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Benchmarking

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Summary

This report presents a benchmarking of due diligence standards and certification schemes against the evolving EU and national regulatory landscape. The analysis is structured in two main parts, reflecting the distinct regulatory and operational dynamics of primary and secondary raw material chains. For primary materials, standards are evaluated against criteria derived from the Corporate Sustainability Due Diligence Directive (CSDDD) and the German Supply Chain Act. For secondary materials, the evaluation criteria are based on the Ecodesign for Sustainable Products Regulation (ESPR), the WEEE and RoHS Directives. For both primary and secondary materials, the assessment also considers the European Battery Regulation (EBR) and the Critical Raw Material Act, applicable to supply chains.

The assessment of voluntary sustainability standards (VSS) for primary raw materials focuses on four initiatives: Initiative for Responsible Mining Assurance (IRMA), the Responsible Minerals Initiative (RMI), The Copper Mark, and CERA 4in1. The selection of these standards was based on their broad recognition within the mining sector and their coverage of different stages of the mineral value chain, with diverse scope and commodity coverage. They were analysed using both qualitative methods and a fuzzy TOPSIS multi-criteria decision-making approach validated by experts. Seven criteria, derived from EU regulations and an extensive literature review, guided the evaluation.

Results show overall solid alignment of VSS with EU regulations. IRMA stands out for comprehensive coverage of due diligence requirements, going beyond them in some areas. RMI aligns solidly with the regulations but without explicit coverage of environmental risks and with less prescriptive requirements on physical transformation. The Copper Mark also shows solid alignment, combining OECD-based due diligence with independent audits and grievance procedures, though its chain of custody and transformation controls rely mainly on reconciliations. CERA 4in1 meets most requirements, applies a transversal risk approach, through critical control points, material balance factors, and robust auditing. For all four, alignment with the CRM Act is only partial, as obligations mainly target competent authorities and “strategic projects” rather than all companies.

For secondary raw materials, the report examines initiatives such as R2v3, e-Stewards, and the Global Battery Alliance's Battery Passport. While EU regulations increasingly emphasise traceability, recycled content, and ESG safeguards, most standards lag in operational implementation. The Battery Passport shows promise in lifecycle traceability and digital integration, whereas R2v3 and e-Stewards prioritise safe handling and reuse, offering only partial alignment with EU expectations.

This divergence could undermine EU efforts to establish a harmonised and circular materials economy. To address this, the report calls for greater standardisation in traceability, stronger environmental and social safeguards, and broader use of technologies for verification and reporting.

The standards play both complementary and competitive roles in the regulatory landscape. Identifying those best aligned with legal obligations is key for companies and standard bodies alike. Policymakers can use these insights to promote more inclusive and enforceable due diligence practices. However, effectiveness remains inconsistent, particularly in high-risk regions with weak governance (STRADE, 2018). Future research should explore other standards and the integration of digital tools such as blockchain to strengthen traceability, verification, and regulatory compliance across supply chains.

Keywords

Due Diligence, standards, critical raw materials, EU regulations, responsible sourcing

Abbreviations and acronyms

3TG	Tin, tantalum, tungsten, and gold
CAHRA	Conflict-Affected and High-Risk Areas
CAMD	Commitment, Assessment, Monitoring, Disclosure
CCS	CERA 4in1 Chain of Custody Standard
CDP	Carbon Disclosure Project
CMRT	Conflict Mineral Reporting Template
CPS	CERA 4in1 Performance Standard
CRM	Critical Raw Material
CRS	CERA 4in1 Readiness Standard
CoC	Chain of Custody
CSDDD	Corporate Sustainability Due Diligence Directive (EU) 2023/2859
CSRD	Corporate Sustainability Reporting Directive
EBR	European Battery Regulation (EU) 2023/1542
ESAP	European Single Access Point
ESG	Environmental, Social and Governance
ESPR	Ecodesign for Sustainable Products Regulation
EU	European Union
GBA	Global Battery Alliance
GRI	Global Reporting Initiative
ICMM	International Council on Mining and Metals
IIRC	International Integrated Reporting Council
IRMA	Initiative for Responsible Mining Assurance
MCDM	Multi-criteria decision-making
LME	London Metal Exchange
LSM	Large-Scale Mining
OECD	Organisation for Economic Co-operation and Development
RMAP	Responsible Minerals Assurance Process

RMI	Responsible Minerals Initiative
RRA	Risk Readiness Assessment
SASB	Sustainability Accounting Standards Board
SDD	Sustainability Due Diligence
SERI	Sustainable Electronics Recycling International
SRM	Secondary Raw Material
SWOT	Strengths, Weaknesses, Opportunities and Threats
TCFD	Task Force on Climate-related Financial Disclosures
TSM	Towards Sustainable Mining
UNGP	United Nations Guiding Principles on Business and Human Rights
VSS	Voluntary Sustainability Standards
WEEE	Waste from Electrical and Electronic Equipment
WGC	World Gold Council
WP1	Work Package 1

1 Introduction

1.1 The place of Deliverable 1.4 in the MaDiTraCe project

Responsible sourcing of critical raw materials and higher transparency over the whole supply chain incorporating them are driven by the reputational-risk-avoiding downstream industrial producers, the increasing demand from consumers of goods and, above all, the existing and upcoming EU and national regulation (e.g., EU Battery Regulation). In response to this pressure, many certification schemes, including traceability requirements, have been developed and implemented worldwide.

The main objective of the MaDiTraCe project is to enhance transparency of supply chains by better tracing the origin and movement of critical raw materials (CRMs) along the commodity supply chains. For this purpose, geo-based and digital technological traceability solutions are advanced, tested, and finally integrated into a comprehensive certification scheme for tracking and certifying responsible and sustainable CRMs along their entire supply chains, applicable to all mineral raw materials worldwide, regardless of the scale of operations (i.e., the four interlinked CERA4in1 certification standards for sustainable raw materials). Through its comprehensive approach, the CERA4in1 certification system will contribute to the need for harmonizing the currently fragmented certification landscape addressing the due diligence in the mineral sector.

The Work Package 1 (WP1), *Assessment of needs and gaps in due diligence*, responds to the following three specific objectives of the MaDiTraCe project:

i) to take stock of the existing due diligence and responsible sourcing regulation, standards, certification schemes and voluntary stakeholder initiatives in the mineral sector, to identify their strengths and weaknesses, as well as the gaps in their suitability for the specific needs of industrial companies;

ii) to analyse the strengths and weaknesses of current due diligence schemes and identify the gaps;

iii) to benchmark the certification schemes and standards against the existing and emerging regulatory due diligence obligations, for ensuring the compliance of the former with the legal due diligence requirements in force, for both primary and secondary raw materials.

As a part of the WP1, the previous Deliverable 1.3, State of Play Report[1], provided an overview of the current due diligence practices in the raw material supply chains, including guidelines, international, regional and national regulation and legislative frameworks, stakeholder initiatives, standards and certification schemes for primary and secondary raw materials. Then, an analysis of the strengths, weaknesses, opportunities and threats (SWOT) of the key standards and certification schemes was also carried out.

Both research endeavours were meant to serve as a knowledge basis for the benchmarking of raw material due diligence standards and certification schemes against the EU and national regulations, which is the main objective of the current deliverable - Deliverable 1.4, *Benchmarking synthesis*. As far as the regulations side is concerned, the scope our study is limited the due diligence regulatory framework at the EU and EU member state level; environmental and mining-related legislation at the EU-level and the EU member state level is outside the scope of our analysis.

[1] MaDiTraCe project´s website, *Results* section - https://www.maditrace.eu/results.

1.2 Structure of the report

The document is structured in two main sections: one focusing on primary raw materials (Section 2) and the other on secondary raw materials (Section 3). Both sections follow the same structure: first, the characteristics of the standards analysed are presented; next, the methodology employed to conduct the study is described; subsequently, the results are provided according to the identified criteria and per standard; and finally, an analysis of the compliance of the standards with EU regulations is presented. Section 4 summarizes the main conclusions of the report, while Section 5 provides a glossary of commonly used terms.

1.3 EU regulatory frameworks

European and national legislations mandating due diligence have emerged as a response to growing pressures from investors, civil society, and the recognized limitations of voluntary private-sector initiatives (ECCJ, 2020). These regulations aim to address critical shortcomings by promoting responsible sourcing, enhancing corporate accountability, and providing legal certainty throughout the European Union (EU). Since the mid-2000s, European and national laws have increasingly aligned with the United Nations Guiding Principles on Business and Human Rights (UNGP) and the Organisation for Economic Co-operation and Development (OECD) Guidelines on Sustainability Due Diligence (SDD), reflecting efforts to create a consistent and equitable business environment (McCorquodale & Nolan, 2021).

A shift toward a harmonized European approach to due diligence legislation has been observed, covering both cross-sectoral and sector-specific policies, with continued expansion anticipated in the coming years (Franken & Schütte, 2022). A key development in this regard is the Corporate Sustainability Due Diligence Directive (EU) 2023/2859 (CSDDD), which entered into force on July 2024. The directive introduces mandatory due diligence requirements outlined in Articles 7 to 16 (CSDDD, 2024). This legislation represents a fundamental advance in the EU regulatory landscape, raising the standards of corporate responsibility in various sectors (Ciacchi, 2024). With the enactment of this legislation, the EU aims to address the multiple challenges of responsible sourcing within global supply chains. Member States must transpose the directive into national law by 26 July 2026, and from 26 July 2027, these obligations will apply to companies following a phased implementation based on company size and turnover, its full application date being set on 26 July 2029 (CSDDD, 2024). These measures are expected to reshape business practices, catalyse significant change and set a new benchmark for sustainability (Farooki et al., 2024). It should be noted that the Omnibus Directive (European Commission, 2024) introduced simplifications to the scope and implementation of the CSDDD. These adjustments reduced the number of companies falling under the directive by raising the employee and turnover thresholds, narrowed the scope of systematic due diligence primarily to direct business partners, and extended the review period for risk assessments from annual to every five years. They also postponed the timeline for climate-related obligations and overall application deadlines, giving companies more time to prepare. In addition, the Omnibus removed the draft's EU-wide civil liability regime and streamlined

stakeholder engagement obligations, while capping the information large firms can request from SMEs to avoid excessive reporting burdens.

Alongside the CSDDD, sector-specific regulations have also emerged to address due diligence obligations in particular industries. An example is the European Battery Regulation (EU) 2023/1542 (EBR), enacted in 2023, which introduces comprehensive requirements for sustainable and safe battery production. Its scope spans the entire product lifecycle, addressing performance standards, end-of-life solutions, and recycling (European Union, 2023). Notably, CHAPTER VII, covering Articles 47 through 53, establishes a due diligence framework, representing a transformative development for the battery industry. This framework ensures the effective management of supply chains for critical raw materials, such as cobalt, nickel, lithium, and natural graphite, and of chemical compounds based on them (EBR, 2023; Mattea, 2023). From 18 August 2027 (Council of the EU, 2025), economic operators placing batteries on the market or putting them into service shall comply with the due diligence obligations set out in the Regulation by implementing specific battery due diligence policies to ensure responsible sourcing and sustainable management of the supply chain recycling (EBR, 2023).

At the national level, Germany had already taken a significant step in strengthening corporate due diligence obligations before the adoption of the CSDDD. The German Act on Corporate Due Diligence Obligations in Supply Chains (*Lieferkettensorgfaltspflichtengesetz* – hereafter German Supply Chain Act) came into force on 1 January 2023 (German Supply Act, 2021). The German Supply Chain Act is currently the only due diligence regulation being applied to companies in the EU, as the CSDDD and the EBR are to be applied in 2028 and 2027, respectively.

The German Supply Chain Act provides clear definitions of "human rights risk" and of "environmental-related risk", based on a thorough list of potential prohibition violations for each of them, in accordance with the related international agreements in place (Section 2). The due diligence obligations stipulated in the German Supply Act apply to all companies with at least 1,000 employees (since January 2024), covering their own business area and their direct suppliers. Indirect suppliers are also considered when companies have "substantiated knowledge" of violations of human rights and environmental obligations induced by the economic actions of indirect suppliers.

The main due diligence obligations of companies set out in the German Supply Chain Act, Section 3, are:

i) To adopt a human rights policy statement,
ii) To put in place a risk management system;
iii) To carry out regular risk analyses to check whether their activities induce human rights and environmental violations;
iv) If prohibition violations are identified, to take the most appropriate measures for preventing, minimizing or ending them in the business area of the firm and at its direct suppliers;
v) To take remedial actions for addressing the human rights violations;
vi) To set up an internal complaint procedure for facilitating detection of relevant risks or prohibition violations arising from firm´s own business operations or from economic actions of suppliers;
vii) Comply with the due diligence obligations related to the risk identified at indirect suppliers (Section 9);
vi) Documenting and annual reporting on fulfilment of due diligence obligations.

The regulation (EU) 2024/1252 or Critical Raw Materials Act (CRM Act) adopted in April 2024 (European Union, 2024b) establishes a framework to ensure a secure, diversified, affordable and sustainable supply of CRMs in the European Union. Unlike other regulations such as the CSDDD or the EBR, the CRM Act does not focus primarily on corporate due diligence. However, it has been included in this analysis due to its strategic relevance to the CRMs sector and to initiatives aimed at supply chain traceability and sustainability. The regulation sets binding targets for the extraction (≥10%), processing (≥40%) and recycling (≥25%) capacity of CRMs within the EU, as well as limiting dependence on third countries to ≤65% for each strategic CRM. It also introduces the concept of "strategic projects", promoting diversification of sources, circularity, recycling, strategic storage and the development of clean technologies. Although most of its provisions are aimed at Member States and the European Commission, the CRM Act has indirect implications for companies, especially those involved in strategic projects, which will have to comply with traceability, sustainability and reporting requirements.

Article 30 of the CRM Act establishes a formal procedure for recognising certification schemes related to the sustainability of CRMs. Scheme owners (governments, industry associations, or organisations) will be asked to apply for recognition by the European Commission, providing evidence that they meet the criteria set out in Annex IV. Recognition specifies (European Union, 2024b):

> (a) the stages of the raw materials value chain covered;
>
> (b) the project life-cycle stages (before, during, and after closure); and
>
> (c) the sustainability dimensions and environmental risk categories addressed.

Annex IV details the minimum requirements for recognition, which include (European Union, 2024b):

- Governance and verification: openness under transparent, fair, and non-discriminatory terms; multi-stakeholder governance; independent and competent verification; and site-level audit reporting.
- Environmental practices: robust requirements for environmental management and impact mitigation across risk categories such as air emissions (including GHG), water use and pollution, soil degradation, biodiversity loss, hazardous substances, noise/vibration, plant safety, energy use, and waste management.
- Social practices: respect for human and labour rights, including the rights and community life of indigenous peoples.
- Business integrity: sound financial, environmental, and social management; anti-corruption and anti-bribery measures.

These provisions create a direct regulatory link between the CRM Act and voluntary sustainability standards (VSS), making the regulation highly relevant for this benchmarking exercise. By establishing a framework for official recognition of certification schemes and defining explicit sustainability criteria, the CRM Act will not only influence how CRMs are obtained, but also incorporate certification mechanisms into the EU's long-term strategy to ensure secure and responsible supply chains.

Although these regulations address overlapping risks, such as forced labour and biodiversity loss, each has specific approaches. The CSDDD sets out a general framework for due diligence across multiple sectors, including an emphasis on climate change

mitigation. The EBR, meanwhile, focuses on the particular environmental impacts of the battery sector, such as water consumption and the use of hazardous substances. Meanwhile, the German Supply Chain Act, while more limited in geographic scope, reinforces compliance with international human rights and environmental standards at the national level, complementing the EU regulatory efforts. In addition, the CRM Act, while not primarily focused on corporate due diligence, is included due to its strategic importance for the CRM sector.

Given their extensive reach and the likelihood of impacting businesses beyond the EU, these regulations are expected to influence global corporate practices and inspire similar legislative developments in other jurisdictions (Johnson & Khosravani, 2024; Thorens et al., 2025). A comparative summary of the scopes, targets, and risks addressed by these four frameworks is presented in Table 1 and 2.

Beyond EU-level frameworks, recent research has also compared the alignment between voluntary sustainability standards (VSS) and national regulations in resource-rich countries. For instance, studies analysing Chilean and Peruvian legislation against IRMA highlight both convergences and regulatory gaps in addressing environmental and social risks in mining (Ibáñez et al., 2024). Similar comparative analyses in the lithium sector show how private standards such as IRMA overlap with, but also go beyond, national regulations, particularly on indigenous rights and transparency (Kramarz et al., 2024). These studies strengthen the understanding of how international standards interact with domestic legal frameworks, providing valuable insights.

	Corporate Sustainability Due Diligence Directive	**European Battery Regulation**
Scope	Applied to EU-based companies with over 5,000 employees and a net worldwide turnover exceeding €1.5 billion (from July 2027), companies with more than 3,000 employees and €900 million in turnover (from July 2028), and companies with more than 1,000 employees and €450 million in turnover (from July 2029). It also applies to non-EU companies with a net turnover of more than €450 million within the EU (European Commission, 2025e).	Applied to companies in the EU with a turnover exceeding €40 million that are part of the battery production or supply chain or/and non-EU companies selling batteries or products containing batteries in the EU market (Article 47).
Target	Target is affected companies to conduct human rights and environmental impacts in their own operations, their subsidiaries, and their global value chains. Due diligence for indirect business partners is required only when there is plausible evidence of potential or actual adverse impacts (European Commission, 2025e).	Target is affected companies within the battery supply chain, involved in the production, import, distribution, and disposal of batteries containing key materials such as cobalt, lithium, nickel, and natural graphite, conduct human rights and environmental due diligence across their entire value chain (Article 47, Annex X).
Social Risks	Freedom of association Forced labour Child labour	Occupational safety Child labour Forced labour

	Discrimination Equal payment	Discrimination Trade union rights Rights of indigenous peoples
Environmental risks	Biodiversity loss Illegal species trade Mercury use Pollution risks (air, water and chemical waste) Deforestation and ecosystem protection Climate change mitigation measures	Air pollution Water usage Soil degradation Biodiversity loss Hazardous substances Noise Energy consumption Waste management

Table 1. The scope, targets and risks addressed by the CSDDD and EBR. Sources: Adapted from CSDDD (2024) and EBR (2023) .

	German Supply Chain Act	**CRM Act**
Scope	Applied to companies that i) have central administration, principal place of business, administrative headquarters, statutory seat or having a domestic branch office in Germany; and ii) employ at least 1,000 employees (threshold applicable since 01 January 2024).	Applies to EU Member States, under the guidance of the European Commission, and companies involved in "strategic projects" for extraction, processing, recycling, or substitution of CRMs. Recognition of certification schemes is open to scheme owners globally. Targets and obligations mainly addressed to public authorities, but indirect obligations apply to companies engaged in strategic projects.
Target	Aims at affected companies to i) identify, assess and address the human rights and environmental risks within their supply chain - i.e., in their own business area (as defined in Section 2) and their suppliers along their global value chains, and ii) to prevent, minimize or end any violations to the human rights and environment-related obligations set out in the Act. Companies are also asked to take due diligence actions (risk management adaptation, complaint procedure set-up, etc. – Section 9) with regard to the indirect suppliers´ actions when there are indications ("substantiated knowledge") of their potential violation of the human rights and environmental obligations.	Establishes binding EU targets for domestic extraction (≥10%), processing (≥40%) and recycling (≥25%) of CRMs, and limits dependence on any third country to ≤65% for each strategic CRM. Requires "strategic projects" to implement recognised certification schemes meeting Annex IV criteria. Indirectly promotes responsible sourcing, transparency, and sustainability in CRM supply chains.
Social Risks	Child labour; Forced labour and slavery	Human rights Labour rights

	Working conditions Occupational safety and health; Adequate wage; Freedom of association; Employee discrimination; Rights of indigenous peoples and protection of their habitat	Protection of the community life of indigenous peoples
Environmental risks	Use of mercury, mercury compounds and waste Pollutants Exposure to toxic chemicals Waste management, including export, imports and disposal of hazardous waste	Air Water Soil Biodiversity Hazardous substances management Noise and vibration control Plan safety Energy use Waste and residues management

Table 2. The scope, targets and risks addressed by the German Supply Act and CRM Act. Source: Adapted from German Supply Act (2021) and CRM Act (2024b).

Due diligence is defined in the UN Guiding Principles and the OECD Due Diligence Guidance, serving as the basis for the development of specific regulatory frameworks. Given that the following regulations, CSDDD, EBR and German Supply Act, are specifically focused on due diligence requirements, Table 3 presents a comparative analysis of their relevant provisions, highlighting the obligations (and their corresponding articles) in each case.

Due diligence criteria	Corporate Sustainability Due Diligence Directive	European Battery Regulation	German Supply Chain Act
Policy Commitment & Integration	Article 7: Ensure due diligence is integrated into governance. Develop code of conduct, description of processes, and measures to verify compliance with the code. Article 8(3): Policy updates based on risk assessments.	Article 48(1); Adopt battery-specific due diligence policy. Article 48(2,3): Maintain documentation of the due diligence policy and audit reports for 10 years.	Section 3. Enterprises should comply with the due diligence obligations set out in the Section 3. Sections 5. As part of the risk management system, companies should carry out a yearly risk analysis (and whenever it is deemed necessary) for identification, weighting and prioritization of risks. Section 6(2). As part of the preventive measures to be implemented, companies should release a policy statement on their human rights strategy, stating their procedure adopted for complying with the due diligence obligations, referring to: i) risk management system set-up; ii) risk analysis, and the priority human rights and environment-related risks and expectations within the companies´ supply chain resulting from it; iii) preventive measures taken within their supply chain; iv) remedial actions

			taken; vi) the complaints procedure established; vi) how they fulfil documentation and reporting obligations. Companies´ compliance with the due diligence requirements should be proved based on an ongoing documentation; the related documents should be kept for at least 7 years form their issuance.
Risk Identification	Article 8(2): Map operations and supply chains, focusing on own operations, subsidiaries, and direct partners. Investigate indirect suppliers only if credible risks arise. Article 8(4): Include subsidiaries and direct partners in risk assessments, ensuring the code of conduct applies throughout the value chain and considering SME support. Article 9(1): Risks must be prioritized based on their severity and likelihood.	Article 49(1)(d): Traceability system including a chain of custody. Article 49(2): Documentation of suppliers, raw materials, supplier details, origin and transactions, material quantity, third-party verification reports, and additional information for conflict-affected areas, with verification reports provided to downstream operators. Article 50(1)(a): Risk assessment focused on high-risk areas.	Sections 4. Companies should take measures for setting up a risk management system capable of i) identifying and minimising the human rights and environmental risks within their business area and along their supply chain; and ii) to prevent, end/minimise the violations of due diligence obligations. Section 5(2) and Section 9. Prioritization of risks within companies´ supply chain should be based on the specific criteria stipulated in section 3(2). According to the section 2(5), a company´ supply chain covers: i) own business area; ii) direct suppliers and iii) indirect suppliers (in the conditions stipulated in Section 9).
Prevention & Mitigation of Risks	Article 10(1): Develop and implement preventive measures based on identified risks. For climate change consider a transition plan- Article 10(2): Seek contractual assurances from business partners to ensure	Article 50(1)(b): Implement risk management measures for risk prevention.	Section 6: Companies must adopt preventive measures in their own business area and regarding their direct suppliers. Section 9: Companies must adopt preventive measures if there are indications of violations of human rights and environmental obligation at their indirect suppliers. In these cases, companies must elaborate and implement a prevention, minimisation or termination concept. Section 7: When a company discovers of violation of due diligence

	compliance with risk management plans.		obligations in its business area or at its direct suppliers, it must take remedial actions for minimizing or ending it; or elaborate a concept, alongside a timetable, for bringing the violation at the direct supplier to an end.
	Article 11(3): Corrective actions must be taken to mitigate, and end identified risks.	Article 50(1)(b)(iii): Suspend or terminate non-compliant business relationships where prevention fails.	Section 9: If there are indication of a violation of human rights or environmental obligation at an indirect supplier, companies have to i) conduct risk analysis; ii) take preventive measures; iii) elaborate and implement a prevention, minimisation or termination plan; and iv) update its policy statement accordingly.
	Article 11(4): Financial or operational adjustments to internal processes may be necessary to mitigate risks.	Article 50(3)(iii): Design risk management strategies and track the performance of risk mitigation efforts.	
Monitoring	Article 10(6): Instead of mandatory termination, companies may temporarily suspend relationships with partners linked to severe adverse impacts while attempting to resolve issues, especially if production depends on the supplier and due diligence measures have been exhausted.	Article 48(2): Due diligence policies must be periodically audited by third parties to ensure compliance and effectiveness.	Section 5: One of the companies´ main due diligence obligations is carrying out annual risk analyses, or on ad-hoc basis in several cases. An assessment of the effectiveness i) of preventive measures (Section 6), ii) of remedial actions taken (Section 7) and iii) of the complaint procedure adopted (Section 8) has to be carried out yearly or on ad hoc basis in several justified cases.
		Article 51(1a-d): Third-party verifications must assess all due diligence activities, ensuring compliance, with audits independence, competence, and accountability	
	Article 15: Regular assessments of due diligence measures are extended from 1 to 5 years to reduce the burden on companies and SMEs. However, ad hoc assessments must be conducted if indications of issues arise before the next scheduled evaluation.	Article 53: The Commission associate with OECD to approve and monitor due diligence schemes to ensure companies meet their obligations, with the power to revoke	

		recognition if they fail to comply.	
Communicate	Article 12(1): Provide remediation for adverse impacts they have caused or contributed to.	Article 49(1)(f): Establish grievance mechanisms for affected stakeholders, based on international standards such as UNGPs.	Section 5: The results of risk analyses should be communicated internally, to the company´s relevant decision makers. Section 6: When taking preventive measures, companies should get contractual assurances from the direct suppliers that they will comply with the company´s expected due diligence obligations and that they will address them properly.
	Article 13: Engage only with relevant stakeholders, limiting consultation to those directly linked to the specific stage of the due diligence process.	Article 50(2): Stakeholders must be consulted before designing and implementing remediation strategies.	Section 8 and 9: Companies should adopt an internal complaints procedure, allowing for reporting violations of due diligence obligations taking place within the company´s own business areas and both at its direct and indirect suppliers. An operational communication with the reporting persons should be ensured by the companies.
	Article 14: Establish a complaints procedure allowing directly affected stakeholders, such as workers, local communities, and individuals impacted by business operations, to raise concerns or report impacts.	Article 51(1c): The notified body will verify compliance, focusing on stakeholder input and checks on undertakings.	Section 10: A detailed yearly report on company´s compliance with the due diligence obligations, including the identified risks and measures taken in this respect, has to be published on its website.
Address	Article 9(2): Reports must address most severe risks and mitigation efforts.	Article 51(2): Verification report to confirm due diligence policies meet legal obligations.	Section 3(2): A company´s response extent and ways of addressing the occurring due diligence obligation violations depend on several factors: i) type and magnitude of company´s business operations; ii) its capacity of addressing the due diligence violations and influencing the party responsible for them; iii) due diligence violation´s severity, reversibility, and probability of taking place; iv) how company caused or contributed to a certain violation.
	Article 16: Annual reporting of due diligence efforts is mandatory, including transparency about identified risks and mitigation steps.	Article 52(2): Transparency with downstream purchasers about raw material sourcing and third-party	

		verification reports is required Article 52(3): Public reports must disclose information on significant risks and remediation actions taken

Table 3. Analysis of the CSDDD, EBR and the Supply Chain Act. Source: Adopted from CSDDD (2024), EBR (2023) and German Supply Act (2021).

2 Primary raw materials

This chapter assesses how closely selected standards and initiatives for primary raw materials are aligned with the normative requirements of EU regulations.

2.1 Standards

Voluntary Sustainability Standards (VSS) cover standards that support companies in aligning with legal requirements, functioning as practical tools equipped with procedures and mechanisms such as independent third-party audits, which are established and managed by governments, industry associations, or other relevant organizations (Sydow & Reichwein, 2018).

VSS utilize diverse strategies to ensure compliance with their established parameters, whether at mining sites or throughout supply chains, forming a robust assurance framework. This framework often involves certifications or labels issued for commodities or products. Research by Potts et al. (2018) reveals that, in large-scale industrial mining, the predominant assurance mechanism is independent third-party verification, followed by internal assessments conducted by the initiative itself, which subsequently determines compliance and issues certification (Franken et al., 2020). To achieve this level of credibility and commitment, VSS often align with recognized authorities like ISEAL, a global entity that ensures standards meet high benchmarks of integrity, integrating robust codes of conduct and measurable impacts into business strategies (ISEAL, 2023).

Despite their intended purpose, the application of VSS is not without complications. Civil society actors have increasingly criticized practices that prioritize superficial box-ticking compliance, overdependence on ineffective supplier audits, and inadequate mechanisms for transparency and accountability (Quijano & Lopez, 2021). Moreover, only a limited number of these initiatives enforce significant consequences for non-compliance, such as imposing fines, initiating criminal actions, or delisting non-compliant entities (Park et al., 2024). Compounding these issues, concerns regarding greenwashing and the overwhelming variety of schemes undermine the ability to reliably evaluate their actual impact, even though VSS are ostensibly designed to enforce binding standards (Murguía & Bastida, 2024).

We examine the key VSS initiatives such as the Initiative for Responsible Mining Assurance (IRMA), the Responsible Minerals Initiative (RMI), The Copper Mark, and the CERA 4in1. Table 4 highlights the most relevant differences between them. The selection of these standards was based on their broad recognition within the mining sector and their coverage

of different stages of the mineral value chain. Furthermore, their diverse scope and commodity coverage allow for assessing how different approaches address similar regulatory requirements.

IRMA is endorsed globally across all minerals, and is implemented at all sizes of minerals, within a broad multi-stakeholder context and over a period of three years, with third-party certification (IRMA, 2018).
RMI addresses smelters and refiners for all minerals, originally designed around tin, tantalum, tungsten, and gold (3TG) due diligence (RMI, 2024a).
The Copper Mark is a relatively new initiative, targeting specific metals (i.e., copper, molybdenum, nickel, and zinc), and emphasising environmental, social and governance alignment for large scale mines and semi-fabricators (The Copper Mark, 2022b).

CERA 4in1 features a set of four standards covering the entire mineral value chain from exploration to final product. Each of these standards focuses on a different interface of the value chain, providing different certification solutions that promote both responsible mineral raw materials production, traceability and well-informed decision making by customers. The following analysis focuses on the CERA 4in1 Performance Standard (mining, processing and smelting) as well as CERA 4in1 Chain of Custody Standard (traded commodities).

Consolidated mining standard initiative

The Consolidated Mining Standard Initiative aims to address the increasing demand of the society for responsible mining by combining four established frameworks (The Copper Mark, the International Council on Mining and Metals (ICMM), Towards Sustainable Mining (TSM) and the World Gold Council (WGC)) into a single worldwide standard upholding strict standard for responsible practices (The Copper Mark et al., 2025). The initiative acknowledges a significant industry issue: most of mining company do not adhere to any set standards because of the several overlapping frameworks (ICMM, 2025). The standard seeks to ease obstacles to adoption, especially for smaller producers who find it difficult to decide which standards to adhere to and how to put them into practice. The CMSI aims to increase the number of businesses adhering to reliable responsible mining standards across all commodities, business sizes, and geographic locations by establishing a single framework (The Copper Mark et al., 2025).

According to WGC (2024), the consolidated standard covers responsible mining through 24 performance areas grouped under four main pillars: social performance, environmental stewardship, ethical business practices, and governance and transparency (ICMM, 2025).

Responsible Organization	IRMA	RMI	The Copper Mark	CERA 4in1
Standard	Standard for responsible mining + IRMA Chain of Custody (CoC) standard	Due diligence Standard for mineral supply chains + Risk Readiness Assessment (RRA) guide +	Joint Due diligence Standard for Cu, Pb, Ni & Zn+ RRA guide + CoC standard	CERA 4in1 Readiness Standard (CRS) + CERA 4in1 Performance Standard I+II (CPS) + Draft CERA

		(Voluntary) Environmental, Social and Governance (ESG) Standard		4in1Chain of Custody Standard (CCS) standard
Commodities	All minerals	All minerals	Copper, Molybdenum, Nickel, Zinc	All minerals
1st Version	Responsible mining (2018) + IRMA CoC (2024)	Due diligence (2022) + RRA guide (2020) + ESG standard (2021)	Joint due diligence (2022) + RRA guide (2020) + The Copper Mark CoC standard (2022)	CPS standard () + CoC standard (2025)
Spatial Focus	Global	Global	Global	Global
Mining Focus	LSM (Large-Scale Mining)	Smelters, Refiners	LSM, Semi-fabricators	All value chain actors from exploration to final product, except ASM
ISEAL Member	Community member	Subscriber	Community member	No
Audit	3rd party verification and certification (every 3 years)	3rd party verification and certification (max. 3 years)	3rd party verification and certification (every 3 years)	3rd party verification and certification (every 3 years)
Applicability assessment and enforcement	Site level	Site level	Site level	Site level

Table 4. Selected key characteristics and focus areas of IRMA, RMI, The Copper Mark and CERA 4in1. Source: IRMA (2025), RMI (2025), The Copper Mark (2025) and MaDiTraCe (2025).

2.2 Methodology

To evaluate the VSS against the EU regulatory framework on SDD, our analysis applied two complementary approaches: a qualitative and a quantitative benchmarking. These approaches are not independent, but rather work together. The qualitative review establishes the conceptual framework, identifies key criteria, and provides contextual insights, while the quantitative fuzzy TOPSIS analysis operationalises these criteria into measurable scores, allowing for comparative evaluation across standards. Together, they ensure that results capture both the depth of regulatory and academic insights and the consistency of a numerical assessment.

2.2.1 Qualitative analysis

The qualitative assessment was based on the review of scientific literature and policy instruments. The literature analysis focused on responsible sourcing, supply chain dynamics, legislation, and VSS in the context of due diligence. The policy review covered the UN Guiding Principles, OECD Guidelines, the CSDDD, EBR, German Supply Chain Act,

and CRM Act, alongside the selected sustainability standards (IRMA, RMI, The Copper Mark, and CERA 4in1).

From this combined review, seven key criteria were identified to assess the effectiveness of VSS in addressing responsible sourcing and due diligence under EU regulatory requirements. These criteria were subsequently validated by five experts.

2.2.2 Quantitative analysis

To complement the qualitative analysis, a fuzzy TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution) multi-criteria decision-making method (C.-T. Chen, 2000; S.-J. Chen & Hwang, 1992) was applied. This method is well-established in the mining sector for robust evaluations, even when the number of experts is limited (Kusi-Sarpong et al., 2015; Luo et al., 2023; Namin et al., 2022; Noori et al., 2018; Saremi et al., 2009).

Unlike previous research that often relied on qualitative comparisons (Heinz et al., 2022), this study compare VSS by transforming expert judgments into fuzzy numbers, thus capturing subjectivity and variability inherent to sustainability assessments. To implement this, a questionnaire was distributed to six decision-makers in sustainability policies and raw materials, all closely related to the selected standards (IRMA, RMI, and The Copper Mark). Fuzzy TOPSIS allows for robust evaluations even with a smaller number of experts (Akpınar et al., 2025). Respondents were asked to rate the importance of each criterion and rank the standards accordingly. A five-point Likert scale was used for weighting (from 0.1 (very low) to 0.9 (very high)), and nine-point scale for performance evaluation (from 1 (very poor) to 9 (very good)), as detailed in Table 5.

Linguistic variable for relative importance weight of criteria		**Linguistic variable for rating**	
Linguistic Variable	Fuzzy Numbers	Linguistic Variable	Fuzzy Numbers
Very Low (VL)	(0.1, 0.1, 0.3)	Very Poor (VP)	(1, 1, 3)
Low (L)	(0.1, 0.3, 0.5)	Poor (P)	(1, 3, 5)
Medium (M)	(0.3, 0.5, 0.7)	Fair (F)	(3, 5, 7)
High (H)	(0.5, 0.7, 0.9)	Good (G)	(5, 7, 9)
Very High (VH)	(0.7, 0.9, 0.9)	Very Good (VG)	(7, 9, 9)

Table 5. Linguistic variables for the rating and relative importance weights of criteria. Source: Awasthi et al. (2010).

2.2.3 Evaluation scale

To ensure clarity in the interpretation of the benchmarking results, a unified four-level colour legend was applied across all evaluation tables. This legend reflects the degree of alignment or coverage of the standards with the identified criteria and regulatory requirements. The levels are as follows:

- Strong alignment: The standard fully meets and often exceeds the requirements, providing comprehensive and verifiable practices.
- Solid alignment: The standard meets most requirements, but shows certain gaps, lower detail, or flexibility in implementation.
- Partial alignment: The standard addresses only part of the requirements, with limited scope, information, or applicability.
- Limited alignment: The standard shows very restricted coverage, addressing only a few aspects of the requirements in a narrow or insufficient manner.

This scale allows for a consistent interpretation of performance across both criteria-based evaluations and alignment with EU regulatory frameworks.

2.3 Results

The following sections present the evaluation criteria for responsible sourcing due diligence under EU regulatory requirements, followed by the assessment of these criteria through an analysis of the standards from both qualitative and quantitative perspectives.

2.3.1 Qualitative analysis: Evaluation criteria for primary raw materials

Following the analysis of EU regulations and the literature review, seven main criteria were identified as critical aspects of due diligence in responsible sourcing. These criteria include traceability systems, risk assessments, corrective action plans, audits, grievance mechanisms, stakeholder engagement, and transparent reporting, and are presented in detail below. Each criterion represents a fundamental element in ensuring compliance with VSS.

2.3.1.1 C1 Traceability mechanism

In the mineral supply chains, sourcing minerals such as cobalt and lithium from conflict zones raises the critical issue of traceability, especially at the production and processing stages, where raw materials lose their traceability characteristics, making it a problematic step in verifying origins and preventing conflict minerals from entering global markets (Manjong et al., 2024). The effectiveness of an assurance system is closely linked to the robustness of its traceability framework, which verifies the origins of materials and ensures that companies avoid sourcing from conflict zones or unsafe operations (Franken et al., 2020). Based on the definition of OECD & IEA (2025), the capacity of tracing a product is defined as including the ability to track four specific types of information: (1) the origin of a product; (2) the geographical path of the product; (3) the chain of custody of the product; and (4) the physical evolution of the product (i.e. the different stages of the product during processing and transformations).

References in EU regulations

- CSDDD is not directly focused on traceability or related processes, only establishing a corporate due diligence framework.
- EBR imposes traceability requirements, requiring comprehensive documentation to track the origin of materials and identify key actors in the supply chain
- German Supply Chain Act does not explicitly set out traceability requirements. However, as companies are asked to implement effective management systems, capable of – inter alia – identifying the human rights and environmental risks in their own business area and at its suppliers, they might opt to implement a traceability system for this purpose.
- CRM Act does not establish a traceability mechanism; It is more oriented toward information reporting.

Definition for evaluating VSS

VSS requires an integrated traceability system for verifying the origin, flow, and handling of materials. While the level of traceability may vary across different supply chain stages, the system ensures data integrity through rigorous documentation.

2.3.1.2 C2 Risk assessment

Regulations require companies to systematically map their operations and supply chains, conducting proactive risk assessments across their direct relationships. This is particularly crucial in high-risk sectors with persistent governance challenges (Bright, 2021). As civil society scrutiny increases, robust risk assessments become vital to addressing these evolving challenges (Cashore et al., 2021). Risk assessment systems also play a key role in developing common frameworks that enable companies to effectively identify and manage risks in complex industrial environments (Mori Junior et al., 2016).

References in EU regulations

- CSDDD adopts a risk-based approach, requiring companies to map their operations and supply chains to identify and prioritize risks based on severity and likelihood. Due diligence focuses primarily on direct partners, with in-depth assessments conducted only after value chain mapping. If credible indications suggest negative impacts from an indirect supplier, companies must investigate further. When necessary information cannot be obtained otherwise, it may be requested from the indirect business partner. Additionally, companies must ensure their code of conduct applies throughout the chain of activities. To reduce the burden on smaller companies, large firms may only request value chain mapping information as defined in the sustainability reporting standard for voluntary use by SMEs (VSME), unless additional data is essential to assess uncovered risks. Moreover, the assessment interval for evaluating the adequacy and effectiveness of due diligence measures has been extended from one to five years, reducing the burden on companies and business partners, including SMEs. However, ad hoc assessments must still be conducted if new risks emerge before the next scheduled evaluation.

- EBR establishes conformity assessment procedures to ensure compliance with sustainability, performance, and safety requirements. Companies are required to implement risk assessment mechanisms throughout the battery life cycle, considering aspects such as carbon footprint and recycled content.
- German Supply Chain Act established and implements a risk management system as one of the nine core due diligence obligations set out Section 4 (1). Once implemented, the risk management system should be capable of i) identifying, prioritizing and minimizing and the human rights and environmental risks within company´s own operation area and at its suppliers and ii) preventing, ending or minimizing the violations to these obligations occurring in its business area or at its suppliers.
- CRM Act requires Member States to monitor supply risks for critical and strategic raw materials and request information from operators. Article 24 obliges large companies in key sectors (e.g., batteries, renewable energy, aerospace, electronics) to conduct a supply chain risk assessment for strategic raw materials at least every three years. This must include mapping sourcing locations, analysing potential supply disruptions, and assessing vulnerabilities.

Definition for evaluating VSS

VSS mandates a structured and systematic approach to identifying, analysing, and evaluating possible social and environmental risks. This includes, periodic, site-specific risk assessments to ensure a proactive and data-driven evaluation of risks throughout the project lifecycle.

2.3.1.3 C3 Risk mitigation

Preventive measures are recognized as the most effective way to safeguard human rights and environmental health by addressing risks before they escalate (Ruggie, 2017).

References in EU regulations

- CSDDD requires companies to implement preventive actions based on identified risks, including contractual assurances from business partners. The directive removes the obligation to immediately terminate relationships in cases of severe adverse impacts. Instead, companies may temporarily suspend partnerships while working with suppliers to resolve issues, particularly when production is dependent on the supplier.
- EBR requires economic operators monitoring and tracking performance of risk mitigation efforts.
- As set out in the German Supply Chain Act, companies must first adopt preventive measures in their own business area and regarding their suppliers (Section 6 and Section 9). if there are indications of violations of human rights and environmental obligations. In the case of indirect suppliers, companies must elaborate and implement a prevention, minimisation or termination plan. Then, when a company discovers of violation of due diligence obligations in its business area or at its direct suppliers, it must take remedial actions for minimizing or ending it; or elaborate a plan, alongside a timetable, for bringing the violation at the direct supplier to an end

(Section 7). In the case of an indirect suppliers, if there are indication of violations of human rights or environmental obligations, companies must i) conduct risk analysis; ii) take preventive measures; iii) elaborate and implement a prevention, minimisation or termination concept; and iv) update its policy statement accordingly (Section 9).

- CRM Act empowers the European Commission and Member States to take measures to mitigate risks to the supply of critical and strategic raw materials, including requesting information from operators and coordinating actions to address vulnerabilities. In the context of Strategic Projects and certain large manufacturers, companies may be required to take measures to address the risks identified in their supply chains (Article 24). Outside of this scenario, the Regulation does not establish a general and continuous framework of corrective measures applicable to all companies.

Definition for evaluating VSS

VSS requires the implementation of risk mitigation strategies to address both potential and actual risks. It prioritizes deficiencies that require urgent corrective action while ensuring enforceability through progressive measures.

2.3.1.4 C4 Audit assessment

A holistic audit approach combines self-assessments, documentation reviews, site visits, and interviews, offering multiple perspectives to ensure comprehensive oversight (ISEAL, 2023). Stricter audit schedules that integrate these methods enhance certification integrity and mitigate risks (Kickler & Franken, 2017). An important point to note is the independence of the audit to protect against potential conflicts of interest, and the success of audits in VSS contexts depends on the technical skills of the auditor to detect non-compliance (Locke et al., 2008).

References in EU regulations

- CSDDD allows companies to use independent third-party verification to support due diligence obligations. Such verification must be conducted with full independence, free from conflicts of interest, and carried out by entities with proven expertise in environmental or human rights matters.
- EBR mandates third-party verifications, ensuring audits that adhere to the principles of independence, competence, and accountability, as outlined in the OECD Due Diligence Guidance.
- German Supply Chain Act empowers the competent authority (i.e., the Federal Office for Economic Affairs and Export Control - BAFA) to check the annual report on the fulfilment of due diligence obligations submitted by the companies for determining the extent of company´s compliance with the due diligence obligations.
- CRM Act does not require systematic third-party audits or verifications for all companies involved in critical raw material supply chains. Recognition of certain certification schemes under the regulation may involve independent third-party verification as part of the scheme's governance, but participation in such schemes is not universally mandatory. Therefore, third-party involvement is indirect and depends on specific contexts.

Definition for evaluating VSS

VSS includes periodic, independent audit techniques to ensure adherence to set standards and use a variety of techniques including on-site surveys, document reviews, self-assessments, and stakeholder interviews.

2.3.1.5 C5 Grievance mechanism

Grievance mechanisms serve as a dynamic communication channel, that allows stakeholders to voice concerns about issues that may arise outside of formal checks (MSIntegrity, 2020). For grievance mechanisms to be effective, they must be accessible to all stakeholders and operate with transparent and well-defined procedures.

References in EU regulations

- CSDDD mandates that companies implement a publicly available, accessible, predictable, and transparent complaints procedure that allows affected persons, trade unions, and civil society organizations to report actual or potential adverse impacts. Companies must ensure confidentiality of complainants and provide follow-up responses, including reasons for decisions and remediation actions taken. Additionally, companies can participate in collaborative grievance mechanisms, provided they meet the requirements of the directive for fairness and transparency.
- EBR requires economic operators to establish a grievance mechanism as part of their due diligence policies, including a risk early warning system and a redress mechanism. These mechanisms can be implemented independently or through collaboration with other organisations.
- German Supply Chain Act asks concerned companies to implement an internal complaint procedure for facilitating detection of relevant risks and for reporting potential prohibition violations arising from own business operations of the firm or from economic actions of suppliers (Section 8 and 9).
- CRM Act does not establish a general obligation for companies to implement complaint mechanisms.

Definition for evaluating VSS

VSS requires or encourages certified entities to establish accessible and impartial grievance mechanisms that allow stakeholders to raise concerns and seek resolution. These mechanisms should ensure independence, transparency, and fairness, with clear procedures, language accessibility, and appropriate remedies or sanctions in case of unresolved grievances.

2.3.1.6 C6 Stakeholder engagement

Stakeholder engagement goes beyond risk management, aiming for genuine two-way communication that respects cultural and geographical diversity (Rathobei et al., 2024). This encompasses specific capacity-building programs that help smaller stakeholders to

participate meaningfully in decision-making and advocate for sustaining practices (Hiete et al., 2019). The optimal compliance scenario involves active participation from civil society, private businesses, and public actors.

References in EU regulations

- CSDDD requires companies to maintain meaningful engagement with relevant stakeholders throughout the due diligence process. This includes providing relevant and complete information, ensuring transparent consultations, and addressing barriers to participation. Companies should also take steps to avoid retaliation or reprisals against participants, such as maintaining confidentiality or anonymity where necessary. The directive clarifies that engagement should be tailored to those directly linked to the specific stage of the due diligence process, meaning companies are not required to consult every possible stakeholder group but must prioritize those directly affected by the company or its supply chain activities.
- EBR recognizes the importance of stakeholder engagement in the implementation of due diligence policies. It mandates economic operators to consult with relevant stakeholders, including suppliers, local and national authorities, civil society organizations, and affected communities, before defining and implementing risk mitigation strategies.
- One of the preventive measures that companies are asked by the German Supply Chain Act to take in its own business area is to elaborate and implement effective procurement and purchasing strategies aiming to prevent o minimizing the humans rights and environmental risks. Selection of suppliers has to consider the human rights and environmental expectations defined in the policy statement issued by the company. Also, companies should obtain from its direct suppliers' contract assurances that they will comply with the company´s defined expectations and their agreement on contractual control mechanisms for compliance verification. Also, support to the indirect suppliers should be provided when there an indication of their potential or actual environmental or human rights violation (Section 9).
- CRM Act requires Strategic Projects to engage in good faith and conduct thorough and equitable consultations with relevant stakeholders, including local communities and, where applicable, indigenous peoples.

Definition for evaluating VSS

VSS requires or encourages companies to implement inclusive and culturally appropriate stakeholder engagement processes that enable meaningful participation of affected and interested parties in decision-making. These processes should be transparent, ongoing, and adapted to the local context, and aim to build trust.

2.3.1.7 C7 Transparent reporting

Transparency legislation aims to ensure that where transparency exists, companies feel forced to improve their track record under pressure from informed stakeholders (Martin-Ortega & O'Brien, 2017). Filling this gap requires disclosure to evolve to include quantifiable sustainability performance, going beyond mere procedural compliance (Ooms, 2022). Transparent reporting allows stakeholders to assess both processes and

concrete impacts, fostering corporate responsibility through clear and accessible information, essential to gauge the true effectiveness of sustainability initiatives (Mori Junior et al., 2016).

References in EU regulations

- CSDDD requires companies to publish an annual report detailing their due diligence efforts, identified adverse impacts, and implemented mitigation measures. This report must be publicly accessible on their website and aligned with the sustainability reporting standards established by the Corporate Sustainability Reporting Directive (CSRD). Starting in 2029, these reports must be submitted to the European Single Access Point (ESAP) in compliance with the digitalized and centralized reporting requirements defined by the European Commission. Both regulatory frameworks work together to enhance transparency and comparability of sustainability information for stakeholders and regulatory bodies.
- EBR mandates annual public reporting by economic operators on their battery due diligence policies, ensuring that stakeholders have access to relevant data on risk management practices, significant adverse impacts, and third-party verifications. This reporting must be easily comprehensible for end-users and include measures addressing identified risks, public participation in decision-making, and access to environmental justice.
- The German Supply Act requires companies to publish a detailed yearly report on the compliance of the company with its due diligence obligations, including the identified risks and measures taken in this respect. The report should be published on their website less than four months after the end of the financial year and be freely accessible.
- CRM Act (Article 8) requires transparency in reporting in specific contexts. In the case of strategic projects, the project promoters must provide regular information to the Commission and the competent authorities on progress and compliance.

Definition for evaluating VSS

VSS promotes public disclosure of key information related to due diligence practices, audit findings, corrective actions, and grievance outcomes to ensure accountability and build trust with stakeholders. Transparent reporting must provide detailed, accessible information on compliance, non-compliance, and improvement efforts include clear timelines.

2.3.2 Qualitative analysis: Performance of standards by criteria

The evaluation against each criterion identified in Chapter 2.3.1, by VSS, is presented below. For each criterion, the specific practices and responses from each of the four VSS are analysed.

2.3.2.1 C1 Traceability mechanism

Based on the definition of traceability provided in Chapter 5 Glossary and subchapter 2.3.1.1, the following paragraphs present an analysis of the fulfilment of this criterion for each of the three standards.

- **IRMA**:

1. Origin of the product: The IRMA CoC standard requires that IRMA audited materials are traced back to the mine of origin. It explicitly mentions that (IRMA, 2024):

> *"The site of origin of the materials must be documented, along with the IRMA achievement level".*

A valid verification number and the name of the certifying body are required. Traceability makes it possible to identify whether the material comes from an IRMA audited mine and whether it meets responsible mining standards. This demonstrates that IRMA complies with the traceability of the origin of the product.

2. The geographical path of the product: The IRMA standard sets out strict requirements for documenting the flow of materials throughout the supply chain, including (IRMA, 2024):
   - Recording of material procurement, storage and processing locations at each stage.
   - Identification of suppliers, transporters and customers at each point in the process.
   - Maintenance of shipping records, including transport documents and invoices with batch details

   These requirements ensure that IRMA complies with the traceability of the geographical routing of the product.

3. The chain of custody: The IRMA CoC (IRMA, 2024) system is based on chain of custody models that guarantee the integrity of the audited materials. These include:
   - Non-mixing models (Identity Preserved and Segregated), where materials remain physically separated from the mine to the end user.
   - Controlled blending models (Controlled Blending, Mass Balance, and Book and Credit), which allow for some degree of blending, but ensure that certified volumes sold do not exceed those purchased.

   Each model has documentation and verification requirements to ensure the integrity of the audited material, indicating that IRMA complies with the product chain of custody.

4. The physical evolution: IRMA CoC requires documentation of the material transformation processes, ensuring that the material is tracked from extraction to sale. This includes (IRMA, 2024):
   - Conversion factors, which relate the amount of material received and processed to the final product.

- Detailed processing records, documenting the physical and chemical changes of the material.
- Inventory balance, which verifies that the quantities of material processed match the quantities sold

➢ **RMI:**

1. Origin of the product & 2. The geographical path of the product: Both criteria are addressed in Step 1 and their red flags in Step 2 (see Figure 1), within the "*Global responsible sourcing due diligence standard for mineral supply chain all minerals*" (RMI, 2024a).

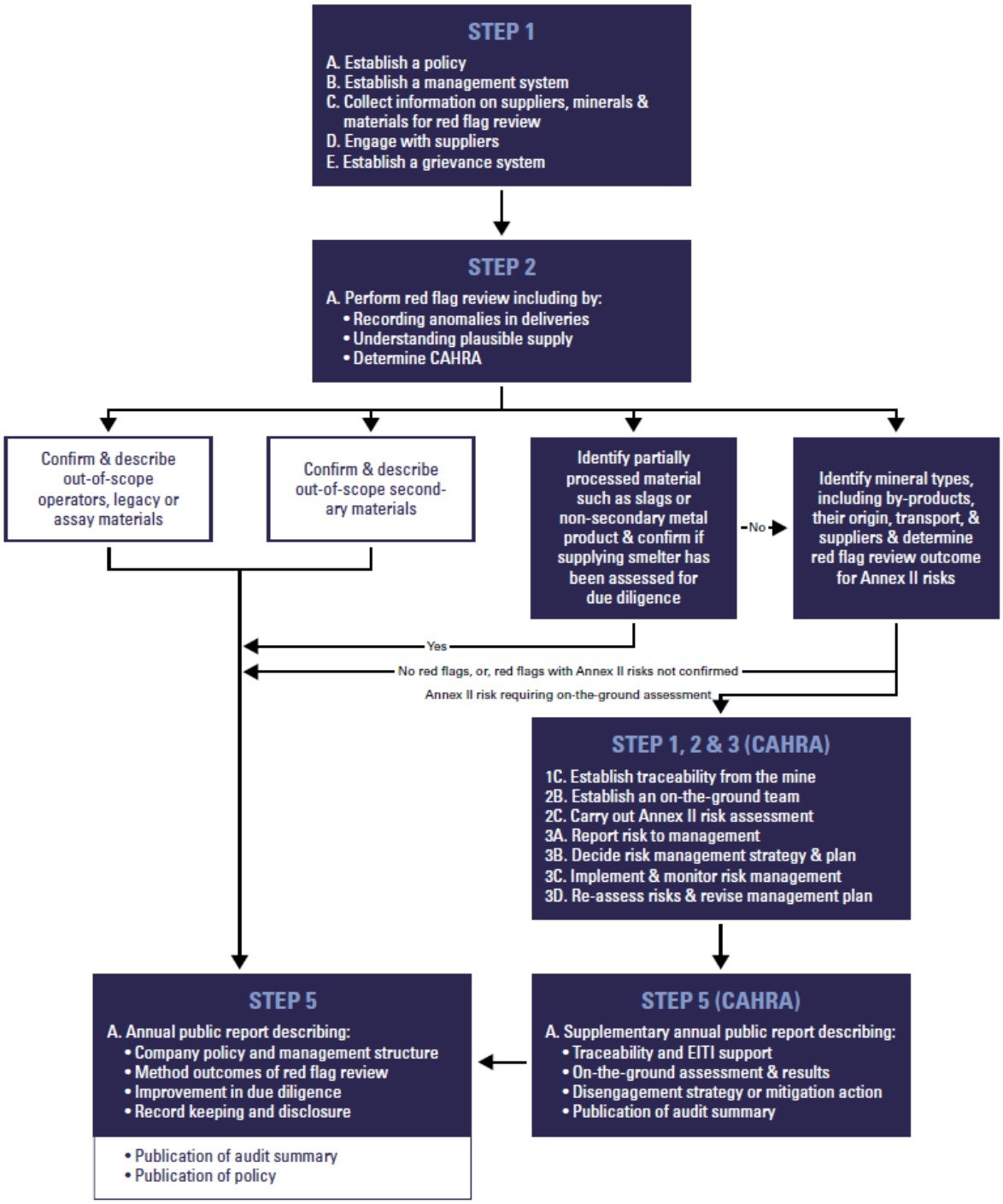

Figure 1: Overview of steps and the applicability of the OECD supply chain due diligence conformance standards. Source: RMI (2024a)

.

This document verifies that companies have implemented supply chain due diligence aligned with the OECD guidelines, adapted to specific circumstances and nature of their operations, considering their position within the supply chain. Following the OECD structure, specifically in step 1C of the documents, it is stated that companies must:

- Regarding the origin of minerals:

> *"Collect and retain available information regarding covered minerals, their origin, transport and transit in order to determine if the known or suspended origin of the mineral is a CAHRA"*, explicitly specifying the "*stated mineral origin (location of extraction, country or regional mining area within a country).*"

- Regarding the geographical path of mineral:

> Companies must "*Collect and retain available information regarding immediate suppliers, and any known actors further upstream in the supply chain identifiable through general business dealings or public reports, in order to determine if supplier trading activities related to covered minerals is associated with known or suspected CAHRA*", this requires maintaining, "*aggregated lists of countries of origin, transport, and transit of minerals from which suppliers have sourced over the last 12 months.*"

3. The chain of custody: The RMI standards do not provide specific CoC models but require companies to implement them (RMI, 2024a).

4. The physical evolution: RMI addresses the physical evolution of the product by requiring inventory reconciliation and the identification of losses within the accounting period, which implies applying a mass balance that reflects the physical and chemical changes occurring in the site's processes (RMI, 2024a).

➢ **The Copper Mark:**

1. Origin of the product & 2. The geographical path of the product: Both criteria are addressed in Step 2: "Red flags identification & risk assessment" (see Figure 2) within the "*Joint Due Diligence standard for Copper, lead, molybdenum, nickel and zinc*" (The Copper Mark, 2022b). This step is specifically applied for the identification of red flags in Conflict-Affected and High-Risk Areas (CAHRA).

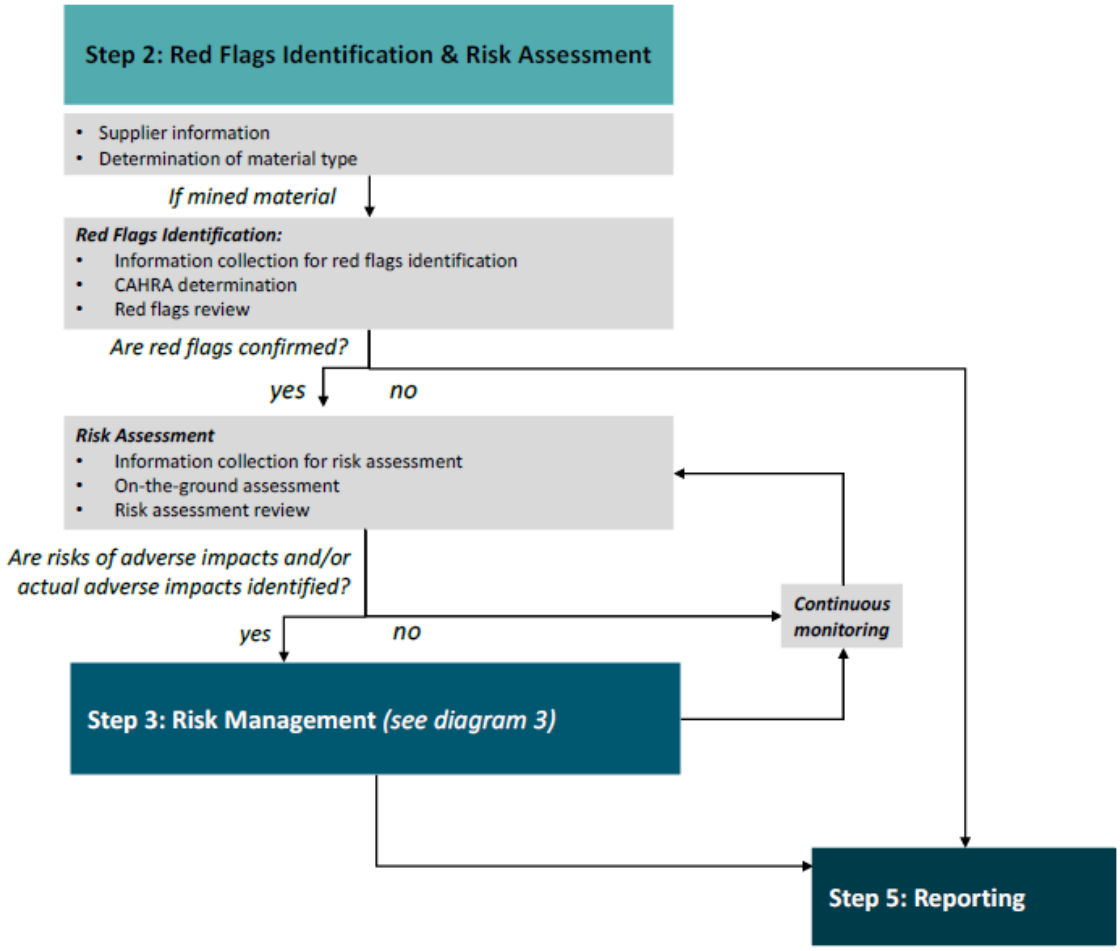

Figure 2: Schematic presentation of Step 2, which specifies the collection of information for the identification of network flags in CAHRA. Source: The Copper Mark (2022).

Additionally, this document states:

> *"To determine the presence of red flags, the company shall make reasonable efforts to collect sufficient and credible information for all mined material received in scope of the assessment, including, at a minimum:*
>
> *Country of origin of the material.*
> *Countries through which the material has been transported or transited prior to delivery to the company.*

Furthermore, the standard includes a roadmap titled "*Joint Due Diligence Assessment Tool*" (The Copper Mark, 2022a), which collects information regarding these two criteria.

3. The chain of custody: The Copper Mark, has an additional document called "*The Copper Mark Chain of Custody Standards*", in which it mentions two CoC models, separation and mass balance (The Copper Mark, 2022c). The mass balance model

allows mixing but requires that at least 90% of the final material remains certified and traceable, with detailed documentation at each stage, from smelting to final product.

4. The physical evolution: The Copper Mark standards do not explicitly require tracking the physical evolution of the product through the different processing stages. Although it recognises processing as a stage where material properties change, there is no specific obligation to record these changes at each processing step, such as refining or smelting. Instead, the standard prioritises the recording of material movements, volumes and custody transfers.

- **The CERA 4in1:**

1. Origin of the product: CCS draft, as a requirement under the topic "Responsible sourcing" (TÜV NORD, 2025d), companies are required to implement processes and procedures to determine the origin of minerals related to CAHRA and also identify areas in the supply chain where minerals originate from illegal mining activities and sanctioned countries, which includes detailed information and supporting evidence and maintain records of the declarations. Furthermore, although the reference to origin is explicit in the context of CAHRA, it is also implicitly addressed through the requirement to source from certified suppliers, an assumption that implies prior verification of the origin and compliance of such suppliers.

2. The geographical path of the product: The CCS draft (TÜV NORD, 2025d) requires companies to implement processes and procedures to identify all critical control points where the tracking of CCS materials may be compromised. This includes the storage areas as well as instances during the transportation of these materials. In addition to identifying the origin, for the minerals related to CAHRA, organisations will also need to record the type of operations, quantities, form, physical description and dates of extraction, and countries through which they were transported and transited.

3. The chain of custody is one of the four components that comprise the CERA 4in1 standard. The draft CCS (TÜV NORD, 2025d) is relevant for both upstream and downstream businesses dealing with traded commodities. It outlines the requirements for effective management systems that guarantee the traceability of responsibly sourced minerals, establish accounting methods, and determine the eligibility of materials under CoC regulations.

4. The physical evolution: The CCS draft (TÜV NORD, 2025d) monitors changes in material quantities and requires companies to implement processes and procedures to ensure adequate and justifiable conversion factors are employed, and organisations will need to account for the material losses that occur due to processing. In addition, the draft CCS standard mandates detailed material balancing procedures, which involve reconciling the quantities of certified inputs and outputs within a defined accounting period. Organisations must maintain documentation of inputs, outputs, stocks, and sales, and ensure these records reflect changes due to processing or transformation (e.g., change in weight, form,

or component structure). The standard allows reconciliation to be conducted on a daily, weekly, monthly, or annual basis, depending on the accounting period, and emphasizes the importance of accurate conversion factors and inventory tracking to reflect the evolution of the material across the supply chain.

2.3.2.2 C2 Risk assessment

The IRMA standard puts emphasis on site-specific risk assessments, with a focus on both environmental and social factors addressed in regulations and beyond, with regular annual reviews ensuring that risks are reassessed throughout the lifecycle of the mine (IRMA, 2022). The following statements are extracted from IRMA Standard for Responsible Mining STD-001 (IRMA, 2018).
For example, in relation to occupational health and safety, the standard states:

> *"The operating company shall implement an ongoing, systematic health and safety risk assessment process that follows a recognized risk assessment methodology for industrial operations." Regarding working hours and leave, it mandates: "A risk management process that includes a risk assessment for extended working hours is established to minimize the impact of longer working hours on the health, safety and welfare of workers."*

IRMA also recommends conducting risk assessments in conflict-affected or high-risk areas. Specifically, it requires that:

In terms of security risk assessment and management, the standard stipulates:

> "*The operating company shall assess the risks to the company, workers and communities associated with operating in or sourcing minerals from the conflict-affected or high-risk area*," and further that, "*Conflict risk assessments shall be updated at minimum, on an annual basis, and more often if necessitated by the situation*."
>
> Specifically, in terms of human rights due diligence requirements, the standard mentions: *"The operating company shall establish an ongoing process to identify and assess potential human rights impacts (hereafter referred to as human rights "risks") and actual human rights impacts from mining project activities and business relationships. Assessment of human rights risks and impacts shall be updated periodically, including, at minimum, when there are significant changes in the mining project, business relationships, or in the operating environment*"

Regarding the social and environmental risks, the standard has a specific chapter, 2.1 Environmental and social impact assessment and management, to manage environmental and social risks and impacts throughout the life of the mine. In particular, during mine development, the management of waste is a critical process. The standard mandates:

> *"A risk-based approach to mine waste assessment and management shall be implemented that includes:*
>
> *a. Identification of potential chemical risks (see 4.1.3.2) and physical risks (see 4.1.3.3) during the project conception and planning phase of the mine life cycle;*
>
> *b. A rigorous risk assessment to evaluate the potential impacts of mine waste facilities on health, safety, environment, and communities early in the life cycle;*
>
> *c. Updating of risk assessments at a frequency commensurate with each facility's risk profile, over the course of the facility's life cycle; and*
>
> *d. Documented risk assessment reports, updated when risk assessments are revised (as per 4.1.4.1.c)."*

With regard to water-related impacts, the standard specifies:

> *"The operating company shall assess security risks and potential human rights impacts that may arise from security arrangements. Assessments of security-related risks and impacts shall be updated periodically, including, at minimum, when there are significant changes in mining-related activities, security arrangements or in the operating environment."* The scope of such assessments includes:
>
> *a. Identification of security risks to the company, workers, and communities, with particular attention to women, children, and other vulnerable groups;*
>
> *b. Analysis of the political and security context of the host country (e.g., human rights records of the government and public/private security forces, rule of law adherence, corruption);*
>
> *c. Analysis of existing and potential conflicts or violence in the host country and affected communities; and*
>
> *d. Risks associated with equipment transfers."*

Finally, during reclamation and closure, particularly in the context of post-closure water treatment, the standard requires the operating company to finance an engineering and risk assessment.

Through these examples, it is evident that the IRMA Standard systematically incorporates risk assessment throughout the entire mining life cycle.

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Throughout the document, some updates and improvements to the risk assessment process are mentioned. For instance, it is noted that such assessments typically consider the range of potential impacts posed by a project or activity. New requirements have been introduced mandating companies to conduct specific risk assessments on child labor and forced labor, as these were not explicitly required under Chapter 3.1 "Fair Labor and Terms of Work", particularly in Subchapter 3.1.10 "Working Hours". Additional changes appear in the "Occupational Health and Safety" section, where it is specified that risk assessments must be based on credible methodologies. A credible methodology is defined as one that is "widely recognized, accepted, and used by experts and practitioners in a particular field of study" (IRMA, 2023). Moreover, these assessments must be reviewed and, if necessary, updated at least annually, or more frequently if workplace conditions change.

In Chapter 3.3 "Community Health and Safety", it is stipulated that risk assessments must be periodically updated whenever there are changes in operations, environmental conditions, or the social context. Similarly, under the "Waste and Materials Management" requirements, a new risk assessment is required following the application of the waste mitigation hierarchy, given that residual risks may persist. Lastly, Chapter 4.2 "Water Management" also mandates updating risk assessments whenever significant changes occur.

For RMI, risk assessments are conducted annually, with regular updates based on ongoing site conditions (RMI, 2024b). As illustrated in Figure 1, during Step 2 of the process, companies are required to conduct a risk assessment based on all the risks outlined in Annex II. These risks are categorized under three overarching criteria: human rights, conflict, and good governance (RMI, 2025b):

- Serious abuses associated with the extraction, transport or trade of minerals
- Direct or indirect support to non-state armed group
- Public or private security forces
- Bribery and fraudulent misrepresentation of the origin of minerals
- Money laundering
- Payment of taxes, fees and royalties due to governments

RMI due diligence standard (RMI, 2024a) prioritizes the risks highlighted in Annex II of the OECD Due Diligence Guidance, particularly those related to conflict, severe human rights abuses, money laundering, and mineral fraud. Although environmental risks are not explicitly addressed in this standard, RMI recognizes a broader set of environmental, social and governance (ESG) risks and actively works to integrate them into its framework (RMI, 2025a).

The Copper Mark includes the risk assessment within the scope of the assessment for the "*Joint Due Diligence Standards for Copper, Lead, Molybdenum, Nickel, and Zinc*" (see Figure 2), as it requires companies to implement the five-step due diligence process defined in the OECD Guidance. The standard stated (The Copper Mark, 2022b):

> *"Companies are guided by their own risk assessments covering, at a minimum, the risks of adverse impacts listed in the OECD Guidance Annex II (Annex II risks), …, Companies are not precluded from including additional social, environmental, and governance risks in their due diligence process.*". The standard also clarifies: *"… the risk assessment, should be carried out with due consideration to the company's position in the supply chain".*

Specifically, the standard has Section *"5.2.4 Information collection for Risk Assessment*". It specifies that companies must undertake an information collection process when red flags are identified. This includes gathering detailed data on extraction, transport, trade, handling, processing, and export within red-flagged supply chains. The company is required to determine and report to senior management whether risks of adverse impacts and actual adverse impacts exist. The company shall make reasonable efforts to collect sufficient and credible information to determine the presence of risks of adverse impacts and/or actual adverse impacts (Reference). The standard explicitly states that companies must at least assess the risks outlined in Annex II, and which are mentioned above.

The CERA 4in1 aims to contribute to the harmonization within the certification landscape. To facilitate this, the requirements in CPS-I structure adopts the 6-step management approach of the OECD guideline and the Plan-Do-Check-Act approach as used by ISO management standards. The CPS-I requirements are organized into the CAMD system, which consists of four stages: Commitment (C) – Assessment (A) – Monitoring (M) – Disclosure (D). This structure mirrors the approaches of OECD and ISO, ensuring that organizations follow a comprehensive, well-established process for effective management and continuous improvement (TÜV NORD, 2025e).

In particular, OECD's Step 2 "Identify & assess adverse impacts in operations, supply chains & business relationships" harmonizes with the CPS-I requirement (A) "Risk and Opportunity Assessment and Treatment" (TÜV NORD, 2025e). All other CERA 4in1 standards, the CRS for exploration (TÜV NORD, 2025c), CPS-II (TÜV NORD, 2025a) and the Chain of Custody Standard draft (TÜV NORD, 2025d) incorporate the same risk assessment.

Based on the CPS-I (TÜV NORD, 2025e), the complete risk assessment approach can be summarized as follows "Avoid or correct harmful events by *assessing its causes or consequences and implementing respective* barriers".

A broad selection of events is already defined by CERA 4in1 within the CPS-I audit catalogue (TÜV NORD, 2025b) and allocated to Key Aspects, that define the scope of ESG within CERA 4in1. These events are defined based on their potential to negatively impact the community, environment, or the organization itself if they occur.

Furthermore, the events are linked to barriers that the organization must implement to address the associated threats, as listed as examples in the audit catalogue (TÜV NORD, 2025b). These barriers are designed to either,

- prevent the occurrence of these events by decreasing the probability;
- mitigate the impact of the event's potential consequences;
- control the occurrence of threats;
- recover from the event by avoiding consequences or mitigating the existing impacts.

During (A), the CPS-I mandates the assessment of the relevant events by implementing the corresponding barriers within the audit catalogue (TÜV NORD, 2025b). In addition, organizations shall demonstrate that they are able to manage their operational risks and opportunities and identify and implement adequate treatment measures according to the Key Aspects and tailor them to their specific operations. This process involves,

- identifying harmful events, evaluating their potential threats, assessing their consequences and opportunities;
- determining the necessary preventive, mitigative, or corrective barriers to effectively manage the events, their threats, and consequences.

To sum-up, CERA 4in1 requires organizations to carry out a Risk and Opportunity Assessment and Treatment of their own operation and these will then be verified by the appropriate certification body. CERA 4in1 also states (TÜV NORD, 2025e):

> *" However, the organization is solely responsible for identifying and implementing additional events and barriers. Should the organization fail to identify applicable barriers, leading to the occurrence of a harmful event with negative consequences. In that case, the responsibility does not lie with the audit team or the certification body"*
>
> *"Alternatively, the organization may utilize internationally recognized standards and frameworks such as ISO 31000:2018 or the Enterprise Risk Management (ERM) Framework as a supporting methodology to ensure the robustness and appropriateness of the risk and opportunity management process."*

An example out of the CPS-I (TÜV NORD, 2025e) is presented below for the *Topic 1 – Corporate Governance*, *Theme 1.1 Legal Compliance*:

A: The organization shall implement all specified barriers according to the Key Aspects as a minimum prerequisite for certification. Furthermore, the organization shall have processes and procedures in place to proactively manage their operation specific risks and opportunities and to identify and implement adequate treatment measures using the methodology provided in section Requirement Structure of the standard document or an equivalent methodology.

- *Legal and Regulatory Compliance (1)*

  The repercussions of not adhering to legal requirements, including national and international laws and regulations, can be detrimental. Non-compliance can potentially jeopardize its reputation and they can incur financial penalties. Organizations must maintain continuous oversight of the evolving landscape of regulations to ensure they remain compliant.

2.3.2.3 C3 Risk mitigation

In IRMA, throughout the requirements, the implementation of mitigation measures or a mitigation plan is consistently suggested to address various risks. Below, several examples extracted from the standard (IRMA, 2018) are presented.

One of the first requirements in which the standard mandates mitigation measures concerns human rights. Regarding identified human rights risks, the standard states (IRMA, 2018):

> *"If the operating company determines that it is at risk of causing adverse human rights impacts through its mining-related activities, it shall prioritize preventing impacts from occurring, and if this is not possible, design strategies to mitigate the human rights risks. Mitigation plans shall be developed in consultation with potentially affected rights holder(s)."* Concerning existing human rights impacts, it further specifies: *"In a timely manner, develop mitigation strategies and remediation in collaboration with affected rights holder…"*

Regarding health and safety, the standard recommends the development of a mitigation plan to address the identified risks. It emphasizes that: "*Mitigation measures shall prioritize the avoidance of risks and impacts over minimization and compensation.*"

In relation to the requirements for mining in conflict-affected or high-risk areas, risk mitigation is addressed through the implementation of a risk management plan, which includes: *"actions to be taken to prevent or mitigate risks identified through the risk assessment process."*

Chapter 2.1 includes a specific subsection, 2.1.5 on Environmental and Social Impact Assessment Impact Analysis, which advises companies to:

> *"Evaluate options to mitigate predicted significant adverse impacts in line with the mitigation hierarchy, prioritizing the avoidance of impacts through consideration of alternative project designs…"* Furthermore, in topics related to reclamation and closure planning, the standard suggests a *"Source mitigation program to prevent the degradation of water resources."*

Other environmental-related measures include the mitigation of risks associated with mine waste facilities. The standard states: *"Mine waste facility design and mitigation of identified risks shall be consistent with Best Available Technologies and best available/applicable practices."* Regarding water-related risks, subsection 4.2.3.1 notes:

> *"The operating company, in collaboration with relevant stakeholders, shall evaluate options to mitigate predicted significant adverse impacts on water quantity, water quality and current and potential future water uses that may be affected by the mine's water management practices. Options shall be evaluated in a manner that aligns with the mitigation hierarchy."*

The chapter on Noise and Vibration contains a specific subsection on the mitigation of impacts on human receptors. It states:

> *"If a credible, supported complaint is made to the operating company that noise or vibration is adversely impacting human noise receptors, then the operating company shall consult with affected stakeholders to develop mitigation strategies or other proposed actions to resolve the complaint…"*

Finally, the section on Biodiversity, Ecosystem Services, and Protected Areas outlines mitigation measures that should be implemented for both new and existing mines.

All these examples serve as evidence that the IRMA Standard aligns with this criterion on risk mitigation to address both potential and actual risks.

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Several updates related to risk mitigation are mentioned in the document. For example, in Chapter 3 "Human rights due diligence", a new requirement is introduced to evaluate the effectiveness of mitigation actions. In "Environmental and social impact assessment and management requirements", stakeholders are allowed to express their views on possible mitigation measures and strategies to enhance positive impacts. Similar provisions are also included to enable the participation of the indigenous people under "Free, Prior and Informed Consent (FPIC) requirements (IRMA, 2023)."

In the section "Land Acquisition, Displacement, and Resettlement", it is stated that mitigation strategies must not exacerbate conflicts within or between communities. In "Occupational health and safety", it is recommended to expand the list of mitigation procedures to include infectious diseases. For "Cultural heritage assessment", new requirements mandate that mitigation measures be developed in collaboration with "affected rights holders and stakeholders," and suggest "best practice mitigation measures if cultural heritage is a protected area." Under "Waste and Materials Management", a new criterion is proposed titled "Material and waste reduction and mitigation", introducing the concept of "waste mitigation hierarchy", which sets out the priority of actions to be taken in managing waste.

Finally, in "Water Management", a new criterion titled "Water management planning and implementation" is introduced, replacing "Prevention and mitigation of impacts to water", with the aim of combining mitigation measures with the development of an adaptive water management plan.

RMI, the Global Responsible Sourcing Due Diligence Standard for Mineral Supply Chains (RMI, 2024a), follows the five steps of the OECD Due Diligence Guidance, particularly emphasizing Step 3, which recommends the design and implementation of a strategy to respond to identified risks. This standard state:

> *"The company must ensure that the plan for risk mitigation has actions from which the outcomes are measurable."* Specifically, the standard suggests: *"Consult with suppliers and affected stakeholders to agree on the strategy for risk mitigation in the risk management plan including qualitative or quantitative measures of improvement."*

This approach ensures alignment with stakeholder expectations. Moreover, the company must guarantee that the plan and mitigation measures are consistent with its overall strategy, and it must *"monitor and track the performance."*

The Copper Mark implements a structured risk mitigation strategy to address identified adverse impacts, ensuring enforceability through progressive measures (see Figure 3). This strategy includes (The Copper Mark, 2022b):

> *"Continuing trade or temporarily suspending trade while pursuing ongoing mitigation of the risk; Immediately suspending trade or disengagement with the supplier where the company identifies reasonable risk of adverse impacts or actual adverse impacts that are deemed too severe".*

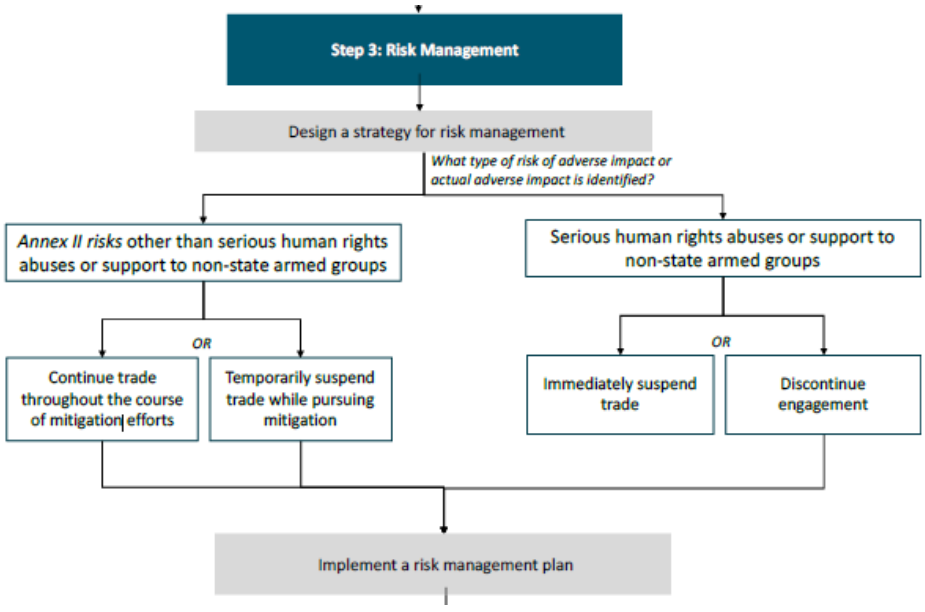

Figure 3: Schematic of step 3, which specifies the risk management plan and the steps of mitigation. Source: The Copper Mark (2022b).

Additionally, the Joint Due Diligence Standards for Copper, Lead, Molybdenum, Nickel, and Zinc emphasize the importance of proactive engagement to mitigate risks within the supply chain:

> *"The company shall, as appropriate, take steps to build and/or exercise influence over the actors in the supply chain who can most effectively prevent or mitigate the identified risks of adverse impacts or actual adverse impacts".*

Risk Readiness Assessment Criteria Guide (RMI & The Copper Mark, 2024), reinforces those statements by providing a framework for due diligence in mineral supply chains.

The CERA 4in1 certification system, from the Readiness Standard (CRS) for exploration to the draft Chain of Custody Standard and the CPS-I and CPS-II Performance Standards for upstream and downstream operations, integrates risk mitigation as a foundational element across all value chain stages (TÜV NORD, 2025e). Risk mitigation is systematically addressed through the CAMD structure (Commitment, Assessment, Monitoring, and Disclosure), which is based on the OECD Due Diligence Guidance, and the PDCA cycle.
Both CPS-I (TÜV NORD, 2025b) and CPS-II (TÜV NORD, 2025a) require organizations to assess their risks and opportunities under Assessment (A) by identifying potential harmful events, analysing related threats and consequences, and implementing preventive, mitigative, and corrective barriers. The Bowtie method is recommended as a visual and structured approach to link causes, events, consequences, and barriers. This process is informed by a double materiality assessment, which ensures that both the impacts of the organization on people and the environment and the financial risks to the business are considered when prioritizing and treating risks.
Under Monitoring (M), organisations are required to evaluate the efficiency and effectiveness of the implemented barriers through defined performance indicators. Disclosure (D) stage covers the update of treatment measures, the implementation of remediation actions when needed, and communication with internal and external stakeholders. This integrated approach to risk mitigation considers topics such as responsible sourcing, human rights, community rights, labour conditions, occupational health and safety, climate change, circular economy, and biodiversity, among others.

2.3.2.4 C4 Audit assessment

In VSS, the frequency and intensity of audits significantly influence their effectiveness: regular audits ensure continuous compliance, while infrequent audits may miss critical events (Tröster & Hiete, 2019).

IRMA assessment system involves an audit structured in multiple stages including self-assessments, document reviews, site visits and stakeholder interviews, which ensures verification of compliance with the Responsible Mining Standard (IRMA, 2018). Initially, mining operations must complete a self-assessment using the Mine Measure tool (IRMA, 2025b), designed to facilitate gap identification and preparation for the formal audit. This tool is mandatory for mines that plan to undergo independent, third-party assessment. There is a USD 2,500 fee for use of the IRMA Mine Measure tool, however, in 2021 all mining companies are granted one free use of the tool (IRMA, 2022).

Subsequently, an independent audit is conducted in two phases: first, a remote desk review of evidence provided by the mine and second, an on-site visit where auditors conduct direct observations, inspections of relevant facilities, review of additional documentation and interviews with both mine personnel and external stakeholders, including local communities, workers, unions, authorities and civil organizations.

Auditors are required to notify rights holders at least 30 days in advance, with information published in English and the local language. Stakeholders can proactively register for interviews and suggest others for inclusion (IRMA, 2022). Moreover, while the audit process provides clear guidelines for worker interviews, including special attention to minorities, the procedures for engaging external stakeholders are less detailed and largely left to the discretion of the auditors. Although requirements for community involvement are not extensively detailed, the process typically involves a broad spectrum of external stakeholders.

To ensure continued compliance, IRMA requires periodic surveillance audits to be conducted between 12 and 18 months after the initial audit report is finalized, and recertification audits must be completed every three years. These periodic assessments are essential to sustained compliance with the Responsible Mining Standard. These activities are performed exclusively by IRMA-accredited independent certification bodies, which ensures the impartiality of the process. However, in terms of conflict-of-interest management, IRMA allows the disclosure of conflicts occurring within the previous five years but does not automatically disqualify auditors. Instead, it allows exceptions on a case-by-case basis if the conflict is considered manageable, which may reduce transparency and consistency in the audit process.

RMI uses independent third-party assessments in accordance with ISO:19011:2018 (RMI, 2024b) to validate conformance with the requirements of the Responsible Minerals Assurance Process (RMAP). To accomplish this, it approves an auditing firm to assess whether a company has implemented supply chain due diligence aligned with OECD guidelines and adapted to the specific circumstances of the company and the type of transaction. Auditors will evaluate (RMI, 2024a):

- Conformance criteria that consist of OECD aligned requirements
- Conformance criteria that consist of Standard Setting Organization requirements. Those are instrumental to the implementation of the OECD Guidelines and associated programmatic and regulatory requirements such as Section 1502 of the US Dodd-Frank Wall Street Reform and Consumer Protection Act (Dodd Frank Act) and Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high risk areas (EU Regulation)

During the assessment, auditors will exercise professional judgment and seek reasonable assurance that the evidence gathered is sufficient and appropriate. Within the standard, the term “must” serves a dual purpose, it indicates both a mandatory requirement for conformance with RMAP standards, and specific activities or tasks that auditors are obligated to perform as part of a quality-assured evaluation.

The company must allow an independent third party to audit its activities, processes, and mineral supply chain due diligence system. Furthermore, it must ensure that relevant documentation is readily available for review during the preparation and execution of the audit, and that auditors are granted access to company facilities, personnel, and all supply chain due diligence records and documents pertinent to the audit scope.

Regarding the frequency of the assessments, results are valid for a period of either one or three years, depending on a number of factors (RMI, 2025c). Additionally, the standard requires auditees to evaluate their performance goals at least once per year, which implies that companies must carry out internal monitoring of their due diligence systems, even though this does not involve conducting full internal audits.

The Copper Mark in its document titled "The Copper Mark assurance process" outlines an audit process that includes periodic and independent site assessments aimed at verifying ongoing conformance with its standards. The site evaluation activities are (The Copper Mark, 2024):

> *"The process to conduct the site assessment must include:*
>
> 1. Planning and preparation:
>   - Complete activities defined in Sections 4.4.2 and 4.4.3; and
>   - Organize the logistics of the site assessment.
> 2. Assessment activities must include:
>   - Opening meeting
>   - Confirmation of scope, including minerals/metals produced on site
>   - Management and worker interviews
>   - Document review
>   - Direct observations of the site operations, buildings, and grounds
>   - Risk-based sampling of records and data that considers inherent risks; control risks; and detection risks
>   - Stakeholder interviews with relevant stakeholders, such as indigenous peoples groups and local communities, NGOs, community organizations, upstream supply chain actors, and government entities, in accordance with the Stakeholder Engagement Guidance provided in Annex I
>   - Confirmation of non-applicability of criteria considered "not applicable"
>   - Closing meeting including a review of any potential gaps in achieving "fully meets"
>   - Note that assessors are not expected to review criteria that are considered equivalent or not applicable during the on-site assessment but are expected to bring to the attention of The Copper Mark and include in their report any areas of concern observed. The Copper Mark will engage the site and, where possible, the equivalent standard owner, to resolver conflicting evidence or assessment conclusions. Sites may also use The Copper Mark Grievance Mechanism to resolve disputes.

Sites must demonstrate continued conformance through a full re-assessment every three year. While interviews with management and workers are mandatory, the number and type

of stakeholder interviews are left to the discretion of the assessor, who are independent parties approved by The Copper Mark to carry out assessment activities. The standard allows for flexibility in interview methods, including virtual meetings, surveys, and phone calls when in-person meetings are not feasible. However, there is no explicit requirement for assessors to be proficient in local languages. Rather, it is stated that:

> *"The Copper Mark, the assessor, or the site may request to have an additional party attend the independent site assessment"*
>
> and
>
> *"Assessors may utilize interpreters or technical experts in the assessment. These individuals must be independent of the site"* and *"assist with local-language interviews or document reviews"*, and they are considered observers.

Regarding conflict-of-interest management, it is stated that:

> *"Assessors must be independent, …, Assessors cannot have been employed directly by or provided consulting or advisory services related to the scope of The Copper Mark Criteria to the site within the last (3 years),…, Assessor must disclose any business or financial relationship with or financial interest in the site,…, Assessors cannot have provided any consulting services to the site or its supply chain entities within the scope of the assessment the past three years."*

Importantly, all assessments must be conducted in alignment with ISO 19011 or ISAE 3000 standards, ensuring methodological rigor and impartiality. The Copper Mark assurance framework mandates assessors to apply a risk-based approach to prioritize information gathering and verification procedures. This approach ensures that higher-risk areas receive greater scrutiny and that the audit remains proportionate, robust, and aligned with international good practices.

The CERA 4in1 follows the 5 OECD steps, in particular, "Step 4: Carry out independent third-party audit of supply chain "due diligence practices" at identified points in the supply chain" fits into the context of this criteria.

CERA 4in1 defines the role of auditors as verifying identified risks and any unidentified risks that could lead to an event occurring. The audit process for the initial and re-certification process consists of seven different steps (TÜV NORD, 2024), see Figure 4:

1. Programme and scope preparation ("initial meeting"): The scope of certification is defined and the agreement with the organisation is made.
2. Audit preparation ("internal setup"): The audit team is appointed, which collects information from the organisation to compile the audit checklist. Applicable undesired events or activities are selected and categorised into input and supplementary criteria which are the basis for evaluation, follow-up as well as improvement and disclosure steps (CAMD system).

3. Audit stage 1 ("pre-audit"): Remote assessment of readiness for CERA 4in1 certification, including assessing the understanding of the company regarding the requirements of the standard, remotely auditing the policies of organisation, identifying non-conformities, assessing site-specific conditions and resources, and establishing the audit approach.
4. Corrective action phase ("1. Corrective action phase"): This is a phase of implementation of initial corrective actions and prevention plans based on the non-conformities identified during Stage 1. Subsequently in Audit Stage 2 - Certification Audit ("audit"), the on-site assessment of the implementation and effectiveness of the standard requirements at management and operational level is performed through individual interviews with personnel, review of documents, records and guidelines. The audit team leader communicates the progress of the audit to the organisation, if there are any discrepancies that cannot be resolved between the audit team and the organisation it will be reissued to the certification body. This concludes with an audit report containing the findings according to the requirements of the CERA 4in1 standard.
5. Corrective action phase ("2. Corrective action phase"): The organisation implements corrective actions and prevention plans based on identified non-conformities against the requirements of the CERA 4in1 standard.
6. Award of certificate ("certificate"): The corrective actions/prevention plans are reviewed and verified in function of the non-conformities of stages 1 and 2. Once the result of the audit is positive, the corresponding certificate is issued for a validity of 3 years.
7. Surveillance audits ("surveillance"): Monitoring includes mandatory periodic post-certification on-site surveillance audits that assess the implementation of standard. These follow-up audits are conducted once a year, except in years where a recertification audit is conducted.

The certification procedure is repeated for each re-certification with the exception of audit stage 1 ("pre-audit"). Re-certification audit activities may need to have an audit stage 1 in situations where there have been significant changes to the management system, the organization, or the context in which the management system is operating (e.g., changes in legislation) (TÜV NORD, 2024).

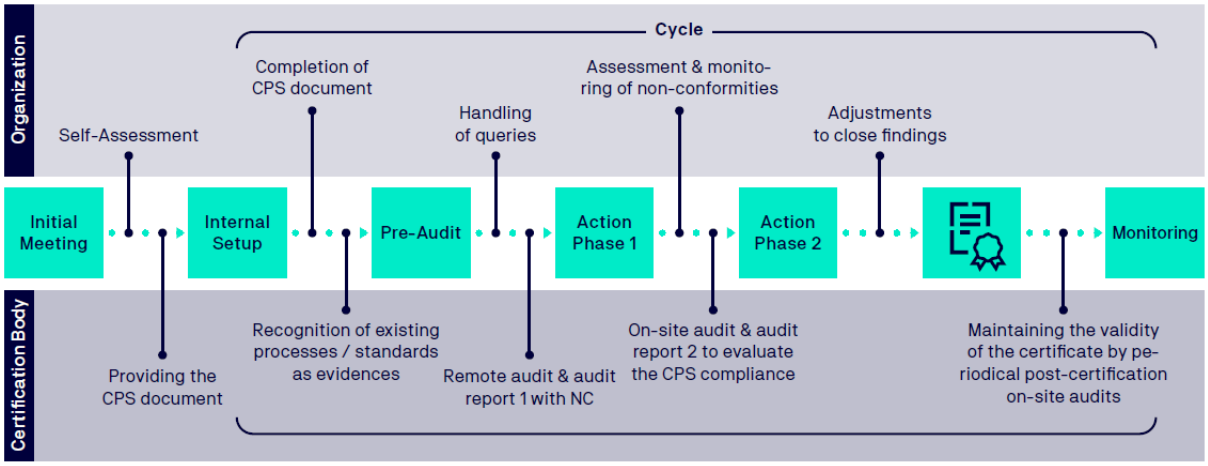

Figure 4: Standardized audit process with audit cycle. Source:) TÜV NORD (2024).

2.3.2.5 C5 Grievance mechanism

IRMA, throughout its standard requires companies to establish grievance mechanisms that are accessible to all relevant stakeholders. Specifically, Chapter 1.4, titled "*Complaints and Grievance Mechanism and Access to Remedy*", encourages mining operations at the site level to implement systems designed to systematically receive, manage, resolve, and communicate with local communities, workers, and other stakeholders regarding any concerns or complaints. To comply with this requirement, IRMA outlines several key expectations (IRMA, 2018):

- Stakeholders must have access to operational-level grievance mechanisms;
- The grievance procedures must be designed in consultation with stakeholders;
- All procedures related to grievances must be documented;
- The performance of the grievance mechanism must be periodically evaluated at the operational level;
- Companies must inform stakeholders about the existence of grievance mechanisms;
- Stakeholders must receive regular updates on submitted grievances and the responses provided, while maintaining confidentiality and ensuring the safety of complainants.

Furthermore, IRMA clarifies that grievance mechanisms should not replace broader community engagement and stakeholder dialogue processes. Instead, it asserts that both are complementary and should reinforce one another:

> *"Grievance mechanisms should not be considered a substitute for community and stakeholder engagement processes that allow for airing of concerns. The two are complementary and should be mutually reinforcing*".

Draft standard for responsible mining and mineral processing 2.0

In Version 2.0 of the IRMA Standard (IRMA, 2023), Chapter 1.4 on grievance mechanisms and access to remedy was revised to enhance its consistency with other chapters. It was clarified that, although grievance mechanisms for workers may overlap with those for other stakeholders, separate procedures may also exist to address workplace-specific grievances. New requirements were introduced for entities to proactively inform stakeholders on how to file a grievance, taking into account potential barriers such as illiteracy. In addition, relevant personnel are required to understand the mechanism and receive training if necessary. The requirement for stakeholder participation in the design of the mechanism was also modified, allowing such participation to occur at any point in time, not only during the initial development.

RMI requires companies to establish grievance mechanisms (See Figure 1), which it is mentioned in OECD Step 1E (RMI, 2024a). This step specifies that companies must:

> *"Have a mechanism allowing any internal or external interested party, including affected parties and whistle-blowers, to voice concerns regarding the circumstances of extraction, trade and handling of covered minerals in order to alert the company to possible risks. The mechanism may be provided through collaborative arrangements with other companies, or by facilitating recourse to an external expert or body, such as an ombudsman."*

RMAP encourages companies to support both site-level and external grievance mechanisms, and to cooperate in good faith with judicial and non-judicial avenues for remedy, including national contact points or ombudsman systems.

The Copper Mark in the Joint Due Diligence Standards for Copper, Lead, Molybdenum, Nickel, and Zinc (The Copper Mark, 2022b) has section 5.1.5, where it stated:

> *"The company shall design and implement a grievance mechanism, …, allow internal and external stakeholder, …, to voice concerns, including anonymously, without fear of retaliation regarding the circumstances of mineral extraction, transport, trade, handling, processing and export of mineral, including CAHRA".*

RMI and The Copper Mark, in their joint "*Risk readiness assessment criteria guide*" mentions its alignment with the UNGP, specifically with the effectiveness criteria outlined in Principle 31. Accordingly, companies must ensure that their operational-level grievance mechanisms are (RMI & The Copper Mark, 2024):

- Legitimate, by involving stakeholders in the design and periodic review of the mechanism, setting clear timelines for processing grievances, and ensuring impartial oversight.
- Accessible, by removing barriers related to language, education, culture, or gender, and by proactively communicating the existence of mechanism to affected stakeholders.
- Predictable, by defining transparent steps for submission, investigation, and resolution of complaints, and by making the process and outcomes understandable and traceable.
- Equitable, by protecting the rights and identities of complainants, enabling access to information and advice, and ensuring fair and respectful handling of grievances.
- Transparent, through regular updates to complainants, public reporting (where appropriate), and documentation of actions taken in response to grievances.
- Rights-compatible, ensuring that grievance resolution respects and aligns with internationally recognized human rights.
- A source of continuous learning, using data from complaints to inform risk assessments, identify systemic issues, and strengthen due diligence practices.

The mechanism is structured through the appointment of a three-member panel of experts to oversee the resolution of complaints, with the option for the complainant to appeal to a newly constituted panel if the outcome is not satisfactory.

The CERA 4in1 standards, from the CRS for exploration (TÜV NORD, 2025c), CPS- I (TÜV NORD, 2025e), CPS-II (TÜV NORD, 2025a) to the Chain of Custody Standard draft (TÜV NORD, 2025d) refer to grievance mechanism. Taking the CPS- I (TÜV NORD, 2025e) as an example, particularly the requirements of Theme 1.4 *Stakeholder involvement* addressing an accessible and effective grievance mechanism:

> "Stakeholder involvement is an integral part of sustainable business conduct. The stakeholder communication process should be proactive, accountable, inclusive, and transparent so the organization can perform to the best of its ability while promoting development opportunities for its stakeholders, including its employees. This section sets out requirements to initiate a comprehensive stakeholder involvement process. An accessible and effective grievance mechanism significantly contributes to the success of strong stakeholder involvement. It provides a platform for stakeholders to raise concerns and a means for the organization to react promptly".

This theme covers the following Key Aspects:

- 1.4.1 Analysis and Prioritization of Stakeholder Groups (5)
- 1.4.2 Participation and Dialogue (6)
- 1.4.3 Public Disclosure and Ongoing Reporting (7)

Further examples are provided by CPS-II and CCS:

- CPS-downstream (TÜV NORD, 2025a) mentions as a requirement to ensure that both internal and external grievance mechanisms are in place for stakeholders (including the community, collaborative initiatives, industry, government, etc.) to report and resolve different types of incidents that may arise. These should work in an effective and timely manner protecting privacy and anonymity to avoid retaliation, intimidation or harassment.
- CCS (TÜV NORD, 2025d) also mentions the implementation of a complaints platform allowing reporting of ESG concerns at the workers, supplier and stakeholder level (including community, collaborative initiatives, industry, government, etc.) and systems to protect their anonymity and data privacy.

2.3.2.6 C6 Stakeholder engagement

The IRMA Standard outlines its expectations for Community and Stakeholder Engagement in Chapter 1.2, recognizing the significant impact mining operations can have on nearby communities. To address this, the standard includes the following key requirements (IRMA, 2018):

- Planning and designing engagement processes: Companies must identify relevant stakeholders and develop engagement plans that reflect the risks and stage of the mining project. These plans should be inclusive, accessible, and culturally appropriate. The company must also show ongoing efforts to reduce barriers to

participation, especially for women, marginalized groups, and vulnerable populations.

- Engagement processes: Stakeholder engagement must begin before or during mine planning and continue throughout the life of the mine. Companies are expected to promote two-way dialogue, share relevant information, invite feedback, and involve stakeholders in the creation of engagement mechanisms, such as advisory committees or community forums.
- Building capacity: Companies are required to work with affected communities to assess and strengthen their ability to participate in consultations, studies, and the development of mitigation, monitoring, and community development plans. Where gaps are identified, the company should offer support to help ensure meaningful participation.
- Communication and access to information: Information must be shared in a timely, understandable, and culturally appropriate way, using formats and languages suited to the affected communities. If information is withheld, the company must provide a written explanation to stakeholders.

Draft standard for responsible mining and mineral processing 2.0

In Version 2.0 of the IRMA Standard (IRMA, 2023), Chapter 1.2 on community and stakeholder engagement was improved through the inclusion of a requirement that entities must have an "access to information" policy (or equivalent), allowing stakeholders to request and obtain information about the environmental and social performance of the operation. This approach replaces previous provisions that were more difficult to audit. Additionally, several key areas were expanded. For example, stakeholder identification now also includes mapping and analysis. Further detail is also provided on what a stakeholder engagement plan should include, such as an analysis of gender roles and dynamics.

RMI and **The Copper Mark** follow "Risk readiness assessment criteria guide", which requires the participation of stakeholders in decisions that affect their health, well-being, safety, livelihoods, communities, and environment through an inclusive and meaningful engagement process. This document mandates (RMI & The Copper Mark, 2024):

- Identify and map (potentially) affected stakeholders and their legitimate representatives, including their ties to specific assets such as land, water, biodiversity, or cultural heritage sites, with particular attention to groups at heightened risk of vulnerability or marginalization.
- Implement a system to ensure inclusive and meaningful engagement, which means:
  - Engaging early with identified and affected stakeholders in decision-making processes.
  - Ensuring stakeholders fully understand how decisions may affect them, and that they are provided with timely, accessible, and culturally appropriate information.
  - Conducting ongoing, two-way engagement that is transparent, fair, and adapted to the local context.
  - Respecting local traditions, languages, timeframes, and decision-making practices.

- Holding a distinct engagement process for Indigenous Peoples where relevant, in accordance with the principle of Free, Prior and Informed Consent (FPIC).

- Publicly disclose identified impacts on stakeholders and the measures taken for their mitigation, ensuring communication is accessible and allows stakeholders to evaluate the effectiveness of the response.

CERA 4in1 considers stakeholder participation throughout the design and implementation of the system. Stakeholder engagement is considered an integral process within the CAMD structure, and communication is proactive, accountable, inclusive and transparent. Under Corporate Governance, the Themes and Key Aspects on Stakeholder Engagement and Communication include: analysis and prioritization of stakeholder groups; participation and dialogue; and public disclosure and ongoing reporting. The requirements also refer to establishing accessible means of engagement; operating grievance mechanisms for internal and external parties with options for anonymity, data privacy, and non-retaliation; documenting responses and remedies; and incorporating stakeholder feedback into monitoring and continuous improvement (TÜV NORD, 2025e).

2.3.2.7 C7 Transparent reporting

IRMA, throughout the standard for different requirements, requires a report that must be available to the general public and, in particular, to the affected stakeholders. For example, under the "*Human rights due diligence requirement*", it is suggested (IRMA, 2018):

> *"The operating company or its corporate owner shall periodically report publicly on the effectiveness of its human rights due diligence activities. At minimum, reporting shall include the methods used to determine the salient human rights issues, a list of salient risks and impacts that were identified, and actions taken by the operating company to prevent, mitigate and/or remediate the human rights risks and impacts…If relevant, the operating company shall publish a report on external monitoring findings and recommendations to improve the operating company's human rights due diligence."*

For the "*Revenue and payments transparency requirements*", an annual report disclosing material payments is also required, which must be made public within 12 months following the end of each fiscal year (this criterion is based on the EITI requirements).

For the "*Environmental and social impacts assessment and management requirement*", a report is required prior to the assessment, which must be published in the local language of the area where the project is to be established. Later, another report detailing the

> *"The findings of conflict risk assessments, risk management plans and monitoring shall be reported to senior management of the operating company; and stakeholders, contractors, mine workers and other employees shall be informed of findings that are relevant to them"* and
> *"On an annual basis, where the operating company is operating in or sourcing minerals from a conflict-affected or high-risk area, the company or its corporate owner shall publicly report on due diligence undertaken to ensure that its actions are not supporting armed conflict or the infringement of human rights in those areas".*

identified impacts must also be made available. Regarding the "*Community health and safety requirements*", companies are encouraged to make information publicly available on the risks and impacts to community health and safety, along with the results of monitoring those impacts. For the "*Mining and Conflict-Affected or High-Risk Area requirements*", it is suggested:

In particular, for some environmental issues, the standard suggests that the company must ensure the information is up-to-date and publicly available, or made available to stakeholders upon request.

Furthermore, IRMA mandates that audit results be publicly accessible on its website, providing a dedicated page for the performance of each mine, which includes both achievements and non-conformances (IRMA, 2022). Also, IRMA gives licensing authorities responsibility for transparency with public reporting of corrective action taken and achieved, then targeted action and monitoring by audits to confirm full compliance enforces the option to suspend or withdraw certification in the event that corrective action to address identified issues is not properly undertaken, thereby guaranteeing enforceability and accountability (IRMA, 2022).

Draft standard for responsible mining and mineral processing 2.0

Below are some of the changes introduced in Version 2.0 of the IRMA Standard (IRMA, 2023) related to reporting and communication requirements. In "Community and Stakeholder Engagement Requirements", provisions have been added regarding how stakeholder input has been taken into account. Subsection 1.4.4 Communication and Reporting Grievances establishes that entities must report directly to affected stakeholders, and introduces a new requirement for general grievance reporting.

In Chapter 1.5 "Financial Transparency and Anti-Corruption", entities are required to report on production, disaggregated by product type and volume, which also applies to processing facilities. Additionally, new disclosure requirements related to anti-corruption measures have been introduced.

In "Waste and Materials Management", reporting requirements have been updated to improve alignment with other IRMA chapters and with international reporting initiatives such as the Global Reporting Initiative (GRI). Reporting requirements related to air quality have also been updated. Finally, Section 4.6.3 "Biodiversity and Ecosystem Services Mitigation and Management" was revised to enhance internal consistency within the standard.

RMI, in "*Global responsible sourcing due diligence standard for mineral supply chains all minerals*" (Step 5, RMI (2024b)), refers to disclosure (see Figure 1), recommending the preparation of annual reports on due diligence practices in the supply chain. The standard states:

> *"Companies should annually report or integrate, where practicable, into annual sustainability or corporate responsibility reports, additional information on due diligence for responsible supply chains of covered minerals."*

This report must be publicly available and include relevant information such as the supply chain policy of the company, the results of audits conducted under the RMAP or an equivalent standard, and a link to the official policy document.

In addition, the report must describe the system used by the company to collect information necessary for the red flag review, how this information has strengthened the due diligence efforts of the company, and how record-keeping is managed. It should also include the methods used to disclose relevant information to downstream actors.

When an Annex II risk assessment is required, the company must report the management systems used, the methods applied, and the type of information collected by the on-the-ground assessment team. The company must also explain how the assessment is conducted and outline the strategy for responding to identified risks. In this context, the standard requires the publication of methodological details, mitigation measures taken, training activities, and monitoring mechanisms.

The supply chain traceability system must also be described, including methods to identify the mine of origin and disclose this information to relevant stakeholders. Companies must also report the results of risk assessments, practices, and methodologies used, always respecting business confidentiality and other competitive concerns.
Additionally, the standard requires the publication of the names of audit firms, the supply chain policy, and, where possible, a summary of the audit report. This report should include audit details, the methodology used, and conclusions.

Finally, the standard calls for the collection of more detailed information when red flags are identified, particularly in artisanal mining operations, among small-scale suppliers and conflict areas. Risk factors such as type of transaction, type of supplier, trade volume, and location must be considered. All this information must be retained for at least five years and made available to auditors or authorized stakeholders.

The Copper Mark in "*Joint due diligence standard for copper, lead, molybdenum, nickel and zinc*" (The Copper Mark, 2022b) requires companies to report annually on their due diligence practices, including a description of their management system, control and transparency mechanisms, and methodology for identifying risks. Reporting must be accurate, clear, comparable, reliable, and timely, allowing stakeholders to assess the performance of the company over time. At a minimum, companies must disclose their supply chain policy and the management system implemented to support it. Reports must also describe how red flags are identified, the methodology used in risk assessments, and the results obtained during the assessment period. If red flags are confirmed, companies must disclose the findings of on-the-ground assessments, the strategy to mitigate risks of adverse and actual impacts, the involvement of stakeholders, and monitoring and evaluation procedures.

Mining companies operating in EITI-implementing countries are additionally required to demonstrate how they meet EITI expectations. This structured reporting approach may be integrated into broader sustainability or corporate responsibility reports, and ensures a balance between accountability and the protection of business confidentiality and competitive concerns.

In addition to company disclosures, The Copper Mark reviews assessment reports from independent assessors during the audit process to ensure alignment with its standards. It then publishes a public summary report with essential site information, assessment details, compliance status, applied methodology, and recognized equivalent systems (The Copper Mark Assurance Process).

RMI and The Copper Mark, in their joint "*Risk readiness assessment criteria guide*" requires companies to identify and report annually on material ESG issues related to their operations and supply chain. These reports must include key information such as identified risks, mitigation actions, relevant policies, and, where applicable, targets and performance indicators. To ensure consistency and quality, sites are encouraged to use internationally recognized reporting standards such as GRI, Sustainability Accounting Standards Board (SASB), International Integrated Reporting Council (IIRC), Carbon Disclosure Project (CDP), or Task Force on Climate-related Financial Disclosures (TCFD). Reports must be (RMI & The Copper Mark, 2024): accurate, accessible, comparable, verifiable, and disclosed with care, respecting confidentiality and competitive concerns.

- Accurate - collected and analysed through robust methodologies and sufficient for stakeholders to evaluate the effectiveness of a Site's due diligence efforts to address material ESG issues.
- Disclosed with care - carried out with due regard for data protection, privacy protection, commercial confidentiality and other competitive or security concerns.
- Clear - available in a manner that is accessible and publicly available to stakeholders.
- Comparable - presented in a way that allows for an assessment of the Sites' performance over time as well as in relation to its peers.
- Verifiable - able to be demonstrated to be true by the Site, for instance via third party verification of the report.

CERA 4in1, from the CRS for exploration (TÜV NORD, 2025c) to the draft CCS for both upstream and downstream operations, these standards refer to reporting. It follows the 5 OECD steps, in particular, "Step 5: Report annually on supply chain due diligence "fits into the context of this criteria. Regarding with the audit for the CPS-upstream is mentioned (TÜV NORD, 2023):

> *"At least the significant results must be published, which contain the status quo against the CPS requirements as well as the improvement measures of the client."*

Both CPS-downstream (TÜV NORD, 2025a) and CCS (TÜV NORD, 2025d) require the implementation of a standardized reporting framework that includes financial and non-financial metrics and the organization's risk profile on different topics, as well as the establishment of transparent channels and clear disclosure procedures for responding to stakeholder requests.

2.3.3 Quantitative analysis: Performance rankings of VSS based on Fuzzy TOPSIS method

The fuzzy TOPSIS analysis, a quantitative evaluation method, assesses the conformity of IRMA, RMI, and The Copper Mark (The analysis did not include CERA 4in1, as it is still in the development phase) with responsible sourcing due diligence under EU regulatory requirements across seven key criteria. This method calculates the relative closeness of VSS to the ideal performance (Table 6).

VSS	Rank
IRMA	1
RMI	2
The Copper Mark	3

Table 6. Rankings of VSS based on key criteria

2.3.3.1 Sensitivity analysis

A sensitivity analysis was performed to test the robustness of the rankings of IRMA, RMI, and The Copper Mark under different scenarios. Each condition represents a variation in the set of criteria used for the evaluation. Condition 1 corresponds to the baseline, where all seven criteria (C1–C7) are included. Conditions 2 to 8 exclude one criterion at a time, allowing to observe whether rankings are particularly sensitive to the absence of a specific factor (e.g., traceability or audit assessment). Condition 9 applies equal weights to all criteria, removing the differentiated importance used in the main evaluation.

Condition	Decision Criteria	VSS Ranking (Respectively)
Condition 1 (Initial Condition)	C1,C2,C3,C4,C5,C6,C7	IRMA, RMI, The Copper Mark
Condition 2	C2,C3,C4,C5,C6,C7	IRMA, The Copper Mark, RMI
Condition 3	C1,C3,C4,C5,C6,C7	IRMA, RMI, The Copper Mark
Condition 4	C1,C2,C4,C5,C6,C7	IRMA, RMI, The Copper Mark
Condition 5	C1,C2,C3,C5,C6,C7	IRMA, RMI, The Copper Mark
Condition 6	C1,C2,C3,C4,C6,C7	IRMA, RMI, The Copper Mark
Condition 7	C1,C2,C3,C4,C5,C7	IRMA, RMI, The Copper Mark
Condition 8	C1,C2,C3,C4,C5,C6	IRMA, RMI, The Copper Mark
Condition 9 (Same Weight)	C1,C2,C3,C4,C5,C6,C7	IRMA, RMI, The Copper Mark

Table 7. Results of sensitive analysis experiments

The sensitivity analysis shows that IRMA is consistently ranked at the top for every condition, indicating its strong correspondence with the evaluation model. RMI typically follows in second place, with The Copper Mark in third. However, in condition 2, where C1 traceability mechanism is excluded, the ranking shifts to IRMA > The Copper Mark > RMI, illustrating how traceability affects the relative position of RMI. This finding highlights the vital role of traceability procedures as a factor influencing the performance of RMI over The Copper Mark.

This ranking method confirmed IRMA as the best-aligned with EU requirements, followed by RMI and The Copper Mark. A sensitivity analysis across nine different weighting scenarios further showed that IRMA consistently ranks first, with variations in RMI and The Copper Mark's positions mainly influenced by the weight given to traceability. For further details on these calculations and analyses, see Akpınar et al. (2025).

2.4 Analysis of VSS alignment with EU regulatory frameworks

The evaluation of IRMA, RMI, The Copper Mark and CERA 4in1 across seven criteria provides a view of their strengths and weaknesses in achieving responsible sourcing due diligence under EU regulatory requirements. While each VSS demonstrates individual strengths, their collective impact on systemic change remains constrained by some gaps.

The first criterion relates to **Traceability**, defined by the OECD & IEA (2025) through four key components: the origin of the product, the geographical path of the product, the chain of custody, and the physical evolution of the product.

Regarding the first component, all standards meet regulatory requirements concerning the traceability of the **origin of the product**. IRMA mandates detailed documentation of the extraction site and the achieved certification level. RMI likewise requires the collection of verifiable information on the extraction location and the retention of related data. The Copper Mark adopts a similar approach, requiring specific information on the country of origin as part of its risk assessment process. CERA 4in1, also addresses origin by requiring procedures to identify the source of minerals, particularly in relation to CAHRAs, and to document any links to illegal or sanctioned areas. Additionally, origin is indirectly ensured by the obligation to source from certified suppliers.

Concerning the **geographical path of the product**, all four standards show adequate alignment. IRMA documents the logistical stages, including suppliers, transporters, and storage locations. RMI mandates maintaining aggregated lists of the countries through which minerals have transited, a requirement also included in The Copper Mark risk assessment methodology. CERA 4in1 complements this by requiring the identification of all critical control points where traceability may be compromised, including storage areas and transportation stages.

With regard to the **chain of custody**, IRMA, The Copper Mark and The CERA 4in1 stand out by incorporating chain of custody models like identity preserved and segregation, that ensure the integrity of materials from their point of origin to the final consumer. RMI, while not prescribing specific models, requires companies to establish appropriate chain of custody mechanisms, allowing for contextual adaptations.

Finally, concerning the **physical evolution of the product**, this subcomponent shows a variable level of alignment. IRMA meets the expectations by requiring detailed documentation of physical and chemical transformation processes, inventory balances, and conversion factors. For RMI and The Copper Mark, although provisions for physical transformation are not explicitly mentioned, there are requirements for reconciliation and loss identification within the accounting period, which must take the site's processes into

consideration. CERA 4in1 strengthens this component by requiring procedures for monitoring material quantities, applying justified conversion factors, and implementing material balancing systems to reconcile certified inputs and outputs over defined periods.

In general, regulatory expectations on traceability are general, relegating them to the mention of incorporating "traceability systems" by companies. Although the standards are generally aligned with regulatory expectations, they do not provide details, clearly defining how traceability information is disclosed. In addition, not all of them mention the incorporation of technologies associated with traceability. In addition, while documentation requirements exist, stakeholders have limited access to traceability data in disaggregated format and generally not in real time, which limits their ability to monitor.

The second criterion is **Risk assessment**.

The IRMA standard shows alignment because it requires site-specific risk assessments throughout the entire life of the mine, including different types of risks. This approach meets regulatory requirements.

RMI also meets regulatory expectations by requiring annual risk assessments and updates based on site conditions. Although its due diligence standard does not address environmental risks, RMI states on its website that it sees the need to include broader ESG issues and is working in that direction.

The Copper Mark also includes risk assessment as part of the five-step due diligence process defined by the OECD.

CERA 4in1 is also based on the OECD framework and requires risk assessments across corporate, environmental, and social dimensions, with companies held fully responsible for identifying and managing risks.

Risk mitigation (Criterion 3) is a key component of due diligence policies, aimed at minimising the potential adverse impacts before they occur.

The IRMA standard aligns with regulatory requirements by consistently mandating the implementation of mitigation measures or plans for both potential and actual risks, covering a range of thematic areas.

RMI, through its due diligence standard, follows the OECD five-step framework, emphasizing Step 3, which requires the design and implementation of a plan to address identified risks.

The Copper Mark also incorporates a structured risk mitigation strategy within its due diligence model. This strategy ranges from maintaining commercial relationships with suppliers while corrective actions are implemented, to temporarily suspending or terminating those relationships in cases of severe impacts.

CERA 4in1 includes risk mitigation and prevention as an integral step in its risk management cycle. It requires organizations to develop corrective and preventive plans based on a hierarchy of actions (avoidance, substitution, reduction, compensation, prevention), and to implement influence strategies across the supply chain.

Audit assessment (Criterion 4) is a fundamental pillar in the verification of standards.

The IRMA standard features a robust evaluation system, structured in multiple phases. IRMA requires both surveillance and recertification audits. However, its approach to managing conflicts of interest is less strict than in other standards, as it allows exceptions to auditor disqualification based on case-by-case evaluations.

RMI also meets high methodological standards by requiring independent audits conducted in accordance with ISO 19011:2018, based on sufficient and appropriate evidence. Audit results are valid for either one or three years, and although formal internal audits are not required, companies must evaluate their performance goals annually.

The Copper Mark, in turn, has an assurance process that includes periodic and independent on-site audits, with full reassessments every three years. While interviews with management and workers are mandatory, interviews with external stakeholders are left to the discretion of the auditor. Additionally, its conflict-of-interest policy is stricter, prohibiting employment or consulting relationships with the audited site within the previous three years.

CERA 4in1 applies a standardized seven-step audit process that includes pre-audit, certification, and surveillance phases. Audits are conducted by independent bodies, and conflict-of-interest policies clarify that auditors are not liable for unidentified risks, reinforcing organizational responsibility.

Overall, a common limitation is the lack of a standardized and mandatory framework for stakeholder engagement in audits. While stakeholder participation is permitted, it is neither required nor systematically integrated into audit findings or follow-up actions.

Grievance mechanisms (Criterion 5) are essential to ensure that affected stakeholders can raise concerns in a safe, accessible, and transparent manner.

The IRMA standard fully aligns with these principles. It requires mining operations to establish operational-level grievance mechanisms that allow local communities, workers, and other stakeholders to file complaints. Moreover, IRMA emphasizes that these mechanisms should not replace community dialogue, but rather serve as a complementary tool that enhances participation.

RMI, in line with the OECD Due Diligence Guidance, requires companies to implement grievance mechanisms that are accessible to both internal and external parties, including whistle-blowers. RMI also encourages the use of judicial and non-judicial avenues, such as national contact points or ombudsman systems, promoting an approach based on international principles.

Similarly, The Copper Mark requires the implementation of mechanisms that enable all internal and external stakeholders to submit complaints safely, including anonymously and without fear of reprisals. A notable feature of RMI and The Copper Mark standards is the establishment of a panel of experts to oversee complaints, with the option to appeal if the outcome is unsatisfactory.

CERA 4in1 requires the implementation of both upstream and downstream grievance mechanisms that ensure the protection of anonymity and data privacy. These systems must enable all stakeholders to report incidents effectively and without fear of retaliation.

In addition, the first three standards mention their alignment with the United Nations Guiding Principles on Business and Human Rights.

Stakeholder engagement (Criterion 6) ensures that affected groups can effectively influence decision-making processes that impact them.

The IRMA standard sets detailed requirements for stakeholder participation, starting from the mine planning phase through to closure.

RMI and The Copper Mark, through their joint guidance, also demonstrate a strong commitment to inclusive engagement. They require companies to identify and map stakeholders, give special attention to vulnerable groups, and ensure transparent consultation processes that are adapted to the local context.

CERA 4in1 integrates stakeholder engagement across its standards, requiring proactive, inclusive, and transparent communication.

Transparent reporting (Criterion 7) is a key condition for accountability in corporate sustainability practices.

IRMA requires public reports on a wide range of topics, from human rights to environmental impacts, and includes requirements for publishing audits and corrective actions. However, while part of this information must be made available in local languages, there is no systematic obligation to translate or adapt all technical content for non-specialist audiences.

RMI sets solid principles for disclosure, including detailed information on supply chains, audits, and risk management. However, although data protection and commercial confidentiality are mentioned, it is unclear to what extent this protection may limit access to critical information for stakeholders.

The Copper Mark has developed a structured reporting approach, including public audit reports and clear disclosure requirements on management systems and due diligence results. The use of international frameworks such as GRI is encouraged, which strengthens its alignment with European regulations. Nevertheless, the standard allows companies significant flexibility regarding the content and format of their reports. Moreover, although it promotes the disclosure of independent assessments, in practice, the published summaries tend to be general and limited in depth, restricting the ability of stakeholders to thoroughly assess critical information.

CERA 4in1 requires standardized reporting on financial and non-financial indicators, including the publication of key audit results and risk profiles. It also mandates accessible disclosure procedures and stakeholder access to relevant information.

Table 8 summarises the performance of the four voluntary sustainability standards (IRMA, RMI, The Copper Mark, and CERA 4in1) against the seven evaluation criteria derived from EU regulations.

Criteria	IRMA	RMI	The Copper Mark	CERA 4 in1
C1 Traceability mechanism	Covers origin, route, custody and physical transformation	Covers origin, route, basic custody (no specific models) and limited physical details	Cover origin, route and custody and limited physical details	Covers origin, route, custody and physical transformation
C2 Risk assessment	Broad coverage of site -specific and lifecycle risks	Annual risk assessment updates; OECD-based; limited on environment	OECD 5-step risk assessment	Comprehensive, OECD-based corporate, social, environmental risks
C3 Risk mitigation	Comprehensive mitigation plans across thematic areas	OECD Step 3; Risk mitigation plans designed; Less prescriptive on environment	Structured plans; Suppliers consultation; Scalable responses; Less detailed on environmental actions	Integrated risk management cycle; Hierarchy of actions and supply chain influence
C4 Audit assessment	Independent third-party audits every 3 years with site visits and document reviews	External verification aligned with ISO/OCDE for smelters and refiners	Independent audits every 3 years; clear procedures and accountability	Standardized 7-step audit process, independent third party verification
C5 Grievance mechanism	Operational-level, community & worker access, confidentiality	Accessible to internal/external; Incl. whistle-blowers	Safe, anonymous complaints, expert panel, appeals	Upstream + downstream, anonymity & data privacy protection
C6 Stakeholder engagement	Covers the whole mining lifecycle (planning to closure), inclusive engagement	Inclusive engagement, mapping vulnerable groups	Consultation adapted to local context	Proactive, inclusive, context-adapted participation
C7 Transparent reporting	Detailed public reporting on HR, environment, and audits	Strong disclosure framework but mainly internal/member-oriented; some access limits	Structured reports and public audits; summaries less detailed	Standardized and mandatory disclosure covering financial and non-financial aspects

Table 8. Alignment between criteria and VSS

Strong alignment

Solid alignment

Partial alignment

In addition to the qualitative assessment, a Fuzzy TOPSIS analysis was conducted to quantitatively compare IRMA, RMI and The Copper Mark (CERA 4in1 was excluded as it is still under development). When comparing both approaches, the qualitative benchmarking (Table 8) highlighted that IRMA consistently achieved strong alignment across most criteria, while RMI and The Copper Mark showed more mixed performance, particularly regarding traceability and reporting. The quantitative Fuzzy TOPSIS analysis reinforced these findings by ranking IRMA first across all scenarios, with RMI and The Copper Mark alternating positions depending on the weight attributed to traceability. Together, these approaches confirm that IRMA is the most comprehensive framework, while also illustrating the sensitivity of RMI's performance to traceability-related requirements.

Table 9 summarises the alignment of VSS with EU regulations. Notably, IRMA stands out for its strong alignment, comprehensively covering due diligence requirements and, in some areas going beyond them.

RMI shows solid alignment across the CSDDD, EBR, and German Supply Chain Act. It follows the OECD five-step framework but does not explicitly cover environmental risks within its due diligence standard. While it requires origin and route information and has a chain of custody system, it is less prescriptive on physical transformation than IRMA or CERA 4in1.

The Copper Mark also aligns solidly with these regulations, applying the OECD framework with graded mitigation, independent periodic audits, grievance procedures, and structured reporting. Its approach to chain of custody and physical transformation relies mainly on reconciliations, offering good alignment but with flexibility in certain implementation aspects.

CERA 4in1 aligns with most CSDDD and German Act requirements, applying the OECD-based CAMD/PDCA framework and a transversal risk approach, with a seven-step audit and standardized reporting. Some scope elements remain under development. It shows very strong EBR alignment through critical control points, material balance factors, and robust auditing that fully meet traceability requirements.

For all four standards, alignment with the CRM Act is only partial. This is because the regulation's binding obligations focus mainly on competent authorities and designated "strategic projects" rather than applying universally to all companies.

Regulation	IRMA	RMI	The Copper Mark	CERA 4 in1
CSDDD				
EBR				
German Supply Chain Act				
CRM Act				

Table 9: Alignment between EU regulations and VSS

Strong alignment

Solid alignment

Partial alignment

External governance

The **IRMA** board of directors is composed of six sectors: mining companies (United Kingdom), downstream purchases (Germany, United Kingdom), investors and finance (United Kingdom), affected communities and indigenous rightsholders (Russia, Canada), organized labor (Switzerland, Canada), and environmental and human rights advocacy NGOs (Tanzania, United States) (IRMA, 2025a). Governance is based on equitable representation and consensus-based decision-making.

The **RMI** steering committee states that it is composed of different sectors, such as companies, auditors, NGOs, affected communities, experts and academics. However, the 2025 Steering Committee appears to be composed mainly of two functional groups: corporate representatives (including industrial companies and associations (Belgium, Japan, Germany, United States and Italy)) and NGOs (United Kingdom, Canada and Netherlands) (RMI, 2025d).

The Board of Directors of **The Copper Mark** is governed by the Articles of Association (The Copper Mark, 2025a). It includes three industry representatives (United States, United Kingdom, International/United States- Europe), three non-industry representatives (United Kingdom, Canada, United States) and the Copper Mark Executive Director (Switzerland).

External governance

The governance structure of **CERA 4in1** does not provide for a public board of directors with clearly established individual memberships. However, the development of the standards has been led by TÜV NORD CERT GmbH (Germany), in collaboration with various European institutions and stakeholders. Major collaborators include Montanuniversität Leoben (Austria), Universiteit Leiden (The Netherlands) and industrial partners from different EU countries (TUVNORD, 2023).

Regarding formal links with European institutions, the European Parliament in 2021 encouraged the European Commission to take as a starting point the **IRMA** standard (European Parliament, 2025). Meanwhile, the European Commission, in its toolbox on due diligence, suggests for downstream companies the use of the Conflict Mineral Reporting Template (CMRT) and the Self-assessment on social and environmental risks in raw material extraction and processing developed by **RMI** (European Commission, 2025a). In addition, the Joint Due Diligence Standard for Copper, Lead, Nickel and Zinc (The Copper Mark, 2022b) was recognized as a conditionally approved standard for Track A of responsible sourcing requirements by the London Metal Exchange (LME) (The Copper Mark, 2021). Finally, the development of **CERA 4in1** received initial funding from the European Institute of Innovation and Technology (EIT RawMaterials), and the full development of the standard is currently framed in the context of the European MaDiTraCe project (MaDiTraCe, 2025).

In conclusion, while all four standards show some degree of engagement with European stakeholders, the scope and nature of their external governance vary. The governance of **IRMA** is notable for its structured multi-stakeholder representation, although it is still predominantly comprised of actors from the UK, North America and, to a smaller extent, continental Europe. **RMI** presents a broader governance but, in practice, its Steering Committee appears concentrated in corporate and NGO representation, with limited visibility of European institutional involvement beyond a few countries. **The Copper Mark** presents a balanced composition of its board, but the majority of its membership remains in North America and the UK, with no formal presence of EU institutions. In contrast, **CERA 4in1** excels in its strong European anchor, not only is its development driven by a German certifier in collaboration with universities and industrial partners from across the EU, but it also benefits from direct EU funding.

3 Secondary raw materials

As the EU accelerates its transition towards a circular economy, secondary raw materials (SRMs), including recycled metals, components and end-of-life materials, are becoming increasingly important (European Commission, 2025b). To ensure the sustainable, safe and transparent use of SRMs, both standards/initiatives and regulatory instruments have begun to address due diligence and traceability in these supply chains. However, the extent of their coverage, the specificity of their requirements, and their level of operational maturity vary considerably.

On the regulatory side, the EU has introduced several instruments that specifically address key aspects of SRMs. The Ecodesign for Sustainable Products Regulation (ESPR), which came into force in July 2024, establishes a general sustainability framework for product design, including provisions for recycled content and recyclability (European Commission, 2025d). ESPR introduced the Digital Product Passport (DPP) as a key tool for tracking product-related sustainability data. The EU Batteries Regulation (2023/1542) (EBR) includes the most specific and binding requirements to date for the traceability of secondary materials (European Commission, 2025a). From February 2027, it will be mandatory to use a digital battery passport, and minimum recycled content targets will be set for critical materials such as cobalt, lithium, and nickel. The CRM Act (Regulation (EU) 2024/1252) further elevates the role of SRMs by setting a binding 2030 target that at least 25 % of the EU's annual consumption of strategic raw materials comes from recycled sources, while also strengthening reporting obligations on material origin, processing, and environmental performance across the value chain (European Union, 2024b). Other EU rules, including the Waste from Electrical and Electronic Equipment (WEEE) Directive, also govern the collection and treatment of waste electrical and electronic equipment, ensuring that end-of-life materials are properly recovered and recycled (European Union, 2012). The RoHS Directive complements the WEEE Directive by restricting the use of hazardous substances in the design phase, thereby enabling safer reuse and recycling practices further down the line (European Commission, 2017).

This chapter assesses how closely selected standards and initiatives for SRMs are aligned with the regulatory requirements of the EU.

3.1 Standards/Initiatives

We examine key standards/initiatives such as the Sustainable Electronics Recycling International (SERI), the e-Stewards and the Global Battery Alliance (GBA) Battery Passport. Table 10 highlights the most relevant differences between them.

Responsible Organization	R2v3	e-Steward	GBA
Standard/Initiative	Responsible Recycling R2 v3 (electronics reuse & recycling)	e-Stewards Standard v4.1 (Integrated with ISO 14001)	Battery Passport framework (Passport Content Guidance v1.0, ESG Rulebooks)
Products	e-waste	e-waste	Batteries (EV batteries and Industrial batteries with capacity >2kWh)
1st Version	R2v3 in 2020 (updated in 2024 with add PV module in appendix G)	e-Steward v1.0 in 2009 and latest v4.1 in 2022	January 2023
Spatial Focus company size	Global	Global	Global
Audit	3rd-party certification, annual audits, recertification every 3 yrs	Accredited 3rd-party certification, surveillance annually, recertification every 3 yrs	Data verification via pilots in 2024; plan for third-party assurance spots/frequency defined by 2025
Applicability assessment and enforcement	Facility-level	Facility-level	Product-level

Table 10. Selected key characteristics of SERI, e-Stewards and GBA. Source: e-Stewards (2025); Global Battery Alliance (2025); SERI (2025).

3.2 Methodology

This analysis uses a qualitative benchmarking approach to assess the alignment of selected standards/initiatives and EU regulatory instruments with key criteria relevant to SRMs. The comparison focuses on the following three core criteria:

C1. Traceability of recycled materials

C2. Environmental risk assessment

C3. Social and human rights considerations

The objective is to evaluate whether each standard/initiative or regulation explicitly addresses these criteria.

The assessment covers the following standards/initiatives:

- R2v3 (Responsible Recycling) by Sustainable Electronics Recycling International (SERI)
- e-Stewards certification
- GBA Battery Passport initiative

EU regulations

- Ecodesign for Sustainable Products Regulation (ESPR)
- EU Batteries Regulation (2023/1542) (EBR)
- WEEE Directive
- RoHS Directive
- CRM Act

This analysis uses policy documents and official standards to determine whether each standard/initiative includes provisions for traceability, environmental risk management, and social human rights protection.

To ensure comparability with the assessment of primary raw materials, the same four-level colour legend introduced in Section 2.2 was applied. This allows for a consistent interpretation of results across both primary and secondary raw material evaluations, with colours indicating strong, solid, partial, or limited alignment.

3.3 Results

3.3.1 Evaluation criteria for secondary raw materials

This benchmarking exercise provides an overview of how well the current standards/initiatives and EU regulations address the core elements of due diligence necessary for advancing responsible sourcing and circularity in supply chains for SRMs.

3.3.1.1 C1 Traceability of recycled materials

Traceability in SRMs involves tracking the origin, movement and processing history of recycled materials. Unlike primary materials from identifiable sources, SRMs often come from mixed or informal streams, which makes documentation challenging. Maintaining traceability is crucial for confirming adherence to sustainability standards, evaluating potential contamination, and substantiating claims related to circularity. It could also help to prevent waste that is unsafe or sourced illegally from entering the supply chain.

References in EU Regulations:

- ESPR (Article 7): Mandates DPPs to trace recyclability and recycled content.
- EBR: It requires digital battery passports and minimum recycled content for critical materials.
- WEEE Directive: Supports traceability through mandatory collection and treatment of e-waste, though post-processing tracking is limited.
- RoHS Directive: Indirectly supports traceability by restricting hazardous substances, reducing contamination risks.
- CRM Act: Sets a 25 % recycled-content target for strategic raw materials by 2030, requires Member States to document and improve recovery from CRM-rich waste streams, and allows the Commission to mandate product-specific recyclability and recycled content rules. Article 29, makers of covered products with more than 0.2 kg

permanent magnets must publish the share of the CRMs recovered from post-consumer waste in the magnets.

Definition for evaluating standards/initiatives:

A standard/initiative meets this criterion if it enables traceability across the supply chain. This ensures reliable tracking of material sources, reprocessing steps and recycled content levels, as well as transparent reporting to downstream users, even when materials are mixed or transformed.

3.3.1.2 C2. Environmental Risk Assessment

While SRMs reduce the need for virgin extraction, they pose environmental risks during collection, sorting, and recycling. These include contamination from hazardous substances, emissions from informal processing, and potential pollution from treatment activities. Environmental risk assessment is essential to identify, manage, and mitigate these impacts across the lifecycle.

References in EU Regulations:

- ESPR (Article 5): Requires environmental performance criteria in ecodesign, covering lifecycle impacts.
- EBR: Mandates lifecycle assessments and carbon footprint declarations, including recycled content.
- WEEE Directive: Ensures environmentally sound collection and treatment of e-waste.
- RoHS Directive: Restricts hazardous substances, reducing environmental risks during recycling.
- CRM Act: Article 27 for environmentally sound waste-recovery operations; Article 28 for safe dismantling (pollution prevention); Article 31 for footprint disclosure.

Definition for evaluating standards/initiatives:

A standard/initiative meets this criterion if it incorporates structured and proactive approaches to assessing and controlling environmental risks related to recycled materials. This covers both recycling processes and the use of recycled content in new products.

3.3.1.3 C3. Social and human rights considerations

SRMs are often processed through informal labour systems with unsafe working conditions and limited social protection, particularly in lower-income countries. Key risks include child labour, exposure to toxins, and unfair compensation in recycling and dismantling activities.

As secondary flows are less frequently covered by formal human rights due diligence frameworks, targeted safeguards are essential.

References in EU Regulations:

- ESPR: While it does not directly address social risks, it may support accountability through broader sustainability goals.
- EBR: It includes due diligence obligations for both primary and recycled critical materials, covering labour rights and safety.

- WEEE Directive: It encourages the formalization of recycling to reduce informal labour risks.
- The RoHS Directive: Supports safer working conditions by limiting hazardous substances.
- CRM Act: Allows Commission recognition of third-party-verified sustainability certification schemes covering environmental and social criteria.

Definition for evaluating standards/initiatives:

A standard/initiative meets this criterion if it explicitly addresses social and human rights risks in secondary material supply chains, with safeguards covering labour conditions, fair compensation, worker safety and the promotion of formalised recycling practices.

3.3.2 Performance of standards/initiatives by criteria

Table 11 summarises the key features of standards/initiatives relating to SRMs, as well as how they perform against the evaluation criteria. While R2v3 offers partial traceability through tiered reuse and downstream due diligence, it lacks detailed recycled content tracking. In contrast, e-Stewards applies stricter precautionary reuse restrictions and emphasises downstream safety, though its traceability is limited to material-type restrictions. The GBA Battery Passport is an ambitious initiative currently in development which aims to achieve full lifecycle traceability, however, its environmental and social components are not yet fully operational.

Criteria	R2v3	e-Stewards	GBA Battery Passport
Traceability of recycled material	Tiered reuse and downstream due diligence	Material-type restrictions for reuse	In development (full lifecycle traceability planned)
Environmental risk assessment	General reuse and handling requirements	Precautionary reuse and handling requirements	In development (criteria not yet operational)
Social & human rights considerations	Focus on downstream vendor practices	Focus on downstream user safety	In development (criteria not yet fully defined)
Notes	No detailed recycled content tracking	Restricts legacy toxic components, with emphasis on safe reuse	Ambitious in scope, implementation details under development

Table 11: Alignment between criteria and standards/initiatives

Strong alignment

Solid alignment

Partial alignment

Limited alignment

3.4 Analysis of Standards/Initiatives alignment with EU regulations

Table 12 shows how the selected standards/initiatives align with key EU regulations governing SRMs. This comparison evaluates how well each standard/initiative addresses the regulatory requirements for traceability, environmental risk and social safeguards.

Benchmarking shows that the GBA Battery Passport demonstrates strong alignment with the ESPR, the EU Batteries Regulation and the CRM Act, while the e-Stewards Standard aligns most strongly with the WEEE and RoHS Directives, but is limited to the CRM Act. R2v3 shows partial alignment with most regulations but aligns particularly well with the RoHS Directive. Overall, the level of alignment varies between the standards, with no single standard/initiative covering all regulatory aspects.

Regulation	R2v3	e-Stewards	GBA Battery Passport
ESPR			
EU Batteries Regulation			
WEEE Directive			
RoHS Directive			
CRM Act			

Table 12: Alignment between regulations and standards/initiatives

Strong alignment

Partial alignment

Limited alignment

4 Conclusions

European regulations have emerged in response to the limitations of voluntary private initiatives in an attempt to overcome the fragmentation and incompleteness of the current certification schemes. This report has conducted a benchmarking analysis of some raw material due diligence standards and certification schemes against EU and national regulatory frameworks for both primary and secondary raw materials.

This study highlights the dual nature of VSS as both competitive and complementary tools in the regulatory landscape. Identifying those most aligned with policy requirements is crucial, not only for companies seeking compliance tools, but also for standard bodies aiming to improve their frameworks and visibility. The study is structured in two parts, reflecting the distinct characteristics and regulations concerning primary and secondary supply chains, as well as the differing objectives of the standards that govern them.

For the primary supply chain, the analysis assessed four VSS against due diligence criteria, identifying both areas of alignment and opportunities for improvement in relation to regulations such as the Corporate Sustainability Due Diligence Directive (CSDDD), the European Battery Regulation (EBR), the CRM Act, and national legislation like the German Supply Chain Act.

We first analysed in detail key VSS, such as the Initiative for Responsible Mining Assurance (IRMA), Responsible Minerals Initiative (RMI), The Copper Mark and the CERA4in1 (under elaboration in the framework of the MaDiTraCe project). Each of them has different characteristics and coverage in terms of mineral scope and supply chain segment coverage, such as mining, smelting, refining, or the entire supply chain. Then, we assessed the effectiveness of VSS against the EU regulatory frameworks based on a set of seven criteria identified as critical aspects of due diligence in responsible sourcing: traceability systems, risk assessments, corrective action plans, audits, grievance mechanisms, stakeholder engagement, and transparent reporting. In the next step, we compared the compliance extent of the three VSS (e.g., IRMA, RMI, and The Copper Mark) by using the fuzzy multi-criteria decision-making TOPSIS method.

Based on **traceability criteria**, the VSS largely meet regulatory expectations regarding product origin and route, consistent with CSDDD and EBR principles. However, these regulatory expectations are often broad, focusing mainly on the requirement to have traceability systems. Most standards provide limited detail on how such information is disclosed and integrated into company operations. Few explicitly reference traceability technologies, and while documentation is generally required, stakeholders often have limited access to disaggregated or real-time data, which hinders effective oversight.

All standards align with regulatory expectations on **risk assessment**, with IRMA and CERA 4in1 standing out for their comprehensive methodologies. In **risk mitigation**, IRMA applies preventive and corrective measures across multiple areas; RMI and The Copper Mark follow the OECD five-step model; and CERA 4in1 adds a hierarchical prevention framework with supply chain influence strategies.

Audit assessment requirements are met by all four standards. IRMA and CERA 4in1 employ detailed, multi-phase methodologies, while RMI and The Copper Mark ensure high technical rigour and auditor independence. However, none require mandatory stakeholder participation in audits. All standards also align strongly on **grievance mechanisms**, with

IRMA emphasising community-level systems, RMI and The Copper Mark ensuring oversight and appeal structures, and CERA 4in1, which integrates privacy and accessibility protection measures throughout the supply chain. **Stakeholder engagement** is consistently addressed, with IRMA leading in lifecycle integration and the others ensuring inclusive, locally adapted processes.

On **transparency and reporting**, CERA 4in1 distinguishes itself with a standardised approach to both financial and non-financial disclosure. IRMA, RMI, and The Copper Mark also promote transparency but face challenges in accessibility, depth, and the mandatory nature of certain disclosures.

The Fuzzy TOPSIS assessment revealed that IRMA consistently ranks highest across the evaluated due diligence criteria, followed closely by The Copper Mark and RMI, highlighting their relative strengths in meeting regulatory expectations. Although the CERA4in1 standard was not included in the final ranking due to its ongoing development, preliminary versions were considered in the qualitative analysis, offering valuable insights into its potential alignment with EU regulatory frameworks.

Overall, IRMA achieves the highest alignment with regulatory requirements, covering all due diligence components and, in some cases, exceeding them. RMI shows solid alignment but is less prescriptive on environmental risks and physical transformation. The Copper Mark combines OECD-based due diligence with strong audit and grievance systems but retains flexibility in chain-of-custody and reporting requirements. CERA 4in1, though still under development, shows strong potential, particularly in traceability through critical control points and material balance systems. For all standards, alignment with the CRM Act is only partial, as its binding obligations target competent authorities and "strategic projects" rather than applying universally.

For the secondary supply chains, the benchmarking exercise highlights the growing convergence between EU regulatory frameworks and standards/initiatives in their approach to addressing secondary raw materials, although some differences remain. Regulations such as the Ecodesign for Sustainable Products and the EU Battery Regulation introduce clear requirements for traceability, recycled content and risk governance. In contrast, standards such as R2v3 and e-Stewards emphasise downstream safety and responsible reuse but only offer partial traceability and limited tracking of recycled content. The Global Battery Alliance Battery Passport is more closely aligned with EU ambitions, particularly through its goal of achieving full lifecycle traceability, while it is still in development.

Overall, although regulations are becoming more specific regarding secondary flows, most standards/initiatives lag in terms of operational alignment. Greater harmonisation, particularly with regard to traceability systems, environmental safeguards and social criteria, will be essential to ensure that SRMs meet the same due diligence requirements as primary materials. In practice, these rules are only achievable with end-to-end traceability of composition, source, and processing pathway. This alignment is essential for enabling a truly circular and responsible material supply system of the EU.

Further research should extend this approach to other standards while investigating how technologies such as blockchain or material fingerprinting techniques can be used to strengthen traceability implementation and data verification. Reaching out to fill these gaps, VSS will be able to further assist the move toward sustainable and responsible supply chains in accordance with changing EU regulatory requirements (Akpınar et al., 2025).

5 Glossary

Blockchain

A system for storing data in which groups of valid transactions, called blocks, form a chronological chain, with each block securely linked to the previous one. Originally invented for the digital currency bitcoin, a blockchain is a permanent, unalterable digital file of encrypted transactions that can be distributed in multiple copies across a network of devices linked to the blockchain. Given that every storage device has an exact and updated copy of the ledger, data can be verified and is considered immutable—an important property when transactions are occurring among users that do not know or trust each other (Cartier et al., 2018).

Chain of Custody[2]

Chain of Custody refers to the recorded sequence of entities that hold custody of minerals or materials as they progress through a supply chain to ensure responsible movement of minerals. This custodial sequence involves the transfer of ownership or control from one custodian to another within the supply chain. The documentation of the chain of custody encompasses a list of all organizations within the supply chain that assume ownership or control of a product during its various stages, including production, processing, shipping, and retail.

Due diligence

Due diligence is an on-going, proactive and reactive process through which companies can identify, prevent, mitigate and account for how they address their actual and potential adverse impacts as an integral part of business decision-making and risk management systems. Due diligence can help companies ensure they observe the principles of international law and comply with domestic laws, including those governing the illicit trade in minerals and United Nations sanctions (OECD, 2016).

Traceability[3]

Traceability refers to the capacity of an entity, whether a public authority, private company, or other organization, to identify, track, and verify information about a product throughout the supply chain. To meet the minimum threshold for traceability, this includes the ability to determine four specific aspects of the product: its origin; its geographical path; its chain of custody; and its physical evolution. Without the capacity to establish all four elements with a reasonable degree of confidence, a product cannot be considered truly traceable. While traceability can also support the inclusion of ESG-related information, such data must complement—not substitute, these foundational components.

[2] Based on OECD (2016) and ISEAL Alliance (2016).
[3] Based on OECD & IEA (2025).

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