

# Decoupling in Practice: Biodiversity Disclosures in First-Wave CSRD Reports

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## Abstract

**Purpose** – This paper aims to provide one of the first empirical assessments of how European companies are implementing ESRS E4 (Biodiversity and Ecosystems) in their inaugural CSRD sustainability statements, mapping current reporting practices across the full ESRS E4 disclosure chain and identifying the progress made and gaps that remain.

**Design/methodology/approach** – A structured content analysis was conducted of 300 sustainability statements prepared for the 2024 financial year, 115 of which recognised biodiversity as material under the double materiality assessment. Disclosure practices were examined across strategy, transition plans, targets, impacts, risks and opportunities (IROs), and financial effects, with cross-sectoral and cross-country comparisons drawn.

**Findings** – A significant minority of early CSRD reporters acknowledge biodiversity as material, and nearly all firms reaching a favourable materiality conclusion link the topic to their strategy and business model. Transition plans and initial actions are widely disclosed, suggesting early managerial engagement. However, disclosure quality weakens markedly in subsequent phases: target-setting remains largely aspirational rather than quantifiable, biodiversity-related financial effects are largely absent, and IRO narratives are primarily characterised by generalised negative impact drivers lacking specificity or actionable detail. Nature-intensive industries and Nordic nations exhibit the highest levels of engagement.

**Research limitations/implications** – The study is based on first-year CSRD reporters, which may not be representative of broader adoption patterns as the reporting population expands. The findings nonetheless highlight that early ESRS E4 reporting reflects procedural adoption of double materiality while remaining weak in quantified targets, location-specific IROs, and financial linkages required for decision-useful and assurance-ready disclosures.

**Practical implications** – The results carry implications for EFRAG, regulators, reporting entities, and assurance providers. In particular, more location-specific and traceable IROs are identified as a precondition for auditable targets and credible biodiversity-related financial effects, pointing to areas where guidance and enforcement attention should be directed.

**Originality/value** – This paper presents one of the first large-scale empirical analyses of ESRS E4 implementation, offering a comprehensive baseline of corporate biodiversity reporting under the CSRD. It contributes to the emerging literature on sustainability disclosure quality and provides actionable insights into the gap between the CSRD's biodiversity objectives and current reporting practice.

**Keywords:** Biodiversity reporting, ESRS E4, CSRD, Double materiality, Sustainability reporting, Decoupling, IRO (Impacts, Risks and Opportunities), Mandatory disclosure

# 1. Introduction

Materiality is a cornerstone of corporate reporting because it determines what information is considered decision-useful and helps manage disclosure overload (AASB, 2014). Yet materiality also increases managerial discretion and can weaken comparability across reports and jurisdictions (Baumüller & Sopp, 2022; Pizzi et al., 2025). The European Union's shift from single materiality to double materiality reframes this balance by treating sustainability matters as material when they significantly affect enterprise value or when the undertaking generates significant impacts on people and the environment. This broadened scope ties decision usefulness to accountability and is intended to align corporate reporting with Europe's wider sustainability transition agenda (Dragomir et al., 2025; European Commission, 2019).

Biodiversity is a particularly hard test for this regulation. Unlike carbon emissions, which companies can measure with one number and track with well-known methods, biodiversity is complex, depends on location, and involves many different ecological processes that are difficult to add up (Bebbington et al., 2023). Despite this growing policy attention, biodiversity remains one of the least developed topics in environmental accounting scholarship, which has historically centred on climate and carbon disclosures (Bebbington et al., 2023). **Unlike carbon, biodiversity reporting faces interlocking challenges of complexity, conceptualisation, and governance, with financial logics persistently overriding the ecological realities that make biodiversity loss difficult to quantify and disclose in a standardised way** (Kashyap et al., 2025). The EU Biodiversity Strategy for 2030, part of the European Green Deal, commits Member States to stop biodiversity loss and restore damaged ecosystems before 2030 (European Commission, 2020). The Kunming-Montreal Global Biodiversity Framework, agreed in December 2022, supports this goal at the global level and asks governments to make sure that large companies report their biodiversity impacts, risks, and opportunities (Convention on Biological Diversity, 2022). **ESRS E4 is the European tool that turns these political commitments into company reporting rules.**

This makes biodiversity reporting a useful case for understanding whether mandatory reporting can go beyond paperwork and actually change what companies do. **If double materiality cannot produce clear, comparable, and checkable biodiversity disclosures, then the broader goal of making companies responsible for their environmental impact is in danger.** Biodiversity is therefore not just one topic among many in the ESRS. It is a frontier case that shows whether mandatory reporting can build the information systems needed for accountability and, in the end, for real ecological improvement (Bebbington & Unerman, 2018).

The ESRS framework covers five environmental topics: climate change mitigation and adaptation (E1), pollution (E2), water and marine resources (E3), biodiversity and ecosystems (E4), and resource use and

the circular economy (E5). This study focuses on ESRS E4. Biodiversity loss is widely recognised as a critical global risk over the coming decade (World Economic Forum (WEF), 2023), yet biodiversity reporting has historically remained fragmented, heavily textual, and uneven in its links to concrete risk exposure or performance outcomes.

Drawing on **institutional theory**, the mandatory ESRS framework can be understood as a coercive isomorphic pressure that induces firms to adopt the visible form of biodiversity reporting - transition plans, governance narratives, and action lists - without necessarily integrating biodiversity considerations into measurement systems, target-setting, or financial planning. This form of decoupling (DiMaggio & Powell, 1983; Meyer & Rowan, 1977) produces compliance artefacts rather than decision-useful disclosures. Complementing this, legitimacy theory (Suchman, 1995) suggests that firms favour symbolic over substantive disclosure strategies when accountability risks are high and measurement methods are uncertain. Sustainability reporting is not only defined by content requirements but by the communicative form through which disclosures are produced and circulated.

Against this backdrop, we map and characterise ESRS E4 biodiversity disclosures in the first wave of CSRD sustainability statements for the 2024 financial year (published January to March 2025). The dataset comprises 300 early CSRD reports, of which 115 recognise biodiversity as material under double materiality. We combine a structured coding of the ESRS E4 disclosure chain with a systematic analysis of IRO narratives. Country and sector comparisons are used as descriptive lenses to show where early implementation is more developed and where recurring frictions are most visible. The IRO analysis is used to explain why the disclosure chain often weakens downstream, because broad or bundled IRO statements provide weak anchors for specific targets, DR E4-5 impact metric disclosures, and financially interpretable pathways. Sustainability reporting is not only defined by content requirements but by the communicative form through which disclosures are produced and circulated. The medium itself reshapes the scale, timing, and interactional properties of reporting, thereby influencing what becomes visible and actionable within disclosure systems (Lodhia, 2018).

Despite growing scholarly attention to sustainability reporting under the CSRD, the literature has not yet examined whether mandatory biodiversity disclosures translate into substantive organisational commitments or remain at the level of narrative compliance. In particular, it is unclear how the progression from acknowledging biodiversity as material to disclosing concrete actions, measurable targets, and financially traceable effects actually unfolds in practice - and where this chain breaks down. **Prior biodiversity reporting research, conducted largely under voluntary regimes, has documented what companies say about biodiversity but has been unable to assess the internal coherence between what companies recognise, what they plan, and what they commit to in measurable terms.** The ESRS E4

disclosure architecture now makes this assessment possible for the first time: its structured chain from IRO identification (ESRS 2) through transition plans (DR E4-1), actions (DR E4-3), targets (DR E4-4), and financial effects (DR E4-6) allows researchers to trace not only the willingness to acknowledge biodiversity-related impacts, risks and opportunities, but also the depth and specificity of the policy, action, and target responses that follow. We exploit this structure to examine:

**RQ1:** The extent to which undertakings disclose the core ESRS E4 elements of governance, policies, transition plans, actions, targets, metrics and qualitative or quantitative financial effects, and where does disclosure specificity weaken across countries and sectors?

**RQ2:** Why do undertakings often provide comparatively strong biodiversity plans and narratives but weaker targets and limited biodiversity-related financial figures in early CSRD reporting?

**RQ3:** How do undertakings identify biodiversity-related impacts, risks and opportunities, including polarity, drivers and contextual information used to justify materiality, and how does this vary across countries and sectors?

To address these questions, we conduct a qualitative document-based analysis of the full sample of 300 reports and a focused ESRS E4 chain assessment for the 115 undertakings that recognise biodiversity as double material. We offer early, evidence-based insights into how organisations operationalise double materiality for biodiversity under the CSRD, and we interpret observed gaps through the lens of institutional theory and legitimacy theory.

This study makes two contributions to the accounting and sustainability reporting literature.

- First, we provide one of the first empirical analyses of ESRS E4 disclosure chain completeness using actual first-wave mandatory CSRD sustainability statements, moving beyond prior work on materiality frameworks (Baumüller & Sopp, 2022), assessment procedures (Dragomir et al., 2025), and voluntary reporting (Boutant Lapeyre & Gatignol, 2025).
- Second, by combining structured chain coding with qualitative IRO narrative analysis, we show where and why the disclosure chain weakens, offering a theoretically informed explanation of the plan-target-financial gap through the lens of **institutional decoupling** and **legitimacy theory**.

The remainder of the paper is structured as follows: Section 2 reviews the regulatory background; Section 3 presents the theoretical framework; Section 4 describes the methodology; Section 5 presents descriptive

findings on ESRS E4 disclosure chain elements, including country and sector patterns; Section 6 reports the qualitative IRO analysis; Section 7 discusses the findings, implications and limitations; and Section 8 concludes.

## 2. Regulatory Background

### 2.1 CSRD, ESRS and the European Standard-Setting Process

The Corporate Sustainability Reporting Directive (CSRD) expands the scope and depth of European sustainability reporting and requires that sustainability information is reported within the management report, digitally tagged, and subject to assurance. The first set of European Sustainability Reporting Standards (ESRS) was adopted through Commission Delegated Regulation (EU) 2023/2772 (Baumüller & Sopp, 2022; European Commission, 2023). EFRAG acts as the Commission's technical advisor and standard-setter in practice, with legitimacy depending heavily on consultation and the involvement of national standard-setters and stakeholder groups (Gäumann & Dobler, 2019).

### 2.2 Double Materiality as an Emerging Disclosure Practice

Double materiality is the conceptual pivot of the CSRD. It requires undertakings to assess and disclose material sustainability matters from two directions: how sustainability matters affect enterprise value and how the undertaking impacts people and the environment. **Empirical evidence on early double materiality disclosures suggests that firms often foreground impact narratives while providing less transparent accounts of assessment procedures** (Dragomir et al., 2025). Implementation readiness also depends on the accounting profession's capacity to interpret new requirements (Krasodomska et al., 2025).

### 2.3 Harmonisation, Assurance and Biodiversity Reporting

Prior to the CSRD, sustainability reporting in Europe developed under a mixed regime in which voluntary frameworks such as the GRI Standards played a dominant role, producing partial harmonisation through de facto standardisation (GRI, 2021; Pizzi et al., 2025). Assurance is central to the CSRD's credibility ambition. Biodiversity reporting is a demanding test case: biodiversity is complex, place-based, and difficult to measure consistently, and corporate disclosures have historically been dominated by narrative claims rather than measurable outcomes (Boiral & Heras-Saizarbitoria, 2017; Boutant Lapeyre & Gatignol, 2025).

Prior research on mandatory reporting has shown that requiring disclosure does not automatically improve the quality or relevance of the information, and that the gap between formal rules and actual reporting practice can be large, especially in the first reporting cycle (Dumay et al., 2019).

## 2.4 Accountingisation and Assurance Readiness in Biodiversity Reporting

From an accounting perspective, the CSRD's double materiality requirement can be read as an attempt to extend the boundary of what becomes reportable, comparable, and eventually assurable for sustainability topics. In biodiversity reporting, this process is particularly difficult because impacts are place-based, pathways are complex, and measurement often depends on external data, scientific models, and contested baselines. This tension motivates the central puzzle of this study: why do undertakings frequently provide relatively strong biodiversity plans and action narratives, yet disclose weaker quantified targets and limited biodiversity-related financial effects?

The biodiversity accounting literature documents several recurring problems. Adler et al. (2018) found that even among the world's largest companies, biodiversity reporting is mostly narrative and rarely connected to measurable outcomes. Maroun and Atkins (2018) developed the concept of "extinction accounting" and argued that traditional financial reporting cannot properly capture biodiversity loss, calling for new forms of ecological and financial disclosure. Roberts et al. (2021) provided a systematic review of the biodiversity accounting field and identified legitimacy theory as the most used theoretical lens, with content analysis as the preferred method. These studies show that the measurement and data problems we observe in our ESRS E4 analysis are not new to the CSRD but reflect deeper tensions in all attempts to make biodiversity visible through corporate reporting. Empirical evidence from large European companies in the pre-CSRD period suggests that companies tend to report more extensively on impact materiality than on financial materiality, with stakeholder engagement relying predominantly on isolated events rather than continuous processes - indicating that the structural challenges of implementing double materiality pre-date the CSRD's entry into force (Dragomir et al., 2025). Large-scale analysis of GRI-based voluntary biodiversity disclosures across 43 countries further reveals that disclosure quality declined after 2015 despite rising policy attention, with companies frequently employing impression management to neutralise or mask negative biodiversity impacts - and with investors demonstrably failing to understand biodiversity dependency risks (Bassen et al., 2025).

## 2.5 Biodiversity Reporting Prevalence and Regulatory Pressure: Positioning of This Study

Biodiversity accounting and reporting research has grown rapidly, but empirical studies repeatedly highlight uneven disclosure prevalence and depth across firms and sectors. ESRS E4 therefore offers a structured setting to examine whether regulatory pressure yields complete, outcome-oriented reporting across the full disclosure chain.

Emerging studies on voluntary biodiversity reporting confirm that narrative prevalence consistently outpaces measurable target-setting and financial integration, with reporting tending toward impression management rather than ecological accountability (Adler et al., 2018; Maroun & Atkins, 2018; Roberts et al., 2021).

The present study addresses this gap by examining actual mandatory disclosures under a single topical standard - ESRS E4 - across multiple countries and sectors. This design allows more granular assessment of disclosure chain completeness than prior work focused on materiality frameworks (Baumüller & Sopp, 2022), assessment procedures (Dragomir et al., 2025), or single-country voluntary reporting (Boutant Lapeyre & Gatignol, 2025).

## 3. Theoretical Framework

Corporate reporting increasingly operates through digital and data-intensive infrastructures that expand the scope, speed, and granularity of disclosed information, while simultaneously reconfiguring how transparency and accountability are enacted in practice (Lombardi & Secundo, 2020). This study draws on two complementary theoretical perspectives to explain the observed patterns in early ESRS E4 biodiversity disclosures: **institutional theory and legitimacy theory**. Together, these frameworks provide a basis for interpreting both the widespread adoption of biodiversity transition plans and the persistent weakness in quantified targets and financial effects - the plan–target–financial gap that is the central empirical puzzle of this study. **Rather than treating this gap as a simple capacity deficit, institutional and legitimacy theory allow it to be understood as a theoretically predictable outcome of how organisations respond to a new mandatory reporting regime.**

### 3.1 Institutional Theory and Coercive Isomorphism

Institutional theory, as developed by Meyer and Rowan (1977) and extended by DiMaggio and Powell (1983), holds that organisations operating within an institutional field adopt structures and practices that conform to socially accepted rules and expectations. Three mechanisms drive this adoption: **coercive pressure from regulatory mandates and authoritative bodies, mimetic pressure from imitation of perceived best practice, and normative pressure from professional norms and training**. The CSRD mandate constitutes a direct coercive isomorphic pressure that compels undertakings to issue ESRS-aligned sustainability statements, regardless of whether the underlying measurement and governance systems are in place to support them.

Crucially, **institutional theory also introduces the concept of decoupling**: organisations may adopt the outward form of a required practice - a transition plan narrative, an action list, a governance policy - without integrating it into actual operational or financial management (Meyer & Rowan, 1977). **Decoupling allows organisations to satisfy external institutional requirements while buffering core technical operations from disruption**.

This symbolic pattern is not confined to biodiversity reporting: large-sample quantitative evidence from 442 European listed companies finds that early adoption of double materiality did not translate into improved ESG risk management, consistent with a systemic decoupling between formal reporting structures and substantive organisational change during the CSRD implementation period (Panfilo et al., 2025).

Recent work on decoupling has made an important distinction that is directly useful for understanding ESRS E4 reporting. Bromley and Powell (2012) separate two types of decoupling: **policy-practice decoupling**, where organisations adopt policies but do not put them into practice, and **means-ends decoupling**, where policies are put into practice but do not produce the intended results. In the context of ESRS E4, both types may happen at the same time. Some firms may write transition plan narratives without actually changing operations (policy-practice decoupling). Others may take real actions but fail to produce measurable biodiversity outcomes because the measurement systems are not ready (means-ends decoupling). This distinction helps explain why the disclosure chain can break down at different points for different firms.

In the context of ESRS E4, decoupling predicts that early reporters will broadly comply at the narrative and governance level - producing the visible artefacts of biodiversity reporting - while lagging significantly at the levels where genuine organisational integration would be required: measurable targets, location-specific IROs, and financially traceable effects.

## 3.2 Legitimacy Theory and Symbolic Disclosure

Legitimacy theory, as synthesised by Suchman (1995), holds that organisations actively seek to maintain a generalised perception that their actions are desirable, proper, or appropriate within a socially constructed system of norms, values, beliefs, and definitions. **In sustainability reporting, legitimacy theory distinguishes between substantive and symbolic strategies: substantive legitimation involves real changes to operations, governance, and outcomes, while symbolic legitimation uses disclosure to manage perceptions without necessarily altering underlying practices** (Cho & Patten, 2007; Deegan, 2002).

Applied to biodiversity reporting, legitimacy theory predicts that **firms operating under high legitimacy pressure - such as the scrutiny created by a new mandatory regime - will favour disclosure forms that are visible and credible in the short term but that carry limited accountability obligations**. Narrative transition plans and qualitative action descriptions satisfy this criterion: they are substantive enough to demonstrate engagement without committing to measurable outcomes that could be audited, compared, or challenged. Quantified targets and financial effects, by contrast, create accountability and comparison risks that symbolic strategies are designed to avoid. The plan–target–financial gap is therefore not simply a capacity constraint but a theoretically predictable product of legitimacy management.

## 3.3 Derived Theoretical Expectations

Drawing on both frameworks, we derive three theoretically grounded expectations that structure the interpretation of findings in Sections 5 and 7.

**First**, consistent with coercive isomorphism, we expect broad adoption of the visible ESRS E4 reporting architecture - strategy narratives, transition plans, and action disclosures - across most DM-positive firms regardless of sector or country, because these elements are easiest to produce through strategy and consulting processes without requiring new measurement infrastructure.

**Second**, consistent with institutional decoupling, we expect a stepwise deterioration of disclosure specificity as the ESRS E4 chain moves from governance and planning toward measurable commitments, because integration of biodiversity into target-setting and financial systems requires genuine organisational embedding that decoupled compliance does not.

**Third**, consistent with symbolic legitimation, we expect that where quantified targets or financial effects are present, they will be concentrated in firms and sectors facing the highest institutional visibility - such as nature-intensive industries and firms in countries with strong sustainability reporting cultures - because substantive compliance is more likely where legitimacy benefits are greatest and reputational risks of non-compliance are highest.

These expectations do not constitute formal hypotheses to be tested statistically; the study is descriptive and exploratory in design. Rather, they provide an interpretive lens through which the patterns documented in Sections 6 and 7 can be understood theoretically and connected to broader accounting and organisational debates about decoupling, symbolic reporting, and the limits of mandatory disclosure regimes.

## 4. Methodology

The study follows a structured content analysis design that treats each CSRD sustainability statement as a unit through which ESRS E4 is translated into disclosure practice. We read and systematically code the reports using a pre-defined codebook to assess how undertakings translate double materiality for biodiversity into ESRS E4 disclosures and where the disclosure chain breaks down. Aligned with the research questions, the analysis proceeds in three steps.

First, we map the ESRS E4 disclosure chain from double materiality recognition to strategy linkage, transition plans, actions, targets and financial effects (RQ1).

Second, we interpret the observed plan–target–financial gap using the presence and quality of downstream disclosures and through descriptive country and sector comparisons (RQ2).

Third, we code biodiversity IRO statements to assess polarity, thematic drivers and specificity, and we use this evidence to explain variation in target-setting and financial linkage (RQ3).

### 4.1 Data Collection

We obtained CSRD sustainability statements from the Sustainability Reports Navigator (Sustainability Reports Navigator, n.d.). We selected reports published between January and March 2025 pertaining to the financial year 2024. We identified a total of 311 CSRD reports published during this window, representing the near-complete population of first-wave CSRD filings available through the Navigator database for the 2024 financial year. Of these, 11 were excluded due to the absence of an English version, resulting in a final dataset of 300 reports. Since the 300 reports represent virtually the entire accessible English-language population from this source rather than a drawn sample from a larger known population, conventional sampling error concerns do not apply.

Of the 311 CSRD reports detected in the initial dataset, four were produced by parent firms based in the United Kingdom. These companies generated sustainability statements complying with the CSRD due to their EU subsidiaries being encompassed under the CSRD's purview. Two of the four UK companies

determined that biodiversity is significant under the double-materiality assessment, resulting in their inclusion in the final sample of 115 biodiversity-reporting companies.

However, two coverage limitations should be noted. First, the Navigator database may not capture all CSRD filings published during this period. Second, the exclusion of 11 non-English reports introduces a language-related coverage gap. Non-English reports are disproportionately likely to originate from smaller firms and from Member States where English is not a business language, which means the dataset may overrepresent larger multinational undertakings. The directional effect of this exclusion is likely to bias the sample toward higher disclosure quality, since larger and more internationally oriented firms tend to invest more heavily in sustainability reporting infrastructure.

## **4.2 Topic Screening (ESRS E4 - Biodiversity & Ecosystems)**

We screened the 300 reports to identify whether ESRS E4 (Biodiversity and Ecosystems) was disclosed as material under double materiality. Following this topic screening, 115 undertakings identified biodiversity as material under ESRS E4 and were retained for comprehensive coding.

## **4.3 Coding Framework**

For the 115 reports that were in scope, we hand-coded disclosures using a codebook aligned with ESRS E4 and the applicable ESRS 2 general disclosures (SBM-3 and IRO-1). The disclosure-chain assessment covers DR E4-1 (transition plan), DR E4-3 (actions and resources), DR E4-4 (targets) and DR E4-6 (financial effects).

DR E4-5 requires disclosure of biodiversity-related impact metrics. In this study, we use DR E4-5 exclusively as an analytical classification framework to organise impact-driver content within IRO narratives. We do not score DR E4-5 impact metric disclosures as an independent element of the ESRS E4 disclosure chain. This decision reflects the empirical reality of the sample: the 115 reports contain insufficient DR E4-5 metric content to support systematic, comparable scoring. The question of whether undertakings will develop the measurement systems necessary to report DR E4-5 impact metrics on a comparable and assurance-ready basis is explicitly left as a direction for future research.

The following paragraphs describe each coded variable, its ESRS basis, and how we operationalised the coding.

- **Double Materiality conclusion for biodiversity (ESRS 2 / topical DM screening).** We coded whether each company concludes that biodiversity is material under double materiality. DM = Yes was assigned when the CSRD statement explicitly identifies biodiversity as material on the basis of impact materiality, financial materiality, or both, consistent with ESRS 2. DM = No was assigned when the report states that biodiversity is not material or provides no DM conclusion for biodiversity. This variable serves as the entry point for topical ESRS E4 disclosures, as ESRS is implemented solely for topics deemed material.
- **Link between strategy and business model (ESRS 2 SBM-3).** We coded whether the report links material biodiversity IROs to the company's strategy and business model. Under ESRS 2 SBM-3, companies are required to explain how material sustainability topics are reflected in strategy, business model, and value chain. We coded them as "Not disclosed" when there is no link and "Not clear" when the language suggests strategic relevance but does not make a clear link.
- **Identifying IROs (ESRS 2 IRO-1) and making a list of them.** We recorded whether the report discloses biodiversity-related IROs, distinguishing between positive (beneficial impacts or opportunities) and negative (adverse impacts or risks). This corresponds to ESRS 2 IRO-1, which requires companies to describe how they identify and assess impacts, risks, and opportunities, and to ESRS E4, which specifies the sources of biodiversity-related impacts, dependencies, and associated risks or opportunities. For each company, we recorded the number of positive and negative IROs, the principal location or ecosystem (if specified), the value-chain position (own operations, upstream, or downstream), and the impact driver (e.g. land-use change, fragmentation, invasive species, water stress, or pollution).
- **Transition Plan and Strategic Response (DR E4-1).** We coded whether each company discloses a biodiversity transition plan under DR E4-1. This disclosure requirement asks companies to explain how material biodiversity impacts, dependencies, risks, and opportunities affect their strategy and business model, including planned strategic adaptations. Coding focused on the existence and quality of the transition plan, without evaluating biodiversity policy under DR E4-2. A plan was coded as 'Plan disclosed' when the report described how the company intends to adapt its business model, strategic assumptions, timeframes, and value-chain scope in response to biodiversity-related impacts. 'Plan indicated, not disclosed' was assigned when a transition plan was mentioned but lacked the elements required by DR E4-1. 'No plan, stated' was assigned when the company explicitly stated it has no plan. 'No plan' was assigned when the report made no reference to a transition strategy.
- **Actions and Resources (DR E4-3).** We coded whether each company discloses specific actions to address biodiversity-related impacts, dependencies, risks, and opportunities, along with the

resources allocated. DR E4-3 requires companies to describe measures following the mitigation hierarchy and to specify resources such as budgets, operating expenditure, capital programmes, or staff capacity. We designated “Action disclosed” when the report included at least one particular action related to biodiversity and included some indication of resources, such as financing, programs, or responsible entities. We designated “Action indicated, not disclosed” when the report mentioned actions or commitments without supplying the essential elements, such as a definitive action description or resources. We designated "No action" when the undertaking indicated the absence of biodiversity-related initiatives or when the report failed to demonstrate any discernible action. This coding assesses whether companies progress from strategic planning to execution, enabling the analysis of the coherence among transition plans, activities, targets, and the significance of biodiversity under ESRS E4.

- **Targets (DR E4-4).** We coded whether the company discloses biodiversity targets, focusing on whether they are time-bound and quantified. DR E4-4 requires targets to be aligned with policies and actions, with clear baselines and timelines. We categorize targets into three classifications: "Quantified & time-bound," "Qualitative or partial," and "Not disclosed." We documented the baselines, units, and their alignment with global frameworks as referenced.
- **Expected financial consequences (DR E4-6).** We coded whether the company discloses financial effects of biodiversity-related risks and opportunities. DR E4-6 requires either quantitative figures or ranges, or qualitative information with supporting rationale including time horizons, key assumptions or uncertainties, and a clear link to specific biodiversity IROs. We categorized "Quantitative disclosed" when monetary figures or ranges are explicitly associated with biodiversity IROs or dependencies, "Qualitative only" when a narrative of financial pathways related to IROs is provided without numerical data (including a rationale for the absence of numbers), "Indirectly disclosed" when financial impacts can be deduced from alternative sources, such as financial statements or general risk sections, yet are not explicitly connected to biodiversity IROs or ESRS E4, and "Not disclosed" when there is an absence of clear disclosure regarding biodiversity-related financial impacts.
- **IRO tagging and thematic classification (crosscutting, ESRS 2 and ESRS E4).** In addition to the chain-level coding, we tagged each biodiversity-related IRO in the 115 DM-positive reports by polarity (positive, negative, neutral) and assigned it to one of 26 thematic categories corresponding to ESRS E4 topics: impact drivers, mitigation actions, governance, targets, and financial effects. The tag book specifying each tag's name, operational definition, polarity, and ESRS E4 linkage was used in coder training and reliability testing. These tag assignments allow us to analyse how companies characterise biodiversity in terms of adverse impacts and risks versus beneficial outcomes and opportunities, and how IRO content aligns with the presence of plans, actions, targets, and financial

effects under ESRS E4. Table 1 lists the tag codes, names, polarity, and ESRS linkage; Appendix A provides the full tag book with definitions and illustrative examples.

### **How the tables were constructed:**

1. Source text was read from company disclosures, isolating the IRO content.
2. Each statement was coded to a polarity-specific Tag-Name that distinguishes negative from positive usage in a consistent way.
3. Every Tag-Name is mapped to the relevant ESRS E4 hook:
  - E4-5 for impact drivers (used here to classify IRO pathways; DR E4-5 impact metrics are not scored as a separate chain element)
  - E4-3 for actions and mitigation
  - E4-4 for targets
  - E4-6 for financial effects
  - E4-1 and E4-2 for strategy and policies, where applicable
4. The Operational Definition is the codebook description that specifies what counts in and what is excluded for each tag so that coding is replicable.

To enhance coding reliability, we maintained a written codebook with operational definitions and illustrative examples for each tag (Appendix A), conducted pilot calibration, and independently double coded a substantial overlap sample. Disagreements were resolved through joint discussion and consensus, with ambiguous passages coded as "Not clear" or left uncoded where the biodiversity link was not supported by the text. A methodological note on the residual tag categories (OTH\_NEG and OTH\_POS) is warranted. During pilot coding, we observed that many IRO statements in CSRD reports combine several impact mechanisms in a single sentence or describe biodiversity pressures at such a general level that no specific driver can be identified. Rather than forcing these statements into narrower categories, we retained the residual tags to preserve the distinction between specific and non-specific disclosures. A high share of residual tags in a given sector is therefore an empirical finding about the quality of corporate IRO narratives, not a limitation of the coding scheme. It indicates that companies are acknowledging biodiversity impacts without specifying the ecological pathways involved, which in turn limits the usefulness of these disclosures for target-setting and assurance.

Tag code	Tag name	Polarity	ESRS E4 link
<b>ACT_CIRC</b>	Circular economy	Negative or Positive	E4-3
<b>ACT_CONS</b>	Conservation and protection	Negative or Positive	E4-3
<b>ACT_RES</b>	Restoration and remediation	Negative or Positive	E4-3
<b>ACT_SRC</b>	Sustainable and certified sourcing	Negative or Positive	E4-3
<b>ACT_STK</b>	Stakeholder and Indigenous engagement	Negative or Positive	E4-3
<b>CTX_REN</b>	Renewable energy projects and biodiversity context	Negative or Positive	E4-3 / E4-5
<b>DRV_HAB</b>	Habitat and species impacts	Negative or Positive	E4-5
<b>DRV_LAND</b>	Land use change and deforestation	Negative or Positive	E4-5
<b>DRV_AGR</b>	Agriculture and forestry practices	Negative or Positive	E4-5
<b>DRV_POL</b>	Pollution and hazardous chemicals	Negative or Positive	E4-5
<b>DRV_MIN</b>	Resource extraction and mining	Negative	E4-5
<b>DRV_SCP</b>	Supply chain biodiversity pressure	Negative or Positive	E4-5
<b>DRV_SIT</b>	Infrastructure and urban development siting	Negative or Positive	E4-5
<b>DRV_DST</b>	Operational disturbances (noise, light, vibration)	Negative	E4-5
<b>DRV_SOIL</b>	Soil degradation and erosion	Negative	E4-5
<b>DRV_FWA</b>	Freshwater ecosystem impacts	Negative	E4-5
<b>DRV_MAR</b>	Marine and coastal ecosystem impacts	Negative	E4-5
<b>FIN_EFF</b>	Financial effects and nature finance	Negative or Positive	E4-6
<b>FIN_REG</b>	Regulatory and permitting risk	Negative	E4-6
<b>FIN_MKT</b>	Brand reputation and market access	Negative or Positive	E4-6
<b>GOV_POL</b>	Biodiversity policies and commitments	Neutral	E4-2
<b>GOV_STR</b>	Biodiversity strategy and integration	Neutral	E4-1
<b>TGT_MET</b>	Biodiversity targets and key performance indicators	Neutral	E4-4
<b>OTH_NEG</b>	Other or unspecified negative biodiversity IROs	Negative	E4-3 / E4-5
<b>OTH_POS</b>	Other or unspecified positive biodiversity IROs	Positive	E4-3 / E4-5

Table 1- summarises the tag codes, tag names, polarity, and ESRS linkage.

#### 4.4 Coding Procedure and Reliability

All 115 in-scope ESRS E4 reports were manually coded by two coders using the codebook in Appendix A, which contains operational definitions, inclusion and exclusion criteria, polarity specifications, and illustrative examples for each of the 25 IRO tags and all chain-level disclosure categories.

Prior to commencing the comprehensive coding, we collaboratively coded a first batch of ten reports. The objective of this pilot was to evaluate the category definitions in application, recognise common borderline circumstances, and enhance the textual coding guidelines. During this phase, we focused on addressing incomplete double materiality claims, mixed or bundled IRO descriptions, and narrative segments that may correspond to several tags.

Subsequent to the pilot phase, the remaining reports were allocated between the two coders with an intentional overlap of approximately 40 percent of the non-pilot reports - corresponding to 115 reports - independently double-coded. All disputes about the primary binary variables (DM, SBM-3, Plan, Action, Target, IRO, and Financial effects) and the allocation of IRO tags were deliberated in joint calibration sessions until a consensus was achieved, grounded in the operational definitions in the codebook. Two conservative coding rules were applied throughout: ambiguous binary statements were categorised as 'Not clear', and IRO statements with unclear biodiversity links were left uncoded.

Inter-coder reliability was assessed using Cohen's Kappa ( $\kappa$ ) across all seven chain-level coded variables in the 115-report double-coded overlap sample. Table 2 summarises the results.

Variable	Type	N (overlap)	Observed agreement	Cohen's $\kappa$
DM Biodiversity	Binary	300	100.0%	1.000
SBM3-E4	Binary	115	100.0%	1.000
Target type	Multi-category	115	99.1%	0.987
IRO clarity	Multi-category	115	98.3%	0.959
Financial effects type	Multi-category	115	99.1%	0.955
Actions	Binary	115	99.1%	0.936
Plan	Binary	115	99.1%	0.905
<b>Mean across all variables</b>			<b>99.4%</b>	<b>0.963</b>

Table 2- Inter-coder reliability results (Cohen's Kappa)

$\kappa \geq 0.81$  = almost perfect agreement (Landis & Koch, 1977). Six disagreements across the full overlap sample - two on IRO clarity, one each on Plan, Actions, Target, Financial effects - all resolved through consensus calibration.

The mean  $\kappa$  of 0.963 (range 0.905–1.000) indicates almost perfect agreement across all seven variables (Landis & Koch, 1977), confirming that the codebook and pilot-tested coding procedure produced highly consistent classifications and providing a strong reliability foundation for the descriptive findings reported in Section 5.

## 5. Descriptive Findings

This section reports results along the ESRS E4 disclosure chain to address RQ1, using country-level and sector-level comparisons to identify where disclosure specificity weakens. Table 3 summarises the overall prevalence of key ESRS E4 disclosures. The aggregate pattern reveals a clear attenuation along the ESRS E4 disclosure chain. Roughly two in five firms recognise biodiversity as material (38.3%); of the 115 DM-positive undertakings, 114 (99.1%) also report under SBM-3, confirming that a favourable materiality conclusion almost uniformly translates into a stated strategic narrative - this variable is therefore not disaggregated further. Disclosure proportions decrease modestly at the transition plan (36.7%) and action (35.7%) stages, drop more noticeably at the target stage (28.7%), and fall to just 4.0% for financial effects. This stepwise decline - strong at the narrative and planning stages, weak at the measurement and financial stages - constitutes the plan–target–financial gap that the remainder of this section documents across countries and sectors.

Metric	Count	Percentage
Total Companies	300	
Biodiversity recognised as material under Double Materiality (DM = yes)	115	38.33%
Biodiversity linked to strategy and business model (SBM-3 = yes)	114	38.00%
Biodiversity transition plan disclosed (Plan_yes)	110	36.67%
Biodiversity actions disclosed (Action_Yes)	107	35.67%
Biodiversity targets disclosed (Target_Yes)	86	28.67%
At least one biodiversity IRO disclosed (IRO_Yes)	85	28.33%
Biodiversity-related financial effects disclosed (E4-6, any form)	12	4.00%

Table 3- Overall prevalence of key ESRS E4 biodiversity disclosures in the sample

## 5.1 DM Recognition, Strategy Linkage and Transition Planning

### 5.1.1 Country-Level Analysis:

Table 4 reports DM recognition rates for the five countries with the most biodiversity-positive firms

Country	Companies	DM_yes	DM_Yes Rate_%
<b>Germany</b>	60	21	35.00%
<b>Denmark</b>	36	17	47.22%
<b>France</b>	40	16	40.00%
<b>Finland</b>	27	14	51.85%
<b>Netherlands</b>	39	12	30.77%

*Table 4- Top five countries by biodiversity double materiality recognition*

The figures show that Germany has the largest absolute number of biodiversity DM positive firms (21 out of 60), followed by Denmark (17 out of 36), France (16 out of 40), Finland (14 out of 27) and the Netherlands (12 out of 39). In relative terms, Finland exhibits the highest recognition rate, with 51.85 percent of reporters concluding that biodiversity is double material, and Denmark follows with 47.22 percent. France and Germany fall in the middle range, with recognition rates of 40.00 and 35.00 percent, respectively, while the Netherlands has the lowest share among the top five, at 30.77 percent. Taken together, these patterns suggest that some Nordic and continental jurisdictions are more inclined to grant biodiversity a double materiality status, while others remain more cautious despite similar or larger reporting populations.

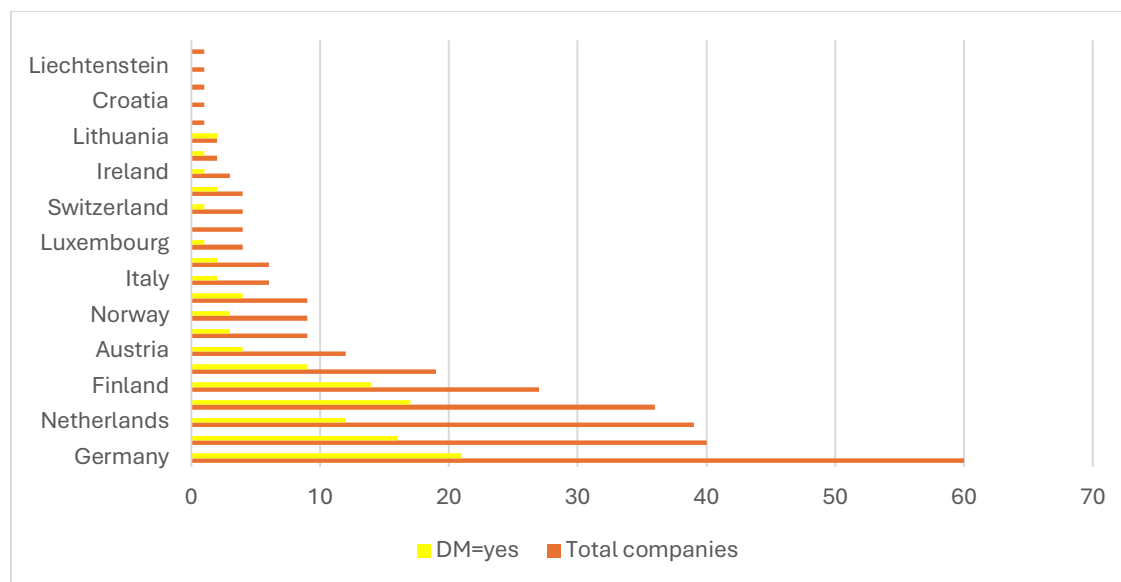


Figure 1- Number of companies with biodiversity DM = yes and of total companies

## 5.1.2 Sector-Level Analysis

Table 5 disaggregates DM recognition by sector.

Sector	Companies	DM_yes	DM_Rate_%
<b>Infrastructure</b>	38	25	65.79%
<b>Financials</b>	62	21	33.87%
<b>Food &amp; Beverage</b>	16	11	68.75%
<b>Transportation</b>	27	11	40.74%
<b>Consumer Goods</b>	21	10	47.62%
<b>Extractives &amp; Mineral Processing</b>	18	10	55.56%
<b>Health Care</b>	22	8	36.36%
<b>Renewable Resources &amp; Alternative Energy</b>	7	7	100.00%
<b>Resource Transformation</b>	38	7	18.42%
<b>Services</b>	14	3	21.43%
<b>Technology &amp; Communications</b>	37	2	5.41%

Table 5- Number of companies recognising biodiversity as double material by sector

The sector patterns show that biodiversity recognition is distributed unevenly across economic activities. Infrastructure has the largest absolute number of DM positive firms (25 out of 38), followed by Financials (21 out of 62), Food and Beverage (11 out of 16) and Transportation (11 out of 27). Extractives and Mineral Processing, Consumer Goods and Health Care also display notable levels of recognition. In contrast, sectors such as Technology and Communications, Services and Resource Transformation present much lower numbers of DM positive undertakings.

These differences are broadly consistent with sectoral exposure to land use, ecosystem dependencies and nature related impacts, and they highlight why sector disaggregation is essential for interpreting biodiversity related materiality assessments under ESRS.

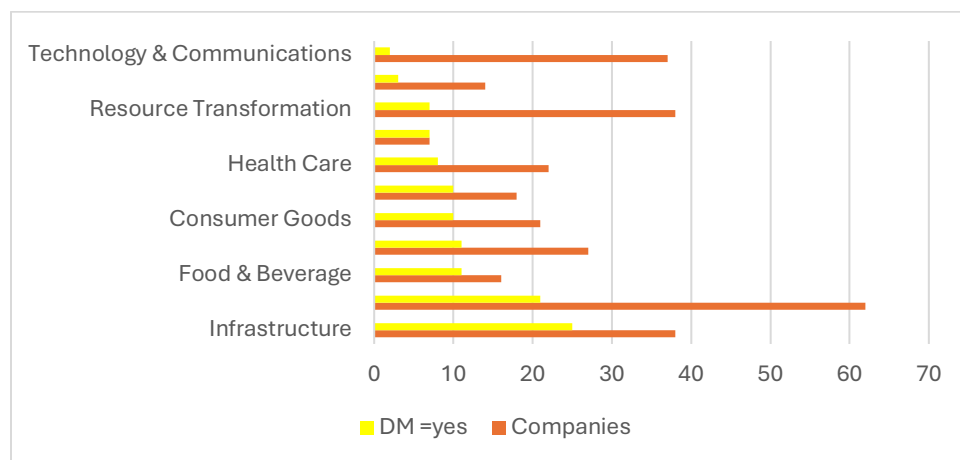


Figure 2- Companies and biodiversity double materiality recognition by sector

## 5.2 Narrative Compliance: Transition Plans and Actions

Among the 115 DM-positive undertakings, 110 (92.98%) disclose a biodiversity transition plan under DR E4-1, and 107 (97.27%) of those also report at least one biodiversity action under DR E4-3. Table 6 summarises both rates across the top five countries and all sectors.

The country pattern is uniformly high: France and Finland achieve full plan-action alignment, Germany and Denmark are at or near 100%, and the Netherlands at 90.91%. Sector-level variation is similarly narrow; all sectors except Financials (18/20 on actions) and Health Care (7/8 on actions) show complete alignment between plan and action disclosure. Overall, this near-universal compliance pattern indicates that the first stage of the ESRS E4 chain - producing a governance narrative and at least one action - has been broadly internalised by early reporters, consistent with institutional theory's prediction of rapid adoption of visible

compliance artefacts under coercive pressure. The analytically meaningful divergence begins at the target and financial effects stages, addressed in the following subsections.

	DM- positive	Has Plan	Plan%	Has Plan & Action	Action%
<b>All firms</b>	115	110	92.98%	107	97.27%
<i>Top five countries</i>					
<b>Germany</b>	21	20	95.24%	20	100.00%
<b>Denmark</b>	17	16	94.12%	16	100.00%
<b>France</b>	16	16	100.00%	15	93.75%
<b>Finland</b>	14	14	100.00%	14	100.00%
<b>Netherlands</b>	12	11	91.67%	10	90.91%
<i>Sectors</i>					
<b>Infrastructure</b>	25	24	96.00%	24	100.00%
<b>Financials</b>	21	20	95.24%	18	90.00%
<b>Food &amp; Beverage</b>	11	11	100.00%	11	100.00%
<b>Transportation</b>	11	10	90.91%	10	100.00%
<b>Extractives &amp; Mineral Processing</b>	10	9	90.00%	9	100.00%
<b>Health Care</b>	8	8	100.00%	7	87.50%
<b>Resource Transformation</b>	7	7	100.00%	7	100.00%
<b>Renewable Resources &amp; Alt. Energy</b>	7	6	85.71%	6	100.00%
<b>Consumer Goods</b>	10	10	100.00%	10	100.00%
<b>Services</b>	3	3	100.00%	3	100.00%
<b>Technology &amp; Communications</b>	2	2	100.00%	2	100.00%

Table 6- Transition plan and action disclosure rates among DM-positive undertakings, by country and sector

Target disclosure is a critical component of ESRS E4, since it determines the extent to which transition plans and actions are framed within measurable or time bound commitments. Table 7 reports, among the 107 undertakings that disclose both a biodiversity transition plan and at least one action, how many also report quantitative targets, aspirational or qualitative targets, or no targets (ND). This provides an overview of how frequently implementation narratives are supported by specific target-setting.

Category	Has Plan & Action	Has Plan & Action & Quantitative Targets	Has Plan & Action & Aspirational Targets	Has Plan & Action & ND Targets
<b>Total</b>	107	37	49	21
<b>Percentage</b>	100	34.58%	45.79%	19.63%

Table 7- Target setting within companies that disclose both a biodiversity transition plan and actions



Figure 3- Distribution of biodiversity target types among companies with both transition plans and actions.

The results show that only one-third of undertakings with both a plan and actions disclose specific quantitative biodiversity targets (34.58 percent). Aspirational targets are more common, reported by 49 firms (45.79 percent), while 21 firms (19.63 percent) provide no targets despite having both a transition plan and actions. This distribution indicates that although most companies progress from planning to implementation, target-setting remains uneven and often lacks measurable detail, limiting the potential for comparability, tracking and assurance under ESRS E4.

## 5.2.1 Country-Level Analysis

Cross-country differences in target composition are substantial (Table 8).

	Grand Total	specific quantitative	aspirational goals	ND Targets
<b>Germany</b>	20	5	9	6
<b>Denmark</b>	16	5	7	4
<b>France</b>	15	9	5	1
<b>Finland</b>	14	6	3	5
<b>Netherlands</b>	10	4	5	1

Table 8- Biodiversity target types among plan and action companies in the top five countries

The figures show clear cross-country differences in target composition. France and Finland have the highest concentration of quantitative targets among plan-and-action firms, with 9 of 15 companies in France and 6 of 14 in Finland reporting specific measurable goals. Germany and Denmark rely more heavily on aspirational targets, and both also have comparatively high counts of companies with no biodiversity targets. The Netherlands sits between these patterns with a balanced mix of quantitative and aspirational targets and only one company without targets. Overall, the evidence suggests that even in the most active reporting countries, a sizeable share of undertakings still favour softer or non-existent biodiversity targets rather than fully quantified commitments.

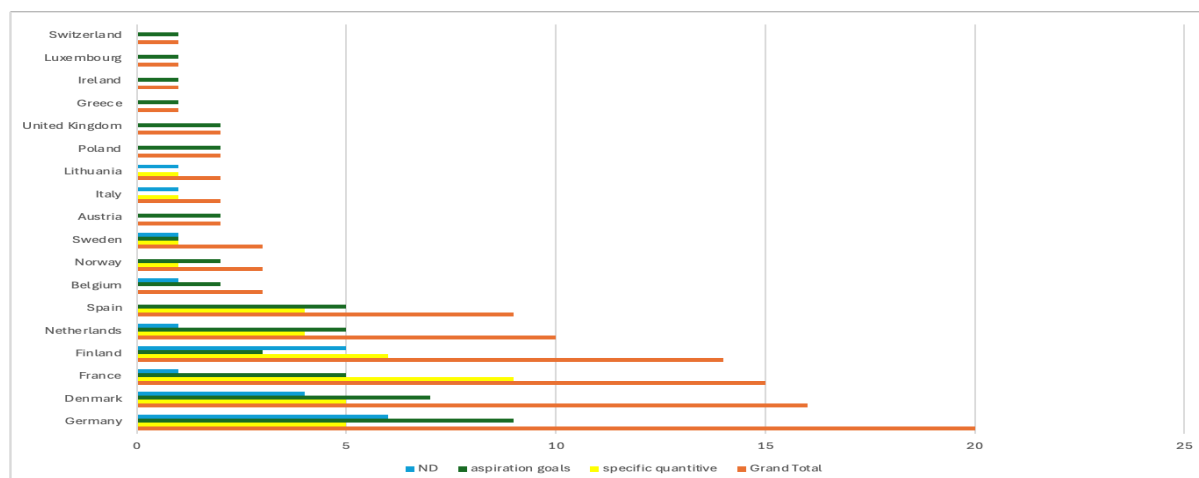


Figure 4- Distribution of biodiversity target types among companies with both transition plans and actions, by country

## 5.2.2 Sector-Level Analysis

The sector view (Table 9) reinforces this pattern.

	Grand Total	specific quantitative	aspirational goals	ND Targets
<b>Consumer Goods</b>	10	3	6	1
<b>Extractives &amp; Mineral Processing</b>	9	3	6	0
<b>Financials</b>	18	4	10	4
<b>Food &amp; Beverage</b>	11	4	4	3
<b>Health Care</b>	7	0	3	4
<b>Infrastructure</b>	24	11	11	2
<b>Renewable Resources &amp; Alternative Energy</b>	6	4	1	1
<b>Resource Transformation</b>	7	5	0	2
<b>Services</b>	3	0	2	1
<b>Technology &amp; Communications</b>	2	1	1	0
<b>Transportation</b>	10	2	5	3
<b>Grand Total</b>	<b>107</b>	<b>37</b>	<b>49</b>	<b>21</b>

*Table 9- Biodiversity target types among companies that disclose both a transition plan and actions, by sector*

The sectoral distribution shows substantial differences in the depth of biodiversity target-setting. Infrastructure stands out with the highest overall engagement, combining large numbers of aspirational and quantitative targets. Financials and Extractives & Mineral Processing also show notable activity but reveal a higher presence of aspirational goals and ND targets, suggesting uneven specificity. Several sectors-such as Food & Beverage, Health Care and Resource Transformation-show mixed practices, with some firms employing quantitative targets but others providing no targets despite reporting plans and actions. Overall, quantitative target-setting remains limited across most sectors, while aspirational goals dominate and ND targets persist, highlighting incomplete alignment between transition planning, actions and measurable biodiversity outcomes.

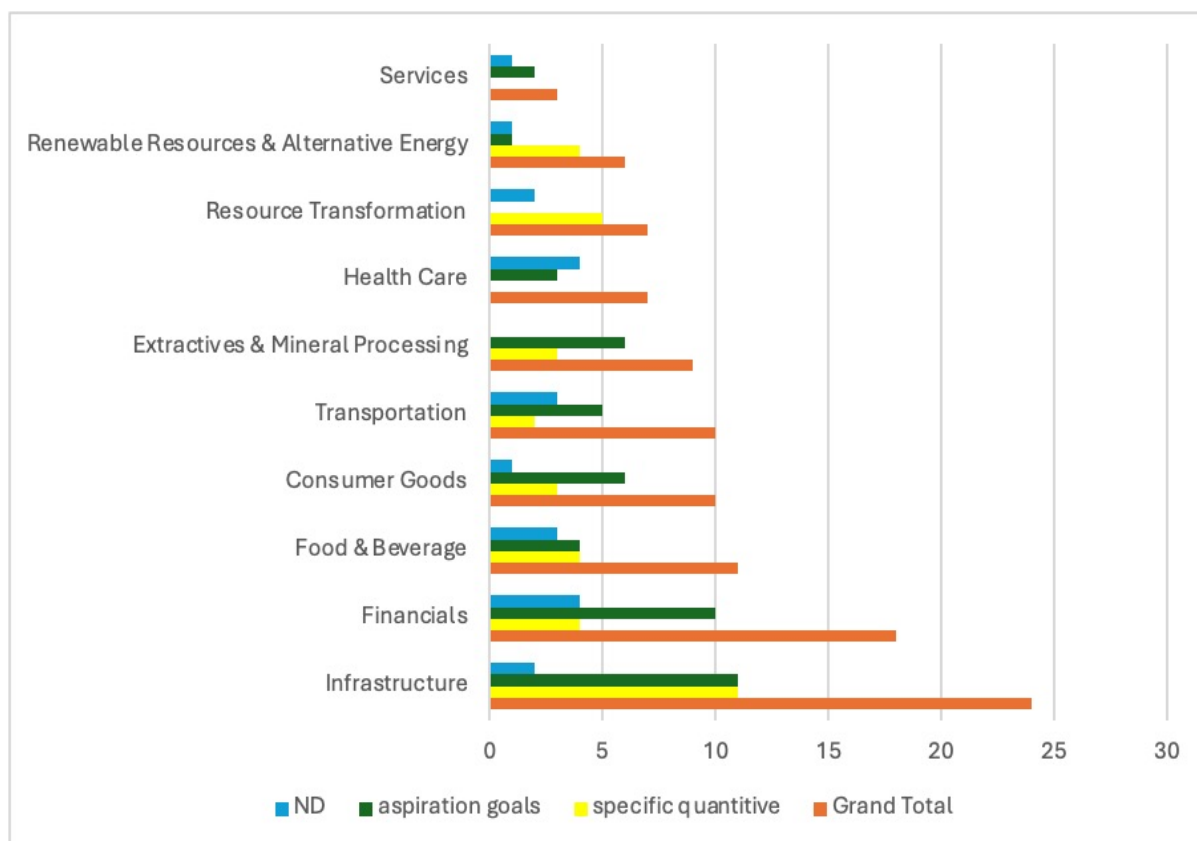


Figure 5- Biodiversity target types among plan-and-action companies, by sector

### 5.3 Financial Effects Disclosures

Financial effects (E4-6) represent the most demanding component of ESRS E4. Table 10 summarises the quality of biodiversity-related financial effects disclosures among the 115 DM-positive undertakings. Only 3 companies (2.61 percent) provide quantitative financial effect disclosures, 6 (5.22 percent) offer qualitative descriptions, 3 (2.61 percent) disclose financial effects indirectly, and the overwhelming majority - 103 companies (89.57 percent) - do not meaningfully disclose financial effects.

Quality of financial effects disclosures	Number of companies	Percentage
Quantitative disclosures	3	2.61%
Qualitative disclosures	6	5.22%
Indirect disclosures	3	2.61%

Quality of financial effects disclosures	Number of companies	Percentage
No disclosures	103	89.57%
<b>Total</b>	<b>115</b>	

Table 10 - Quality of biodiversity-related financial effects disclosures under ESRS E4

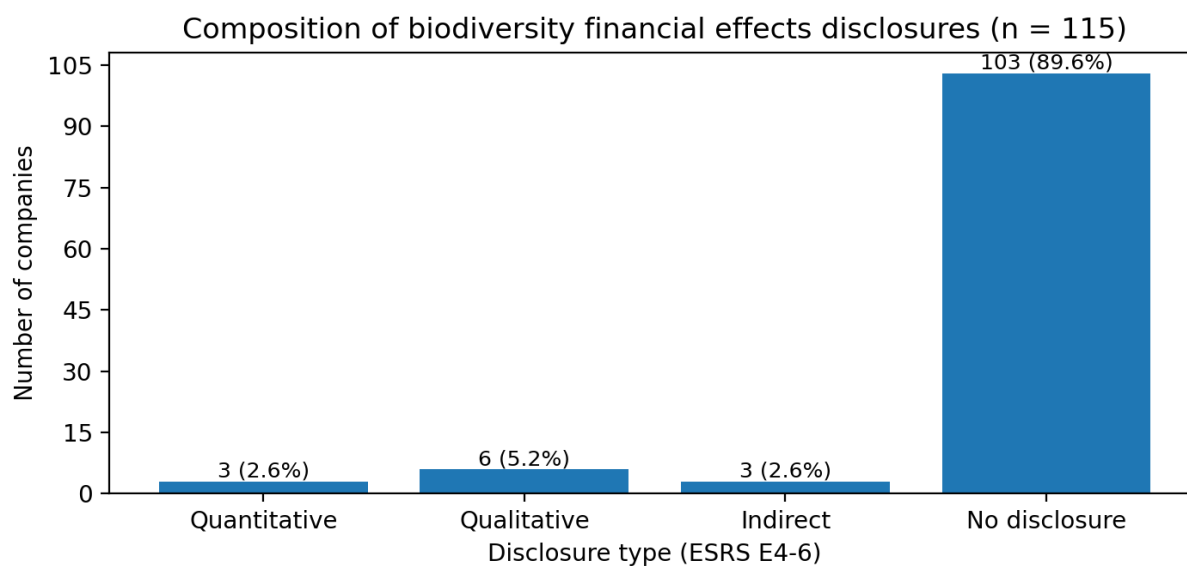


Figure 6-Composition of biodiversity financial-effects disclosures under ESRS E4 (n = 115).

The 12 firms with any form of financial effects disclosure are distributed across only six countries. Quantitative disclosures come from a single firm each in Germany, Greece, and Norway; qualitative disclosures appear in Denmark (3 firms), Norway (1), Finland (1) and Spain (1); and indirect disclosures are confined to Denmark (3 firms). Denmark accounts for the largest cluster of any-form disclosures, though these are predominantly qualitative or indirect rather than fully quantified. This geographic concentration underscores that meaningful biodiversity financial effects reporting remains experimental and limited to a small number of early-mover jurisdictions.

### 5.3.1 Sector-Level Analysis

Sectorally, the picture is equally sparse (Table 11).

Sectors	Quantitative Disclosures	Qualitative Disclosures	indirect Disclosures	not Disclosed	Grand Total
Consumer Goods	1	0	0	9	10
Extractives & Mineral Processing	1	0	0	9	10
Financials	0	0	0	21	21
Food & Beverage	0	0	2	9	11
Health Care	0	0	1	7	8
Infrastructure	1	3	0	21	25
Renewable Resources & Alternative Energy	0	1	0	6	7
Resource Transformation	0	0	0	7	7
Services	0	0	0	3	3
Technology & Communications	0	1	0	1	2
Transportation	0	1	0	10	11
<b>Grand Total</b>	<b>3</b>	<b>6</b>	<b>3</b>	<b>103</b>	<b>115</b>

*Table 11- Sector distribution of biodiversity financial effects disclosure types under ESRS E4*

The results underscore the extremely uneven development of financial effects disclosures across sectors. Only three sectors—Consumer Goods, Extractives & Mineral Processing and Infrastructure—contain firms reporting quantitative financial effects, and even in these cases the counts are minimal. Qualitative disclosures appear in a handful of industries, including Infrastructure, Renewable Resources & Alternative Energy and Technology & Communications, but they remain rare. Most sectors show exclusively “no disclosure” outcomes, with Infrastructure alone contributing 21 of the 103 firms that do not report any financial effects. Overall, the table highlights that biodiversity related financial effects remain largely absent from sectoral reporting practices, regardless of industry exposure to nature related risks or dependencies.

## 5.4 IRO Disclosures Quality

To assess how clearly undertakings describe biodiversity related impacts, risks and opportunities (IROs), Table 12 classifies DM positive companies into three groups: firms that provide at least one clearly identifiable biodiversity IRO (Yes), firms with ambiguous or incomplete IRO information (Not clear) and firms that do not disclose any biodiversity IROs (No). The table reports both counts and percentages for each category.

Quality of IRO Disclosure	Number	Percentages
<b>YES</b>	85	73.91%
<b>NOT Clear</b>	15	13.04%
<b>NO</b>	15	13.04%

*Table 12- Quality of biodiversity IRO disclosures among DM - positive companies*

The figures show that 85 companies, or 73.91 percent of the DM positive group, disclose at least one biodiversity IRO in a way that can be clearly identified and coded. A further 15 undertakings (13.04 percent) provide IRO information that is not clear enough to determine the underlying impact, risk or opportunity, while another 15 firms (13.04 percent) do not disclose any biodiversity IROs at all. This pattern indicates that although most companies with biodiversity double materiality conclusions acknowledge related IROs, a sizeable minority either omit them or present them in a vague manner that limits their usefulness for analysis and assurance.

### 5.4.1 Country-Level Analysis

Table 13 reports, for the five countries with the highest number of clear biodiversity IRO disclosures, how many undertakings provide at least one identifiable IRO (Yes), how many offer only unclear IRO information (Not clear) and how many do not disclose biodiversity IROs at all (No). This highlights cross-country differences in the articulation of biodiversity related impacts, risks and opportunities.

IRO Disclosure	YES	NOT clear	NO
<b>Germany</b>	15	2	4
<b>Denmark</b>	14	1	2
<b>Finland</b>	14	0	0
<b>France</b>	13	1	2
<b>Netherlands</b>	9	1	2

Table 13- Biodiversity IRO disclosure quality in the top five countries by number of clear IROs

Germany, Denmark and France each have a small group of firms that either provide unclear IRO information or omit IROs altogether, despite relatively high numbers of clear disclosures. Finland stands out with a particularly strong pattern, as all 14 firms in the Finnish subset provide at least one clear biodiversity IRO and none fall into the Not clear or No categories. The Netherlands shows a mixed picture with 9 clear IRO disclosures and 3 firms that are either unclear or silent. Overall, the table suggests that while leading countries differ in the clarity of their IRO reporting, Finland currently offers the most consistent articulation of biodiversity related impacts, risks and opportunities among DM positive undertakings.

## 5.4.2 Sector-Level Analysis

Sector-level variation is substantial (Table 14).

Row Labels	NO	NOT clear	YES	Grand Total
<b>Infrastructure</b>	2	3	20	25
<b>Financials</b>	4	4	13	21
<b>Extractives &amp; Mineral Processing</b>	0	1	9	10
<b>Consumer Goods</b>	2	0	8	10
<b>Transportation</b>	0	3	8	11
<b>Food &amp; Beverage</b>	2	2	7	11
<b>Health Care</b>	2	0	6	8
<b>Renewable Resources &amp; Alternative Energy</b>	1	0	6	7
<b>Resource Transformation</b>	1	1	5	7
<b>Services</b>	0	1	2	3
<b>Technology &amp; Communications</b>	1	0	1	2
<b>Grand Total</b>	<b>15</b>	<b>15</b>	<b>85</b>	<b>115</b>

Table 14- Sector distribution of biodiversity IRO disclosure quality among DM - positive companies.

The results reveal substantial variation in IRO disclosure quality across sectors. Infrastructure stands out with the largest number of clear IRO disclosures (20), although it also contains several firms with unclear or absent IRO content. Extractives & Mineral Processing and Renewable Resources & Alternative Energy display strong clarity, with nearly all companies in these sectors providing identifiable IROs. In contrast, sectors such as Financials, Food & Beverage and Transportation exhibit more mixed patterns, with a combination of clear, unclear and missing IRO disclosures. A few sectors-including Consumer Goods, Health Care and Technology & Communications-include firms that do not disclose IROs despite recognising biodiversity as double material. Overall, the table indicates that while most sectors show meaningful engagement with IRO reporting, clarity and completeness remain uneven, reflecting different levels of maturity in ESRS E4 implementation across industries.

## 6. IRO Analysis

This section addresses RQ3 by characterising the impacts, risks and opportunities (IROs) used to justify biodiversity materiality, including their polarity, thematic drivers and level of specificity. Sector-level IRO analysis is presented in depth for Infrastructure and Resource Transformation. These two sectors are selected because they represent distinct ends of the nature-exposure spectrum - Infrastructure is asset-heavy and site-specific in its biodiversity impacts, while Resource Transformation is input-chain-dependent - and together they produce the highest IRO intensity per disclosing firm in the sample. Financials, despite having a similar number of DM-positive firms, shows a more diffuse and indirect relationship with biodiversity impacts that warrants separate future analysis.

### 6.1 IRO Taxonomy Setup and Descriptive Overview

The coding procedure and tag construction process are described in Section 4-3. Tables 15 and 16 present the complete negative and positive tag sets with their ESRS E4 linkages.

No	Tag Name	ESRS Link
1	restoration & remediation — shortcomings/risks	E4-3
2	circular economy — shortcomings/risks	E4-3
3	conservation & protection — shortcomings/risks	E4-3
4	stakeholder and indigenous engagement — shortcomings/risks	E4-3
5	sustainable & certified sourcing — shortcomings/risks	E4-3
6	renewables — siting/impact	E4-3/E4-5
7	habitat & species impacts — impact	E4-5
8	land-use change & deforestation — impact	E4-5
9	pollution/chemicals — pressure	E4-5
10	extraction & mining — impact	E4-5
11	agriculture and forestry impacts — impact	E4-5
12	supply-chain pressure — impact	E4-5
13	urban and infrastructure siting — impact	E4-5

No	Tag Name	ESRS Link
14	chemicals' specific hazards — impact	E4-5
15	disturbance / noise / collision — impact	E4-5
16	soil & erosion — impact	E4-5
17	freshwater ecosystem impacts — impact	E4-5
18	marine and coastal impacts — impact	E4-5
19	financial effects and nature finance — impact	E4-6
20	permitting and regulatory risk — impact	E4-6
21	brand and market access — impact	E4-6
22	policies and commitments — impact	E4-2
23	strategy and transition alignment — impact	E4-1
24	other/unspecified — negative	E4-3/E4-5
25	targets and KPIs on nature — impact	E4-4

Table 15-Negative IRO tags and ESRS E4 links

No	Tag Name	ESRS Link
1	conservation & protection — action/opportunity	E4-3
2	restoration & remediation — action/opportunity	E4-3
3	sustainable & certified sourcing — action/opportunity	E4-3
4	renewables — avoidance/mitigation	E4-3/E4-5
5	habitat & species impacts — mitigation/action	E4-5
6	land-use change & deforestation — mitigation/action	E4-5
7	pollution/chemicals — phase-out/control	E4-5
8	agriculture and forestry impacts — mitigation/action	E4-5
9	supply-chain pressure — mitigation/action	E4-5
10	urban and infrastructure siting — mitigation/action	E4-5
11	financial effects and nature finance — mitigation/action	E4-6

No	Tag Name	ESRS Link
12	others/unspecified — positive	E4-3/E4-5

Table 16 - Positive IRO tags and ESRS E4 links

## 6.2 IRO Disclosure Overview

### 6.2.1 Total IRO Volume

	Number
Negative IRO Tags	521
Positive IRO Tags	61

Table 17- Aggregate IRO counts for firms with DM = yes that disclose at least one IRO

Across the 85 disclosing firms, we identify 521 Negative IRO tags and 61 Positive IRO tags, which implies an overall ratio of roughly 8.5:1. The total view indicates that disclosures are weighted toward impact drivers and risk narratives relative to mitigation, stewardship, or opportunity narratives, a pattern consistent with the impact-materiality focus embedded in ESRS E4's disclosure chain.

### 6.2.2 Sector Distribution

Sector results show where biodiversity IRO discourse is concentrated in the sample and how negative and positive tags are distributed across economic activities.

Sector	Negative IROs	Positive IROs	Company Count (DM Yes, With IRO)
Infrastructure	94	13	20
Financials	73	7	13
Extractives & Mineral Processing	35	6	9
Consumer Goods	69	3	8
Transportation	37	5	8
Food & Beverage	47	2	7

Sector	Negative IROs	Positive IROs	Company Count (DM Yes, With IRO)
Health Care	23	5	6
Renewable Resources & Alternative Energy	42	11	6
Resource Transformation	88	7	5
Services	7	2	2
Technology & Communications	6	0	1

Table 18- Sector-level IRO counts for firms with DM = yes that disclose at least one IRO

Negative items are highest in Infrastructure (94), Resource Transformation (88), Financials (73), and Consumer Goods (69). Positive items are led by Infrastructure (13) and Renewable Resources & Alternative Energy (11). Looking at intensity per disclosing firm strengthens the interpretation:

**Resource Transformation** totals 95 items with 5 firms, about 19 items per firm, indicating concentrated and intensive disclosure.

**Infrastructure** totals 107 items with 20 firms, about 5.4 items per firm, indicating wide coverage across many reporters.

**Renewable Resources & Alternative Energy** has 53 items with 6 firms, about 8.8 items per firm, and the highest positive share among heavy-disclosure sectors.

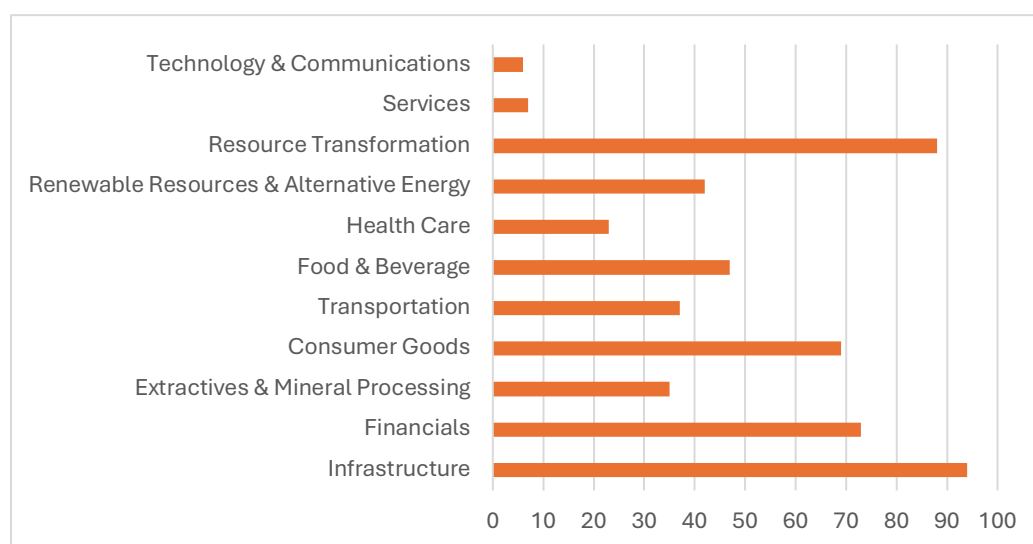


Figure 7- Negative IRO counts by sector for firms with DM = yes

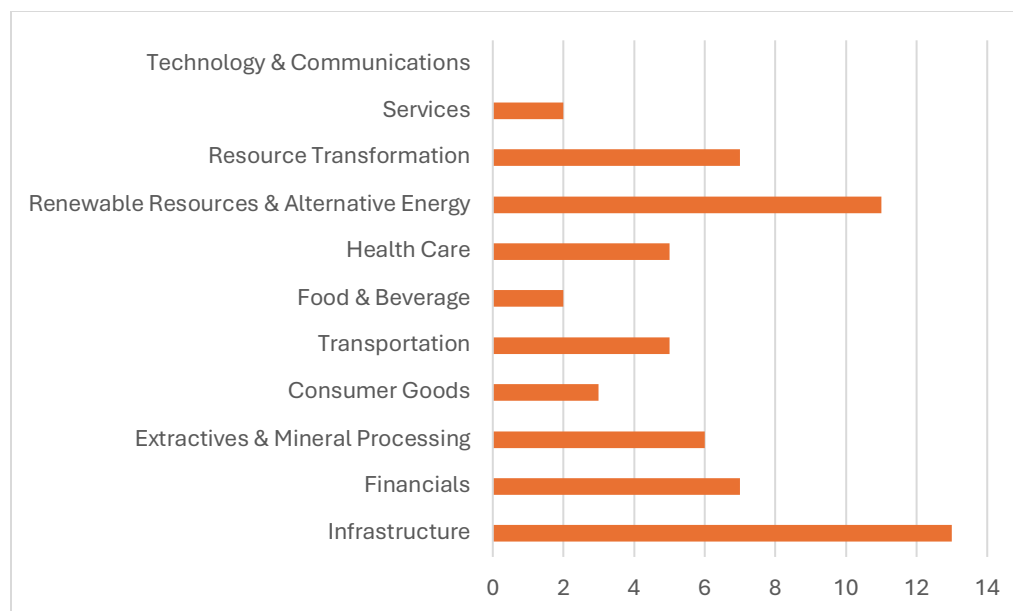


Figure 8-Positive IRO counts by sector for firms with DM = yes

### 6.2.3 Country Distribution

The country view focuses on the five jurisdictions with the largest number of disclosing firms.

Country	Negative IROs	Positive IROs	Company Count (DM Yes, With IRO)
Germany	178	16	15
Denmark	39	8	14
Finland	89	15	14
France	74	11	13
Netherlands	34	7	9

Table 19 - Country-level IRO counts for firms with DM = yes that disclose at least one IRO, top five countries

Negative counts are highest in Germany (178), followed by Finland (89) and France (74). Positive counts are led by Germany (16) and Finland (15), with Denmark (8) and the Netherlands (7) also contributing. Considering intensity per disclosing firm:

**Germany** totals 194 items with 15 firms, about 12.9 items per firm.

**Finland** totals 104 items with 14 firms, about 7.4 items per firm.

**France** totals 85 items with 13 firms, about 6.5 items per firm.

**Denmark** totals 47 items with 14 firms, about 3.4 items per firm.

**The Netherlands** totals 41 items with 9 firms, about 4.6 items per firm.

These patterns indicate that Germany and Finland combine relatively high total volume with a sizeable base of disclosing firms, while Denmark and the Netherlands have lower per-firm intensity. This suggests that some jurisdictions have produced more extensive IRO narratives per firm, while others achieve broader coverage with less detail per disclosure.

To illustrate how the tag-level analysis works in practice and what it reveals about the character of IRO narratives, we present detailed sector case studies for Infrastructure and Resource Transformation. Infrastructure was selected because it has the largest number of DM-positive firms (25), the highest total IRO volume (94 negative, 13 positive), and the clearest exposure to land-use and habitat-related impact drivers. Resource Transformation was selected as a contrasting case: it has fewer DM-positive firms (7) but a distinctively different IRO profile dominated by pollution and resource-extraction pathways. Together, these two sectors cover the two principal biodiversity-impact mechanisms in our sample - physical habitat disruption and chemical/extractive pressure - and illustrate both the strengths and the limitations of current IRO narratives. A full sector-by-sector IRO breakdown is beyond the scope of this paper but would be a valuable extension in future research.

### 6.3 Analysis of IROs in the Infrastructure Sector

This subsection analyses biodiversity-related IROs in the Infrastructure sector using the polarity-specific ESRS E4 tag set. The analysis covers the subset of DM-positive Infrastructure companies that disclose at least one IRO.

#### 6.3.1 Composition of Negative IROs

The distribution of negative IRO tags across the codebook categories is shown in Table 20. Six tag types appear in the Infrastructure sample. The tag labels correspond to the negative side of the ESRS E4 tag set.

Tag Name	ESRS Link	ESRS Note	Negative IRO Count
<b>other infrastructure related impacts</b>	E4-3/E4-5	General or residual biodiversity impact	50
<b>habitat and species impacts</b>	E4-5	Impact driver (habitat/species)	26
<b>land use and sea use change</b>	E4-5	Impact driver (land/sea-use change)	12

Tag Name	ESRS Link	ESRS Note	Negative IRO Count
<b>disturbance and construction impacts</b>	E4-5	Disturbance pathway during construction/operation	3
<b>pollution and hazardous substances</b>	E4-5	Impact driver (pollution)	2
<b>soil erosion and sedimentation</b>	E4-5	Impact driver (soil/erosion)	1

Table 20 - Negative IRO tag distribution in Infrastructure

More than half of the negative tags in this sector (50 of 94) fall into the other infrastructure related impacts category. This indicates that many impact descriptions are still rather general, or combine several mechanisms in a single statement, and therefore cannot be linked to one specific driver in the codebook. Habitat and species impacts form the second-largest group (26), followed by land use and sea use change (12). The remaining categories - disturbance and construction, pollution, and soil erosion - appear in smaller numbers.

### 6.3.2 Composition of Positive IROs

Positive IROs in the Infrastructure sector are materially fewer and concentrated in a small set of categories. Table 21 summarises the tag distribution for positive items. Again, the tag labels correspond to the positive side of the tag set.

Tag Name	ESRS Link	ESRS Note	Positive IRO Count
<b>other infrastructure related impacts and opportunities</b>	E4-3/E4-5	General or residual positive biodiversity IROs	8
<b>habitat and species impacts</b>	E4-5	Impact driver framed as reduced impact or avoided loss	3
<b>land use and sea use change</b>	E4-3/E4-5	Context-dependent avoidance or lower-impact siting	1
<b>restoration and remediation actions</b>	E4-3	Restoration and remediation measures	1

Table 21- Distribution of positive IRO tags in the Infrastructure sector

The most common group of positive tags, like the negative side, is 'other infrastructure-related impacts and opportunities' (8 of 13 tags). This group includes stories that are mixed or residual, including ecological

improvements or general biodiversity action plans. More specific positive tags such as habitat mitigation or restoration actions appear only once or twice each.

### 6.3.3 Examples of Coded IRO Statements

To illustrate how the codebook is applied, Table 22 presents paraphrased formulations typical of how CSRD reports in the Infrastructure sector express each tag on both the negative and positive sides. The examples are not verbatim quotations from individual companies but stylised sentences representative of the kinds of disclosures encountered.

Polarity	Tag Name	Illustrative Formulation
Negative	conservation and protection actions	"Existing biodiversity conservation measures are not yet systematically embedded in all infrastructure projects and sensitive habitats."
Negative	disturbance and construction impacts	"Construction and operation of wind farms and grid lines can cause collision risk for birds and bats and disturbance from noise and moving shadows."
Negative	habitat and species impacts	"New road and rail projects may lead to habitat loss, fragmentation and disturbance of protected or red-listed species along the corridors."
Negative	other infrastructure related IROs	"The expansion and operation of the group's infrastructure portfolio increases pressure on surrounding ecosystems and local biodiversity."
Negative	pollution and hazardous substances	"Operational activities generate wastewater and chemical runoff that can degrade nearby water bodies and associated habitats."
Negative	soil erosion and sedimentation	"Earthworks and slope stabilisation create a risk of soil erosion and sedimentation that may affect adjacent watercourses and habitats."
Positive	land use and sea use change	"Project development processes include commitments on deforestation and land-use change, favouring brownfield redevelopment and lower-impact routing options."
Positive	other infrastructure related IROs	"Mitigation measures such as ecological compensation, habitat enhancement projects and biodiversity action plans are implemented across the infrastructure value chain."
Positive	restoration and remediation actions	"Decommissioning and refurbishment projects include restoration and remediation activities that aim to improve local ecosystems relative to the pre-project baseline."

Table 22- Illustrative IRO formulations - Infrastructure sector

These examples show that negative tags are applied to concrete effects such as habitat loss, construction-related disturbance, pollution incidents and erosion risks, while positive tags cover initiatives such as biodiversity-friendly building design, land use commitments, ecological compensation and active restoration. The dominance of residual 'other' categories on both sides reflects the generalised nature of many Infrastructure IRO narratives.

### 6.3.4 Country Distribution of Infrastructure IRO Disclosure

Table 23 shows how Infrastructure IRO disclosure is distributed across countries. The table reports, for each country with DM = yes Infrastructure firms, the number of companies that disclose at least one IRO and the number that do not.

Country	Companies with IRO	Companies without IRO
Austria	0	2
Belgium	0	2
Denmark	3	0
Finland	2	0
France	2	0
Germany	3	1
Greece	1	0
Lithuania	2	0
Netherlands	2	0
Norway	1	0
Spain	3	0
Sweden	1	0

Table 23- Infrastructure firms with and without IRO disclosure by country (DM = yes). Source: authors

The country pattern is irregular. None of the DM = yes Infrastructure companies in Austria and Belgium share IROs, showing that IRO disclosure is not routine even when companies recognise double materiality. By contrast, Denmark, Spain, Germany and the Nordic countries have a considerably higher disclosure frequency. Overall, Infrastructure is a biodiversity-intensive sector with a lot of negative IRO disclosure

but very few and typically generic positive narratives, and IRO disclosure practices vary by jurisdiction in ways that affect comparability.

## 6.4 Analysis of IROs in the Resource Transformation Sector

The following analysis applies the same framework used for Infrastructure. It covers the five Resource Transformation companies with DM = yes that disclose at least one IRO, examining the composition of negative and positive tags, illustrative formulations, and geographic distribution.

### 6.4.1 Composition of Negative IROs

The distribution of negative IRO tags across codebook categories for Resource Transformation is presented in Table 24.

Tag Name	ESRS Link	ESRS Note	Negative IRO Count
other resource transformation related IROs	E4-3/E4-5	General or residual biodiversity IROs in resource transformation	60
pollution and hazardous substances	E4-5	Impact driver (pollution or hazardous substances)	15
habitat and species impacts	E4-5	Impact driver (habitat or species)	6
extraction and mining impacts	E4-5	Impact driver (extraction or mining)	3
land use and sea use change	E4-5	Impact driver (land or sea use change)	3
disturbance and operational impacts	E4-5	Disturbance pathway during operations	1

Table 24- Distribution of negative IRO tags across codebook

There are almost two-thirds of all negative items in the sector (60 of 88) that are classified as other resource transformation related IROs. This indicates that many disclosures describe general pressures or cumulative effects that cannot be linked to a single specific driver. The second largest group, pollution and hazardous substances (15 tags), reflects concerns about chemicals used and released during resource extraction and processing. More specific ecological drivers, such as habitat and species impacts, extraction and mining, and land and sea use change, appear but are less frequent. Only one tag is labelled as disturbance and

operational impacts, suggesting that operational disturbance is rarely framed explicitly as an IRO in this sector.

### 6.4.2 Composition of positive IROs

Positive IROs are relatively scarce, but they provide insight into how Resource Transformation firms frame mitigation and opportunity narratives. Table 25 summarises the positive tag distribution.

Tag Name	ESRS Link	ESRS Note	Positive IRO Count
other resource transformation related IROs	E4-3/E4-5	General or residual positive biodiversity IROs	4
pollution and hazardous substances	E4-3/E4-5	Measures to remove or reduce hazardous chemicals or pollution	2
conservation and protection actions	E4-3	Conservation, protection or no-go commitments	1

Table 25- Positive IRO tag distribution in Resource Transformation

Positive IROs are significantly more concentrated in residual categories than negative IROs. Four of the seven positive tags are classified as other resource transformation related IROs and tend to use general phrases such as greener product design or greener packaging without explaining the underlying biodiversity mechanisms. Two positive tags are linked to pollution and hazardous substances and usually describe the removal or reduction of hazardous chemicals in products or processes. There is only one tag for conservation and protection actions, indicating that explicit commitments to protect ecosystems or avoid sensitive areas are rarely reported in this sector.

The sector is clearly unbalanced: there are many detailed descriptions of pollution and resource related risks on the negative side, but only a few clearly specified initiatives to reduce or safeguard biodiversity on the positive side.

### 6.4.3 Example IRO statements

Table 26 provides paraphrased example formulations that reflect how Resource Transformation IROs are typically expressed in the CSRD reports and how these narratives map into tags.

Polarity	Tag Name	Illustrative Formulation
Negative	disturbance and operational impacts	"Manufacturing facilities can generate noise, light and wastewater discharges that disturb local fauna and nearby habitats."
Negative	extraction and mining impacts	"Extraction of raw materials for our products may cause land degradation, loss of natural habitats and increased pressure on local ecosystems."
Negative	habitat and species impacts	"The company's activities can contribute to negative impacts on biodiversity through conversion of natural habitats and disturbance of species in production areas."
Negative	land use and sea use change	"Land-use change associated with resource extraction, processing plants and logistics infrastructure modifies ecosystems and can reduce biodiversity."
Negative	other resource transformation related IROs	"Our use of biomass, water and other natural resources, if not managed sustainably, may negatively affect biodiversity along the value chain."
Negative	pollution and hazardous substances	"Emissions, effluents and hazardous substances from production processes can cause soil and water pollution and terrestrial degradation in surrounding ecosystems."
Positive	conservation and protection actions	"Selected products and services are designed to support more sustainable farming practices and help preserve soil quality and biodiversity when used as intended."
Positive	other resource transformation related IROs	"By redesigning food and consumer packaging, the group aims to reduce the use of primary materials and waste, thereby lowering pressure on ecosystems."
Positive	pollution and hazardous substances	"We are phasing out hazardous chemicals across all customer applications and replacing them with alternatives that reduce ecotoxicity and biodiversity risks."

Table 26- Illustrative IRO formulations - Resource Transformation sector

The pattern is highly concentrated. All Resource Transformation companies with IRO disclosures in our sample are located in Finland and Germany. Germany additionally has one DM = yes company that does not disclose any Resource Transformation IROs, and Italy has one DM = yes Resource Transformation company that does not disclose any IROs. This supports the view that IRO disclosure practices are not consistent across sectors, jurisdictions, or even within countries. In a biodiversity-intensive sector such as

Resource Transformation, some companies that recognise double materiality still do not translate this into clear ESRS E4 aligned IRO narratives. In general, the Resource Transformation sector exhibits many generic negative IROs related to pollution and resource use, very few positive IROs, and a small geographic concentration of disclosures.

## 7. Discussion

This study contributes to accounting and sustainability reporting research by showing how biodiversity is being operationalised as an accounting judgement topic under the CSRD's double materiality logic.

### 7.1 Interpretation of the Main Findings

#### Descriptive Layer - What the Data Shows

As documented in Section 5, biodiversity is recognised as material in 115 out of 300 reports. Among DM-positive cases, reporting is strongest at the strategy and implementation narrative stages: transition plan disclosure under DR E4-1 and action disclosure under DR E4-3 show high alignment rates across most leading countries and sectors. However, disclosure specificity weakens as the chain moves from narrative planning toward measurable commitments.

#### Theoretical Interpretation Layer - What Institutional and Legitimacy Theory Predicts

These descriptive patterns are consistent with the theoretical predictions outlined in Section 3. Institutional theory anticipates that coercive regulatory pressure will produce broad but potentially decoupled adoption. The very high transition plan and action disclosure rates across sectors and countries are consistent with this: under a new mandatory regime, governance narratives and action lists can be produced through strategy and consulting processes even where underlying monitoring systems and data infrastructure remain underdeveloped. Legitimacy theory predicts that firms will favour narrative plans over quantified targets, since plans carry legitimacy benefits while creating limited accountability obligations compared to quantified targets and financially traceable pathways.

The Bromley and Powell (2012) distinction between policy-practice decoupling and means-ends decoupling helps explain variation within the DM-positive group. Companies that disclose transition plans and actions but set no targets at all (21 of 107 plan-and-action firms, Table 7) fit the pattern of policy-practice decoupling: the policy exists on paper but has not been translated into operational commitments.

Companies that do set targets but frame them in aspirational rather than quantified terms (49 of 107) may reflect means-ends decoupling: they are attempting to act on their biodiversity commitments, but the measurement systems needed to produce specific, trackable outcomes are not yet in place. The distinction also helps explain the near-total absence of financial effects disclosures. Connecting biodiversity IROs to financial estimates requires cooperation between sustainability teams, risk management, and finance departments. Where this cooperation has not happened, even companies that have taken real biodiversity actions cannot produce the financial numbers that DR E4-6 requires. This is means-ends decoupling at the organisational level: the intent may be genuine, but the internal systems do not yet deliver the intended output.

### **Why Plans Are Strong but Targets and Financial Effects Are Weak**

The data in Section 5 and the IRO analysis in Section 6 together point to a reason for the plan-target-financial gap that extends beyond simple organisational capacity constraints. The first and most important reason is the quality of the IRO statements themselves. As Tables 20 and 24 show, most IRO tags in both Infrastructure and Resource Transformation fall into the residual "other" category.

This means companies describe biodiversity impacts in general terms, for example "our operations may affect local ecosystems," rather than naming specific locations, species, or ecological processes. When the IRO is vague, there is no concrete referent against which a target can be set. A company that says it has negative impacts on biodiversity in general cannot commit to reducing those impacts by a specific percentage within a specific time, because there is no defined baseline and no clear pathway. The vagueness at the IRO stage therefore flows downstream through the whole disclosure chain, making it very difficult to produce specific targets and financial estimates, even when the company wants to. Empirical evidence further indicates that expanded sustainability reporting may not translate into improved organisational outcomes and can instead reflect legitimacy-seeking behaviour under conditions of information asymmetry and agency conflict (Gupta, 2025).

Second, biodiversity is much harder to measure than other ESRS topics. Climate targets can use well-known greenhouse gas accounting methods and a single metric (tonnes of CO<sub>2</sub>). Biodiversity has no single metric, and meaningful measurement needs site-level ecological data, species surveys, and ecosystem assessments that most companies do not yet collect in a structured way (Kashyap et al., 2025).

Third, the first CSRD reporting cycle creates specific pressures. There are no benchmarks yet, methods are uncertain, and companies may be concerned that early targets could prove

unrealistic or be used against them in later assurance reviews. In this situation, waiting before making specific commitments is a logical response. This is consistent with both institutional decoupling (adopting the form while waiting for the field to settle) and legitimacy management (avoiding commitments that could create problems later).

Fourth, producing financial estimates for biodiversity under DR E4-6 requires cooperation between sustainability teams, risk management, and finance. In most organisations, these departments work with different data, different time horizons, and different methods. The almost complete absence of E4-6 disclosures in our sample suggests that this cooperation has not happened yet, and that biodiversity remains a sustainability department topic rather than a financially integrated one (Krasodomska et al., 2025).

These four reasons reinforce each other. Vague IROs make it hard to set specific targets, which in turn makes it impossible to estimate financial effects. Measurement uncertainty gives companies a legitimate reason to wait, and the lack of cooperation between departments means that even well-meaning companies do not have the internal systems to connect ecological data to financial reporting. The result is the step-by-step weakening we see across sections 5 and 6: strong at the narrative level, weak at the measurement level, and almost absent at the financial level.

## **7.2 Implications for Double Materiality and ESRS E4 Practice**

The Section 5.2 evidence on DM recognition and SBM-3 alignment suggests that the cross-cutting ESRS 2 architecture can connect strategic narratives with formal materiality status. However, DM-positive undertakings that still provide weak IRO specification, limited target-setting, and almost no financial effects indicate that a DM conclusion does not by itself generate a complete ESRS E4 chain. The near absence of E4-6 disclosures is particularly consequential, because it is consistent with the interpretation that firms are not yet connecting impact materiality and financial materiality in the way the standard intends.

This asymmetry between narrative plans and measurable targets is not unique to biodiversity reporting: qualitative evidence from early-adopting family businesses similarly shows a stronger orientation toward financial risks and opportunities than toward outward-facing impact assessment, with companies described as technically prepared but insufficiently shifted in their fundamental approach to double materiality (Bartolacci et al., 2025).

### **7.3 Implications for Accounting Debates on Materiality, Comparability and Assurance**

These results speak directly to accounting debates about decision usefulness, comparability, and assurance in a double materiality regime. The plan–target–financial gap documented in Tables 7 through 14 reduces decision usefulness and weakens comparability across firms, sectors, and countries. From an assurance perspective, the incomplete chain constrains what can be verified: when IROs remain broad and targets or financial effects are absent, assurance risks becoming focused on process descriptions and narrative consistency rather than on substantiating measurable outcomes. This mirrors findings from pre-ESRS assurance research showing that sustainability assurance statements are most informative when they address quantified outcomes rather than process compliance. (Fuhrmann et al., 2017; Simnett et al., 2009)

### **7.4 Practical Implications for EFRAG, Regulators, Companies and Auditors**

#### **Implications for EFRAG**

IRO disclosures in first-wave ESRS E4 reports are frequently generic and lack location specificity. EFRAG should address this directly by issuing minimum quality standards for IRO content in DM-positive cases - specifying that material biodiversity impacts must be linked to specific sites, value-chain stages, or ecosystems rather than described at the level of general corporate policy. EFRAG should also clarify that structured qualitative disclosures with explicit IRO linkage, time horizons, and directional financial estimates constitute meaningful partial compliance with DR E4-6, even where full quantification is not yet feasible. This clarification would reduce the current all-or-nothing dynamic in which companies default to complete non-disclosure rather than incremental reporting. Finally, EFRAG should develop sector-specific implementation guidance for nature-intensive industries - particularly agriculture, forestry, and extractives - where the gap between transition plan prevalence and target-setting is most acute.

#### **Implications for National Regulators and Oversight Bodies**

The evidence that a DM-positive conclusion does not reliably produce a complete ESRS E4 disclosure chain shows that oversight focused solely on topic recognition is insufficient to enforce the CSRD's substantive ambitions. National competent authorities should shift enforcement attention toward chain completeness - evaluating whether DM-positive reports contain not just strategy narratives but also specific targets and, where material, financial effects disclosures. Regulators should treat the absence of DR E4-4

targets alongside DR E4-1 transition plans as a red flag warranting supervisory follow-up in second-cycle reviews. In countries where DM-negative conclusions are disproportionately concentrated in nature-intensive sectors, regulators should scrutinise whether materiality assessments reflect genuine ecological analysis or strategic avoidance of disclosure obligations.

### **Implications for Reporting Companies**

The plan–target–financial gap shows that many early CSRD reporters are treating ESRS E4 as a narrative drafting task rather than an accounting and measurement obligation. Companies should invest now in the internal infrastructure required to close the gap in second-cycle reporting: site-level biodiversity baselines, value-chain dependency mapping, and explicit linkages from identified IROs to time-bound targets and financial estimates. Companies that have already disclosed transition plans and actions under DR E4-1 and DR E4-3 are well-positioned to extend their reporting chains - the barrier is not fresh data collection but the integration of existing biodiversity and financial management systems. Waiting for TNFD adoption or sector-specific ESRS guidance before building this infrastructure will widen the gap further and increase assurance risk in subsequent cycles

### **Implications for Auditors and Assurance Providers**

The combination of high transition plan disclosure rates and very low quantified target and financial effects rates means that early ESRS E4 assurance is currently concentrated on process descriptions and narrative consistency rather than on substantiating measurable outcomes. This mirrors findings from pre-CSRD assurance research showing that sustainability assurance statements are most informative when they address quantified outcomes rather than process compliance (Fuhrmann et al., 2017; Michelon et al., 2019b; Simnett et al., 2009)

Assurance providers should develop explicit evaluation criteria for IRO traceability - specifically, whether identified material impacts can be traced through to targets, financial estimates, and management responses. Where this traceability is absent, assurance statements should reflect the limitation rather than providing comfort on the completeness of the disclosure chain. As the literature on sustainability assurance shows, institutional and sectoral factors shape both the demand for assurance and the quality of assurance statements (Fuhrmann et al., 2017; Simnett et al., 2009) - and these dynamics will determine whether assurance functions as a credibility mechanism or a legitimacy signal in early CSRD biodiversity reporting.

## 8. Conclusion

This study examined how early CSRD reporters operationalise double materiality for biodiversity through ESRS E4 and whether disclosures progress from materiality conclusions to comparable, decision-useful and assurance-ready information. The evidence indicates partial implementation: adoption is strongest in governance, policy framing, transition planning and action narratives, but weakens markedly where measurement, traceability and finance integration are required.

As documented in Section 5, biodiversity is recognised as double material in a meaningful minority of first-wave sustainability statements and is typically connected to strategy and the business model. Transition plans and actions are widespread among DM-positive undertakings, but the chain weakens markedly at target-setting and reaches its lowest point at financial effects disclosure. The full statistical picture is presented in Tables 3 through 14 and summarised in Section 5.1.

As interpreted through the institutional and legitimacy theory framework in Section 3 and discussed in Section 7.1, the plan–target–financial gap reflects a theoretically predictable outcome of decoupling and symbolic legitimation under a new mandatory regime, compounded by genuine measurement and governance system constraints. Companies are producing the visible artefacts of biodiversity reporting - transition plans, action lists, governance statements - while lagging significantly at the levels where genuine organisational integration would be required: measurable targets, location-specific IROs, and financially traceable effects. This pattern is consistent with broader evidence that early adoption of double materiality tends to be symbolic rather than substantive, with formal reporting structures decoupled from underlying risk management and operational systems (Dragomir et al., 2025; Panfilo et al., 2025).

The trajectory of ESRS E4 reporting across future CSRD cycles will be the critical test of whether the current pattern represents a transitional first-cycle limitation or an entrenched structural feature of biodiversity disclosure. The evidence base established by this study - covering 300 first-wave reports with systematic disclosure chain coding across all five ESRS E4 disclosure requirements - provides a baseline against which second and third-cycle reporting can be directly measured. If the plan–target–financial gap narrows as companies build biodiversity monitoring infrastructure, integrate IROs into financial planning, and respond to regulatory and assurance pressure for chain completeness, the first-cycle patterns documented here will prove to have been a predictable but temporary feature of regulatory transition. If the gap persists across multiple cycles, it will indicate deeper structural limits to what mandatory reporting can achieve for a topic as ecologically complex and financially opaque as biodiversity - and will raise more fundamental questions about whether the CSRD's double materiality architecture is sufficient to generate the decision-useful, comparable, and assurance-ready biodiversity information that the EU's sustainability transition agenda requires. Biodiversity is not only a reporting challenge; it is, as Bebbington et al. (2023)

argued, one of the most underdeveloped frontiers in environmental accounting - and the ESRS E4 evidence presented here confirms that closing that frontier will require sustained effort well beyond the first reporting cycle.

## **Future Research**

Several questions raised by this study go beyond what document-based analysis can establish and represent priorities for future empirical work. First, and most important, whether the plan–target–financial gap narrows in subsequent CSRD reporting cycles - and whether companies that disclosed transition plans in year one convert these into quantified targets and financial estimates by year two or three. Second, whether cross-country differences in IRO specificity and target-setting reflect systematic differences in regulatory oversight intensity, national biodiversity governance culture, or corporate governance quality. Third, whether DM-negative conclusions in nature-intensive sectors represent genuine materiality assessments supported by documented analysis or strategic avoidance of disclosure obligations - a question that requires access to internal materiality assessment documentation rather than published reports alone. Fourth, whether early assurance engagement at the planning stage of the reporting cycle produces measurably different outcomes in target quality and financial effects coverage compared to retrospective assurance. Fifth, whether the biodiversity-specific challenges documented here - location-dependence, measurement uncertainty, cross-departmental coordination - are systematically more severe than in other ESRS topical standards, or whether the plan–target–financial gap is a general feature of first-cycle CSRD reporting across all environmental topics. Addressing these questions longitudinally, and triangulating document evidence with interviews of preparers, auditors, and regulators, will be essential for understanding how mandatory biodiversity reporting matures - and whether it ultimately delivers the ecological accountability that motivated the ESRS E4 standard.

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## Appendix A. Biodiversity IRO Tag Book

The table below reports the full biodiversity IRO tag book used in the analysis. For each tag we present the tag code, tag name, operational definition, polarity, and the ESRS E4 disclosure requirement to which it is linked. The tag book was used for coder training, inter-coder reliability checks and the thematic analysis of biodiversity impacts, risks, opportunities and responses.

Tag Code	Tag Name	Operational Definition	Polarity	ESRS E4 Link
ACT_CIRC	Circular Economy	References to circular economy practices (e.g. recycling, resource efficiency) in the context of biodiversity. Negative when lack of circularity poses risk; positive when actions mitigate biodiversity impact.	Neg/Pos	E4-3
ACT_CONS	Conservation & Protection	Mentions of conservation/protection efforts for biodiversity. Negative for gaps/risks, positive for active conservation actions.	Neg/Pos	E4-3
ACT_RES	Restoration & Remediation	Mentions of ecosystem restoration/remediation. Negative for failures, positive for active restoration actions.	Neg/Pos	E4-3
ACT_SRC	Sustainable & Certified Sourcing	Mentions of biodiversity-related sourcing practices. Negative for unsustainable sources, positive for certified/sustainable sourcing efforts.	Neg/Pos	E4-3
ACT_STK	Stakeholder & Indigenous Engagement	Mentions of stakeholder/Indigenous engagement on biodiversity. Negative for lack/conflict, positive for proactive collaboration.	Neg/Pos	E4-3
CTX_REN	Renewable Energy Projects	Mentions of renewable projects and biodiversity. Negative for impacts (e.g. wind farm collisions), positive for avoidance/mitigation benefits.	Neg/Pos	E4-3/E4-5

Tag Code	Tag Name	Operational Definition	Polarity	ESRS E4 Link
DRV_HAB	Habitat & Species Impacts	Mentions of impacts on habitats/species. Negative for degradation/loss, positive for mitigation or protection.	Neg/Pos	E4-5
DRV_LAND	Land Use Change & Deforestation	Mentions of land-use change/deforestation. Negative for conversion causing biodiversity loss, positive for prevention or sustainable land use.	Neg/Pos	E4-5
DRV_AGR	Agriculture & Forestry Practices	Mentions of agriculture/forestry impacts. Negative for unsustainable practices, positive for sustainable methods.	Neg/Pos	E4-5
DRV_POL	Pollution & Hazardous Chemicals	Mentions of pollution/chemical pressures. Negative for risks, positive for control/phase-out measures.	Neg/Pos	E4-5
DRV_MIN	Resource Extraction & Mining	Mentions of biodiversity impacts from extraction/mining. Negative only.	Negative	E4-5
DRV_SCP	Supply Chain Biodiversity Pressure	Mentions of supply chain pressure on biodiversity. Negative for impacts, positive for upstream/downstream mitigation.	Neg/Pos	E4-5
DRV_SIT	Infrastructure & Urban Development	Mentions of urban/infrastructure siting and biodiversity. Negative for encroachment, positive for biodiversity-conscious design.	Neg/Pos	E4-5
DRV_DST	Operational Disturbances (Noise/Light)	Mentions of biodiversity risks from noise, light, or vibration. Negative only.	Negative	E4-5
DRV_SOIL	Soil Degradation & Erosion	Mentions of soil degradation/erosion affecting biodiversity. Negative only.	Negative	E4-5
DRV_FWA	Freshwater Ecosystem Impacts	Mentions of harm to freshwater ecosystems. Negative only.	Negative	E4-5

Tag Code	Tag Name	Operational Definition	Polarity	ESRS E4 Link
DRV_MAR	Marine & Coastal Ecosystem Impacts	Mentions of marine/coastal ecosystem harm. Negative only.	Negative	E4-5
FIN_EFF	Financial Effects & Nature Finance	Financial implications of biodiversity. Negative for risks/costs, positive for gains/opportunities/nature financing.	Neg/Pos	E4-6
FIN_REG	Regulatory & Permitting Risk	Biodiversity-related regulatory or permitting risks. Negative only.	Negative	E4-6
FIN_MKT	Brand Reputation & Market Access	Biodiversity effects on brand or market access. Negative for reputational risk, positive for strategic advantage.	Neg/Pos	E4-6
GOV_POL	Biodiversity Policies & Commitments	Mentions of policies, principles, or commitments to biodiversity. Neutral governance disclosure.	Neutral	E4-2
GOV_STR	Biodiversity Strategy & Integration	Mentions of biodiversity strategy or integration into business model/transition plans. Neutral governance disclosure.	Neutral	E4-1
TGT_MET	Biodiversity Targets & KPIs	Stated biodiversity targets or KPIs (qualitative or quantitative). Neutral disclosure of goal-setting.	Neutral	E4-4
OTH_NEG	Other/Unspecified (Negative)	Generic or uncategorised biodiversity-related negative disclosures. Use only if not covered by defined tags.	Negative	E4-3/E4-5
OTH_POS	Other/Unspecified (Positive)	Generic or uncategorised biodiversity-related positive disclosures. Use only if not covered by defined tags.	Positive	E4-3/E4-5

Table 27-Full Biodiversity IRO Tag Book (Appendix A)