addition to some forerunners in the movement Economy for the Common Good and environmentally-orientated consulting networks, the Value Balancing Alliance (VBA, <https://www.value-balancing.com>) has taken on a pioneering role, even before international regulations came into force. In particular, the VBA has jointly developed a standardised methodology with its member companies to present their economic, social and ecological value contributions in such a way to enable comparison with the performance of other companies. In this way, internal actors and external stakeholders find out where a company's sustainability management stands in comparison with its rivals and in which areas of action there is a need for adjustment.

As part of the European Green Deal – and especially with the introduction of the Non-financial Reporting Directive (NFRD) of 2017 – the European Union has taken a leading role in standardising mandatory sustainability reporting for companies (Breijer and Orij 2022). In November 2022, the European Commission adopted a legally-binding framework for companies: the Corporate Sustainability Reporting Directive (CSRD, Chapter 4). According to this Directive, around 40,000 companies in the EU, including about 15,000 in Germany, will have to regularly monitor, evaluate and transparently disclose the risks, dependencies and impacts of their activities on biological diversity. This also places a spotlight on their supply and value chains. The challenge is to reduce the complexity of biodiversity and ecosystem services for companies in order to derive meaningful recommendations for action (Förster et al. 2023).

## **Ecosystem services and biodiversity: What information is available at national level in Germany?**

### **Initiatives and milestones in information gathering**

The concept of ecosystem services (ES) first appeared in environmental debates of the 1990s. In addition to widely recognised publications, in particular de Groot (1992), Daily (1997) and Costanza et al. (1997), other important milestones in popularising this concept include the Millennium Ecosystem Assessment (MEA – Millennium Ecosystem Assessment 2005), the Economics of Ecosystems and Biodiversity study (TEEB – The Economics of Ecosystems and Biodiversity 2009) and the Strategic Plan 2011-2020 adopted for the 10<sup>th</sup> Conference of the Parties to the Convention on Biological Diversity (CBD – Convention on Biological Biodiversity 2010). The Kunming-Montreal Global Biodiversity Framework can certainly be seen as the latest important milestone in this process (CBD – Convention on Biological Biodiversity 2022b).

The aim of the ES concept is to prevent the overuse and degradation of our natural living conditions by taking better account of ecological services in decision-making processes and thus ensure sustainable land use. The implementation of ES in decision-making requires appropriate information. By linking research approaches on ecosystem functions and biodiversity with human well-being, it is possible to build a bridge between scientific disciplines and political sectors (Grunewald and Bastian 2023).

The following section outlines important stages in the collection of data on biodiversity and ecosystem services with a focus on Germany:

- The aim of the project **Natural Capital Germany – TEEB-DE** (<http://www.naturkapital-teeb.de>) was to use case studies to highlight the services and values of nature for Germany and to develop proposals on how natural capital can be better integrated into private and public decision-making processes. This includes reports on biodiversity and climate policy, ES and the development of rural areas, natural services in the city as well as a summary report with options for action. Building on this, the project “Mainstreaming Natural Capital Germany”, led by Deutsche Umwelthilfe (DUH), aimed to make the value of nature and the importance of ES in Germany more visible to political and administrative decision-makers as well as interest groups (<https://www.natur-ist-unser-kapital.de/>).
- Action 5 of the EU Biodiversity Strategy 2020 explicitly calls for improved knowledge of ecosystems and ecosystem services: “Member States, with the support of the Commission, will map and assess the status of ecosystems and ecosystem services in their national territory by 2014, assess the economic value of such services and promote the inclusion of these values in accounting and reporting systems at EU and national level by 2020” (EC - European Commission 2011).
- This requirement triggered a huge amount of activity on ecosystem assessment in the EU Member States, coordinated by the EU’s MAES working group (The Working Group on Mapping and Assessment of Ecosystems and their Services) and the ES MERALDA project ([www.esmeralda-project.eu](http://www.esmeralda-project.eu)), supported by the European Environment Agency (EEA).
- In this context, the German environmental authorities (Federal Ministry for the Environment, Federal Agency for Nature Conservation/Federal Environment Agency) initiated various research projects for the systematic and comprehensive recording, assessment and mapping of ES (quantitative, repeatable) at national level. In addition to the European objective, consideration was also given to ways of supporting the implementation of the National Biodiversity Strategy (BMU - Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2007) and its re-orientation in 2030 (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023).

As a result, the knowledge and methodological tools for ES have significantly expanded (see, e.g. Burkhard and Maes (2018), Grunewald and Bastian (2023), Vári et al. (2024)). After lengthy official consultation, the national MAES report was published in 2024 under the title “Nature under Pressure – report on the state of ecosystems and their services for society and economy. German MAES Report on Target 2, Action 5 of the EU Biodiversity Strategy 2020” (Schweppe-Kraft et al. 2023).

In the meantime, the methodological and legal framework for new accounting procedures for ecosystems and their services has also seen significant improvement: the UN Statistical Commission has adopted the conceptual and methodological framework SEEA EA (United Nations 2021) as an international statistical standard. The work was carried out in collaboration with the World Bank’s Wealth Accounting and the Valuation of Ecosystem Services (WAVES) initiative and the EU’s Natural Capital Accounting and Valuation of Ecosystem Services (NCAVES). The EU is adapting the Regulation on European environmental economic accounts (No. 691/2011, Annex IX) accordingly and is also expanding EU indicator systems against the background of the Green Deal (EC - European Commission 2019, EC - European Commission 2022).

In 2017, Germany’s Federal Agency for Nature Conservation (BfN) commissioned the pilot projects “Integration of ecosystems and ecosystem services into environmental economic accounting” and “Ecosystem services and environmental economic accounting – digital assessment” (<https://www.ioer.de/projekte/accounting-ii/>). The EU Horizon 2020 project MAIA also provided support for German ecosystem accounting (<https://maiaportal.eu>).

More recently, in December 2022, ecosystem assessment and accounting enjoyed a further boost at the 15<sup>th</sup> Conference of the Parties to the Convention on Biological Diversity when almost 200 countries adopted the Global Biodiversity Framework (GBF) (CBD – Convention on Biological Biodiversity 2022b). With the EU Biodiversity Strategy 2030, which was adopted in 2020 and the GBF, important frameworks now exist that, on the one hand, promote the integration of biodiversity and ES into economic reporting systems (Förster et al. 2023) and, on the other, make such new information relevant for decision-making processes at national level (Zieschank and Grunewald 2023). This will also be incorporated into the German government’s new National Biodiversity Strategy 2030 (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023).

## **Ecosystem accounting by the Federal Statistical Office as new data products**

The accounting of ecosystems and their services is a new part of the already established environmental economic accounts (EEA), which reflect the interactions between the environment and the economy, such as the environmental impact of the economy, the yields of natural resources and the value of environmental protection measures ( Felgendreher and Schürz 2023). The SEEA EA framework defines the structure and



accounting methods of the new reporting system, while the specific implementation for the European context is defined by the EU regulation No. 691/2011 (EC - European Commission 2022). It is worthwhile to mention that the European Commission's proposal amend this regulation with ecosystem accounts\*<sup>9</sup>

<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:329:FIN>

The proposal will very likely be adopted as a regulation by the end of this year since there is agreement from the European Parliament and the Council.

### Organisation and structure of the SEEA EA framework

Ecosystems and their services are captured in accounts that reflect their extent, condition and services (physical and monetary) (Fig. 1). The content of these accounts is reported as a time series (every three years for extent and condition, annual for services) on comparable aggregation units (national level, individual *Länder*, municipalities) with initial and final stocks and changes. Extent and condition are stock variables used to derive the flow variables, i.e. the ecosystem services.

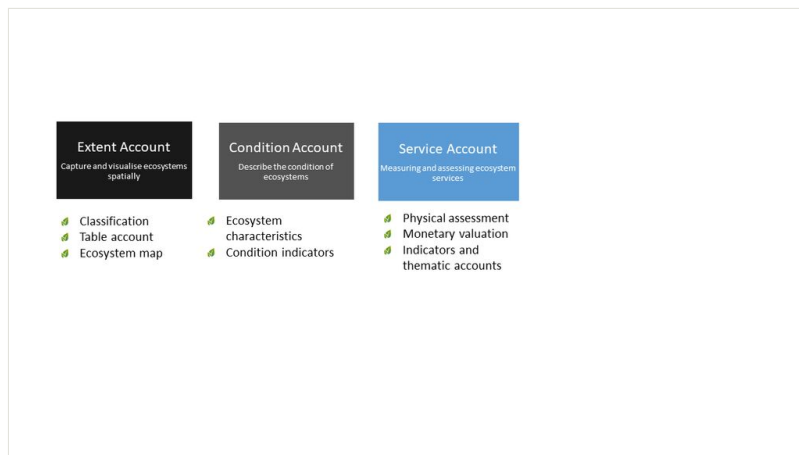


Figure 1.

Structure of the nationwide ecosystem accounts (according to United Nations (2021)).

The systematic approach of the accounts also allows the supply and demand for ES to be interpreted over time by consulting information on the extent (e.g. renaturalised areas) and condition (e.g. drought). In this way, the interaction between humans and nature, including feedback effects and tipping points, can be mapped (Felgendreher and Schürz 2023).

The ecosystem accounts are fed by a large number of datasets drawn from remote sensing, land cadastres, ecological mapping and monitoring systems. A special feature and basic condition is the explicit spatial structure of the data and its temporal consistency. This means that all areas throughout Germany are presented as ecosystems

and the statistical results can be visualised not only as tabular accounts, but also as maps (Felgendreher and Schürz 2023).

**What will be available in 2024?**

Previously, the Ecosystem Extent Account was compiled by the Federal Statistical Office for the time steps 2015, 2018 and 2021. Now it is in continuous production. The basis of the Ecosystem Extent Account is the national system of ecosystem classification, which categorises areas based on ecological and structural characteristics and comprises 74 classes, 21 groups and six divisions (terrestrial and marine, Bellingner et al. (2021)).

The Ecosystem Atlas (<https://oekosystematlas-ugr.destatis.de/>) shows the diversity and distribution of Germany’s ecosystems at municipal, district and *Länder* level. The Atlas also offers overview maps in raster format (resolution: 100 metres) and a download function for georeferenced data.

The Ecosystem Condition Account, which was first published in 2023 (tables and selected maps in the Ecosystem Atlas), describes the condition of ecosystems for the country as a whole. Based on the Ecosystem Extent Account, it provides information on the capacity, stability, integrity and resilience of ecosystems. The classification of condition is based on the specifications of the SEEA EA to allow international comparability of ecosystems.

Table 1 shows the range of variables employed, here using the ecosystem class “forests & woody plants”. Information on the individual ecosystem variables and their processing is also provided in fact sheets.

Table 1.  
 Typology and variables for ecosystem condition assessment, illustrated using the example of the ecosystem class “forests & woody plants” ([https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/JGR/oekosystemgesamtrechnungen/Publikationen/Downloads/methode-zustandsbilanzierung-5853202239004.pdf?\\_\\_blob=publicationFile](https://www.destatis.de/DE/Themen/Gesellschaft-Umwelt/Umwelt/JGR/oekosystemgesamtrechnungen/Publikationen/Downloads/methode-zustandsbilanzierung-5853202239004.pdf?__blob=publicationFile)).

Condition typology		Ecosystem variable
Abiotic	Abiotic – physical	Soil moisture (total soil) + unusual dryness / drought
	Abiotic – chemical	Organic soil carbon
		Soil pH
		Ground-level ozone
		Particulate matter (PM2.5)
Biotic	Biotic – composition	Characteristic bird species
		Diversity of the main tree species
	Biotic – structure	Canopy density
		Deadwood stock
	Biotic – function	Vegetation index NDVI

Condition typology	Ecosystem variable
	Vegetation period (length)
Pressure	Fire-damaged area
Management	Protected area
Additional data	Precipitation
	Air temperature
	Snow cover

The balances of selected ecosystem services are currently being compiled. These are expected to be published successively in 2025, initially as physical data, but later also in monetary terms. The recording of seven ES will be made mandatory throughout the EU by the European EEA regulation No 691/2011 (EC - European Commission 2022): Provision of wood and crops, local and global climate regulation, air filtration, pollination and nature-based tourism.

## Information from other institutions

In addition to the work of the Federal Statistical Office, other institutions are investigating aspects of biodiversity and ecosystem service accounting and the underlying data. For instance, research institutions such as the Leibniz Institute of Ecological Urban and Regional Development (IOER), the Helmholtz Centre for Environmental Research (UFZ) and the Johann Heinrich von Thünen Institute (Federal Research Institute for Rural Areas, Forests and Fisheries) are greatly involved in the generation of information, particularly the methodological development of indicators on the status and services of ecosystems.

## Overview of available data at national level

Freely accessible data on land use and land cover are increasingly available throughout Germany. Some of these data are provided at good temporal and spatial resolution and thus can form an important basis for surveys of ES (Grunewald et al. 2022b). Prominent examples of such datasets are CORINE Land-Cover Data (CLC) and the “Land Use and Coverage Area frame Survey” (LUCAS) programme.

More precise data for the analysis of ES is also available for Germany’s individual *Länder*, for example, biotope mapping. However, national comparison is often hindered by the use of different classification systems and mapping periods. Positive exceptions in this regard are the Digital Basic Landscape Model (Basis-DLM) of the Official Topographic-Cartographic Information System (ATKIS) and the Digital Land-Cover Model for Germany (LBM-DE).

There exist a number of Europe-wide or nationwide monitoring systems that regularly provide specialised indicators on landscape development in a temporally and spatially

comparable manner which can also be used to quantify particular aspects of ES at national level. These include:

- Sustainability indicators of the 17 UN Sustainable Development Goals (SDGs), which are managed and published by the Federal Statistical Office (DESTATIS – Statistisches Bundesamt 2020);
- Länderinitiative Kernindikatoren (LiKi) of the Working Group of Federal and Länder Environmental Authorities (LiKi 2020);
- The German Strategy for Adaptation to Climate Change (DAS) (UBA - Umweltbundesamt 2019);
- The UBA's approximately 50 environmental indicators that capture trends in environmental protection (UBA - Umweltbundesamt 2020);
- The National Strategy on Biological Diversity (NBS) of 2007; additional data collected by the BfN includes the condition of floodplains and public awareness of biodiversity (BMU - Bundesministerium für Umwelt, Naturschutz und Reaktorsicherheit 2007);
- The “SEBI” indicator set of the European Environment Agency (EEA) as part of the EU Biodiversity Strategy. This names a total of 34 indicators that are collected by the Member States according to standardised procedures (EEA – European Environment Agency 2020).

### **Germany's ecosystems**

The system of ecosystem classification, mapping and evaluation (monitoring of changes in the extent ecosystems) was developed by the IOER on behalf of the BfN and forms the basis for the assessment of ecosystem conditions and services (Grunewald et al. 2020). This requires national digital topographic data, in particular the land-cover model (LBM-DE), which is updated every three years (2012-2015-2018-2021 etc.), as well as European classifications of land use and ecosystem (<https://ioer-fdz.de/oekosysteme-deutschland>).

### **Indicators of ecosystem condition**

While the condition of an ecosystem and the services it provides are obviously interdependent, this relationship varies from service to service and is often non-linear. In many cases, ecosystems in better condition will support a greater quantity and quality of relevant ES (for a meta-analysis, see Smith et al. (2017)), making the case for sustainable ecosystem management. The relationship between the condition of ecosystems and the provision of services is central to the concept of ecosystem capacity (United Nations 2021).

Many datasets and indicators on condition are collected by institutions such as the UBA, BfN, BfG, BGR or the Thünen Institutes as part of sectoral environmental monitoring. The UFZ Drought Monitor, for example, provides comprehensive information every day on soil moisture in Germany. (<https://gdz.bkg.bund.de/index.php/default/duerreatlas.html>). The IOER Monitor ([www.ioer-monitor.de](http://www.ioer-monitor.de)) offers processed information on land use and its

development, as well as on landscape quality for the entire country. The IOER's new Research Data Centre (RDC) provides data on the conservation status, ecological connectivity and use of the six nationally dominant landscape types, amongst other things (<https://ioer-fdz.de/oekosysteme-deutschland>).

Some indicators that can be used to characterise ecosystem condition are already politically established and legitimised in nationwide indicator systems as part of the Federal Government's sustainability strategy (SDG indicators, Federal Government (2021)) and the National Biodiversity Strategy (NBS indicators, BMU – Bundesministerium für Umwelt, Naturschutz und nukleare Sicherheit (2015)). In most cases, however, they must also be processed and interpreted regarding the extent of ecosystem types and the provision of ecosystem services. In addition, a specific form of mapping ("spatialisation") may be required (Grunewald et al. 2022b).

**Biodiversity** is an essential factor when measuring the condition of ecosystems. In particular, biodiversity metrics such as species abundance, species richness or other species-based indices are often used to measure various aspects of ecosystem condition (Rendon et al. 2019). Here, we can particularly mention the updated Red List of Germany's Mammals (Meinig et al. 2020) and the Red List of Endangered Biotope Types (<https://www.bmu.de/download/rote-liste-der-gefaehrdeten-biotoptypen-deutschlands>).

Clearly, human life depends on a wide diversity of animal/plant species and habitats to ensure efficient and well-functioning ecosystems. The overarching goal of the National Strategy is, thus, to achieve a good state of biodiversity across the most important landscape and habitat types in Germany, i.e. in agricultural landscapes, forests, settlements, inland waters, floodplains and moors, as well as on coastal areas and in seas (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023). The achievement of targets is to be measured primarily via the main indicator **species diversity and landscape quality** (JWB - Jahreswirtschaftsbericht der Bundesregierung 2024, also an established NBS and SDG indicator). This indicator reflects the population trends of 51 bird species, representing the most important landscape and habitat types in Germany. The size of the populations (by number of territories or breeding pairs) reflects the suitability of the landscape as a habitat for the selected bird species. In addition to birds, other species are also dependent on a richly structured landscape with intact, sustainably utilised habitats, which is why the indicator also indirectly reflects the development of numerous other species in the landscape and the sustainability of land use. In fact, this is a "high-end indicator", i.e. one that does not merely provide information on bird species, but also on wider material and physical interventions in the environment that affect bird populations. These bioindicators are designed to reveal the quality of landscapes/main ecosystems in Germany; their specific objects of interest are not bird species, but ecosystems.

Current data for the aggregate indicator show that stocks have deteriorated over the last ten years (2010: 79.5 per cent; 2019: 75.3 per cent). The most important sub-indicator in terms of area, i.e. agricultural land, has actually fallen significantly in recent years, from

83.0 per cent in 2010 to 69.9 per cent in 2019 (JWB - Jahreswirtschaftsbericht der Bundesregierung 2024).

A nationwide indicator **biotope value of Germany's ecosystems** is currently being developed to enable monetary valuation. This indicator, which expresses the “services of ecosystems for the conservation of biodiversity”, uses biotope value points (expressed as cardinals) calculated by the Federal Compensation Ordinance. Results are available for 2018 (Grunewald et al. 2023, Schweppe-Kraft et al. 2020; Grunewald et al. 2023, Schweppe-Kraft et al. 2020). The indicator approach is not only consistent with other accepted recording and evaluation procedures (FFH and WFD reporting, HNV mapping, Federal Forest Inventory) and enables aggregation to an overall value for biodiversity based on a legally recognised procedure (Federal Compensation Ordinance), but is also well suited for monitoring measures (e.g. Restoration Law), as biotope conversion and enhancement are directly reflected in the indicator.

Data on **nature-rich areas and nature conservation areas in Germany** are relatively simple parameters giving a rough spatial assessment of near-natural habitats and habitats of nature conservation value. In the IOER Monitor, the indicator “Proportion of nature and species conservation areas in the target area” is currently available at *Länder*, regional planning, district and municipal level, as well as in grid form between 10 km and 100 m for the time periods 2006 and 2008 to 2018. The data can be found at <https://monitor.ioer.de/> and are freely accessible. This indicator provides information on the extent to which protected areas contribute to the ES “conservation of biodiversity” as well as “aesthetic values”, “opportunities for recreation and tourism” etc.

## ES indicators

A number of national ES indicators have been developed, harmonised and published within various research projects focusing on priority ES classes and the development of principles for describing indicators (Grunewald and Bastian 2023, Schweppe-Kraft et al. 2023). Table 2 provides an overview of available national ES indicators.

Table 2. Selected nationwide indicators on ecosystem services for Germany.		
Category	ES indicator	References
Provisioning ecosystem services	Agricultural biomass production: arable yield potential* (availability of soils with high natural fertility)	Grunewald 2021
	Raw timber production (timber growth, gross revenue potential)*	Elsasser et al. 2020
Regulating ecosystem services and biodiversity	Water retention potential of floodplains: area for flood retention	Walz et al. 2019
	Pollination service: habitat potential for wild bees	Meier et al. 2021
	Regulation of soil erosion by water: capacity of ecosystems to minimise erosion	Syrbe et al. 2018

Category	ES indicator	References
	Climate regulation in cities	Syrbe et al. 2024
	Climate protection service of forests* (carbon storage)	Elsasser et al. 2020
	Conservation of biodiversity: biotope area indicator to assess the existence and conservation values of nature *	Ekinci et al. 2022a, Grunewald 2021, Schweppe-Kraft et al. 2020
	Greenhouse gas sequestration	Syrbe et al. 2024
Cultural ecosystem services**	Recreational services of urban green spaces: accessibility of urban green spaces; amenity value *	Ekinci et al. 2022b, Grunewald et al. 2017, Grunewald 2021
	Recreational services of forests *	Elsasser et al. 2020
	Nature conservation and scenic views* (forest ecosystems)	Elsasser et al. 2020
	Nearby recreation* (landscape-based recreation)	Hermes 2023

\* including valuation of the monetary benefits of the ecosystem service.

\*\* Cultural ecosystem services are usually a bundle of provided/addressed services.

The development, harmonisation and implementation of these indicators is an ongoing process that will, in the future, also include ES from Germany's marine and coastal areas. The indicators "accessibility of urban green spaces", "habitat potential for wild bees" and "biotope area indicator" are currently being updated at the IOER. The IOER's RDC will ensure that these data are made available in a user-orientated manner after the conclusion of the research projects (<https://ioer-fdz.de/en/>).

## Challenges and opportunities

New reporting systems, based on ecosystem information, are being developed in Germany as well as in many other countries. These pose challenges not only for statisticians, but also for all researchers and practitioners in this field.

**Data availability:** Ideally, the ecosystem calculations are fed by a large number of quality-checked datasets that are homogeneous, consistent over time and permanently available at the highest possible temporal and spatial resolution. The nationwide approach to ecosystem accounts means that the reporting system would benefit from well-functioning data provision at national level. Yet at present, for instance, standardised, high-resolution data on surface waters and biotope mapping are not available for the whole country. While rapid developments in remote sensing are clearly a great opportunity for ecosystem accounts, it would be helpful if international and national institutions provided more quality-tested, ready-to-use and (in certain cases) customised data products and guaranteed their long-term updating, also coined as "account-ready data".

This last consideration also concerns one of the major functional advantages of the ecosystem accounting system. Due to the standardised units of spatial analysis and the accounting structure, the majority of accounts can be created quickly with only minimal effort required to calculate further time steps.

The self-contained yet interconnected nature of the accounts means that various “product exits” can be taken from this data “motorway”. In particular, the results of the individual accounts, thematic evaluations, calculations of sustainability indicators and visualisations in map form can be created as “by-products” alongside the recording of ES (Felgendreher and Schürz 2023).

**Monetary valuation:** A further challenge is the monetary valuation of ecosystem services, for which no broad consensus has yet been reached conceptually or methodologically. Consequently, the chapters of the SEEA EA dealing with monetary valuation are merely recognised as guidelines rather than establishing a statistical standard. Of course, the monetary valuation of goods and services provides a common metric to allow aggregation and comparison, in particular the comparison of ecosystems and ES with other capital values and services that feature in national accounts. While the accounting system is essentially based on nominal market prices, the economic (welfare) value is based on a person’s willingness to pay for goods. A database of the valuation studies available for Germany and the monetary values determined therein for ES is compiled in the appendix to Förster et al. (2019).

Economic values depend on the scarcity of services. This means that, where nature provides a particularly high physical output, the value may be the lowest (but only if demand is low; with high supply, but higher demand, values are also high). In addition, valuation at market prices is sensitive to market structures, external price fluctuations and political interventions. Possible misinterpretations of monetary values must be avoided by communicating the data transparently and with mention of the ecological and economic context. In addition, as several valuation methods may be available for any one service, it is vital to prioritise these based on scientific “best practice” (Felgendreher and Schürz 2023).

**ES indicators:** With regard to the development of ES indicators, there is clearly a considerable challenge to simultaneously meet complex requirements from different perspectives, namely:

- environmental policy: ES indicators should be intuitive and understandable, coherent, applicable across media, focused on the cause of change, adaptable, orientated towards long-term monitoring and relevant to nature conservation policy and other sectoral policies;
- economic policy: in particular, they should reveal cost-benefit analysis, options for action and identify solution pathways;
- scientific: they should be analytically robust, validated in accordance with current scientific/technical knowledge and international standards, but also



simple, measurable (also periodically), practicable, easy to interpret, physically precise within Germany and reveal trends over time.

Accordingly, it is necessary to make compromises in the development of indicators. Scrutiny is required to determine what the indicators “indicate” for whom as well as which social objectives are associated with an indicator. The focus of is, of course, not the indicator *per se*, but that which it indicates, namely some real-world feature that is not directly measurable and which is often a complex situation or condition/performance undergoing change (Grunewald and Bastian 2023).

### **Potential applications**

Ecosystem-based information and accounts are potentially the source of a range of data products that can be used in many different ways. Demand for this type of information is increasing.

Internationally, ecosystem accounts can provide comparable information across countries to benefit, for instance, a common EU environmental policy. Additional indicators from ecosystem accounting can be integrated into international or national sustainability and biodiversity strategies.

Similar to national accounts, the accounting system can be used at the macro level as a input-output analytical tool, i.e. as the ecological counterpart to the representation of relationships in economic production. Assuming that regularly updated spatial data on ecosystems are available, ecosystem accounts can serve as an input for science (evaluation of measures, modelling of future scenarios). The visualisation of findings in maps enables easy-to-understand communication of results to the general public (Felgendreher and Schürz 2023).

National ES indicators can be used for environmental policy, especially if these are intuitive and comprehensible, coherent, applicable across media, focused on the cause of change, easily adaptable, orientated towards long-term monitoring and are relevant for nature conservation policy and other sectoral policies. In some cases, scientists are required to take on “translation tasks” for policy and practice.

## **Corporate reporting on biodiversity - from voluntary commitment to mandatory regulation**

### **Current status of sustainability reporting**

The economic and political need to create and establish globally recognised standards for financial reporting has forced companies to make their economic performance much more transparent. In contrast, the process of revealing the socio-ecological contributions of companies is still in its infancy (Laine et al. 2022). Unlike the development of established financial reporting standards, the process of sustainability reporting is largely initiated and driven by private-sector institutions and associations. Academic expertise

from the fields of sociology, ecology and economics plays a major role here (Bebbington et al. 2021). It is only in recent years that, triggered by increasing social pressure and the adoption of international legal frameworks such as the *Paris Climate Agreement* or the *Kunming-Montreal Biodiversity Convention*, sustainability – and biodiversity, in particular – has gained more attention on the national/international political and regulatory agendas.

### **The EU perspective**

As part of its European Green Deal and, in particular, since the first application of the Non-Financial Reporting Directive (NFRD) in 2017, the European Union has taken a leading role in standardising mandatory sustainability reporting for companies (Breijer and Orij 2022). With the introduction of the Sustainable Finance Disclosure Regulation (SFDR) and the EU taxonomy for sustainable activities (EU Taxonomy) in 2021 and 2022, respectively, the EU has explicitly imposed extensive and strict disclosure requirements on the financial sector (Cremasco and Boni 2022). However, the existing NFRD does not stipulate comprehensive and mandatory sustainability reporting for large parts of the economy. This has led to a situation where the financial sector is required to assess and disclose various sustainability aspects of its clients without having access to a standardised and legally indicated database on their sustainability performance. In a rapidly growing market for sustainable financial products, this lack of relevant and reliable data is causing a significant lack of transparency and ultimately an increasing risk of greenwashing (Wildner et al. 2022).

Against this background, voluntary – mostly private sector – reporting standards and frameworks, such as those of the Global Reporting Initiative (GRI), the Sustainability Accounting Standards Board (SASB) or the International Integrated Reporting Committee (IIRC), have become increasingly important. Regionalised guidelines such as the German Sustainability Code (DNK) have also become more relevant. However, the currently limited standardisation hinders comparability of sustainability information between companies and sectors (Wildner et al. 2022).

To address this problem, the EU is gradually obliging approximately 50,000 EU companies to implement a comprehensive and binding sustainability reporting standard as part of the *Corporate Sustainability Reporting Directive* (CSRD), which has been in force since 1 January 2024. Targeted companies must report on their impacts on, as well as their dependencies and risks to, nature and society, on a site-specific basis and across their entire value chain (EU - European Union 2022).

This comprehensive and detailed consideration of sustainability issues and their impact on the company (**outside-in perspective**), as well the impact caused by the company (**inside-out perspective**) in conjunction with the requirement for continuous coordination and validation with relevant stakeholders, clearly distinguishes the EU CSRD and the reporting framework on which it is based, the *European Sustainability Reporting Standards* (ESRS), from other sustainability reporting standards (Wildner et al. 2022).

With regard to reporting on nature, the **ESRS E4** set of standards is of central importance. According to these, companies must assess, measure and ultimately disclose both their impact and dependence on nature, its ecosystems, species and related services (EU - European Union 2023c).

### **International perspective**

At an international level, the Global Reporting Initiative (GRI) framework, introduced in 1999 and used by around 10,000 companies in more than 100 countries, is essential for sustainability reporting, particularly in relation to biodiversity (Machado et al. 2021).

The standards on sustainability reporting of the International Sustainability Standards Board (ISSB) of the IFRS Foundation, some of which have already been published with others in the process of being developed, are also significant due to their solid reputation as international standard setters with regard to corporate financial reporting (Förster et al. 2023).

In contrast to the EU's ESRS, reporting in accordance with the GRI standards focuses exclusively on the inside-out perspective (GRI 2022), while the ISSB sustainability standards currently only offer an outside-in perspective, with an exclusive focus on climate reporting (International Financial Reporting Standards Foundation 2023).

In the short period since the ESRS reporting requirements have come into force, it has become clear that they, in general – and ESRS E4, in particular – are going to have a major impact on international reporting standards. As a result, the role and importance of comprehensive reporting on the interaction of companies with nature, its components and services is going to become ever more prominent.

### **The role of biodiversity, ecosystems and their services in sustainability reporting**

Reporting on biodiversity, ecosystems and their services plays a central role within the EU CSRD and its ESRS, while other reporting standards and regulations mostly focus on specific sub-aspects. Fig. 2 shows how the economy and society exert influences (impact drivers) on ecosystems and species (assets) and, in turn, are dependent on these or on corresponding ecosystem services (flows). The resulting impacts and dependencies on nature give rise to risks (transitory, physical and/or systemic) and opportunities for the company as well as for the economy and society, which must be reported on transparently as part of CSRD-compliant reporting.

The corresponding thematic standard of the CSRD is the so-called ESRS E4 (EU - European Union 2023b). This demands a holistic view of biodiversity, based on its individual components – species, ecosystem, ecosystem services and drivers of nature loss – and is, therefore, written and understood as a consolidating standard for all environmental topics. For example, while the impact driver “pollution” has its own thematic standard in ESRS E2 (EU - European Union 2023c), key metrics and

information must also be reported in ESRS E4 or at least referenced accordingly. The aim of reporting in accordance with ESRS E4 is, therefore, a holistic presentation of a company’s impacts as well as its dependencies on ecosystems, species and ecosystem services (EU - European Union 2023b). With the ESRS and, particularly, ESRS E4, the concept of double materiality is thus implemented for the first time in an internationally-binding standard for sustainability reporting (EU - European Union 2023a).

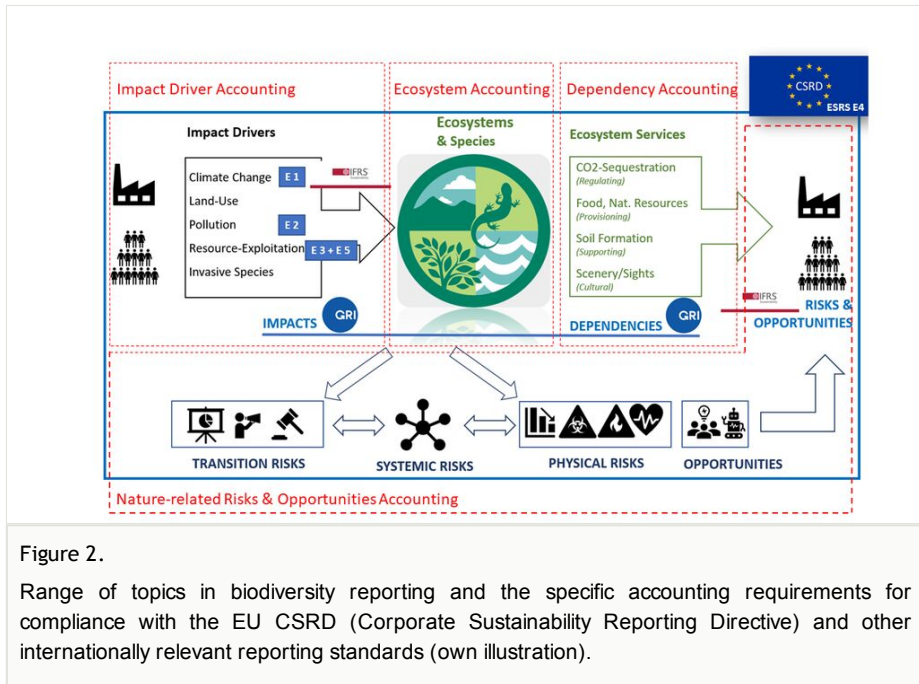


Figure 2.

Range of topics in biodiversity reporting and the specific accounting requirements for compliance with the EU CSRD (Corporate Sustainability Reporting Directive) and other internationally relevant reporting standards (own illustration).

Of fundamental importance in the context of biodiversity reporting is a correct understanding of the term “biodiversity” and its scope from an accounting perspective: While the notion of biodiversity consistently follows the definition of the International Convention on Biological Diversity (CBD) and, thus, aims to encompass the diversity of natural life and the resulting structures and services (CBD – Convention on Biological Biodiversity 2022b), the measurement, quantification and subsequent reporting of this diversity requires individual accounting/reporting systems and methods. Consequently, as Fig. 2 shows, ESRS E4-compliant biodiversity reporting is divided into four distinct accounting and reporting systems. When combined, these systems provide a complete overview of the reporting company’s interaction with nature and its dependence on it.

**Impact driver accounting**

Impact driver accounting examines the current and potential impact drivers or impacts that economic activities have on ecosystems, species and (ultimately) ecosystem services. This assessment forms the basis for a structured materiality analysis, which is the first step in ESRS-aligned reporting (EU - European Union 2023a). It focuses on the main drivers of nature loss as identified by the *Intergovernmental Science-Policy Platform*

on *Biodiversity and Ecosystem Services* (IPBES): climate change, pollution, land use, exploitation of natural resources and invasive species (IPBES 2019).

Impact driver accounting aims to identify, measure and report on factors that have a demonstrable impact on the environment and are caused by economic activities. Examples of measurement points include water consumption in cubic metres, the land use of a production site in hectares or CO<sub>2</sub> emissions in tonnes. *The Natural Capital Protocol* (Capital Coalition 2016) and the *Natural Capital Management Accounting Method* (Value Balancing Alliance, Capitals Coalition 2023) provide a widely accepted and established framework for the practical implementation of such a reporting system of impact driver accounting (Wildner et al. 2023) and the monetisation of corresponding data points.

The implementation of these frameworks requires companies to provide transparent and quantifiable data on their environmental impact. This information is essential for stakeholders and investors, who are increasingly incorporating sustainability into their decision-making processes. It is also important for companies themselves, as it enables holistic – and thus sustainability-informed – risk management and performance optimisation, as well as contributing to commonly accepted sustainable development goals and targets (Wildner et al. 2023).

Impact driver accounting, particularly in the context of the EU CSRD, demonstrates the need for accountability and a shift towards more sustainable practices that consider the long-term well-being of society and the planet. This highlights the growing awareness of the interdependence of economic activities and environmental well-being, as well as the responsibility of companies to operate within environmental boundaries (Value Balancing Alliance, Capitals Coalition 2023).

### **Ecosystem accounting**

In contrast to impact driver accounting, which examines the environmental impact of economic activities, ecosystem accounting describes the related changes that take place in nature. Ecosystem accounting, which also includes species accounting, aims to capture the extent, composition, condition and changes in nature affected by a company's economic activities.

While such accounting and reporting is primarily relevant for national reporting based on the *UN Framework for Environmental Economic Accounting* (United Nations 2021), the focus of corporate reporting is predominantly on consolidated indicators (Finance for Biodiversity Foundation 2022). Examples of these indicators are the Mean Species Abundance (MSA) or proximity to sensitive natural areas or endangered species. This form of reporting represents a considerable simplification compared to national reporting, mainly due to the otherwise considerable effort required to carry out a site-specific, detailed ecosystem accounting across a company's entire value chain (Wildner et al. 2022).

Additional metrics result from mandatory compliance with other regulations, such as the EU regulation for deforestation-free products or local environmental impact assessments. An important aspect, particularly with regard to compliance with the EU taxonomy and the SFDR, is the specification of the spatial proximity of economic activities to highly protected areas and species.

In the context of corporate reporting, it can be a problem to combine various forms of ecological data, which is often difficult for laypersons to understand, into a format that is accessible and relevant for the creators and users of such reporting. At the same time, this process must be practicable for the reporting company to implement. Companies must assess their direct impacts and record their environmental footprint, including the changes in the natural environment for which they are responsible. This form of accounting is becoming increasingly important in the field of corporate sustainability reporting as it provides a more comprehensive view of a company's connection to the natural world and aids understanding of the potential threats and dependencies that companies face due to their impact on the environment.

### **Dependency accounting**

Dependency accounting differs from both impact driver accounting and ecosystem accounting by focusing on the reporting company and investigating how it is influenced by nature. This type of accounting reveals a company's dependence on ecosystems and their services, which are often obtained free of charge or even unwittingly. It highlights certain ecosystem services that are crucial for economic processes and whose decline can have economic repercussions, such as increased costs or production stoppages (Power et al. 2022). Examples of such dependencies include power plants that require clean, cool water in sufficient quantities, intact vegetation that protects against unwanted environmental influences and insects that provide important pollination services for farms and, thus, the food industry. In addition to a basic dependency profile for each economic activity, dependency accounting requires site-specific identification, measurement and reporting of the ecosystem services (and their availability) which have been identified as essential (EU - European Union 2023b). While the accounting and reporting of commodity-type ecosystem services, such as the provision of water, wood or biomass, is relatively straightforward, there is a lack of established indicators and an overarching accounting method for the majority of regulating, cultural and supporting ES. The paucity of data and conceptual guidance impedes the integration of dependency accounting-related information with corresponding information depicted within both impact driver and ecosystem accounting (TNFD - Taskforce on Nature-related Financial Disclosures 2023). Initial studies and methods to address and establish such methods have been proposed at the macroeconomic level, particularly by the World Bank (Johnson 2021) and the European Central Bank (Boldrini and et al. 2023). The topic is also important in the context of the United Nations System of Environmental-Economic Accounting – Ecosystem Accounting and, thus, in national reporting (United Nations 2021).

Additionally, the EU Horizon project SELINA (SELINA 2023) seeks to create a comprehensive framework for evaluating ES. Meanwhile, the ENCORE Partnership

(ENCORE Partners 2024) is in the process of updating its rating methodology, which also addresses dependencies and plays a crucial role in many of the previously mentioned studies and methods.

### **Nature-related risks and opportunities accounting**

As shown in Fig. 2, the identification, quantification and assessment of the financial risks and opportunities arising from a company's interaction with natural ecosystems is a vital aspect of sustainability reporting in accordance with the EU CSRD and ESRS E4. The risks can be subdivided into the categories transitional, physical and systemic as follows (EU - European Union 2023b):

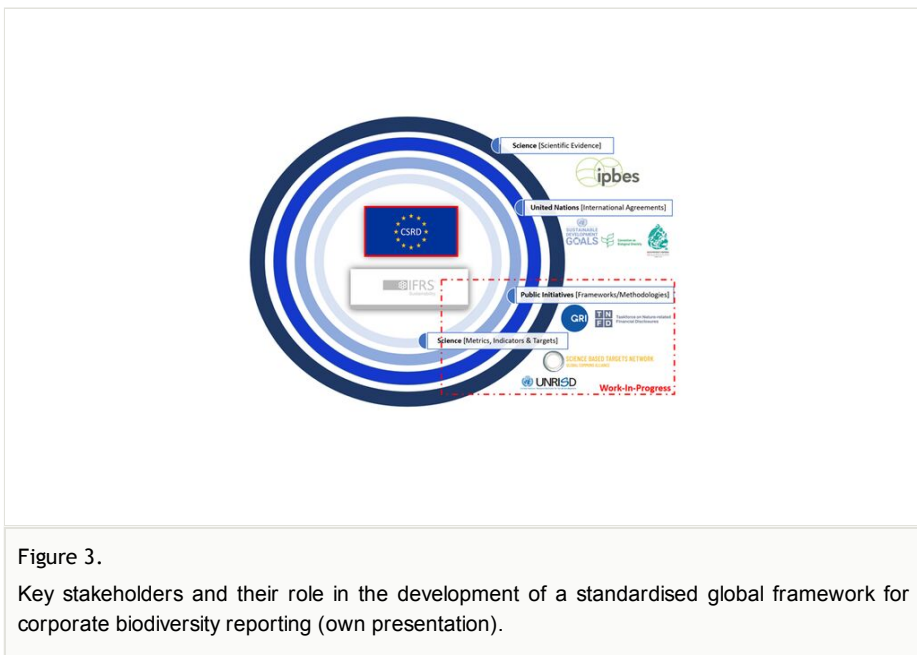
- **Transition risks** arise mainly from legal, regulatory and societal requirements in response to negative impacts that the company has or could have on society and nature. Companies must adapt to these to avoid sanctions, regulatory penalties or reduced consumer demand; this may require adjustments to operational processes or strategic direction.
- **Physical risks** arise primarily from unrecognised or poorly-managed dependencies on natural systems and their services that can suddenly become significant costs or liabilities due to changing environmental conditions or a lack of cost-effective substitutes. For example, if a critical component of a supply chain is heavily dependent on the ecosystem service of pollination, a financial risk arises in terms of nature-related risks and opportunities accounting if this service is threatened and the costs of adaptation or substitution are likely to be significant.
- **Systemic risks** include both transitional and physical risks that are aggregated at the level of individual sectors or the macroeconomy. Typical dependency and risk profiles are created and the impact on an industry, the national economy, the financial markets or the global economy is often modelled using risk scenario analyses. In corporate reporting, the focus is on analysing specific supply chains on which the company's business model is heavily dependent and which – in turn and ultimately systemically – depend on an interaction with nature.

Similar to dependency accounting, nature-related risks and opportunities accounting is at an early stage of a standardisation process that should enable companies to publish efficient, scientifically sound and internationally recognised analyses, measurement systems and indicators. While a number of central banks are already working on such frameworks at macroeconomic level (NGFS - Network for Greening the Financial System 2022), the EU is planning to develop such a framework for use by companies as part of a multi-year EU Horizon project (EC - European Commission 2023). In addition, the financial sector is also focusing ever more on this extremely important topic (Förster et al. 2023).

## Current status of nature reporting and relevant stakeholders

The process of creating a globally accepted standard for reporting on biodiversity, ecosystems and ecosystem services is being shaped and driven by a small number of very influential stakeholders. Here, we can detect similar features and characteristics to the already established climate change reporting environment. The current focus is on developing scientifically sound yet practical guidelines for corporate nature reporting in order to achieve the goal of providing relevant, accurate and objective information about a company's impacts and dependencies on nature.

Fig. 3 shows the key stakeholders, their role and objectives in developing a standardised global framework for biodiversity reporting. The EU CSRD is of central importance and refers in its reporting standard on biodiversity and ecosystems (*ESRS E4*) and corresponding application aids (some of which are still under development) to work and guidelines from those stakeholders.



The core task of IPBES is to raise global awareness of the current state of nature, of the trend of ongoing nature loss and the role of society in this process on the basis of scientific findings (Diaz 2015). The global assessments of IPBES provide an internationally recognised framework and roadmap for the protection of biodiversity and ecosystem services for international policy and regulation. Consequently, IPBES and its findings are of fundamental importance for the encouragement of nature reporting alongside the other four main drivers, for example, the ESRS E4 or GRI-304 (GRI - Global Reporting Initiative 2023) standards, as well as the work of the Taskforce on Nature-



related Financial Disclosure (TNFD - Taskforce on Nature-related Financial Disclosures 2023).

In recognition of the importance of the IPBES results, the United Nations has included these in its *2030 Agenda* for Sustainable Development and, in particular, in the 17 SDGs (Bennich et al. 2020). Many global regulations and legal frameworks and – increasingly – corporate policies and strategies refer to the United Nations' SDGs. While SDGs 14 and 15 explicitly refer to nature conservation, each SDG recognises and supports the fundamental role that ecosystems and their services play in equitable and sustainable societal development. This integration underscores the critical link between human well-being and the conservation of biodiversity and ecosystems upon whose services society is fundamentally dependent.

In response to scientific findings and the global importance of biodiversity, the UN Biodiversity Conferences convened under the Convention on Biological Diversity (CBD) have played a central role in shaping international frameworks and regulations. In December 2022, more than 190 countries agreed to adopt the **Kunming-Montreal Global Biodiversity Framework (GBF)** of the CBD, which defines legally-binding targets for halting and reversing biodiversity loss by 2030 and 2050 (CBD – Convention on Biological Biodiversity 2022b). Similar to many of the goals and targets of the Paris Climate Agreement, the GBF and its targets are of fundamental importance for corporate biodiversity reporting, as they form a key reference point in most reporting standards and frameworks for defining the overarching policy objectives to which reporting should contribute.

The **Global Reporting Initiative (GRI)** is also important for corporate sustainability reporting. Since 1999, GRI reporting standards have been recognised worldwide as the leading framework for the transparent disclosure of a company's environmental, social and governance (ESG) impacts. In response to the growing awareness of the importance of biodiversity and ecosystems, the GRI has included these topics in a separate standard, GRI-304 (GRI - Global Reporting Initiative 2016). In order to achieve close alignment with the general objectives of the CBD GBF and the ESRS E4 of the EU CSRD, at the beginning of 2024, the GRI published an updated and extended biodiversity standard, GRI-101 (GRI - Global Reporting Initiative 2024). While the current standard, which will be mandatorily replaced by GRI-101 from 1 January 2026, only takes into account a company's impact on nature, the updated standard will require companies to consider their dependence on nature and its services.

The **Task Force on Nature-related Financial Disclosures (TNFD)** is establishing itself as the leading and globally accepted framework for nature reporting in practice (Wildner et al. 2022) – parallel to the Task Force on Climate-related Financial Disclosures (TCFD). Fundamentally aligned with the objectives of the EU CSRD, the TNFD aims to integrate environmental considerations into financial decision-making by requiring companies to report on both their impact on and dependence on biodiversity, ecosystems and their services. As a non-profit organisation, the TNFD focuses primarily on the financial risks associated with the ongoing loss of nature, but in the general framework of impact and

dependency accounting and within the scientific boundaries defined by IPBES (ibid.). After about two years of public consultation, the TNFD published its final framework in September 2023 (TNFD - Taskforce on Nature-related Financial Disclosures 2023) and, in the future, will continue to update and supplement further guidance on topics such as scenario analysis or the valuation of nature and its services (ibid.).

Similar to the Science-based Target Initiative (SBTi) on climate-related targets and metrics, the **Science Based Targets Network (SBTN)** plays a fundamental role in defining scientifically-backed targets and metrics for use in corporate nature reporting (Wildner et al. 2022). Initial guidelines on targets and metrics for freshwater and terrestrial ecosystems have already been published (Gambetta 2023). By mid-2025, the SBTN aims to publish its first complete framework for all relevant areas of impact and ecosystem accounting (Gambetta 2023, SBTN - Science Based Targets Network 2023).

While the work of the TNFD and SBTN focuses on practical implementation aids for nature reporting and accounting, the work of the *United Nations Research Institute for Social Development* (UNRISD) and the *World Benchmark Alliance* (World Benchmark Alliance 2024) provides scientifically sound and practicable guidance on defining and setting meaningful thresholds and benchmarks for individual indicators and targets. Corporate reporting and corporate practice should, therefore, be aligned with the overarching goal of respecting local, regional and global ecological tipping points, so as to avoid or at least minimise the likelihood of systemic changes to the natural and, ultimately, the social environment (UNRISD - United Nations Research Institute for Social Development 2022).

In summary, the direct or indirect collaboration between IPBES, the UN, CBD, EFRAG, GRI, TNFD and SBTN illustrates both the interdependence and importance of social, economic and environmental factors. It also shows the similarities between nature reporting and established best practices in climate reporting in terms of stakeholders, process and structure. Together, these organisations have established a comprehensive, science-based, yet pragmatic understanding of the fundamental role of nature in corporate sustainability reporting and how such reporting can be meaningfully implemented to meet stakeholder needs and expectations. The general perspective is that humans and the environment can co-exist in harmony. This includes the realisation that human well-being, economic prosperity and social justice are closely linked to the preservation and protection of our planet's ecosystems and biodiversity.

## **Synergies and differences between national accounting following SEEA EA and corporate sustainability reporting**

The EU Corporate Sustainability Reporting Directive (CSRD) with the interlinked European Sustainability Reporting Standard (ESRS) for biodiversity and ecosystems (ESRS E4)\*<sup>2</sup> requires affected companies to systematically assess and disclose any information and data on impacts and dependencies on biodiversity and ecosystems. This raises the question whether information from national reporting of the German Federal

Statistical Office (DESTATIS – Statistisches Bundesamt (2024)), which accords with the guidelines of the United Nations System of Environmental-Economic Accounting – Ecosystem Accounting (SEEA EA; United Nations (2021)), can also be used for the purpose of corporate sustainability reporting. In particular, the transparency, quality and comparability of corporate sustainability reporting could be increased if companies made use of information from statistically robust and officially recognised national reporting. While corporate reporting could benefit from national data sources, corporate data on biodiversity could potentially also be considered for inclusion in national reporting. Some fundamental synergies as well as differences are outlined below\*<sup>3</sup>.

## Synergies

The deliberately open, principles-based design of the CSRD ESRS E4 provides some flexibility in selecting indicators and methods for corporate sustainability reporting on biodiversity and ecosystems. The use of information from national reporting on ecosystem accounting (DESTATIS – Statistisches Bundesamt 2024) is legitimate, as the CSRD ESRS E4 reporting standard explicitly refers to the SEEA EA framework (United Nations 2021) and recommends using SEEA EA for guidance on metrics for ecosystem extent and condition (ESRS E4 § AR33). Hence, synergies between the two reporting systems can be expected, in particular for information on ecosystems. Further, while SEEA EA provides guidelines for the accounting of ecosystem services, it is also planned in the future to include such information in national reporting for Germany. Therefore, we can expect synergies between the use of national reporting data for corporate reporting and the assessment of potential dependencies of companies on ecosystem services.

In Germany, the Ecosystem Atlas of the Federal Statistical Office (DESTATIS – Statistisches Bundesamt 2024) offers a system of ecosystem accounts that follow the guidelines of the SEEA EA framework and provides information on ecosystem extent and condition (Chapter 2) at a spatial resolution of 100 metres and with regular three-yearly updates. Data of this quality can help companies conduct an initial assessment of relevant ecosystems potentially affected by their business activities within Germany as part of the materiality assessment that they are required to conduct for sustainability reporting (see section 'Ecosystem accounting by the Federal Statistical Office as new data products').

Particularly if a company makes significant impacts such as increased soil sealing, land-use changes, freshwater consumption or the exploitation of marine ecosystems, data from national reporting could provide relevant information on potentially affected ecosystems. The national ecosystem classification system is also compatible with international standards, allowing a crosswalk between the different classification systems for land cover and land use, including the Corine Land-Cover Classes (CLC) and the IUCN Global Ecosystem Typology (Bellinghen et al. 2021, Keith et al. 2022). Monitoring changes in ecosystem extent and condition can also allow conclusions to be drawn on some of the causes of ecosystem change (United Nations 2021). The classification of ecosystems also gives information on vegetation and characteristic plant species (e.g.

dominant tree species of forest ecosystems) (Bellinghen et al. 2021). With this publicly available data, companies could be supported in analysing the surroundings of their own operative sites as well as sites of their suppliers within Germany in order to discuss potential impacts of their activities on biodiversity and ecosystems as part of the materiality analysis (as required by ESRS E4 § 41 and § AR38). As information on ecosystem services is expected to be added to the national accounts in the future, it is likely that companies can benefit from such data for identifying potential dependencies on ecosystem services.

Furthermore, if the materiality assessment finds significant impacts on protected areas, endangered species, the status of species and their habitats, as well as the spread of invasive species, companies are required to report on these topics (ESRS E4 § 16, § 39 and § 40). However, the national reporting does not include the monitoring of data on the status of individual species, populations or habitats. Hence, other data sources also have to be consulted, such as national data on protected areas in Germany, which is provided by the Federal Agency for Nature Conservation (BfN - Bundesamt für Naturschutz 2024). This can help identify areas of particular importance for biodiversity located near company sites (ESRS E4 § 16a i. and § 19a). However, such national data can only indicate the existence of *potential* impacts from corporate activities (e.g. land use) on biodiversity and ecosystems; *actual* impacts have to be assessed and measured at corporate and site level.

If a company's activities are likely to significantly drive a loss of nature (for example revealed by ecosystem accounting), site-specific indicators on the drivers leading to the impacts on biodiversity and ecosystems have to be assessed (impact driver accounting including emissions, pollution, the use of water, land and other natural resources). This is particularly the case if no actions have yet been taken to avoid negative effects (e.g. actions determined by environmental impact assessments). At this level of site-specific activities, other data sources with higher resolution could help companies achieve greater accuracy and improved guidance. For example, previous environmental impact assessments can supply much more detailed information on corporate activities and their site-specific impacts and, in some cases, also reveal dependencies on ecosystems. If such environmental impact assessments are already available for a company's sites, these can be included in the reporting. Hence one recommendation is for company-related environmental impact assessments to be made available within a public national register. In this way, more systematic information on the impacts and dependencies of companies on biodiversity and ecosystems could be made available over time at national level. However, legal restrictions regarding the publication of such data could prove to be an obstacle.

The first interim conclusion is that information from national reporting can provide companies with relevant data, in particular to provide information for their materiality assessment on possible locations where impacts and dependencies on biodiversity and ecosystems should be assessed at greater detail.

## Differences

There are also fundamental differences in the motivation and objectives of SEEA EA national reporting and CSRD corporate sustainability reporting.

The aim of introducing ecosystem accounts into national reporting is to ensure that ecosystems are measured in a consistent and statistically robust manner for the entire territory of Germany, thereby providing consistent, robust and reliable information on the extent and condition of ecosystems and possible changes over time (Bellingeren et al. 2021). The goal here is to achieve a methodologically standardised, statistically coherent collection of predominantly primary data for the whole of Germany to assist in environmental economic accounting. The data collected should fulfil the requirements of the SEEA EA framework to ensure international alignment and comparability of national statistics (Bellingeren et al. 2021). Datasets with inconsistent coverage and/or resolutions must therefore be rejected, even if they may provide greater accuracy for selected areas (e.g. for some of the *Länder*). Thus, the “smallest common denominator” in terms of nationwide availability, resolution and monitoring at recurring intervals will determine the eligibility and inclusion of data in national reporting.

This is in contrast to the motivation and requirements for corporate sustainability reporting in accordance with CSRD ESRS E4 on biodiversity and ecosystems. If a company identifies significant impacts and dependencies on biodiversity and ecosystems, these should be assessed and reported on a site-specific basis, where possible. This applies to both the company’s own sites and its supply chain (ESRS E4 § 17a, b and § AR6). While national reporting data can provide some initial guidance on potential impacts and dependencies, this is too coarse for site-specific assessments. The less frequent updating of national reporting can be a challenge: national data are only collected every three years and reported with a time lag, yet companies have to report annually. Furthermore, national reporting only covers the territory of Germany, which means that national data cannot be used for international sites and supply chains. Companies are also not tied to a specific method: they are free to choose which methods and indicators to use to present and report impacts and dependencies on biodiversity and ecosystems in a plausible, robust and transparent manner. In addition, companies can select between primary data, secondary data or even modelled data as long as the underlying method is made transparent (ESRS E4 § AR27). This is in contrast to the statistical coherence aimed for within national data under SEEA EA, where consistency is fundamental for national reporting. Sector-specific guidelines are being developed for the implementation of the CSRD ESRS, so that, in the future, companies of the same sector could adopt standardised methodological approaches, thereby enhancing inter-company comparability. However, it is likely that the statistical coherence of the data in corporate sustainability reporting will not meet the same statistical requirements as data in national reporting.

There are also differences in the demanded spatial and temporal resolution of data. If biodiversity and ecosystems are determined to be material, companies have to address biodiversity with annual reports and location-specific assessments, while national

ecosystem accounts are only updated on a three-year basis. The indicators and data collected by companies should ideally also assist in the monitoring of targets, as well as measure the success of actions to reduce impacts on biodiversity and ecosystems (ESRS E4: E4-4 on metrics and targets). This would enable companies with material impacts on biodiversity and ecosystems to disclose transition plans and report on progress in achieving targets (ESRS E4: E4-1 on transition plan). Key performance indicators (KPIs) are required here to monitor the impact of corporate actions on the loss of nature (impact driver accounting), their effects on ecosystems (ecosystem accounting), as well as dependencies on ecosystem services (dependency accounting). Such KPIs should thus also support management decisions as well as strategic decision-making. Of course, information from national reporting is currently unsuitable to provide such detail for corporate management. Furthermore, national reporting can only provide data for Germany and does not include information on locations and supply chains at international level. However, if national reporting is standardised for Europe and globally in accordance with the SEEA EA framework, this information may well be applicable to preliminary materiality assessments of companies and their supply chains. Since the SEEA EA framework is currently being implemented by 41 countries (UNSD 2023), it will take some time before global coverage of national ecosystem accounting is achieved.

### **Bottom line: synergies have been created, but not yet fully utilised**

Germany's Ecosystem Atlas of national reporting (DESTATIS – Statistisches Bundesamt 2024) is aligned with SEEA EA standards (United Nations 2021) and can be used by companies for a preliminary materiality assessment of those ecosystems potentially affected by their activities. However, further analyses are required of corporate activities that drive ecosystem change to determine the actual impacts on ecosystems. It is likely that national reporting will, in the future, consider selected ecosystem services and thus provide companies with information on potential dependencies on these. However, as is the case with using national data to assess ecosystems potentially affected by corporate activities, national data on ecosystem services will also provide only an indication of potential dependencies. Data at company level are needed to fully assess and measure actual impacts and dependencies.

There are also some significant differences between national reporting and the requirements for corporate sustainability reporting, both in terms of objectives and data quality, such as spatial and temporal resolution. Companies that fall under the reporting requirements of the CSRD must assess and report site-specific information on those aspects identified as material within the materiality assessment. Information from previous environmental impact assessments could provide relevant information for such reporting.

Nevertheless, national reporting data can already provide a starting point, particularly for an initial materiality assessment to identify relevant ecosystems. The planned inclusion of additional indicators in national accounting and reporting in accordance with SEEA EA can further support corporate sustainability reporting. This is particularly true of indicators

of ecosystem services and more granular information on the fragmentation of ecosystems. However, corporate sustainability reporting often has to cover companies active around the world and with global supply chains. It is therefore crucial for the broader use of data from national accounts for corporate sustainability reporting that the requirements of the SEEA EA framework (United Nations 2021) are also implemented internationally by as many nation states as possible.

As the impacts on biodiversity and ecosystems, as well as dependencies on ecosystem services, can be very specific according to sector, business activity and location, more detailed, sector-specific information will be required in future. Assessing such sector-specific information could also make a significant contribution to environmental research. While “citizen science”, i.e. the collection of scientific data by the general public, is already common to biodiversity research, companies themselves will increasingly have to collect information on biodiversity. Hence, “business science” should, in the coming years, become a prominent feature of biodiversity research. Such research should also help provide application-orientated information to support corporate management in addressing the role of biodiversity and ecosystems in decision-making, particularly to reduce impacts and identify dependencies. Eventually such information should provide the information for the implementation of transition plans seeking to pinpoint and deal with risks and opportunities related to nature and which guide decision-making aiming to establish more sustainable business practices.

## **Institutions and players influence the field of action of extended reporting**

If natural capital and intact ecosystems were regarded as essential to our material prosperity and social welfare – alongside productive capital, “social capital” and the intangible capital of good governance – this would transform the current externalising mindset of traditional economic reporting, which excludes the knock-on costs of social and ecological impacts. The expansion of economic reporting in this way could be understood as a kind of “social innovation”.

As a rule, such innovations do not simply “happen”; they are dependent on the attitudes and behaviour of actors and, thus, can also fail. Protagonists can, for example, become demotivated by the excessive effort involved or, to use the terminology of political scientists, find themselves confronted by “veto players”. Ultimately, a wide range of influencing factors determines whether innovations are implemented in the field of structured statistical systems, which otherwise can be described as rather conservative. Accordingly, the consideration of ES is not solely dependent on scientific expertise, but ultimately on different players with their own logics, interests and resources as well as emerging alliances. Thus, the identification, calculation and consideration of ES should be viewed as a multi-layered social process (not solely a scientific or statistical issue). To try to unpick this process, investigations were carried out as part of the Bio-Mo-D project (<https://bio-mo-d.ioer.info/>) to pinpoint the various relevant organisations and actors, as

well as their respective interests. This stakeholder analysis can be broken down into two phases:

- the gathering of ES information for reporting systems (“supply side”);
- knowledge transfer and the social reception of this information (“demand side”).

### Structuring the policy area according to the two phases in Germany

Depending on the phase of the innovation field, different stakeholders play a role in the modernisation of economic reporting in Germany. For example, stakeholders possessing relevant datasets or forms of data collection are important for the compilation of relevant, exemplary ES in physical and, in some cases, monetary terms.

**Generation of ES data and accounting:** For many years, scientific institutions in Germany were the drivers of integration. Initially, the focus was on justifying the need for this integration, then increasingly on the classification of ecosystems, as well as the technical collection and provision of data, supported by government research projects (BMUV/BfN, BMBF, BMEL). The Ministry of the Environment played – and continues to play – a leading role with its political backing to key international agreements, the institutionalisation of the “Agenda” and, of course, the provision of research funding. In particular, the process has been supported by the Federal Agency for Nature Conservation (BfN), which is the primary actor in efforts towards ES integration. The BfN promotes the scientific underpinnings, as well as the collection and provision of data by awarding research contracts and organising conferences. Together with the Federal Statistical Office, which is now responsible for the operational implementation of the SEEA EA as a result of the decision of the UN Statistical Committee, these agencies create a network that spurs the expansion of the ES and creates the necessary data.

In Germany, only the “supply side” of ES information was active in this first phase\*<sup>4</sup>. There have been previous attempts to put the extensive research work on “Natural Capital Germany” and corresponding descriptions in Germany including important ecosystem services on the political agenda – see in particular the 2018 study by the Helmholtz Centre for Environmental Research (UFZ Leipzig) entitled “Identifying the values of nature and integrating them into decisions” (Naturkapital Deutschland – TEEB DE 2018). However, it seems from previous efforts in other countries that too little attention has been paid to relating the development phase of environmental economic accounts (SEEA) to their potential utilisation phase, as the following quote illustrates:

*“But, in most cases, those who set up the accounts are not those who use the resulting information”* (Ruijs et al. 2019, p. 715).

**Knowledge transfer and utilisation of information:** Important in the knowledge transfer phase are those stakeholders who see themselves as “standard bearers” for the recognition of national accounting results or corporate sustainability accounting in decision-making processes or who can be regarded as “pioneers” and “first movers”.



Stakeholders who can generally broaden communication are also important in fostering demand for ES information as a way to raise appreciation of biodiversity in society. However, it should not be forgotten that there are also actors and interests that want to ignore or even block greater consideration of biodiversity and ES, especially in monetary form.

In the main group of political-administrative actors, some ministries and authorities would like to proactively make use of results, in particular the BMUV (Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz) for the planned new national biodiversity strategy and the BMWK (Bundesministerium für Wirtschaft und Klimaschutz) for a further development of the annual economic report. Other ministries and the Federal Statistical Office itself would also like to incorporate results, such as the ecosystem atlas and information on ecosystem services from important ecosystems into the German sustainability strategy and the associated progress report, which serves as an accompanying data and indicator basis for the status of sustainable development in Germany.

NGO stakeholders on the demand side are primarily the WWF, the German Association for Landscape Conservation (DVL) and the German Forestry Council (DFWR). Progress made in the recording of ecosystem services by scientific institutions, such as the Thünen Institutes, the BfN or the German Centre for Integrative Biodiversity Research (iDiv), not least in monetary form, establishes a basis for the imminent expansion of ES and social rewarding of services, especially to farmers and foresters for the preservation of intact ecosystems and biodiversity, as they can now increasingly be understood as “public goods”. The Commission on the Future of Agriculture (ZKL) also addressed this point in its 2021 report in which it emphasised the importance of rewarding farmers for measures to conserve biodiversity and ES (Zukunftskommission Landwirtschaft (Hrsg.) 2021).

In addition, there are always scientifically inspired collaborations with potential users of new information bases. One example here is a project funded by the German Federal Environmental Foundation in which forest owners analyse ecosystem services<sup>5</sup>. A further example is the Eklipse project, which aims to process scientific knowledge in such a way that governments, institutions and companies can make informed decisions regarding biodiversity and ES. The BioAgora project also aims to improve the interaction between science and politics, as well as with other stakeholders. It also forms the scientific pillar of the planned EU Knowledge Centre for Biodiversity (KCBD). Independently of this, in recent years, the Michael Otto Environmental Foundation has also pursued a greater appreciation and valorisation of forests as a basis for life in its “Hamburg Talks for Nature Conservation” series.

All of these factors have been behind the rising pressure from academics and individual state actors to reform official economic reporting.

Overall, evaluations of countries that have already drawn up natural capital assessments reveal the great importance of interaction with the public and potential information users: *“They show that mainstreaming should be considered as a process to engage*

*“policymakers, civil society and the private sector and to demonstrate the long-term benefits of protecting natural capital”* (Ruijs et al. 2019, p. 715).

This communicative exchange between statistical offices and the public targets of their information not only implies and facilitates the perception of mutual perspectives, but often also enables a co-operation of interests and, thus, over time, an alliance of common interests for the integration and use of information on the quality of domestic ecosystems and their services for society. This assumption is underpinned, for example, by experiences in the UK with the Natural Capital Committee or pilot projects as part of the so-called NCAVES initiative with the support of the World Bank, which have also included countries such as Mexico.

### **Relevant advocacy coalitions**

As institutionalisation progresses on the information supply side, the focus in this policy field is shifting towards the reception and acceptance of information on ecosystems and their services. The question now increasingly arises as to which of the stakeholders in politics, business and society could exploit SEEA EA results (including other ES indicators from research institutions and authorities) to act as a multiplier or information broker in the form of a scientific or commercial information platform or advisory service. Stakeholder and public demand, as well as international reporting obligations, are becoming ever more prominent and gradually fostering application by the state and companies (in the sense of mainstreaming and refinement/optimisation).

The following developments can be predicted in constellations of interests around state SEEA EA: As far as can be discerned from previous research work, constellations of actors are emerging with a similar interest in obtaining more information and – in some cases in other constellations – also using information on biodiversity, ES and natural assets. However, they do not necessarily know each other yet or even form a “conscious” alliance: The concept of *advocacy coalitions* (see, in particular, Sabatier and Weible (2007), Weible et al. (2010)) common to political science ranges here from tangible and coordinated alliances of interests to constellations of actors pursuing similar interests, but who have not yet established a framework for a joint coordinated strategy.

As regards the Bio-Mo-D project, interest alliances range from actors in the research landscape directly involved in the integration process (usually in conjunction with clients, such as the German Ministry of the Environment (BMUV) and the environmental authorities (BfN, UBA), the Ministry of Research (BMBF) and – more sporadically – also the Ministry of Agriculture (BMEL) with the Thünen Institute of International Forestry and Forest Economics) to statistical authorities and other government ministries, such as the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Federal Ministry for Economic Cooperation and Development (BMZ) (although this may seem surprising at first glance, the involved Germany Society for International Cooperation (GIZ) has long been familiar with the importance of ecosystem services). In addition, such an advocacy coalition could, in principle, include NGOs and stakeholders or

organisations, such as the German Association for Landscape Conservation or members of the Future Commission for Agriculture.

It should be emphasised how closely some environmental organisations are also working on this topic, also through a general interest in environmental management systems, such as the Nature and Biodiversity Conservation Union Germany (NABU), the WWF or the B.A.U.M. e. V. network for sustainable management.

Some of these NGOs, i.e. WWF, NABU and the Capitals Coalition, even advised EFRAG, which, in turn, (co-)created the content for the CSRD of the EU Directive. The practical partner of the Bio-Mo-D project, the Value Balancing Alliance (VBA), is particularly important here. The members of the EU Align project should also be mentioned\*<sup>8</sup>.

Overall, the field of policy advice in this transition phase is interesting because it supports the formation of political opinion. Examples include the German government's Sustainable Finance Advisory Council, the German Council for Sustainable Development and the Parliamentary Advisory Council on Sustainable Development (PBnE).

Protagonists from the media landscape are, of course, important agenda-setters for the inclusion of natural assets in reporting systems. In a broader sense, they could certainly be categorised as one element in a coalition of interests. Examples from the multiplier and network sector include journalists (e.g. the *Tagesspiegel* background information service on sustainable finance or at *Handelsblatt* in the area of sustainable investments) and the Biodiversity Network Forum (NeFo). At an early stage, Deutsche Umwelthilfe (DUH) organised a series of information events on ecosystem services. Interested foundations already contributing to the broadening of the discussion on ecosystem services and biodiversity include the Bertelsmann Foundation, the Michael Otto Foundation and others.

The green finance sector is becoming increasingly relevant as it begins to take biodiversity risks into account in its own risk management systems. The international "Network for Greening of the Financial System" (NGFS - Network for Greening the Financial System 2022), whose role has so far garnered little recognition, brings together central banks and financial supervisory authorities. In March 2022, it published a report on the risks of biodiversity loss not only for individual companies or sectors, but also for the *financial stability of countries*. In Germany, the topic has now been taken up and addressed in a "Green Finance" department at the Deutsche Bundesbank. The aforementioned Sustainable Finance Advisory Council of the German Federal Government could be one potential member of an advocacy coalition working to refine and extend the ES concept.

Fig. 4 provides an overview of current research work relating to stakeholder modelling in the project.

If one goes on to consider extended corporate reporting as indicated in the EU's Corporate Sustainability Reporting Directive, additional players immediately spring to mind, in particular the Value Balancing Alliance, the EU-ALIGN project, Biodiversity in

Good Company e.V. and, in connection with this, the German Chamber of Industry and Commerce (DIHK). In the meantime, these players have come to recognise each other's activities.

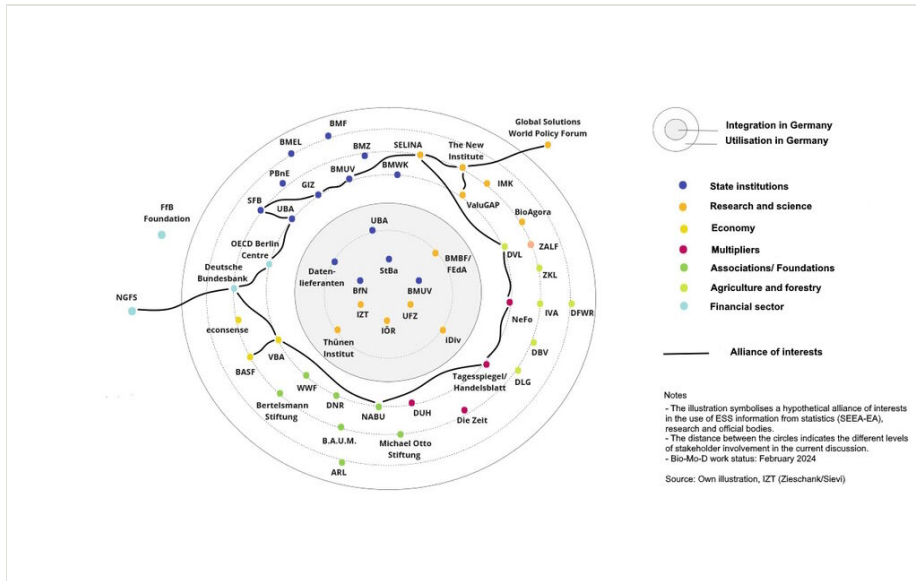


Figure 4. Potential stakeholder alliances: interest in national ecosystem accounting and ES information.

Noteworthy here is the pioneering role of the Swiss re-insurance company Swiss Re, which at an early stage created the first set of indicators for assessing biodiversity risks in various countries (Swiss Re Institute 2020).

Regarding international organisations, the OECD can also be assigned to an advocacy coalition, in this case for its support of extended welfare reporting (keyword “well-being economy”), with the OECD Centre Berlin being a fairly active representative in Germany.

As far as future alliances/interest constellations are concerned, landscape and spatial planning institutions could and should be recipients of official ecosystem accounting information (Grunewald et al. 2022a). In some cases, the ES concept is already known, for example, at municipal level in the Gartenamtsleiterkonferenz (GALK e.V.).

Not to be forgotten are actors from the fields of science and research who are open to an advocacy coalition or are already part of one, such as the SELINA project at European level or iDiv in Germany<sup>6</sup>. In addition, research institutes such as the Institute for Ecological Economy Research (IÖW), the Leibniz Centre for Agricultural Landscape Research (ZALF) and the German ESP network are just some of the scientific stakeholders already working with concepts of ecosystem assessment, evaluation and implementation. The research landscape itself is expanding more and more as the framework conditions for dealing with ecosystems and their utilisation improve. The vast

majority of these R&D projects are urged to liaise with social stakeholders and pursue participatory research processes. This also applies to projects that deal with methods or integration processes of biodiversity-related information in business processes (e.g. ALIGN project).

## **New challenges**

At the same time, the number of so-called “real laboratories” is increasing in science and practice, which, although they bring the topic of biodiversity and ecosystem services as well as natural capital to a broader audience, are also weighed down by the freight of a large number of individual and isolated solutions whose relevance is questionable after the end of such on-site projects. A “real laboratory” is a new format/method of transdisciplinary and transformative sustainability research, in many cases situated at the local or regional level in Germany, in order to develop an innovative technical or social approach. Both in terms of the desired “scaling effect” and “sustainable knowledge transfer”, these “real laboratories” and their partial solutions have not yet induced an overarching strategy of ES implementation in *central decision-making processes* at policy or corporate level.

The increasing number of international and national research and development projects to record and evaluate ecosystem services is now leading to an obvious dilemma: on the one hand, methodological diversity is helpful for reasons of scientific progress and pluralistic research and is also constitutively anchored as a basic democratic principle applied to scientific freedom. On the other hand, methodological pluralism, particularly in the monetary valuation of ecosystem services, can easily lead to the formation of factions amongst stakeholders and, even more problematically, to an incompatible approach. If the international resolutions, particularly those of the UN Statistics Committee and the Global Biodiversity Framework 2022 by the Convention on Biological Diversity (CBD), as well as the EU Commission’s endeavours in ecosystem accounting are not taken into account, a variety of disparate, methodologically-induced results on ecosystem services could hinder further acceptance and thus implementation. In a worst-case scenario, scientific disagreement will not only delay the entire process of official ecosystem accounting, but also undermine it due to a lack of acceptance amongst other stakeholders.

## **Reflecting disagreement - rare constellations**

Finally, space should be given to critical voices that specifically reject the monetisation of ecosystem services and often also the concept of “natural capital”.

While the modernisation of economic reporting can be understood as a process of social innovation shaped and influenced by stakeholders, this does not suggest that implementation is guaranteed. For instance, one only has to recall the long lead-up to the addition of supplementary progress indicators to GDP in the context of the long-standing “Beyond GDP” debate. It is also interesting to note the lines of conflict that can arise from

within organisations and cause internal controversies, as well as those forms of resistance that issue from organisations that are not politically aligned. For example, there are indications of conflicting assessments of the significance of monetary valuations of ecosystem services within the Bündnis90/Die Grünen party spectrum. While Die Grünen (the Greens) parliamentary group is in favour of a broader view of prosperity that includes natural capital, the Heinrich Böll Foundation operates a website with opposing arguments. Concerns about reporting systems that use monetary indicators for the degradation of nature in national or corporate reporting systems have also been voiced by parts of NABU, the WWF, the Free Democrats think tanks, the BDI environment (The Voice of German Industry), the political party Die Linke, the Economy for the Common Good and representatives from the field of psychology.

### **Social Tipping Points**

The policy field of ES integration is an ideal example of a social tipping point, which can be seen here as a positive analogy to the often negatively connotated scientific tipping points of global change<sup>\*7</sup>. Firstly, it is important to note that the process, the actors and the increasing international coordination to integrate ES and natural assets into social reporting systems can be seen as an evolving policy field. As a whole, this is solidifying via targets, international commitments and new regulations that encompass agreements on standardisation and legal requirements at EU level. No doubt more players will come on to the scene in the coming years, fostering increased discussion on the impact and benefits of the new corporate accounting and ecosystem accounts. If the integration of ES is sufficiently successful, we see this not only as a social innovation, but also as an opportunity for a social tipping point that will bring about a qualitative change in the system – in this case a fresh view of biodiversity as a central component not only of nature conservation, but also of social prosperity. Currently, actors from the fields of science and statistics have an opportunity to make a significant contribution to this transformation.

### **Conclusion and outlook**

As a first step, it is vital that we assess natures' values and integrate ecosystem services into government and business reporting systems as this will allow a proper valuation of these factors and encourage their inclusion into political and economic decision-making processes. This, in turn, will help reposition nature conservation policy from the "traditional" idea of protecting limited habitats and animal and plant species to a real social policy, thereby making a significant contribution to social well-being. This new framing of the societal relevance of ecosystems and biodiversity should, in the long term, lead to investments not only – as until now – in productive assets or "human capital", such as education, health and social security, but equally in intact ecosystems and diverse living landscapes, i.e. in "natural assets".

## National reporting in Germany

The framework for national accounting systems that provide nature conservation information has already been defined with SEEA EA (United Nations 2021). However, further development of methods, criteria and standards for these ecosystem calculations is necessary to adequately capture the values and services of biodiversity and ecosystems, as well as to integrate these into decision-making processes. In the future, this will primarily affect standardised approaches and methods for the monetisation of ecosystem accounts. In this respect, research requires new knowledge bases and a regular exchange with society and business regarding methods and approaches.

In Germany, the Federal Statistical Office is responsible for the regular provision of up-to-date data and its inclusion in the environmental accounting system. At the same time, indicators that reflect biodiversity and ecosystem services at the national level are being developed, particularly by public institutions and transferred to systematic monitoring, for example, in the newly-established National Monitoring Centre for Biodiversity or in the data centre of the Leibniz Institute of Ecological Urban and Regional Development (IOER). In particular, when ES indicators are included in national strategies (National Biodiversity Strategy, German Sustainability Strategy), they gain in political relevance and can develop their potential for informing and steering at the federal level, as well as at the levels of the *Länder* and municipalities.

For stronger mainstreaming, i.e. the inclusion of the topics of biodiversity and ES in other policy areas, it is also vital to involve the various stakeholder groups (keywords: “formation of advocacy coalitions”). These are primarily environmentally-orientated political actors and those from NGOs, as well as business and government consulting organisations and social opinion leaders who can act as multipliers. It is, therefore, important to demonstrate how actors can create networks across individual sectors and enable the development of previously unsuspected alliances. These can be, for example, environmental associations, the German Bundesbank, the German Association for Landscape Conservation with the concept of a “common good premium” or actors in the field of “sustainable finance”.

The expansion of public economic reporting systems (e.g. annual economic reports of the federal government, welfare reporting) to include key indicators of biological diversity and ecosystem services, as well as their multiple inherent value is, generally speaking, a time-consuming and challenging political process.

In its draft of the new German Strategy for Biological Conservation (NBS) 2030, the federal government stated the following goal (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023, p. 89): “By 2026 and beyond, statements and indicators on biodiversity and natural capital will be an integral part of the federal government’s annual economic and welfare reporting and will continue to be systematically expanded – also with regard to ecosystem accounting” (see also JWB - Jahreswirtschaftsbericht der Bundesregierung (2024)). The following additional

goals and measures were slated for discussion in the NBS (BMUV - Bundesministerium für Umwelt, Naturschutz, nukleare Sicherheit und Verbraucherschutz 2023, p. 88/89):

- By 2025, a research project on a “natural capital check” for legal and planning decisions will be initiated aimed at providing important additional decision-making bases for evaluating development scenarios and optimising the cross-sector management of ecosystems by taking into account the value of ecosystem services (e.g. legal impact assessment, Environmental Impact Assessment (EIA), SEA, cost-benefit analyses of projects).
- By 2025, an initiative will be launched by the Standing Conference of Ministers of Education and Cultural Affairs (KMK – Kultusministerkonferenz) to ensure that educational materials on natural capital approaches are integrated into the curricula of relevant degree programmes, at least in the areas of economics, landscape planning, urban planning and construction, transport planning, agricultural and forestry sciences.
- By 2026, projects will be initiated to further develop methods of recording and evaluating natural capital, to collect and record the data required for this and to develop meaningful indicators.
- By 2026, the corresponding ecosystem accounts will be compiled by the Federal Statistical Office; here, results will gradually be made available online and publicised with support given by a national monitoring committee for natural capital recording for the purposes of scientific advice, networking of the relevant authorities, as well as informing and involving other social actors.

### **Business reporting**

Accounting and reporting on the relationship between companies and biodiversity, ecosystems and their services is of crucial importance as it helps raise awareness amongst businesses and the public about the progressive loss of nature, its repercussions and the resulting significant financial risks. Reporting should, thus, not only be seen as a duty and bureaucratic burden, but also as an opportunity to make better and more sustainable business decisions, based on improved and more comprehensive data.

In the past, this opportunity has been missed due to the voluntary, limited and often superficial nature-related reporting by companies. In this context, the EU CSRD – in particular the ESRS E4 and its practical interpretation and application – as well as the application aids of the TNFD are crucial for the quality, scope and transparency of future reporting. In principle, meaningful reporting of impacts on nature (inside-out perspective) and its relevant aspects requires significant resources, particularly the commitment of entire companies and not just their accounting departments. An understanding of individual dependencies on natural resources and services (outside-in perspective) can boost the awareness and consequently the management of social and financial risks. Furthermore, this understanding offers the opportunity to identify potential risks or opportunities and, thus, to enable truly sustainable business practices and strategies that support the goals of investors and society, as well as those of protecting our planet.



Despite the rapid development of corporate environmental reporting, mainly encouraged by the EU CSRD requirements, there are still many obstacles that require targeted and practical scientific knowledge. Scientists can play a central role in this process, particularly in developing methods for dependency accounting and the accounting of nature-related risks and opportunities, as well as to improve the availability and accessibility of scientific research data and insights tailored to the needs of companies and regulators.

The traditional nature conservation sector, not just environmental associations, but also public administrations and governmental ministries, is still often unfamiliar with economic accounting and financial approaches. Thus, there is a need for further discussions to show that creating a system of ES accounting is not about attaching “price tags” to those natural assets that ensure the well-being of people and society, but rather about revealing the previously unrecognised contribution of intact ecosystems to our future health and prosperity and, thus, opposing the ongoing degradation of nature associated with “blind” growth. To this end, improved reporting should be (further) developed to capture prosperity economically, socially *and* ecologically. One key lever to assist in this transformation of the economy is to create a more sensible and all-encompassing form of welfare measurement and economic reporting, for example, by expanding ecosystem accounting and integrating natural capital into economic decision-making mechanisms. Current attempts to design ecological-economic reporting at national level have been included in the special chapters “Ecological Limits” and “Welfare Measurement and Social Progress” of the German government’s annual economic reports from 2023 (JWB - Jahreswirtschaftsbericht der Bundesregierung 2024). In the future, ecosystem accounting can make a key contribution to this.

Real progress is being made in Germany to reflect the state of ecosystem services and biodiversity in economic and welfare reports. The aim of this accounting is to create transparency. In the future, science, business and society should record, interpret and incorporate the data in environmentally relevant decisions.

**It can be seen that the narrative is changing:** Economics is becoming more and more concerned with natural assets. Ecosystem accounting can show whether Germany’s biodiversity goals are being achieved or missed. The expectation is that, with the help of accounting, decision-makers from other policy areas will be motivated to take practical steps in this direction. Certainly, actors today can no longer ignore the shift from “mere” discussion to real action. Questions about improved knowledge transfer – or more broadly: science-policy interfaces – will doubtless take on an even more prominent role in the years to come .

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Conceptualisation (all authors), Investigation/Writing – Introduction/Conclusion (all), Ecosystem Services (KG), Corporate Reporting (TMW), Synergies (JF, BH, TMW), Institutions (RZ), Project administration (KG), Funding acquisition (RZ, KG, JF, BH)

## Conflicts of interest

The authors have declared that no competing interests exist.

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## Endnotes

- \*1 <https://www.unep.org/explore-topics/green-economy/what-we-do/economic-and-trade-policy/metrics-and-measurements>
- \*2 CSRD ESRs E4 Biodiversity and Ecosystems. URL: [https://www.efrag.org/Assets/Download?assetUrl=%2Fsites%2Fwebpublishing%2FSiteAssets%2FESRS%2520E4%2520Delegated-act-2023-5303-annex-1\\_en.pdf](https://www.efrag.org/Assets/Download?assetUrl=%2Fsites%2Fwebpublishing%2FSiteAssets%2FESRS%2520E4%2520Delegated-act-2023-5303-annex-1_en.pdf)
- \*3 To discuss synergies, a workshop was held as part of the Bio-Mo-D project on 15 June 2023, attended by stakeholders from state institutions and companies.
- \*4 In other countries, however, there was already a participatory exchange with stakeholders during the preparation of information in order to facilitate mutual understanding of information and implications (Hein et al. 2020, p. 2/11).
- \*5 More details at: <https://www.umweltdialog.de/de/umwelt/biodiversitaet/2022/Geld-fuer-Oeko-Leistungen-des-Waldes.php>
- \*6 For more information, see “Science for Evidence-based and Sustainable Decisions about Natural Capital” <https://www.project-selina.eu/> and German Centre for Integrative Biodiversity Research (iDiv): <https://www.idiv.de/de/forschung.html>.
- \*7 Processes which, when exceeded, induce new feedback processes in the same direction; in the case of climate change for example, the thawing of permafrost regions: when the tipping point is reached in the Siberian tundra, huge quantities of methane gas will be released into the atmosphere, further fuelling the greenhouse effect.
- \*8 The stakeholder landscape of corporate reporting is also discussed in more detail in Section 'Current status of nature reporting and relevant stakeholders'.
- \*9 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM:2022:329:FIN>; The proposal will very likely be adopted as a regulation by the end of this year since there is agreement from the European Parliament and the Council.