MADITRACE

State of Play and SWOT Analysis

Current interventions for due diligence in the material supply chain

Deliverable D1.3

Version N°5

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Document information

Grant Agreement	n°101091502
Project Title	Material and digital traceability for the certification of critical raw materials
Project Acronym	MaDiTraCe
Project Coordinator	Daniel Monfort, BRGM
Project Duration	1 January 2023 – 31 December 2025 (36 months)
Related Work Package	WP1
Related Task(s)	T1.2 State of Play SWOT Analysis
Lead Organization	MU Leoben
Contributing Partner(s)	ULEI
Due Date	M18
Submission Date	22/07/2024
Dissemination level	Public

History

Date	Version	Submitted by	Reviewed by	Comments
10/06/2024	V1	Paulina Fernández (MU Leoben)	Michael Tost (MU Leoben)	First Draft
13/06/2024	V2	Paulina Fernández (MU Leoben)	Daniel Monfort (BRGM) Yanan Liang (ULEI) Sónia Cunha (ULEI)	Second draft
20/06/2024	V3	Paulina Fernández (MU Leoben)	ULEI, BGRM, DMT, GTK, U Gent, EIT RM, LGI, ISMC, ICAMCYL, CEA, AHK Group, Funditec, MO Group, Spherity	Third draft
27/06/2024	V4	Paulina Fernández (MU Leoben)	Daniel Monfort (BRGM)	Fourth draft

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			Capucine Nouvel (BRGM)	
28/06/2024	V5	Paulina Fernández (MU Leoben)	Daniel Monfort (BRGM) Mariana Terreros (LGI)	Quality check

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Summary

Due diligence is a crucial, ongoing process that helps companies in the Critical Raw Materials (CRMs) supply chains to identify, prevent, mitigate, and account for potential and actual negative impacts, such as financing armed conflicts, labour exploitation, environmental harm, and violation of community rights. It is essential for maintaining the integrity, legality, and sustainability of CRM extraction and trade. In the current landscape of increasing awareness and evolving regulations, the role of due diligence has become more significant in responsible business management. This shift is reflected in the development of laws, frameworks, initiatives, and standards that guide industries towards responsible sourcing and transparency, with a growing emphasis on enhancing and enforcing mechanisms to monitor and control the supply chain.

The present document, D1.3 Current State and SWOT Analysis, aims to provide an overview of the current state of due diligence interventions within the supply chain, covering frameworks, laws, international instruments, initiatives, and standards for primary and secondary raw materials. In addition, a SWOT analysis of key standards is included. These collective efforts aim to establish a shared knowledge base for later phases of the project. The document also offers definitions of key concepts used and identifies gaps and needs, presenting opportunities for improvement within the scope of the MaDiTraCe project.

The report highlights the need to address gaps in due diligence frameworks for CRM material supply chains, emphasizing the lack of harmonization and coherence as key challenges. It proposes the creation of more detailed and contextualized guidelines tailored to specific sectors, such as mining, which incorporate elements such as financial transparency and grievance mechanisms. Additionally, the complexity of legislation in different jurisdictions for international companies is highlighted, underscoring the need to clearly define the responsibilities of each actor in the supply chain, including governments and civil society, to promote transparency, accountability, and sustainability.

The report also points out the importance of establishing objective metrics to evaluate the benefits of company initiatives and the need for constant monitoring and effective collaboration between companies. It emphasizes the need for accessible and adaptable technological and chemical solutions that comply with legal regulations. At the same time, the evolution in the inclusion of ESG criteria and the recycling stage in supply chain standards is recognized. However, a lack of inclusivity and flexibility in current standards is identified, underlining the need to adapt them to specific needs to encourage greater adoption and compliance.

Finally, the report addresses the challenges of traceability in global supply chains and the importance of improving traceability systems for CRMs, considering critical aspects such as data security, labour rights, and environmental impact. A SWOT analysis is conducted to identify critical areas and opportunities for improvement. Additionally, significant challenges for secondary raw materials are highlighted, such as the scarcity of specific information, emphasizing the need to standardize recycling practices and the safe disposal of electronic waste.

In summary, regarding traceability aspects, the document reveals that traceability solutions are segmented, focusing on various areas such as technology, fingerprinting, or certification, yet they lack holistic integration. This represents an opportunity to develop

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more comprehensive and cohesive solutions that enhance the effectiveness and coherence of supply chain traceability.

Keywords

Due Diligence, supply chain, CRMs, framework, initiative, laws and international instruments, standard, SWOT analysis.

Abbreviations and acronyms

Acronym	Description
3TG	Tin, Tantalum, Tungsten and Gold
AMI	Advance Materials Initiative
APR	Asia Pacific Rayon
ASI	Aluminium Stewardship Initiative
ASC	Aquaculture Stewardship Council
ASM	Artisanal and Small-scale Mining
ASMO	Artisanal Small-Scale Mining Organizations
CADD	Consolidated Autonomous Due Diligence
CAHRAs	Conflict-Affected and High-Risk Areas
CCCMC	China Chamber of Commerce of Metals, Minerals & Chemicals Importers & Exporters
CE-RISE	Circular Economy Resource Information Systems
CEP	Circular Electronics Partnership
CERA 4in1	Certification of raw materials
CFSP	Conflict – Free Smelter Program
CFTI	Conflict Free Tin Initiative
CIRAF	Cobalt Industry Responsible Assessment Framework
CIRPASS	Collaborative Initiative for a Standards-based Digital Product Passport for Stakeholder-Specific Sharing of Product Data for a Circular Economy
CoC	Chain of Custody
COP	Code of Practices
CORE	Canadian Ombudsperson for Responsible Enterprise
CRMs	Critical Raw Materials

CRT	Cathode Ray Tube
CSDD	Corporate Sustainability Due Diligence
CSyARES	Circular System for Assessing Rare Earth Sustainability
CTC	Certified Trading Chains
D	Deliverable
DDII	Diamond Development Initiative International
DMCC	Dubai Multi Commodities Centre
DPP	Digital Product Passport
DRC	Democratic Republic of the Congo
EBSI	European Blockchain Services Infrastructure
EITI	Extractive Industries Transparency Initiative
EPRM	European Partnership Responsible Minerals
ESG	Environmental, Social and Governance
ESPR	Ecodesign for Sustainable Product Regulations
ESTMA	Extractive Sector Transparency Measures Act
EU	European Union
FCA	Fair Cobalt Alliance
FSC	Forest Stewardship Council
FutuRaM	Future Availability of Secondary Raw Materials
GBA	Global Battery Alliance
GDL	Good Delivery List
IBM	International Business Machines
ICGLR	International Conference on the Great Lakes Region
ICMM	International Council on Mining & Metals
ICT	Information and Communication Technology
IED	Industrial Emissions Directive
ILA	International Lead Association
IMOA	International Molybdenum Association
IRBC	International Responsible Business Conduct
IRMA	Initiative for Responsible Mining Assurance

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ISAE	International Standard on Assurance Engagements
ISEAL Alliance	International Social and Environmental Accreditation and Labelling Alliance
ISO	International Organization for Standardization
ITSCI	International Tin Supply Chain Initiative
IZA	International Zinc Association
KP	Kimberley Process
KPCS	Kimberley Process Certification Scheme
LBMA	London Bullion Market Association
LME	London Metal Exchange
MAC	Mining Association of Canada
MaDiTraCe	HORIZON-RIA project: Material and digital traceability for the certification of critical raw materials
MIIT	Ministry of Information and Industry Technology
MOBI	Mobility Open Blockchain Initiative
MSC	Marine Stewardship Council
NGOs	Non-governmental organizations
NI	Nickel Institute
OECD	Organization for Economic Co-operation and Development
PCBs	Polychlorinated biphenyls
PEFC	Programme for the Endorsement of Forest Certification
PGM	Platinum Group Metals
RBC	Responsible Business Conduct
RBI	Responsible Business Initiative
RBS	Rwanda Bureau of Standard
RCI	Responsible Cobalt Initiative
RCM	Regional Certification Mechanism
REEs	Rare earths
RINR	Regional Initiative against the Illegal Exploitation of Natural Resources
RJC	Responsible Jewellery Council
RMAP	Responsible Minerals Assurance Process
RMI	Responsible Minerals Initiative
RSP	Responsible Sourcing Programme

SDG	Sustainable Development Goal
SEC	Securities and Exchange Commission
SMEs	Small and Medium-sized Enterprises
SP	Sustainable Procurement
SWOT	Strengths, Weaknesses, Opportunities and Threats
TIC	Tantalum-Niobium International study Center
Trace4EU	Traceability Reference Architecture Conformant EBSI for the European Union
TraceMet	Traceability for sustainable Metals and minerals
TRG	Track Record Global
TSM	Toward Sustainable Mining
T&T	Tracking and Tracing
UN	United Nations
UNRMS	United Nations Resource Management System
US	United States
WDC	World Diamond Council
WGC	World Gold Council
WP	Work Package

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1 Introduction

Due diligence is a continuous and reactive process that enables companies to identify, prevent, mitigate, and account for their actual and potential adverse impacts within the critical raw materials (CRMs) supply chain. In these supply chains, companies face significant risks associated with the extraction and trade of minerals, ranging from financing armed conflicts, labour exploitation, and environmental degradation, to violations of local community rights. Therefore, due diligence plays a fundamental role in ensuring the integrity, legality, and sustainability of CRM extraction and trade.

In the current landscape of increasing awareness and ever-evolving regulations, the significance of due diligence in supply chains has significantly grown, becoming a fundamental aspect of responsible business management. This evolution is evident in the emergence of laws, frameworks, initiatives, and standards aimed at guiding an industry focused on responsible sourcing and transparency. Transparency, in particular, exerts growing pressure on the industry concerning the chain of custody (see models and definitions in Annex) control mechanisms.

In this context, MaDiTraCe emerges with the primary goal of expanding and integrating technological solutions for the traceability and certification of responsible and sustainable raw material supply chains into a digital product passport (DPP) compatible with the EU battery passport. This project aims to:

- Enhance the reliability of CRM tracking and promote transparency in the use of raw materials within complex supply chains.
- Increase the technological readiness level for CRM traceability and the integration of these digital and analytical technologies into a universal certification system for responsible and sustainable CRMs throughout mineral supply chains, from the mine to the final manufactured and recycled products.

Within the project, this document, D1.3 State of Play and SWOT Analysis, is included in WP1 Assessment of needs and gaps in due diligence. Its purpose is to provide an overview of due diligence in the CRM supply chain by delivering an inventory of the current state of regulations, frameworks, available standards, certification schemes, and technological solutions for primary and secondary raw materials within the industry, civil society, and policy development. This includes an analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) of the key standards and certification methods. The document establishes a common knowledge foundation for the remainder of the project.

1.1 Structure of the report

The document is structured as follows. Section two describes the methodology used to carry out this research. Section three describes current supply chain due diligence interventions, identifying frameworks, laws, initiatives and standards. It also highlights significant interventions focused on traceability within the supply chain in different sectors. Section four shows the SWOT analysis of the main due diligence standards. Section five presents the main conclusions of the report. Finally, Section six presents a glossary of common terms used.

1.2 The Supply Chain

The MaDiTraCe project primarily focuses on the traceability of CRMs utilized by five key industries: magnets, batteries, automotive, photovoltaic, and microelectronics. Among these CRMs, lithium, natural graphite, cobalt and neodymium are considered highly relevant for these five key industries. This section will focus on the supply chains of the selected CRMs. These supply chains encompass multiple stages, ranging from extraction to disposal and recycling, as illustrated in Figure 1. It is important to note that in this section only some characteristics of the supply chain of these minerals will be mentioned since more detailed information will be provided in D3.1 Draft report supply chain mapping, requirements elicitation, classification.

Figure 1: Stages of magnets, batteries, automotive, photovoltaic, and microelectronics supply chains (related to Li, Co, Nd, and natural graphite).

Lithium[1] production in 2023 was around 180,000 metric tons, concentrated in Australia (48% of the total), Chile (24% of the total) and China (18% of the total). Smaller production, in Argentina, Brazil, Canada, Zimbabwe, and within Europe in Portugal also contributed to the global lithium output. Global lithium resources are estimated at 105 million tons, with significant concentrations in Bolivia (22% of the total), Argentina (21% of the total), Chile (11% of the total) and Australia (8.3% of the total). Within Europe, approximately 7 million tons are distributed across countries such as Germany (3.6% of the total), Czech Republic (1.2% of the total), Serbia (1.1% of the total), Spain (0.3% of the total), Portugal (0.3% of the total), Finland (0.1% of the total) and Austria (0.1% of the total). The downstream industries that mainly require lithium compounds are those generating products such as batteries (87%), ceramics and glass (4%), lubricating greases (2%), air treatment (1%), flux powders for continuous casting moulds (1%), medical (1%) and other uses (4%). In particular, Figure 2 represents the battery producers in Europe, highlighting Northvolt, VW, and ACC as the main ones. They are expected to account for a third of the European battery production capacity until the year 2030. Other major non-European companies are CATL (China) and Tesla (USA), which also produce a large amount of batteries in Europe (Weymann & Leidenberger, 2022). By 2030 and based on the steady growth of the European battery industry, a production capacity of ~1.75 TWh is expected. Germany will produce the most battery cells with 430 GWh. Other players will be Hungary with 207 GWh, Sweden with 130 GWh, Great Britain with 130 GWh and France with 125 GWh. (Weymann & Jung, 2022).

[1] Production, resources and uses of lithium extracted USGS (2024).

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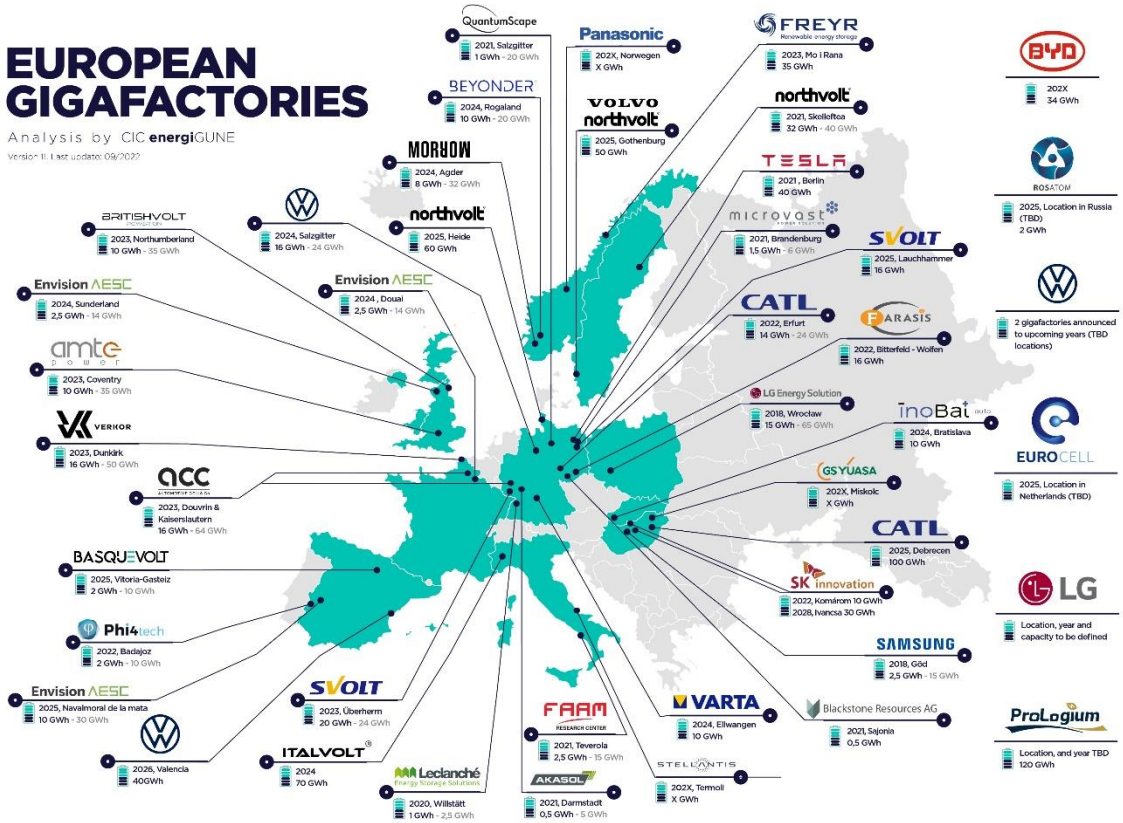

Figure 2: Battery producers in Europe. Source: CIC energiGUNE (2022).

Regarding the recycling of lithium contained in batteries, in the European Union, lithium is currently hardly recycled due to the complexity and high costs associated with this process (European Commission, 2023d). The complexity centres on the fact that batteries do not have standardized cell designs and specific chemistry for the products in which they are used, which interferes with the desire to establish a solid recycling procedure for all types of lithium-ion batteries (Neumann et al., 2022). To address this situation, a new battery regulation has come into force in the European Union. According to this regulation, manufacturers are required to recover 50% of lithium by 2027 and 80% of lithium by 2031 (Zarcone, 2023).

The production of natural graphite[2] in 2023 was around 1,600,000 metric tons, with China being the main producing country (77% of the total), followed by Madagascar (6.3% of the total) and Mozambique (6% of the total). In Europe, production in 2022 was noted in Norway (0.5% of the total), Ukraine (0.13% of the total), Austria (0.03% of the total), and Germany (0.01% of the total). The main uses of natural graphite have been for refractories, batteries, friction materials and lubricants (European Commission, 2023f).

In the context of electric vehicle batteries, in recent years, attention has been focused on the cathodes, which use raw materials such as lithium, cobalt, and nickel. However, it is essential to highlight the production of the materials needed for the anodes, such as natural graphite, in order to meet the growing demand for electric vehicles (Barrera, 2021). The manufacture of the anodes involves the use of spherical graphite, processed from natural flake graphite. This operation is primarily carried out in China due to its technical expertise,

[2] Production, resources and uses of natural graphite from USGS (2024a).

competitive production costs, and environmental constraints (Barrera, 2021). In Europe, specifically in Sweden, global technology company ABB and battery anode and graphene additive company Talga Group have signed a Memorandum of Understanding to jointly develop Talga's Vittangi anode project in northern Sweden (Brand, 2020).

As for the recycling stage of natural graphite, Europe currently lacks industries engaged in this practice, but numerous projects are underway. For instance, in Germany a novel method for graphite recycling has been developed. Through foam flotation, it becomes feasible to separate graphite from other materials, such as rare earths and lithium. Up to this point, this process has only been carried out in the laboratory (EIT RawMaterials, 2022b). Furthermore, in 2023 the EU funded a project named GR4FITE3 to research on a sustainable supply chain for the European graphite and carbon products. It specializes on the lithium-ion- battery industries in Europe, which are used in electric vehicles and energy storage systems for solar and wind farms (European Commission, 2023b).

Cobalt mining and refinery production have been on an upward trajectory, with the Democratic Republic of Congo (DRC) maintaining its position as the foremost source of mined cobalt, contributing approximately 74% of global cobalt production. China, meanwhile, leads in refined cobalt production, approximately 77% (European Commission, 2023e; USGS, 2024a). In the European context, the region in 2021 contributed to approximately 0.8% of world cobalt production (134,000 metric tons) and 9.4% of world refined cobalt production (166,000 metric tons) (European Commission, 2023e). Notably, in 2021, Finland became the leading primary producer of cobalt in Europe, mining 1,084 metric tons of cobalt. Big companies in this sector are Norilsk Nickel and Umicore. Only Norilsk Nickel produces materials for the battery industry (MiNMET, 2021). Furthermore, in the same year, Finland stood out as one of the leading refining centres in Europe, with a 91.7% share of the cobalt refining process, while Belgium contributed the remaining 8.3% (European Commission, 2023e). Despite the relatively minor role of Europe in cobalt production, there are collaborative efforts in the search for extraction prospects, including geological studies in Finland, Norway, Sweden and Greece have identified 104 deposits (see Figure 3), of which 79 are located in Finland, Norway and Sweden (Horn et al., 2021).

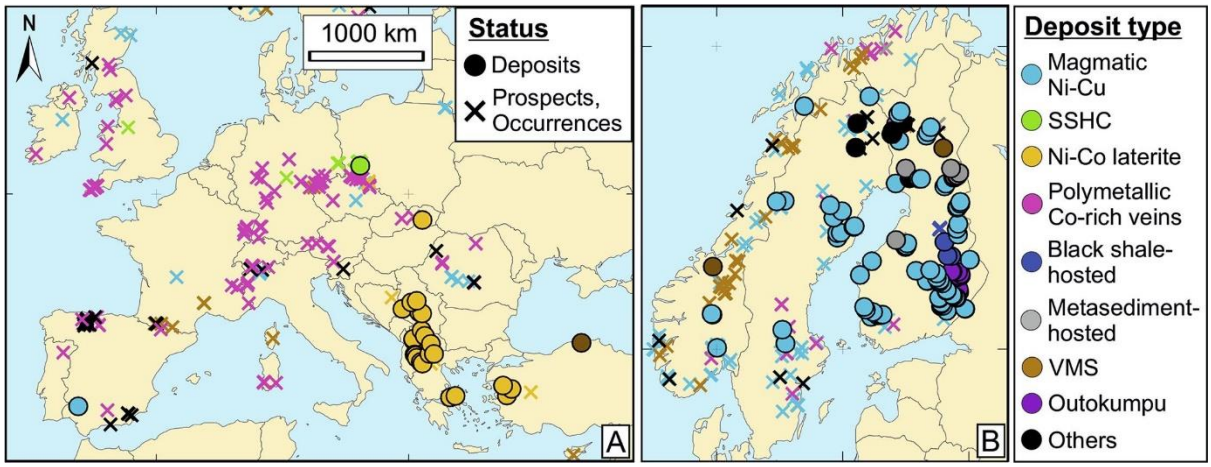

Figure 3: Cobalt deposits and prospects occurrences in Europe. Source: Horn et al. (2021).

Same as for the recycling stage of lithium, there are companies in Europe specialized in recycling cobalt-containing batteries. For example, Umicore in Belgium recycles 7,000 tons of batteries per year (Umicore, 2022).

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Neodymium has gained enormous interest in recent years. The primary global producers are China (62%), Myanmar (14%) and the USA (11%). In 2021 there was a total production of 47,500 ton of Neodymium oxides, which is mainly being used for the magnet industry (98%) (European Commission, 2024a). The strongest permanent magnets are created for electronic devices, wind turbines and electric car motors. While Europe is a leading consumer and manufacturer of these high-tech products, it does not produce neodymium itself. Europe gets his consumption mainly from China (European Commission, 2023g). Nevertheless, exploration projects are currently underway in Sweden, Spain, Germany and Finland (Bye, 2023; European Commission, 2023a; Intitut Für Seltene, 2023; Teivainen, 2023) to mitigate this dependence. In addition, regulations such as the European Commission (2024b) aim to reduce the percentage of a raw material sourced from a single country to 65%, with a particular focus on raw materials such as rare earths, aiming to diversify the sourcing and lessen this dependency. In particular, it is noteworthy that this regulation has a specific chapter to address the issue of magnet recycling.

Regarding the neodymium recycling phase, the EU-funded QUMEC project studied the potential for rare earths recycling in Europe. In particular, they found that neodymium recycling is of great relevance due to the dependence of Europe on imports for its supply. Currently, 80% of neodymium-containing waste is collected with the intention of recycling it. If the European Union recycled all neodymium from urban sources, it could supply about 60% of total consumption (European Commission, 2020a). In addition to this, in 2019, the European Commission funded the SUSMAGPRO project to develop a pilot supply chain from recycled neodymium magnets (SUSMAGPRO, 2023) and published in 2023 a new call relevant to Nd magnets recycling: HORIZON-CL4-2023-RESILIENCE-01-09: Recyclability and resource efficiency of rare earth based magnets (IA) (European Commission, 2023c), where two projects were accepted for funding: MAGELLAN, led by ORANO and HARMONY, led by CEIT. For both projects, started on January 1, 2024. Additionally, in France, there are two companies focused on rare earth recycling: CARESTER and MagREEsource. The former has been conducting chemical studies to recycle elements with potential monetary value (CARESTER, 2024), and the latter is developing new technologies for the recycling process (MagREEsource, 2024).

2 Methodology

The methodology and procedures adopted in the activities of D1.3 are explained in this section. To clarify, the methodology can be divided into two parts. The first part explains the collection of information regarding the current state of interventions for supply chain due diligence. The second part describes all the steps involved in conducting the SWOT analysis.

2.1 State of play

In order to conduct a thorough literature analysis, the information gathering process began with an understanding of the project partners. During the initial general meeting of the consortium, a workshop was organized to gather data on standards, certification schemes, and initiatives related to the tracking and tracing of primary and secondary materials. This information was collected and stored using the MURAL application (https://app.mural.co). Subsequently, scientific reports, public standards, regulations, and initiatives in the field of due diligence and, more specifically, traceability were reviewed to refine the previously gathered data. To improve the understanding of the collected dataset, it was decided to categorize the information into four distinct categories:

- **Frameworks**: A framework is a set of detailed guidelines, recommendations, principles or structures that provide guidance on meeting responsible sourcing expectations and achieving sustainable practices. These translate global or legally binding standards into implementation guidelines for companies or sectors (Kickler et al., 2018). The frameworks serve as a reference to effectively structure primary and secondary raw material due diligence processes.

- **Laws and International Instruments**: Laws and international instruments are legally binding regulations, agreements or standards established by governments or international bodies to govern due diligence activities related to primary and secondary raw materials. This category also includes conventions, which become binding when ratified by countries which then commit themselves to applying the convention in law (Kickler et al., 2018). Countries and organizations must adopt them to protect the environment, respect human rights and ensure responsible sourcing practices.

- **Activities and collaborations**: Activities and collaborations are integral components dedicated to promoting sustainable practices within the supply chain. They encompass a range of actions, initiatives, projects, methods, tools and technologies designed to ensure the efficient and sustainable operation of the entire supply chain, while considering long-term socio-economic and environmental requirements. These efforts aim to mitigate risk, improve transparency, traceability, sustainability and ethical considerations. They often involve collaboration between non-governmental organizations, companies, affected communities, trade unions and other stakeholders to drive positive development impacts and gain a competitive advantage in the marketplace. This category can be classified:

  Initiatives and projects
  The initiatives correspond a set of actions and activities aimed at ensuring the efficient and sustainable functioning of the entire supply chain, considering both socioeconomic and environmental needs. Projects are a series of activities aimed at

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achieving clearly specified objectives within a given timeframe and budget. A project includes: clearly identified stakeholders, including the main target group and the final beneficiaries.

Company Initiative
Company initiatives refer to campaigns or projects to bring about positive changes in their operations, corporate culture, long-term strategies or corporate responsibility. These initiatives are voluntary and may focus on improving supply chain due diligence and implementing sustainability measures. They involve learning from successful companies and measuring results against market leaders.

Technological and chemical Solutions
Technology and chemical solutions refer to strategies, tools, methods and techniques developed to improve supply chain transparency. These solutions encompass advanced approaches such as chemical traceability methods, technology-based traceability solutions and traceability tools.

- **Standards**: A standard is a technical document or set of requirements that serves as a rule, guideline or definition for conducting due diligence activities related to primary and secondary raw materials. These systems develop, revise and/or implement sector or problem-specific standards that set sustainability practices and/or reporting indicators (Kickler et al., 2018), e.g. transparency in the supply chain, promote best practices and improve product safety, quality and sustainability. In general, they also require certification or verification processes, most of which are voluntary.

From the analysis of the information contained in each of the collected documents, it was identified: which part of the supply chain was involved, the central theme of the document, what minerals or products were included, and the target entity or country. Specifically, for the "Activities and Collaborations" category, the Development Level (DL) of the initiative or project was included, classifying the information according to whether it was in the initial stage (I), in Development (D), or Mature (M), indicating whether the project or initiative was established or already completed.

Finally, in addition to describing the information in the previously mentioned categories, the final sections of the literature review summarize the main interventions related to the project and highlight significant interventions focused on traceability within the supply chains of other sectors.

2.2 SWOT analysis

SWOT analysis is one of the best-known analysis methods that provides perspective and can be used to evaluate a new technology or trend (Yontar, 2023). It can be extended in order to provide a framework for deriving strategies based on promising combinations of found strengths, weaknesses, opportunities or threats (Lombriser & Abplanalp, 1998). SWOT analysis highlights how external opportunities can be exploited and weaknesses are minimized, and how the issue can be protected against external threats, given the strengths of the subject under consideration (Gould, 2012).

Based on Yontar (2023) and contextualized to the analysis of standards, the elements of the SWOT analysis express the following meanings:

- **Strengths:** Situations in which the standard is more effective and efficient than its competitors with its capabilities.

- **Weaknesses:** Situations where the standard can or should improve because it is less effective than its competitors.
- **Opportunities:** Favourable conditions for the standard to successfully achieve its objectives. In this context, standards should constantly strive to understand and anticipate the environment in order to comprehend opportunities and benefit from them.
- **Threats:** Negative indicators occurring in the environment that could end the existence of the standard or stop its development, thus requiring measures to be taken.

To perform the SWOT analysis, the first step was to determine the criteria for recognizing strengths and weaknesses, opportunities and threats. Once these criteria were defined, the most important ones were prioritized using the Analytic Hierarchical Process (AHP). Subsequently, a SWOT analysis was performed for each standard. This analysis was primary conducted by reviewing the documentation of each standard and complementary studies such as Kickler & Franken (2017) and Erdmann & Franken (2022). A linguistic analysis was conducted using the LancsBox tool to examine the performance standards, recognizing the complexity of the standards concerning governance, social and environmental criteria. The details are described below.

2.2.1 Prioritization of criteria

To recognise the elements of the SWOT analysis for each standard, the first step was to define the criteria through consultations with three standards experts, as presented below.

The strengths and weaknesses (SW) were identified by examining 6 main categories:

- **SW1 Standard owner and standard:** It includes the analysis of the following subcategories: (SW11) The number of member standard owner; (SW12) Credibility of the standard owner, analysed according to the experience of the standard owner (age); (SW13) ISEAL membership, which guarantees credibility and trust in adhering to social and environmental practices; (SW14) The governance structure, with multi-stakeholder governance guaranteeing balanced and legitimate decisions; (SW15) The mandatory nature of the standards, which ensures efficiency in compliance; (SW16) The consolidation of the standards based on the length of time they have been published; (SW17) Incorporation new topics, indicative of continuous updating; (SW18) The level of stakeholder collaboration during the development and implementation of the standard; (SW19) The renewal period of the standards.
- **SW2 Standard content:** It encompasses the scope of the standards and the specific topics they address. It includes the analysis of the following subcategories: (SW21) Geographical range covered; (SW22) Stages of the supply chain; (SW23) Compliance with sustainability criteria: Governance; (SW24) Compliance with sustainability criteria: Social; (SW25) Compliance with sustainability criteria: Environmental; (SW26) Compliance with sustainability criteria: Economic; (SW27) Data security risks; (SW28) Resistance to share data within; (SW29) Complexity of multi-tier supply.
- **SW3 Documentation and support:** It represent the documentation and support mechanisms provided for the standards. It includes the analysis of the following subcategories: (SW31) Information on management structure, corresponds to the organizational hierarchy and governance of the standard.; (SW32) Guides on how to implement the standards; (SW33) The presence of additional documentation to

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facilitate the adoption of the standard; (SW34) Clarity of documentation, analysed by including definitions and languages; (SW35) Mechanisms for grievances and whistle-blowing; (SW36) Guidelines for information disclosure.

- **SW4 Recognition and conformity:** It reflect the acknowledgment of other standards within the CRMs supply chains, the acceptance of international documents, and compliance with local and global laws. It includes the analysis of the following subcategories: (SW41) The level of mutual linkage with other standards; (SW42) The recognition of the OECD Due Diligence and UN Guiding Principles; (SW43) Conformity with ISO standards; (SW44) Regulatory alignment.
- **SW5 Assurance Process:** Certification and verification encompass features related to the certification and verification process. It includes the analysis of the following subcategories: (SW51) Type of audit (Self-assessment, verification (3er party), verification (3er party) and certification (3er party)); (SW52) The level of verification (Enterprise level without site-specific verification; Enterprise level supported by site specific verification (sample); Site-specific verification); (SW53) The disclosure of audit results; (SW54) The frequency of assurance mechanisms (initial, surveillance, recertification); (SW55) The number of certified companies.
- **SW6 System of traceability:** It encompasses features associated with traceability throughout the supply chain. It includes the analysis of the following subcategories: (SW61) The integration of traceability concepts; (SW62) The information on material control: how the standard deals with inputs; (SW63) The information on material control: Type of accounting methods (Identity preservation, Mass balance, etc.); (SW64) The information on material control: how the standard deals with outputs; (SW65) Documentation to transfer the material; (SW66) The incorporation of technologies for traceability.

The opportunities (O) were identified by examining 8 main categories:

- **O1 Emerging trends:** Latest developments, innovations or changes in the practices of the different sectors within the supply chain that could influence or promote the adoption of new standards.
- **O2 Strategic collaboration:** Partnerships or alliances with other companies, government entities, or non-profit organizations that can facilitate or enhance the implementation of a standard.
- **O3 Growing Demand from Consumers or Investors**: Increasing interest or requirement from consumers or investors for companies to adhere to specific sustainability practices.
- **O4 Scalability:** Opportunities for expanded adoption of the standard.
- **O5 Market Differentiations:** Unique features that differentiate the standard from other standards.
- **O6 Advancement in technologies:** Development and application of new technologies that improve efficiency, sustainability and transparency throughout the supply chain.
- **O7 Development of training programmes or resources:** Educational tools and resources that support the understanding and implementation of a standard.
- **O8 Alignment with corporate social responsibility trends:** Corporate Social Responsibility (CSR) refers to practices that integrate social and environmental concerns in business operations.

The threats (T) were identified by examining 9 main categories:

- **T1 Competition with other standards:** Existence of standards that cover the same minerals and have the same objectives.
- **T2 Changing regulations:** Regulatory or legislative changes that could affect the adoption of the standard.
- **T3 Changes in mineral demand:** Economic risks that could affect the standard, such as fluctuations in mineral prices or changes in market demand.
- **T4 Challenges in sustainability and social responsibility:** Environmental, social or ethical concerns that could negatively influence the perception of the standard.
- **T5 Perceptions:** Company perception of the complexity of the processes they must comply with and the associated costs they must bear.
- **T6 Innovation:** The ability of the standard to remain relevant and effective by adopting the latest technologies and practices.
- **T7 Credibility:** The trust and reliability of the standard, demonstrated through transparency, consistency and effectiveness in meeting its objectives**.**
- **T8 Stability:** Resilience of the standard in the face of geopolitical, economic or industrial challenges.
- **T9 Operational management:** The effectiveness of the standard in ensuring quality control, safe handling and proper management of materials and operations, particularly with regard to hazardous or special care materials.

The next step was the application of the AHP to prioritize the importance of these criteria. AHP is a mathematical method for analysing complex multi-criteria decision problems developed by Saaty (1977, 1980). It allows to intuitively evaluate the relative weight of multiple criteria or options in relation to given criteria. Numerical techniques are then used to derive quantitative values from verbal comparisons. Basically, the results of an AHP analysis are the overall priorities of the decision alternatives (Kurttila et al., 2000).

The idea of using AHP was to systematically evaluate the above criteria and measure their intensities. With this analysis, additional value was achieved by performing pairwise comparisons between criteria to examine more comprehensively which criteria were important to recognize when analysing the standards. Five decision-makers, who were part of the project and had experience in these topics, were surveyed. After making these comparisons, new quantitative information about the decision-making situation was obtained, such as whether there was a specific criterion that required full attention when comparing the standards with each other. In case you need more details about the method, check out Saaty (1977, 1980).

Finally, once the criteria had been prioritized, a SWOT analysis was performed for each standard, focusing on the most important criteria.

2.2.2 Assessment of sustainability criteria

Most of the standards analysed consist of two main types: Performance Standard and Chain of Custody. In general, the Performance Standard covers the sustainability criteria and requirements that companies must follow. To analyse the compliance of the standards with sustainability criteria, issues and sub-issues were selected based on the review by Kickler & Franken (2017) and GRI (2024), where key topics were defined for each sustainability

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component (governance, social and environmental). The issues and sub-issues (see Appendix 8.1 tables 49, 50 and 51) can be applied to all standards at all stages of the supply chain they address. Particularly for standards that address the extraction stage of the supply chain, special sub-issues were selected.

The analysis was conducted by evaluating only the primary documents of each standard, thus excluding guidance notes, audit guidelines, and other supplementary documents. Therefore, the evaluation might present a different picture if secondary documents are also included or, especially, if compliance and on-the-ground impact are investigated.

The LancsBox tool version 6 (Brezina et al., 2015), a corpus analysis tool developed by Lancaster University, was used to explore, analyse, and visualize linguistic data, allowing work with large text sets (corpora) to identify patterns, collocations, frequencies, and perform advanced statistical text analysis. To simplify the analysis, one parameter provided by the program was analysed: frequency, to study the attention that the standards give to these issues and sub-issues. It should be noted that the approach used does not consider the quality of text passages (e.g., redundant or extensive writing style) and that the absence of an issue or sub-issue does not mean that the standard does not address those topics.

3 State of play: Current interventions for supply chain due diligence

Due diligence is a process that aims to ensure the extraction and trade of raw materials along supply chains come from responsible sources, avoiding illegal, conflict-related, and/or environmentally harmful sources. This process is of utmost importance due to the multiple risks associated with mineral extraction and trade, such as financing armed conflicts, labour exploitation, environmental degradation, and violations of the rights of local communities.

Over time, the significance of due diligence in the mineral supply chain has grown significantly. This is reflected in the evolution of various initiatives, regulations, standards, and diligence frameworks focused on managing risks related to mineral extraction and trade, corporate social responsibility, and transparency. In the latter aspect, new techniques for tracking and tracing critical minerals have been developed, along with the incorporation of technologies to provide clear and verifiable information about the origin and production conditions of minerals.

Furthermore, due diligence is encouraged through the development of interventions, which are actions or processes that promote due diligence in a supply chain. Such interventions are developed in the form of instruments at industry and policy levels, for example, by developing frameworks, laws and international instruments, standards, and initiatives (see Figure 4). This section will explore four types of due diligence interventions, which are also emphasized in Section two. Additionally, it highlights which interventions are related to the project concerning critical raw materials and the minerals used, and incorporates traceability interventions from other sectors.

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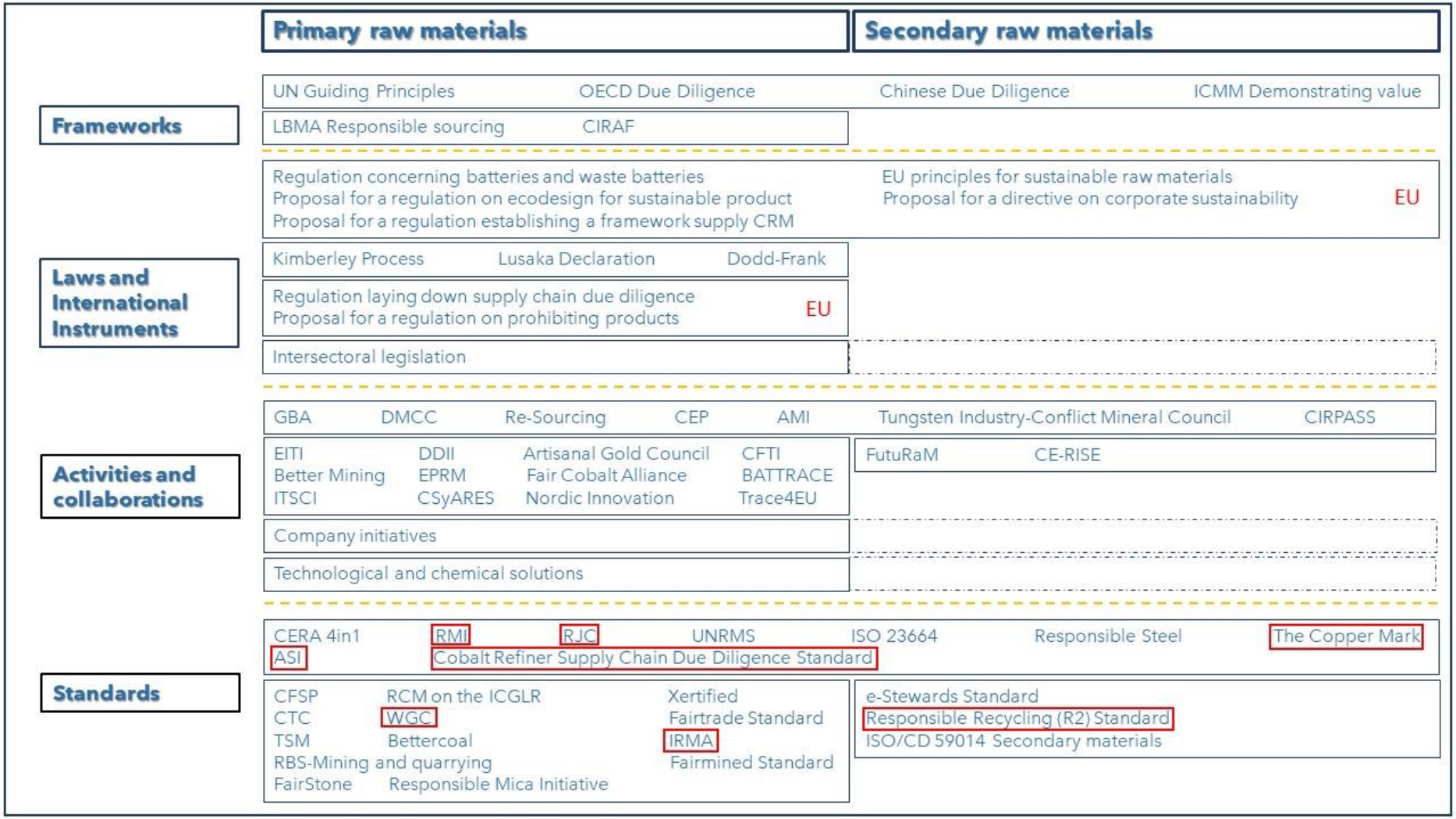

Figure 4: Current interventions for due diligence in supply chains. The red rectangles indicate the standards to be used for SWOT analysis.

3.1 Frameworks

Table 1 presents a summary of the supply chain related frameworks.

Frameworks	Year	Part of supply chain	Focus	Minerals / Products included	Scope
UN Guiding Principles on Business and Human Rights	2011*	Overall	Human Rights	Overall	Company
ICMM Demonstrating value - A guide to responsible sourcing	2015*	Overall	Responsible Sourcing	Overall	Company
Chinese Due Diligence Guidelines for Responsible Mineral Supply Chains	2022**	Overall	Responsible Sourcing	Overall	Country (China)
LBMA Responsible Sourcing Programme	2022**	Overall	Conflict minerals	Gold and Silver	Refiners
OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (CAHRAs)	2016**	Primary	Conflict minerals	Overall, with specific information for Tin, Tantalum, Tungsten and Gold (3TG)	Company
CIRAF	2019*	Primary	Responsible sourcing	Cobalt	Industry

Table 1: Overview frameworks. *Launching year; **Latest update.

The following sections describe in more detail documents just mentioned.

3.1.1 UN Guiding Principles on Business and Human Rights

This framework encompasses the "Guiding Principles on Business and Human Rights," established by the United Nations (UN), with the aim of protecting, respecting, and remedying human rights. They apply to all companies, including both transnational and other types of companies, regardless of their size, sector, location, ownership, or structure.

Guiding principles on business and human rights are classified into foundational and operational categories, encompassing the following (UN Human Rights Office of the High Commissioner (OHCHR), 2011): (a) The State duty to protect human rights; (b) The corporate responsibility to respect human rights; (c) Access to remedy. Within the first category, foundational principles are based on the State's role in protecting against human rights violations committed within its territory by third-parties, including companies, and in establishing the expectations from all companies operating within its jurisdiction regarding human rights. The operational principles outline the obligations that the State must fulfil and its supervisory role in meeting its international human rights obligations. Additionally, the State must promote respect for human rights by businesses operating in conflict-affected areas and ensure policy coherence.

In the second category, the foundational principles state that companies must respect human rights by establishing requirements, policies, and appropriate procedures to achieve this goal. The operational principles emphasize that companies should express their policy commitments and conduct due diligence on human rights, which includes assessing adverse impacts. If companies identify that they have caused adverse impacts, they must remedy or contribute to their remediation.

In the third category, the foundational principles establish that States should guarantee affected individuals' access to effective remedy mechanisms. Furthermore, the operational principles require States to establish and ensure the effectiveness of state judicial mechanisms, non-judicial state-based grievance mechanisms, and non-state grievance mechanisms. To ensure the aforementioned, these mechanisms must be legitimate, accessible, predictable, equitable, transparent, compatible with human rights, and a source of continuous learning.

3.1.2 OECD[3] Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas

The OECD Due Diligence Guidance provides guidelines to companies that are required to file a conflict mineral report under the document "Final rule conflict mineral." The objective is to assist these companies in upholding human rights, avoiding contributing to conflict, human rights abuses, and insecurity resulting from their mineral sourcing practices. Additionally, the framework seeks to foster transparent mineral supply chains and promote sustainable corporate engagement in the mineral sector. It suggests that the companies identify the factual circumstances surrounding the extraction, transport, handling, trading, processing, smelting, refining, alloying, manufacturing, or selling of products containing minerals originating from CAHRAs.

This document presents a model mineral supply chain policy, encompassing a set of principles, suggested risk mitigation measures, and indicators for measuring progress. Two supplements focusing on tin, tantalum, tungsten, and gold are included. These supplements offer specific due diligence recommendations tailored to the diverse positions and roles companies may hold within their supply chain structure for these minerals. In particular, the strategy encourages companies to integrate these guidelines into their management systems (see Figure 5).

Regarding traceability and CoC issues, Step 1C outlines requirements to ensure existing due diligence. This includes implementing an internal control system over the minerals in their possession, ensuring CoC or traceability. The framework establishes specific recommendations for various entities, such as local mineral exporters, international concentrate traders, mineral re-processors, smelters, refiners, and all upstream companies. These entities are advised to collect and disclose information pertaining to the mine of mineral origin, quantity and extraction dates, extraction methods, locations where minerals are consolidated, transportation routes, trade or processing, recording all payments and identification of all actors involved, among other key aspects.

[3] Third edition.

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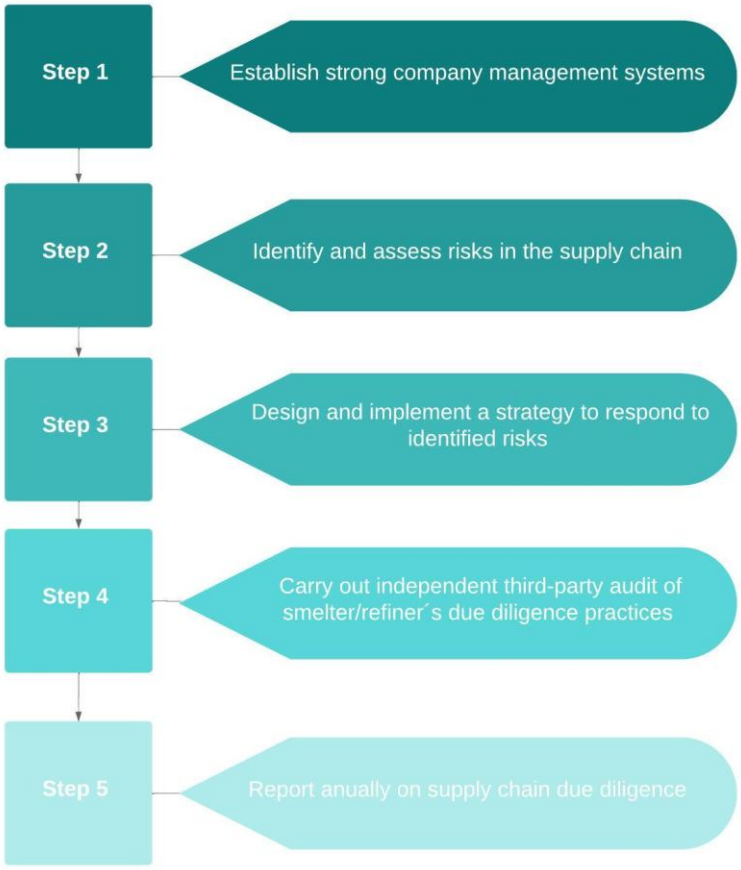

Figure 5: Five-step framework for risk-based due diligence in the mineral supply chain. Based on OECD (2016).

3.1.3 Chinese Due Diligence Guidelines for Responsible Mineral Supply Chains

The objective of this document is to help companies to understand the characteristics of due diligence with consideration of the context of their own business, and flexibly adjust the specific measures and processes of due diligence (CCCMC, 2022). By adopting these Chinese Guidelines, companies can achieve a range of benefits. They will be better positioned to align with the requirements and expectations of customers and markets that demand responsibly sourced minerals. This adoption also enhances their supply chain management systems, increasing awareness and control over potential risks in mineral sourcing. Furthermore, it improves the transparency and stability of the mineral supply chains of the company, which in turn can boost its international reputation and market recognition. Additionally, the guidelines help to reduce disruptions caused by conflicts and weak governance impacting the supply chain, and provide essential guidance for non-mineral natural resource companies that are looking to conduct supply chain due diligence.

The Chinese Due Diligence Guidelines are based on the UN Guiding Principles on Business and Human Rights[4] and the OECD Due Diligence and are intended to promote relevant standards, regulations, and initiatives. As a result, the suggested approach for due diligence consists of six steps: Step 1: Establishing a corporate due diligence system; Step 2: Risk

[4] United Nations Human Rights Office of the High Commissioner (OHCHR) (2011).

identification and assessment; Step 3: Risk prevention and mitigation; Step 4: Internal and external assessment; Step 5: Reporting and dissemination and Step 6: Providing for or cooperating in remediation when appropriate.

Concerning traceability issues, the document highlights several chapters where it is mentioned that in the presence of red flags, there should be collaboration between upstream and downstream companies to share information about their chains of custody. Additionally, in the context of establishing an internal supply chain management system, it is noted that companies should implement a chain of custody and/or traceability system. Furthermore, in the context of artisanal and small-scale miners, the introduction of robust chain of custody or traceability systems is recommended to progressively collect and maintain information about each shipment of gold from different mine.

3.1.4ICMM Demonstrating value - A guide to responsible sourcing

ICMM Demonstrating value is a framework for sustainable development aims to assist ICMM (International Council on Mining & Metals) members in developing or enhancing their governance structures, business practices, and standards. These improvements are essential for effective participation in responsible supply initiatives and the execution of Sustainable Procurement (SP) programs. This framework stands as a leading example of how an industry can define and uphold its responsibilities. By adhering to the assurance requirements, ICMM members can showcase their effective management of environmental and social responsibilities and provide direction on working with others in the minerals and metals value chain to ensure long-term societal benefits from these materials. The framework sets out a set of sustainability principles for ICMM members to follow (see Table 2).

N°	Principles
1	Apply ethical business practices and sound systems of corporate governance and transparency in support of sustainable development
2	Integrate sustainable development considerations within corporate strategy and decision-making processes
3	Respect human rights and the interests, cultures, customs and values of employees and others affected by our activities
4	Implement effective risk management strategies and systems which are based on sound science and account for stakeholder perceptions of risks
5	Pursue zero harm and continual improvement in our health and safety performance
6	Pursue continual improvement in our environmental performance, on issues such as water stewardship and energy and climate change
7	Contribute to the conservation of biodiversity and integrated approaches to land use planning
8	Facilitate and support the knowledge-base and systems for responsible design, use, re-use, recycling and disposal of products containing metals and minerals
9	Pursue continual improvement in social performance and contribute to the social, economic and institutional development of host countries and communities
10	Proactively engage key stakeholders on sustainable development challenges and opportunities in an open and transparent manner and effectively report and independently verify progress and performance

Table 2: The ten sustainable development principles of the ICMM. Source: ICMM (2015).

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The document is organised around four main themes and their associated actions: 1. Mapping the value chain; 2. Developing effective programs and standards; 3. Engagement with suppliers and the value chain; and 4. Data and information.

Traceability issues are addressed in topics one and two, which refer to the actions that ICMM members should consider in developing SP programs. In theme one, the significance of comprehending the complete value chain of products is highlighted to identify opportunities for improvement. Therefore, knowledge of traceability and Chain of Custody (CoC) is crucial for existing SP. This section emphasizes collecting information and provides an example of traceability through Valcambi, owner of Global Gold Refineries Ltd (Valcambi, 2023b). In 2013, Valcambi became the first gold refinery to produce traceable gold, known as Valcambi Green Gold (ICMM, 2015), sourced exclusively from mines that adhere to high environmental, safety, and human rights standards. In theme two, specific guidance is provided for the establishment or enhancement of SP programs, including the setting of appropriate standards aligned with Track Record Global (TRG). According to TRG, a responsible sourcing program should incorporate both Traceability and CoC, ensuring a transparent and independently verifiable CoC between the source and the end market.

3.1.5 LBMA Responsible Sourcing Programme[5]

The Responsible Sourcing Programme (RSP), designed by London Bullion Market Association (LBMA), aims to ensure the continuous improvement of responsible sourcing business practices. The Guidance provides greater alignment with the OECD Due Diligence Guidance Step five reporting requirements and, in instances, goes beyond this to encourage more transparent and meaningful communication by Refiners (LBMA, 2022):

The objective is to provide support Good Delivery List (GDL) refiners in effectively implementing the reporting and disclosure requirements specified by the program. To achieve this, it is essential to establish a comprehensive Disclosure Framework (see Figure 6). This framework consists of three components: a compliance report, subject to an annual third-party audit; Country of origin Annex, is also subject to the annual third-party assurance and it is not a report that is required to be made public; and Ongoing Disclosure, where refiners must adopt disclosure practices that reflect the continuous nature of due diligence efforts.

Regarding T&T matters, the list of requirements for refiners that refiners must demonstrate compliances with the Responsible Sourcing Guidelines and establish a robust internal system of due diligence and transparency controls over precious metals supply chains, including traceability and identification of other actors in the supply chain. In addition, refiners have until December 31, 2023 to comply with the following requirements (LBMA, 2022):

1. List of gold sources by country and by type of material obtained, and related information.
2. Total gold obtained by type of material (ASGM, ASM, recycled gold, protected stocks) in the reporting period.
3. The identity of the refiner and local exporter must always be disclosed, if they are located in high-risk locations, except in cases of de-linking.

[5] Based on LBMA (2020).

When comparing the current guidance with the 2020 version, an advance in terms of traceability can be noted, where the current guidance asks refiners for higher requirements in terms of "proof of origin" for them to demonstrate due diligence practices.

Figure 6: Disclosure framework. Source: LBMA (2022).

3.1.6 CIRAF

CIRAF (Cobalt Industry Responsible Assessment Framework) is a management framework designed for all companies whether or not they are producing and/or sourcing from high-risk countries (Cobalt Institute, 2019). This framework aims to coordinate the due diligence activities carried out by companies across the cobalt industry to demonstrate best practices and satisfy the demands of civil society.

As a fundamental requirement, participants must secure third-party assurance of their policy and due diligence management system concerning human rights. Additionally, participants must make public a summary of the risk assessment, provide documentation illustrating the implementation of a policy and due diligence management system to address identified risks, and demonstrate the application of existing responsible production and sourcing standards.

The benefits offered by CIRAF are: 1. Strengthens the ability of cobalt producers and buyers to assess, mitigate, and report on responsible production and sourcing risks in their operations; 2. Enable a more coherent and consistent approach to cobalt due diligence and reporting by the cobalt industry; and 3. Allow participants to demonstrate that they are aligned with global good practice on responsible production and sourcing (Cobalt Institute, 2019).

3.2 Laws and International Instruments

The following section describes laws and international instruments with a focus on the EU (European Union) and China, followed by relevant cross-sectoral legislations and international instruments.

3.2.1 Legislation for mineral supply chains

Table 3 presents a summary of the supply chain related legislation.

Laws and international instruments	Year	Part of supply chain	Focus	Minerals / Products included	Scope
Chinese Interim measures New Energy Vehicle Power Battery	2018	Overall	Batteries	Overall	China

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Regulation concerning batteries and waste batteries	2020	Overall	Batteries	Copper, Cobalt, Lithium and Lead	EU
EU principles for sustainable raw materials	2021	Overall	Sustainable raw materials	Overall	EU
Proposal for a Regulation on Ecodesign for Sustainable Product Regulations	2022	Overall	Ecodesign	Overall	EU
Proposal for a Directive on Corporate Sustainability Due Diligence	2022	Overall	Due Diligence	Overall	EU
Regulation establishing a framework for ensuring a secure and sustainable supply of critical raw materials	2024	Overall	CRMs	2020 List of CRMs[6]	EU
Kimberley Process	2003	Primary	Conflict minerals	Diamonds	Global
Lusaka Declaration of the International Conference on the Great Lakes Region	2010	Primary	Conflict Minerals	Gold, Colombo-Tantalite, Wolframite and Cassiterite	Great lakes region
Dodd-Frank Wall Street reform and consumer protection act	2010	Primary	Responsible sourcing	3TG	USA
Regulation laying down supply chain due diligence for Union importers	2017	Primary	Conflict minerals	3TG	EU
Proposal for a Regulation on prohibiting products made with forced labour	2022	Primary	Forced labour	Overall	EU

Table 3: Overview legislation for mineral supply chain.

The following sections describe in more detail some of the documents just mentioned and Figure 7 show how each regulation connects or alludes to the other regulations with each other.

3.2.1.1 Regulation of the European Parliament and of the Council concerning batteries and waste batteries

Regulation on batteries and waste batteries approved by the European Commission in 2023. This regulation aims to enhance market efficiency while ensuring the sustainability of

[6] 2020 List of CRMs.

batteries throughout their entire lifecycle. It also seeks to prevent and reduce the adverse environmental and human health impacts associated with batteries. The regulation sets forth requirements regarding sustainability, safety, labelling, marking, and information to facilitate battery marketing. Additionally, it establishes minimum requirements for producer responsibility, battery collection, and treatment of battery waste. Furthermore, it imposes due diligence rules and outlines requirements for eco-friendly public procurement when purchasing batteries or products containing batteries (European Commission, 2023d).

This regulation applies to all categories of batteries: portable batteries, starter batteries, ignition and lighting (SLI) batteries, light means of transport (LMT) batteries, electric vehicle batteries, and industrial batteries, irrespective of their shape, volume, weight, design, material composition, use, or purpose. It also encompasses batteries incorporated into or added to other products.

Economic actors in the EU market are required to adopt and communicate a supply chain management policy. They must identify, manage, and mitigate social and environmental risks and maintain documentation attesting to compliance with due diligence obligations, which should be verified by a third-party. Furthermore, it is imperative to ensure traceability of batteries throughout the supply chain, either through a chain of custody or tracking system or by identifying previous participants in the supply chain. This approach simplifies the work of market surveillance authorities when investigating those responsible for marketing, placing on the market, or putting into service non-compliant batteries.

3.2.1.2 EU principles for sustainable raw materials[7]

In 2021, the European Commission, in collaboration with the raw material supply chain group, has developed and agreed upon a set of voluntary, non-mandatory EU principles for sustainable practices. The objective is to establish a common understanding of sustainable raw materials extraction (from exploration to post-closure) and processing operations among Member States, while also aligning with the general direction of the Sustainable Development Goals (SDGs). These principles seek to promote coherence among emerging certification and labelling schemes, while recognizing existing practices, codes, and standards. Moreover, they aim to enhance public acceptance by facilitating better communication with the public about the conditions under which sustainable raw materials extraction and processing take place in Europe.

The EU principles for sustainable raw materials are structured around three key aspects: 1) Social, which addresses concepts such as human rights, engagement with communities of interest, employment, health, and safety; 2) Economic and Governance, focusing on concepts like business integrity, transparency, and wider economic contribution; and 3) Environmental, which encompasses concepts related to environmental management and impact mitigation. These principles apply within the EU context to the extraction and processing stages of non-energy raw materials and cover the entire lifecycle of mineral value chains, from exploration to post-closure. Additionally, they are relevant to the production of secondary raw materials derived from extractive waste streams, such as waste rocks and processing wastes.

3.2.1.3 Proposal for a Regulation on Ecodesign for Sustainable Product Regulations (ESPR)

The ESPR regulation was published by the European Commission in 2022. The main objective is to reduce the negative life cycle environmental impacts of products and

[7] Based on European Commission (2021b).

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improve the functioning of the internal market, while benefiting from efficient digital solutions (European Commission, 2022b). This regulation is intended to expand the scope of the Ecodesign Directive to encompass a broader range of products and new types of requirements. Consequently, for legal clarity, the Ecodesign Directive should be repealed.

The ecodesign requirements, to be further developed by the Commission, will comprehensively address all stages of the life cycle of products. The primary focus is on enhancing various aspects, such as durability, reliability, reusability, upgradability, reparability, maintenance and refurbishment, capabilities, the presence of substances of concern, energy use or energy efficiency, resource use or resource efficiency, recycled content, potential for remanufacturing and recycling, and the possibility of recovering materials. Moreover, the requirements will encompass environmental impacts, including carbon and environmental footprints, as well as the expected of waste materials.

The Commission shall provide ecodesign requirements that shall include, where appropriate (European Commission, 2022b):

1. Performance requirements based on parameters such as durability and reliability, ease of repair and maintenance, upgrading, reuse, remanufacturing and reconditioning, recycling, use of substances, energy consumption, water and resource usage, content of recycled materials, environmental footprint of the product, and conditions of use, among others.
2. Information requirements, encompassing product passport (a tool for making information available to actors along the entire value chain) and information related to substances of concern. They shall include information related to product performance, information for consumers, information for treatment facilities on disassembly, and other relevant information that may impact the way the product is treated.

To ensure transparency, products introduced to the market will require a product passport that fulfils the following conditions (European Commission, 2022b):

(i) The product passport must be linked to a unique product identifier through a data carrier.

(ii) The data carrier shall be physically present on the product, its packaging, or the accompanying documentation.

(iii) The data carrier and the unique product identifier shall comply with standard ("ISO/IEC") 15459:2015;

(iv) All information contained in the product passport shall be based on open standards, machine-readable, structured, and searchable in an interoperable format.

(v) The information contained in the product passport shall relate to the product model, lot or article, as specified.

(vi) Access to the information contained in the product passport shall be regulated.

An advancement in comparison to the 2009 Directive is the inclusion of transparency aspects involving T&T concepts.

3.2.1.4 Proposal for a Directive of the European Parliament and of the Council on Corporate Sustainability Due Diligence

Proposal for a directive on Corporate Sustainability Due Diligence (CSDD) was presented by the European Commission in 2022. By integrating human rights and environmental concerns into business operations and corporate governance, the goal is to promote sustainable and responsible corporate behaviour. This proposal is expected to yield significant benefits for citizens, companies, and developing countries. For citizens, the benefits include enhanced protection of human rights, including labour rights, a healthier environment, increased trust in businesses, greater transparency, and improved access to justice. For companies, advantages encompass a harmonized legal framework within the EU, heightened customer trust and employee commitment, better awareness of their negative environmental and human rights impacts, improved risk management and adaptability, and increased access to finance. Moreover, developing countries stand to benefit from the adoption of international standards by improving the protection of human rights and the environment, raising stakeholder awareness of important sustainability issues, increasing sustainability investment, improving sustainability-related practices, and improving living conditions for their citizens. It is important to note that this directive promotes the OECD Guidelines for Multinational Enterprises (OECD, 2023), including the advancement of relevant due diligence standards.

Regarding due diligence in supply chains, companies are required to apply it not only to their own business activities but also to direct and indirect suppliers. The key steps for companies to establish due diligence along the supply chain include (European Commission, 2022a):

1. Integrating due diligence into their policies and effectively controlling and monitoring its implementation.
2. Identifying actual or potential adverse impacts and implementing appropriate measures to prevent, mitigate, or remediate them.
3. Establishing and maintaining an accessible complaints procedure for all stakeholders along the supply chain.
4. Ensuring transparent and public communication regarding their due diligence practices.

The proposed rules will apply to different categories of companies:

(i) Large EU limited companies: It includes companies operating in specified high impact sectors, such as textiles, agriculture, and mineral extraction with about 500 employees and a worldwide net turnover of more than EUR 150 million in the most recent fiscal year. It also includes businesses with about 250 employees and worldwide net turnover of more than EUR 40 million. A two-year transitioning period will be given to the latter group of companies.

(ii) Non-EU companies: Third-country companies active in the EU with turnover thresholds aligned with Groups one and two, generated within the EU.

(iii) Micro companies and Small and Medium-sized Enterprises (SMEs): They are not going to be directly impacted. However, they may feel an indirect impact because the proposal provides supporting measures for SMEs.

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The trialogue phase (involving the three EU legislative institutions) to discuss the document has been concluded. The next step is to work the agreement into the legal text of the Directive at a technical level. Subsequently, the text must receive formal approval from the European Parliament and its Legal Affairs Committee, as well as from the EU Council, after which it can enter into force. The text of the Directive is expected to be available in 2024, at which time the EU will provide another update.

3.2.1.5 Regulation of the European Parliament and of the Council establishing a framework for ensuring a secure and sustainable supply of critical raw materials

The EU Regulation adopted on April 11, 2024 and entered into force on May 23, 2024. This regulation aims to improve the functioning of the internal market by establishing a framework to ensure the Union's access to a secure, resilient and sustainable supply of critical raw materials, including by fostering efficiency and circularity throughout the value chain (European Commission, 2024b).

To achieve the general objective, the regulation lays down measures aiming to (European Commission, 2024b):

1. Reducing the risk of supply disruptions related to critical raw materials that may distort competition and fragment the internal market.
2. Improving the Union's capacity to monitor and mitigate the supply risk related to critical raw materials.
3. To ensure the free movement of critical raw materials and products containing critical raw materials placed on the Union market.

The EU regulation also emphasizes enhancing the Union's monitoring capabilities to foresee and mitigate supply risks associated with critical raw materials. It seeks to support the free movement of these materials within the Union market, ensuring stable and fair access for all Member States. Additionally, the regulation includes measures to bolster recycling and circular economy practices, aiming to reduce dependency on primary raw materials by increasing the use of secondary sources. It highlights the importance of coordinated actions among Member States to avoid market distortions and ensure competitive equality across the Union.

3.2.1.6 Regulation of the European Parliament and of the Council laying down supply chain due diligence for Union importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas[8]

The EU Regulation, created in 2017, establishes the supply chain due diligence obligations for EU importers of tin, tantalum, tungsten, their ores, and gold. Its primary aim is to reduce opportunities for armed groups and security forces to trade in these minerals. This challenge has brought together governments, international organizations, economic operators, and civil society organizations, including women's organizations to address the exploitative conditions imposed by these groups and forces.

[8] Based on European Union (2017).

Regarding T&T, the regulation recognizes the crucial role of smelters and refiners in global mineral supply chains. These entities are typically the last stage where effective due diligence can be assured by collecting, disclosing, and verify the information on the origin of the mineral and the CoC. Once the minerals reach this stage, tracing their origins often becomes unfeasible.

As part of their management system obligations, EU metal importers are advised to operate a CoC or supply chain traceability system, providing the following information:

1. Name and address of the smelters and refiners in the supply chain of the Union Importer.
2. If available, records of third-party audit reports of the smelters and refiners or evidence of conformity with a supply chain due diligence scheme. If this information is not available, the countries of origin of minerals in the supply chain of smelters and refiners should be provided.

Additionally, the CoC or supply chain traceability must include the following information: a description of the mineral or metal, including its trade name and type; the name and address of the supplier to the Union importer; the country of origin of the minerals; and quantities and dates of extraction, if available, expressed in volume or weight. Ensuring the availability of this information helps to promote transparency and responsible sourcing practices throughout the supply chain.

3.2.1.7 Proposal for a Regulation on the European Parliament and of the Council on prohibiting products made with forced labour on the Union market

The international community has made a commitment to eradicate forced labour by 2030[9]. In this context, a proposal for regulation, created in 2022, prohibiting products made with forced labour has been developed. The objective of this proposal is to effectively prohibit the placing and making available on the EU market and the export from the EU of products made with forced labour, including forced child labour (European Commission, 2022c).

To achieve this goal, products entering and leaving the EU market must be subject to controls and measures. These measures include providing information to customs authorities regarding the characteristics of the products, the manufacturer or producer, and information about the product suppliers. If a product fails to meet the required standards, the authorities shall suspend its release for free circulation or its export from the EU.

To ensure the effectiveness of controls and to adopt a risk-based approach, competent authorities and customs authorities should cooperate closely and exchange information related to product risk. This collaborative effort will enhance the ability to identify and prevent products made with forced labour from entering or leaving the Union market. By implementing these measures, the EU aims to contribute to the global effort to combat forced labour and protect human rights.

[9] The Sustainable Develop goals (SDG) 8 Decent Work and Economic Growth mentions in target 8.7: Take immediate and effective measures to eradicate forced labour, and modern slavery and human trafficking.

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3.2.1.8 Dodd-Frank Wall Street Reform and Consumer Protection Act[10]

The Dodd-Frank Act, passed by the Obama administration in 2010 and enforced by the Securities and Exchange Commission (SEC), aims to improve corporate accountability and transparency and establish specialized disclosure provisions for the responsible sourcing of minerals. For this, companies must provide accurate and complete information about their financial activities and operations, fostering investor confidence and protecting consumers from unfair and deceptive practices.

Section 1502 of the Act specifically addresses certain minerals classified as "conflict minerals", i.e., tin, tantalum, and tungsten, their ores, and gold, to prevent armed groups in the DRC and surrounding regions from benefiting from the sale of these minerals. According to the law, public companies in the United States (US) must disclose whether they use these minerals in their products and determine if they are sourced ethically. If the product originates from the DRC or an adjoining country, the company must provide a Conflict Mineral Report audited by an independent private auditor. This report must describe the due diligence measures undertaken, such as identifying the facilities used for the production of conflict minerals, their country of origin, and the CoC of 3TG minerals.

It is crucial to highlight other sections of the Act as well. For instance, in 2011, the SEC adopted Mine Safety Disclosure rules under Section 1503, requiring mine operators to disclose any violations, orders, or citations received from the Mine Safety and Health Administration.

3.2.1.9 Chinese Interim Measures for the Management of Recovery and Utilization of New Energy Vehicle Power Battery[11]

In 2018, the Chinese Ministry of Information and Industry Technology (MIIT) issued a regulation with the objective of enhancing the management of electric vehicle power battery recycling and utilization. The regulation also emphasizes the promotion of comprehensive resource utilization and the protection of public safety. The measures suggested by this regulation are applicable to power batteries within the territory of the People's Republic of China.

In terms of design, production, recycling and manufacturers are required to create components that are easily disassembled, thus facilitating recycling processes. Additionally, manufacturers must provide technical information to subsequent users, particularly automobile manufacturers, to assist them in the disassembly and proper storage of power batteries. Moreover, automobile manufacturers must actively disclose information, including the type of power battery used, the content of toxic and hazardous components, and the recycling measures. It is essential that all recycling activities adhere to relevant national laws, regulations, and standards.

To foster closer cooperation between battery and automobile manufacturers, the regulation proposes the establishment of "the Integrated Management Platform for the National Monitoring of New Energy Vehicles and Traceability of Power Battery Recycling". This platform aims to facilitate information sharing concerning battery production, sales, usage, end-of-life, recycling, and utilization.

[10] Based on U.S. Congress (2010).
[11] Based on Ministry of Industry and Information Technology (2018).

3.2.1.10 The Kimberley Process[12]

The Kimberley Process (KP) is a multilateral trade regime that was developed in 2003 with the objective of eradicating conflict diamonds from the global supply chain while safeguarding legitimate trade in rough diamonds. The KP lacks a permanent staff and office space in contrast to a worldwide organization. Instead, it is based on the "burden sharing" approach, in which people make contributions and get assistance from business and civil society. The implementation of the KP occurs through the national legislative efforts of its participants.

The inception of the KP dates back to a meeting in Kimberley, South Africa, in May 2000, where Southern African diamond-producing states convened to address the issue of "conflict diamonds" and ensure that diamond sales do not fund armed rebellions. Currently, the KP boasts 59 participants representing 85 countries, with the European Community as a single participant. Together, they are responsible for regulating 99.8% of global conflict diamond production. The participants encompass all major rough diamond-producing, exporting, and importing countries. Additionally, the diamond industry, represented by the World Diamond Council, and civil society groups play integral roles within the KP.

At the heart of this regime lies the Kimberley Process Certification Scheme (KPCS), which mandates that states implement safeguards on shipments of rough diamonds and certify them as "conflict free". Participants in the KPCS must fulfil the following requirements:

1. Satisfy "minimum requirements" and establish national legislation, institutions, and import/export controls.
2. Commit to transparent practices and the exchange of critical statistical data.
3. Trade only with fellow members who also satisfy the fundamentals of the agreements.
4. Certify shipments as conflict-free and provide the supporting certification.

3.2.1.11 Lusaka Declaration of the International Conference on the Great Lakes Region (ICGLR)

The Lusaka Declaration was signed by the Heads of State and Government on December 15th, 2010. They made a commitment to combat the illegal exploitation of natural resources through national, regional, and international legal means. In addition to this commitment, they approved six tools that were developed under the Regional Initiative against the Illegal Exploitation of Natural Resources (RINR) and pledged to adopt the ICGLR Protocol on the Illegal Exploitation of Natural Resources in the Great Lakes Region. These six tools are as follows (ICGLR, 2010):

1. Regional Certification Mechanism
2. Harmonization of national Legislation
3. Regional Database on Mineral Flows
4. Formalization of the Artisanal Mining Sector
5. Promotion of the Extractive Industry Transparency Initiative
6. Whistle Blowing Mechanism

It is essential to highlight that the Lusaka Declaration supports the OECD Due Diligence Guide as a fundamental element of the Regional Initiative on the Fight against Illegal

[12] Based on Kimberley Process (2003).

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Exploitation of Natural Resources. Furthermore, it calls upon companies that procure minerals from the Great Lakes region to comply with the six aforementioned tools.

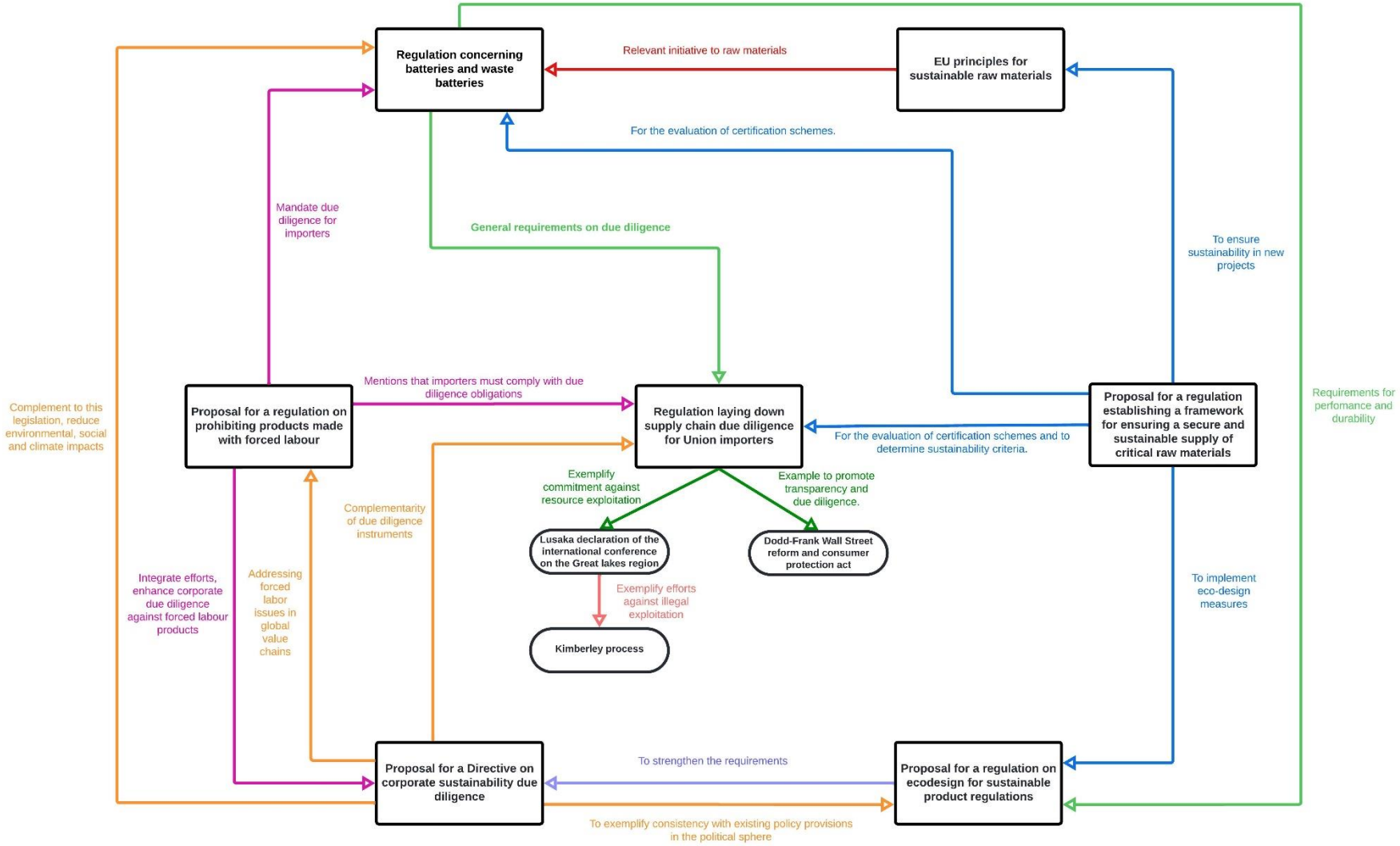

Figure 7: This diagram illustrates how various regulations refer to each other. The arrows indicate that the originating regulation mentions the regulation pointed to by the arrowhead. Colour coding helps to avoid confusion by distinguishing the different regulations mentioned above.

3.2.2 Intersectoral legislation

Table 4 presents a summary of the supply chain related intersectoral legislation.

Intersectoral legislation	Year	Part of supply chain	Focus	Minerals / Products included	Geographical scope
RBC – Responsible Gold Agreement[13]	2017	Overall	Responsible sourcing	Gold	Netherlands
IRBC agreements for the metals sector[14]	2019	Overall	Responsible business conduct	Overall	Netherlands
The California Transparency in supply Act[15]	2010	Primary	Human trafficking and slavery	Overall	US (California)
ESTMA[16]	2014	Primary	Transparency	Overall	Canada
Modern Slavery 2015[17]	2015	Primary	Modern Slavery	Overall	UK
Law of Vigilance[18]	2017	Primary	Human rights abuses	Overall	France
Modern Slavery Act 2018[19]	2018	Primary	Modern Slavery	Overall	Australia
CORE[20]	2019	Primary	Human rights abuses	Overall	Canada
The Swiss RBI[21]	2021	Primary	Human rights and environmental protection	Overall	Switzerland
Belgian proposal on Duty of Vigilance[22]	2021	Primary	Supply chain	Overall	Belgium
Fighting against forced labour and child labour in supply chain act[23]	2022	Primary	Force and child labour	Overall	Canada
The Norwegian Transparency Act[24]	2022	Primary	Human rights and environmental conditions	Overall	Norway

[13] Government of the Netherlands (2023).
[14] SER (2023).
[15] State of California Department of Justice Office of the attorney general (2023).
[16] Government of Canada (2023b).
[17] Government UK (2015).
[18] Business & Human Rights Resource Centre (2016).
[19] Federal Register of Legislation (2018).
[20] Government of Canada (2023a).
[21] Hoyos (2021).
[22] ETUCLEX (2023).
[23] Parliament of Canada (2023).
[24] Norwegian Government (2023).

Draft Bill on the Protection of Human Rights, Sustainability and Due Diligence[25]	2022	Primary	Human rights and environment	Overall	Spain
Act on Corporate Due Diligence Obligations in Supply Chains[26]	2023	Primary	Human rights and environmental risk	Overall	Germany

Table 4: Overview intersectoral legislation.

Countries that have already enacted legislation include the **Netherlands**, which has implemented The Responsible Business Conduct (RBC) - Responsible Gold Agreement. This emphasizes socially responsible practices abroad, particularly within the gold supply chain and the International Responsible Business Conduct (IRBC) agreements for the metals sector, which promote collective responsibility in identifying, mitigating, and reporting risks associated with human rights and environmental violations.

The **United States** has introduced the California Transparency in Supply Act, specifically dedicated to combating human trafficking and slavery.

Canada, the Extractive Sector Transparency Measures Act (ESTMA) requires extractive entities operating in the country to publicly disclose payments made to governments, aiming to reduce corruption in oil, gas, and minerals sectors. Furthermore, the establishment of the Canadian Ombudsperson for Responsible Enterprise (CORE) offers a mechanism for reviewing and mediating complaints of alleged human rights abuses involving Canadian organizations in specific sectors, thereby fostering responsible conduct and accountability.

In the **United Kingdom**, the Modern Slavery Act 2015 targets modern slavery offenses by obligating large organizations to provide annual statements outlining measures taken to prevent such abuses within their supply chains. Similarly, **Australia´s** the Modern Slavery Act 2018 introduces analogous reporting requirements for companies operating within the country, encouraging responsible practices and transparency throughout supply chains.

France, through the France Loi de Vigilance, concentrates on human rights abuses, introducing a civil duty of vigilance and mechanisms for reparation, effectively holding companies accountable for their actions.

Turning to countries where political processes are currently underway or where laws are just taking effect, **Canada´s** Fighting Against Forced Labour and Child Labour in supply chains Act and to amend the Customs Tariff (Bill S-211) introduces reporting mandates aimed at preventing forced labour and child labour in supply chains, enhancing transparency and oversight.

Switzerland is reinforcing human rights and environmental protection through the Swiss Responsible Business Initiative (RBI), which necessitates Swiss companies to adhere to due diligence standards in their global operations.

[25] Pacto Mundial Red Española (2023).
[26] The Federal Government (2021).

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Belgium is considering The Belgian Proposal on Duty of Vigilance, which if passed, will mandate value chain due diligence, especially in high-risk sectors, compelling companies to publish annual vigilance plans.

Norway´s Norwegian Transparency Act mandates due diligence activities to ensure human rights and decent working conditions are upheld throughout supply chains.

In **Spain**, The Preliminary Draft Bill on the Protection of Human Rights, Sustainability, and Due Diligence in Transnational Business Activities envisions due diligence procedures for Spanish and foreign transnational companies to uphold human and environmental rights across their global operations.

Lastly, **Germany's** German Act on Corporate Due Diligence Obligations targets large companies, obliging them to adhere to social and environmental standards within their supply chains and operations, thereby enhancing transparency and accountability.

These various regulations underscore the global commitment to ethical and sustainable business practices, each contributing to a more responsible business ecosystem. As businesses operate across borders, understanding and adhering to these various regulatory frameworks becomes essential to foster ethical trade and uphold human rights and environmental standards along supply chains.

3.3 Activities and collaborations

In the following section, activities and collaborations dedicated to promoting sustainable practices in the supply chain (see the definition in Section 2) are described, involving various stakeholders such as governments, companies, communities, and others.

3.3.1 Initiatives and projects

Table 5 presents a summary of the supply chain related initiatives and projects.

Initiatives	Year	DL	Part of supply chain	Focus	Minerals / Products included	Scope
GBA	2017*	M	Overall	Sustainable Battery value chain	Cobalt, Nickel, Lithium and Graphite	Industry
DMCC Rules for Risk Based Due Diligence	2020**	M	Overall	Responsible global supply chain	Gold and Precious Metals	Company
Re-Sourcing[27]	2020*	M	Overall	Responsible Sourcing	Overall	Renewable energy, mobility, electric and electronic sectors

[27] Re-Sourcing (2023).

Circular Electronics Partnership (CEP)[28]	2021*	D	Overall	Circular solutions for electronics	Overall	Electronics sector and waste management
Advance Materials Initiative (AMI)[29]	2022*	D	Overall	Circular economy	Overall	EU
Tungsten Industry – Conflict Mineral Council[30]	2022*	M	Overall	Conflict Mineral	Tungsten	Industry
CIRPASS[31]	2022*	D	Overall	DPP	Electronics, batteries and textiles	EU
Battery Pass[32]	2022*	D	Overall	DPP	Batteries	EU
National Battery Strategy[33]	2023*	I	Overall	Support domestic production of raw materials and traceability of batteries	Batteries	Australia
EITI	2003*	M	Primary	Transparency	Overall	Industry
Diamond Development Initiative International (DDII)[34]	2005*	M	Primary	Conflict minerals	Diamond	Artisanal and small- scale mining (ASM)
Artisanal Gold Council[35]	2007*	M	Primary	Responsible Artisanal Gold	Gold	ASM
Conflict Free Tin Initiative (CFTI)[36]	2012*	M	Primary	Conflict minerals	Tin	DRC
Better Mining[37]	2018*	M	Primary	Human rights, health and safety conditions	3TG, cobalt, copper and mica	ASM sites in DRC, Rwanda and Madagascar
EPRM	2019*	M	Primary	Conflict Minerals	3TG	ASM

[28] CEP (2023).
[29] AMi2030 (2023).
[30] TI CMC (2023).
[31] CIRPASS (2023).
[32] Battery Pass (2023).
[33] STIP COMPASS (2023).
[34] RESOLVE (2010).
[35] Artisanal Gold Council (2023).
[36] RESOLVE (2014).
[37] RCS Global Group (2023).

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Fair Cobalt Alliance	2020*	M	Primary	Supply responsibility	Cobalt	DRC
BATTRACE[38]	2020*	D	Primary	Traceability of battery metals, minerals and materials	Cobalt, lithium and graphite	Battery industry
ITSCI	2021**	M	Primary	Responsible Sourcing	3T	Central Africa
Circular System for Assessing Rare Earth Sustainability (CSyARES)[39]	2022*	D	Primary	Transparency and sustainability	Rare earths	Global
Nordic Innovation-Sustainability Minerals: Traceability[40]	2022*	D	Primary	Traceability	REEs and basalt fibres	Nordic countries
Development of a trusted supply chain for Australian battery minerals and product[41]	2022*	D	Primary	Batteries	Lithium	Australia
Trace4EU[42]	2023*	I	Primary	Traceability	Seafood, Agrifood, Halloumi and Battery Traceability	EU
UN CRM sustainability & resilience	2023*	I	Primary	Traceability standards	CRMs	Global
Future Availability of Secondary Raw Materials (FutuRaM)[43]	2022*	D	Secondary	Availability and recoverability of secondary raw materials	CRMs from batteries, electrical and electronic equipment, vehicles, mining, slags and ashes and construction and	EU

[38] GTK (2020).
[39] EIT RawMaterials (2022a).
[40] Nordic Innovation (2022).
[41] Vasilyev et al. (2022).
[42] Spherity (2022).
[43] FutuRaM (2023).

					demolitio n	
Circular Economy Resource Information Systems (CE-RISE)[44]	2023*	I	Second ary	R-strategies and traceability	Printers. Air Condition ers, Solar Panels, Batteries and Laptops	EU

Table 5: Overview Initiatives. * Launching, foundation or adoption year; **Latest update. DL: Development Level of the initiative/project. I: Initial. D: Development. M: Mature (project or initiative established or already completed).

The following sections describe in more detail some of the documents just mentioned.

3.3.1.1 Global Battery Alliance

The Global Battery Alliance (GBA) took place in 2017 within the World Economic Forum, marking the emergence of a collaborative cross-sectoral endeavour. This alliance is committed to fostering the establishment of a resilient battery value network by the year 2030, with a strong focus on sustainability. Towards 2030, the GBA envisions creating a battery value loop that incorporates ethics, responsibility, and equity. The GBA forges partnerships with international bodies, non-governmental organizations, industry, academia, and governments to jointly promote the ideals of circularity, environmental protection, and sustainable progress. This commitment is underlined by a set of 10 guiding principles, which are summarized below (Global Battery Alliance, 2020):

Establish a circular battery value chain as a major driver to achieve the Paris Agreement

1. Maximizing the productivity of batteries in their first life
2. Enabling a productive and safe second life use
3. Ensuring the circular recovery of battery materials

Establish a low carbon economy in the value chain, create new jobs and additional economic value

4. Disclosing and progressively decreasing greenhouse gas emissions
5. Prioritizing energy efficiency measures and substantially increase the use of renewable energy as a source of power and heat when available
6. Fostering battery-enabled renewable energy integration and access with a focus on developing countries
7. Supporting high quality job creation and skills development

Safeguard human rights and economic development consistent with the UN Sustainable Development Goals

8. Immediately and urgently eliminating child and forced labour, strengthening communities and respecting the human rights of those employed by the value chain
9. Fostering protection of public health and the environment, minimizing and remediating the impact from pollution in the value chain

[44] CE-RISE (2023).

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10. Supporting responsible trade and anti-corruption practices, local value creation and economic diversification

By gathering, disseminating, and presenting trustworthy information to stakeholders throughout the lifecycle, the GBC created the Battery Passport as a mechanism to improve transparency across the battery value chain. This passport facilitates the documentation of battery practices and their effects along the value chain, establishes baseline criteria for batteries to meet sustainability standards, and tracks advancements towards sustainable, responsible and resource-efficient batteries.

3.3.1.2 DMCC Rules for Risk Based Due Diligence

The Dubai Multi Commodities Centre (DMCC) provides the Rules for Risk-Based Due Diligence in the Gold and Precious Metals Supply Chain. These rules align with the five-step framework for risk-based due diligence of the OECD (2016). The primary goal is to guarantee the conscientious management of the global supply chain for gold and precious metals in order to assist Accredited Members in (DMCC, 2020):

1. comply with best practice and standards in anti-money laundering and combating terrorism financing, avoid contributing to conflict, and prevent abuses of human rights;
2. where possible, build constructive engagement with suppliers to source responsibly from CAHRAs; and
3. act in good faith, demonstrate significant and measurable efforts to improve on the ongoing due diligence, including monitoring emerging risks in the supply chain.

3.3.1.3 Extractive Industries Transparency Initiative (EITI)

The EITI, launched in 2003, brought together 140 delegates from governments, companies, industry groups, international organizations, civil society organizations, and investors who agreed upon the EITI Principles[45]. These principles established the EITI as a multi-stakeholder organization and formed the basis of its mission. The objective of the EITI is to enhance comprehension of the management of natural resources, reinforce transparency and accountability in both public and corporate governance, and provide data for shaping policies and enabling collaborative discussions among diverse stakeholders in the extractive sector.

Additionally, EITI has implemented the EITI Standard, which introduces requirements aimed at enhancing public understanding of the impact of the energy transition on the oil, gas, and mining sectors and informing policymaking. These requirements consist of seven key aspects (EITI, 2023):

1. Oversight by the multi-stakeholder group, for effective multi-stakeholder oversight, including a multi-stakeholder group involving government, business, and the full, independent, active, and effective participation of civil society.

2. Legal and institutional framework, including the allocation of contacts and licenses, to understand the laws and procedures for granting exploration and production rights, the legal, regulatory, and contractual frameworks that apply to the extractive sector, and the institutional responsibilities of the state in managing the sector.

[45] EITI (2003).

3. Exploration and production, disclosures of information related to exploration and production, enabling stakeholders to understand the potential of the sector.

4. Revenue collection, to understand company payments and government revenues that can inform public debate on the governance of extractive industries.

5. Revenue management and distribution, to understand how revenues are recorded in national and, where appropriate, sub-national budgets, as well as to track corporate social expenditures.

6. Social and economic spending, to help stakeholders assess whether the extractive sector is delivering the desired social, economic, and environmental impacts and outcomes.

7. Outcomes and impact, to ensure that stakeholders are involved in the dialogue on the management of natural resource revenues.

3.3.1.4 European Partnership Responsible Minerals (EPRM)[46]

The EPRM, launched in 2019, is a multi-stakeholder partnership accompanying the EU Conflict Minerals Regulation. The EPRM provides support for mining operations in CAHRAs. The aim of the EPRM is to enable more mines to meet the standards required by the OECD Due Diligence Guidance and thus increase the proportion of responsibly produced minerals from CAHRAs while supporting socially responsible mineral extraction that contributes to local development. The EPRM focuses on 3TG.

The EPRM provides support to mine sites in CAHRAs by financing various projects, some of which focus on responsible supply chain and due diligence practices. Some of the highlighted projects include:

1. The SustainBlock project, which aims to demonstrate supply chain accountability from ASM mine sites all the way to mineral and metal end-users. This, in turn, provides downstream companies with access to information on the origin of minerals in their products.
2. The Consolidated Autonomous Due Diligence project (CADD), which aims to develop and pilot an open-source, public framework for upstream supply chain stakeholders to implement requirements from the OECD Due Diligence Guidance.
3. The Promoting Responsible Minerals Supply Chains project, which will facilitate a productive partnership between the government of Uganda, mine operators, exporters of 3TG, ASMs of 3TG, and civil society organizations.
4. The MAX-D: Maximizing Due Diligence in Mineral Supply Chains project, which will help expand the public procurement market in Europe for responsible mining through tenders that reward supply chain actors with better human rights and environmental due diligence.

3.3.1.5 Fair Cobalt Alliance

The Fair Cobalt Alliance (FCA), launched in 2020, serves as a multi-stakeholder action platform that brings together participants from across the entire cobalt mineral supply chain to address growing scrutiny of ASM cobalt mining and the DRC mining sector. Its purpose is to contribute to the development of a responsible DRC cobalt mining sector that is recognized as a reliable source of minerals for a new green economy. This involves mobilizing resources from the entire supply chain to provide technical assistance and

[46] European Partnership for Responsible Minerals (2023).

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investment, ultimately achieving the vision of a formal, equitable, and safe ASM cobalt sector.

The FCA currently consists of 24 members who commit to: (a) recognize the legitimacy of cobalt from responsible ASM operations; (b) provide resources for the development of responsible ASM; and (c) promote the objectives of the FCA, which are as follows (Fair Cobalt Alliance, 2023):

1. Driving the supply chain of Fair Cobalt, to make miners safer, minimizing environmental impact, and creating dignified working conditions for men and women working at the mines.
2. Working towards child-labour-free communities, to remediate and mitigate child labour in and around ASM sites and throughout local communities.
3. Economic diversification, to promote the ASM community transition into sustainable livelihoods.

3.3.1.6 International Tin Supply Chain Initiative (ITSCI)

The International Tin Association and Tantalum-Niobium International Study Center (TIC) launched the ITSCI, a due diligence program that aids member companies in managing risks in their supply chains. It provides full visibility of minerals from mine to smelter, along with information and tools to assist with OECD (2016). ITSCI collaborates with government partners in Central Africa to improve due diligence practices throughout the 3T supply chain and enhance the capacities of companies and other stakeholders. The objectives of the ITSCI are as follows (Nimmo & Burt, 2012): (a) Provide a joint industry programme from mine to smelter, meeting international requirements; (b) Allow relevant U.S. and multi-national companies to report on due diligence, required by US law; (c) Provide information for end user smelter audit; and (d) Promote continued access to international markets for the 3T mineral sector in the Central African region.

ITSCI currently has 131 active members in 47 countries, drawn from mining cooperatives, local traders or exporters, international concentrate traders, mineral reworkers, smelters, refiners, and any company associated with upstream mineral trade, such as mineral transport and assaying companies.

In terms of transparency, ITSCI facilitates mineral traceability from mine to export and records data from export to smelters. Smelters can access traceability data for their due diligence and corporate audit procedures. Smelters can ask the ITSCI data team for tag information, and they will fill out the request and check to see if the ITSCI data matches the information they have received from physical tags, such as the weight of the ore when it arrives. While traceability is a significant aspect of ITSCI, it constitutes only a portion of due diligence, which also encompasses an incident management system to identify and verify risks.

3.3.1.7 Critical Raw Materials Sustainability & Resilience

The Critical Raw Materials Traceability and Sustainability Project (UN, 2023), aligned with UN sustainability goals, aims to develop a framework for traceable, sustainable critical raw materials supply chains. It seeks to combat greenwashing by ensuring verifiable sustainability in these supply chains, emphasizing minimizing environmental impact and maximizing human welfare. The project addresses challenges in interoperability and vocabulary across diverse ESG standards, fostering standards-based transparency for global supply chains. Its success hinges on scalable implementation, evidenced by diverse

participants and transparent supply chain data for a significant number of consignments. This project invites broad participation, including primary producers, manufacturers, and regulators, under the UN/CEFACT Open Development Process.

3.3.2Company initiatives

Table 6 presents some examples of company level initiatives related to the supply chain.

Company (Initiative)	Year	DL	Part of supply chain	Focus	Minerals / Products included	Scope
Brilliant Earth (Beyond Conflict FreeTM Diamonds)[47]	2005[1]	M	Overall	Responsible sourcing	Diamonds	Canada, Lesotho, Namibia, Gondwana and South Africa
Fairphone (Fairer electronics)[48]	2013[1]	M	Overall	Fairer electronic	Gold, cobalt, tin, tungsten, copper, REEs, lithium and aluminium	Global
Apple (Blockchain traceability)[49]	2022[3]	D	Overall	Conflict Minerals	3TG, cobalt and lithium	Global
Valcambi (Green Gold)[50]	2008[2]	M	Primary	Responsible gold sourcing	Gold	EU
AVX Corporations and Motorola Solutions (Solutions for Hope)[51]	2012[2]	M	Primary	Conflict free minerals	Tantalum and gold	DRC, Colombian and Global artisanal mining
Intel (Conflict free)[52]	2013[2]	M	Primary	Conflict free supply chain	Tantalum	DRC
De Beer Group (Tracr)[53]	2018[2]	D	Primary	Provenance of the diamond	Diamonds	Company
BMW (PartChain)[54]	2019[2]	D	Primary	Blockchain and supply	Auto-mobiles	Global

[47] Brilliant Earth (2023).
[48] FAIRPHONE (2023).
[49] Apple (2022a).
[50] Valcambi (2023a).
[51] Rüttinger et al. (2015).
[52] Intel (2013).
[53] De Beers group (2022).
[54] BMW GROUP (2020).

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				chain transparency		
Rio Tinto (START)[55]	2021[2]	D	Primary	Responsible Sourcing	Aluminium	Global
Eramet (EraTrace)[56]	2023[2]	I	Primary	Traceability	Mineral sands	Senegal

Table 6: Overview Company Initiatives. 1.Company founding year; 2. Initiative start year; 3. Initiative update. DL: Development Level of the company initiative. I: Initial. D: Development. M: Mature (project or initiative established or already completed).

Companies have developed a number of initiatives to improve their procedures within the mineral supply chain with the intention of incorporating due diligence and enhancing operational effectiveness. Among the companies embracing these practices is **Brilliant Earth**. Committed to ethics and sustainability, Brilliant Earth has introduced its own customized standard, **Beyond Conflict FreeTM Diamonds**, guiding the ethical and environmentally responsible selection of diamonds. This standard requires robust CoC protocols from diamond suppliers, facilitated by blockchain technology, for transparent tracking of diamond origin and attributes. Furthermore, the concern of Brilliant Earth extends to diamond recycling, ensuring a sustainable lifecycle for these precious gems.

Fairphone, on the other hand, fosters a deeper connection between people and its products through the creation of the fairer electronics movement. In their pursuit of ethical and environmentally responsible practices, Fairphone is committed to sourcing each of the minerals they use from ethical sources, in some cases, recycled sources. Among their achievements in the use of recycled materials, for the Fairphone 4, they utilize 100% recycled tin in the solder, and the modules are made with more than 50% post-consumer recycled plastic. For the Fairphone 3, approximately half of the copper comes from recycled sources, and the modules are also made with 50% post-consumer recycled plastic. Regarding rare earth elements, for both Fairphone 3 and Fairphone 4, an agreement has been made with suppliers to use 100% recycled rare earth in the speakers and 90% in the vibration motor. Additionally, they note that around 45.1% of the materials in a Fairphone can be recovered when applying the most optimal recycling routes (FAIRPHONE, 2024a). Furthermore, they encourage their customers to return their old phones, offering incentives such as Fairphone gift cards for future purchases. In 2020, they managed to recycle more than 17,000 phones (FAIRPHONE, 2024b).

Fairphone have initiated or engaged in various initiatives. For instance, they have The Fairphone Refurbished Program, takes discarded smartphones and refurbishes them through a process in which the devices are refined to bring back their original functions (Aguilar-Hernandez et al., 2023). Furthermore, they are co-founders of the Fair Cobalt Alliance, they champion responsible cobalt sourcing. When it comes to tin, tungsten, and copper, Fairphone utilizes these materials through recycling. Fairphone is also a member of the Responsible Lithium Partnership for lithium sourcing and the ASI for aluminium sourcing. Additionally, Fairphone collaborates with Open Sourcemap to map their supply chain (sourcemap, 2020). This partnership enhances their commitment to transparency in sourcing, allowing for a clearer understanding of where and how the materials in their products are obtained.

[55] Rio Tinto (2023).
[56] ERAMET (2023).

Apple has committed to responsible sourcing through various due diligence initiatives, such as the continuous identification and assessment of risks in its mineral supply chain, the use of blockchain solutions to track 3TG and other minerals in the supply chain while aiming to protect data privacy, and the implementation of third-party audits to ensure that smelters and refineries have appropriate due diligence systems in place.

Valcambi, a global leader in gold refining and manufacturing, has introduced an initiative known as **Valcambi Green Gold**. This initiative presents fully traceable gold, sourced from mines that adhere to stringent benchmarks in areas of environmental conservation, health and safety, labour practices, and human rights. Their facilities ensure complete segregation of green gold throughout its journey, from the moment it arrives until it is transformed into a finished or semi-finished product. Additionally, the entire green gold supply chain operates under the scrutiny of independent monitoring and rigorous auditing processes.

Solutions for Hope is a collaborative initiative in the electronics industry aiming to ensure ethical and responsible sourcing of conflict minerals. It involves companies, NGOs, and government bodies. The initiative implements traceability and transparency practices throughout the supply chain, verifying the legitimacy of minerals to prevent conflict financing. These measures include documenting origin, adopting due diligence standards, promoting sustainability, and preventing exploitation in mining communities.

Intel is one of the world's leading semiconductor technology and manufacturing companies. The company committed to a conflict-free supply chain, launching its **Conflict Free** initiative in response to concerns about minerals from conflict zones, especially in the Great Lakes region of Africa. Intel worked to ensure that the minerals used in its microprocessors, such as tin, tantalum, tungsten and gold, did not fund armed conflict.

Tracr is a blockchain platform developed for the diamond industry, created in collaboration with **De Beers Group**. Tracr aims to enhance transparency and traceability in the diamond supply chain, from their extraction in mines to their sale to the end consumer. Tracr's goal is to increase confidence in the authenticity and ethics of diamonds on the market.

BMW has started using Blockchain technologies to ensure the traceability of components and raw materials in international supply chains. The BMW Group initiated the **PartChain** project, which enables the collection and transaction of data to ensure immediate data transparency in complex supply chains and to improve as necessary.

Rio Tinto is engaged in various responsible sourcing initiatives. In the realm of copper, it was among the first producers to achieve the Copper Mark. In the realm of aluminium, the company collaborated in 2012 to establish the Aluminium Stewardship Initiative (ASI). Building on this commitment, in 2021, Rio Tinto introduced **START**, the first sustainability label for responsible aluminium. Utilizing blockchain technology, START is awarded to customers and provides transparent and traceable key information regarding the sustainable nature of their aluminium products.

Finally, **Eramet** launched the **EraTrace** platform to increase transparency throughout the value chain of its products. This platform creates a kind of product passport using blockchain technology, providing customers with information about the product manufacturing process and its environmental sustainability.

In a joint effort to improve transparency and accountability in the mineral supply chain, these companies implement due diligence initiatives and sustainable practices. These actions

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show a commitment to ethics, the environment, and society, redefining standards and contributing to a more responsible industry.

3.3.3 Technological and chemicals solutions

Table 7 presents some technological and chemical solutions related to the supply chain.

Company/ Initiative/ Research (Solutions)	Year	DL	Part of supply chain	Focus	Minerals / Products included	Scope
OPTEL GROUP (Battery Passport)[57]	1989*	D	Overall	Responsible Sourcing	Overall	Industry
Sourcemap (Software for supply chain map)[58]	2011*	M	Overall	Supply chain	Overall	Global
Circularise (DPP)[59]	2016*	M	Overall	DPP, traceability	Overall	Automotive, aviation, battery, electronics and metallurgy companies
MOBI (Battery Identification)[60]	2018*	D	Overall	Batteries	Overall	Industry
Circulor (Circulor´s Battery Passport)[61]	2018*	M	Overall	Responsible Sourcing	Overall	Industry
SourceCertain (TSW Trace) [62]	1970**	M	Primary	Provenance	Overall	Industry
Everledger (Diamonds provenance)[63]	2015*	M	Primary	Blockchain in diamond traceability	Diamond	Global
Haelixa[64]	2016*	M	Primary	Traceability solutions	Gemstones and precious metals	Precious Metals and Gemstones Companies
The origin of gold (Geoforensic Passport)	2016*	M	Primary	Origin of mined gold	Gold	Gold deposits
Spherity (DPP)[65]	2017*	M	Primary	DPP	Overall	Industry
MINESPIDER (DPP)[66]	2018*	M	Primary	Responsible Sourcing	Tin	Pilot in Peru and project in

[57] OPTEL GROUP (2023).
[58] Sourcemap (2023).
[59] Circularise (2023).
[60] MOBI (2022).
[61] Circulor (2023).
[62] SourceCertain (2023).
[63] Everledger (2023).
[64] Haelixa (2023a).
[65] Spherity (2023).
[66] MINESPIDER (2023).

						Rwanda and Brazil
IBM (Blockchain Network)[67]	2018**	M	Primary	Responsible sourcing	Cobalt	Company
TraceMet (Blockchain)[68]	2019*	D	Primary	Tracking metal and minerals	Overall	Sweden
ReSource (Platform for traceability)[69]	2019*	M	Primary	Origin of the minerals	Cobalt, graphite, lithium, manganese and nickel	DRC
Analytical Proof of Origin for Raw Materials (Analytical Tools)	2021*	M	Primary	Analytical proof of origin for Raw Materials	Overall	Global
Tracing the origin of lithium in Li-ion batteries using lithium isotopes (Fingerprint)	2022*	M	Primary	Tracing the origin of lithium	Lithium	North American, Finland, Chile, Argentina, Australia and China

Table 7: Overview technological solutions. 1. Year of foundation of the company, initiative or research; 2. Solutions start year. DL: Development Level of the solution. I: Initial. D: Development. M: Mature (project or initiative established or already completed).

In recent times, traceability has gained significant importance in demonstrating transparency in the mineral supply chain, driving the development of various tools for this purpose. In the chemical domain, diverse methods and traceability techniques have been explored. These range from broader approaches, such as **Melcher et al. (2021)** study for raw materials, which supports the verification of the origin of specific materials, to more focused investigations, like the **Geoforensic Passport** for minerals like gold. The latter is a scientific tool used to validate the declared origin of any extracted gold (Beck & Jodry, 2021). Similarly, for lithium, there's the study of **Desaulty et al. (2022)** to demonstrate that Li isotopic "fingerprints" are a useful tool for determining the origin of lithium. In addition to traceability methods and techniques outlined in scientific publications, there are companies like **Source Certain** that offer services such as **TSW Trace** to determine the origin of minerals with specificity beyond the country or region of origin. Similarly, **Haelixa** offers traceability solutions by integrating a liquid formulation applied through **automated spray systems**. These applications are subsequently verified using digital reports through blockchain technology.

Another solution is **Sourcemap**, a tool that illustrates how supply chains evolve in real time. Sourcemap is software that automates supplier network mapping, allowing companies to

[67] IBM (2023).
[68] TraceMet (2020).
[69] Re Source (2023).

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collect detailed information on shipping routes and transactions along the supply chain. This platform provides support to companies seeking to exercise due diligence in their supply chains by promoting not only transparency, but also ethical and sustainable practices throughout their supplier network.

Regarding technologies, a significant focus has been placed on exploring the potential of blockchain technology to trace minerals along the supply chain. Companies like **Optel Group, Circularise, Mobility Open Blockchain Initiative (MOBI), Circulor, Everledger, Spherity, Minespider and International Business Machines (IBM)** are at the forefront with various projects integrating these technologies to provide traceability solutions for batteries and digital product creation in the cases of the first five.

Other initiatives incorporating blockchain technology include Traceability for sustainable metals and minerals (**TraceMet**), which aims to assess whether a blockchain-based solution can provide buyers of metals with a specific level of sustainability, and **ReSource** is oriented towards ensuring the origin of minerals and making the mineral supply chain sustainable through a blockchain-based traceability platform.

3.4 Standards

The standards not only set out the requirements for more sustainable and responsible supply chain due diligence, but also drive ESG (environmental, social and governance) performance (Erdmann & Franken, 2022) and guide companies and stakeholders in ensuring the ethical sourcing of minerals. In order to provide a clear overview of these standards, Table 8 presents a summary of the supply chain related standards.

Developers (Standard)	Year*	Part of supply chain	Focus	Minerals / Products included	Scope
RMI (Responsible Minerals Assurance Process, Tin and Tantalum Standard; Tungsten Standard; Gold Standard)	2018	Overall	Responsible Sourcing	3TG	Tin, tantalum, tungsten smelters and Gold refiner
RJC (RJC Code of Practices (COP); RJC CoC)	2019	Overall	Responsible Sourcing	Gold, silver, Platinum Group Metals (PGM), diamond and coloured gemstone	Company
UNECE (United Nations Resource Management System (UNRMS))	2021	Overall	Resource Management	Overall	Countries, organizations and industries
ISO (ISO 23664: Traceability of rare earths in the supply chain)	2021	Overall	Sustainable supply chain	REEs	Company

SCS-007 Jewelry Sustainability Standard	2021	Overall	Environmentally and socially responsible production	Gemstones and precious metals	Gemstone and diamond companies
RCI and RMI (Cobalt Refiner Supply Chain Due Diligence Standard)	2022	Overall	Due diligence and responsible production	Cobalt	Crude and fine refiners
Responsible Steel (Responsible Steel International Standard)	2022	Overall	Responsible Sourcing	Steel	Company
The Copper Mark: -The Copper Mark CoC -Joint Due Diligence Standard)	2022	Overall	Transparency	Copper	Global copper sites
	2022	Overall	Responsible sourcing	Copper, lead, molybdenum, nickel and zinc	Companies extracting, producing and/or trading these metals
ASI (ASI Performance Standard; ASI Chain of Custody)	2023	Overall	Responsible Sourcing	Aluminium	Company
EICC and GeSI (Conflict – Free Smelter Program (CFSP))	2008	Primary	Conflict Mineral	Columbite-Tantalite, Cassiterite, Gold and Wolframite	Smelters and refiners
Rwanda Bureau of Standard (RBS) (Mining and quarrying – Code of practices)	2011	Primary	Code of practice	Overall	Rwanda
WGC (Conflict free gold standard)	2012	Primary	Conflict minerals	Gold	Gold producers
Fairtrade (Fairtrade Standard for Artisanal and Small-Scale Mining)	2013	Primary	ASM	Gold and precious metals	ASMs in the world
Fairmined and ARM (Fairmined Standard for Gold from ASM, including associated precious metals)	2014	Primary	ASM	Gold and precious metals	Artisanal and Small-scale Mining Organizations (ASMO)
DMT (CERA 4in1)	2015	Primary	Raw materials	Overall	Global
XertifiX (XertifiX Standard – Certification)	2018	Primary	Responsible corporate behaviour	Stone	Quarries and factories
BGR (Certified Trading Chains (CTC))	2019	Primary	Responsible sourcing	3T (Rwanda)	Rwanda and DRC

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				and gold, copper, cobalt, coloured gemstones (DRC)	
ICGLR (Regional Certification Mechanism (RCM))	2019	Primary	Conflict Minerals	Cassiterite, coltan, gold and wolframite	Great Lakes region
TSM (TSM standard)	2019	Primary	Responsible Sourcing	Overall	Canada and associated countries
IRMA (IRMA Chain of Custody Standard for Responsibly Mines Materials; IRMA Standard for Responsible Mining IRMA -STD-001)	2020	Primary	Responsible sourcing	Overall	Mines, Manufacturers and traders
	2018				Mining industry
Fair Stone (International Standard for the Natural Stone Industry)	2020	Primary	Decent labour and working conditions	Stone	Asia, Latin America and Africa
Bettercoal (Bettercoal standard: The Code 2.0)	2021	Primary	Sustainability performance	Coal	Company
RMI (Responsible sourcing, environmental, health and safety due diligence standard for mica processors)	2021	Primary	Responsible sourcing, environmental, health and safety	Mica	Mica processors
SERI (The Sustainable Electronics Reuse & Recycling (R2) Standard)	2020	Secondary	Responsible reuse and recycling	Polychlorinated biphenyls (PCBs), Mercury, Cathode Ray Tube (CRT) Glass, Batteries and Circuit Boards	All organizations within the recycling chain
e-Stewards (The e-Stewards Standard for Ethical and Responsible Reuse, Recycling and Disposition of Electronic	2022	Secondary	Ethical and responsible reuse, recycling and disposal	Overall	Recycling and refurbishment companies

Equipment and Information Technology)			of electronics		
ISO (ISO/CD 59014 Secondary materials)	Under development	Secondary	Environmental management and circular economy	Overall	Recycling industries

Table 8: Overview standards. *Standard update.

The following sections describe in more detail some of the documents just mentioned.

3.4.1 RMI Standards

The Responsible Minerals Initiative (RMI), part of the Responsible Business Alliance, sets forth standards for smelters and refiners involved in the Responsible Minerals Assurance Process (RMAP) program (formerly the Conflict Free Smelter Program (CFSP)). The establishment of RMAP aims to foster transparency within mineral supply chains. Its primary objective is to deter the use of minerals sourced from conflict zones, prevent human rights violations, and mitigate instances of instability.

For tin, tantalum, tungsten, and gold, distinct standards have been developed, each detailed in separated documents covering tin and tantalum smelters, tungsten smelters, and gold refiners (RMI, 2018a, 2018b, 2018c). These standards provide a practical structure for consistently auditing the operations and practices within the tin, tantalum, tungsten, and gold sectors. Auditees are required to implement due diligence commensurate with the risk profile of their tantalum, tin, tungsten, and gold sources and suppliers, considering the level of identified risks and their associated impacts. Importantly, RMI has created a standard for responsible sourcing in the mineral supply chain that includes all minerals[70].

In the case of cobalt, the Responsible Cobalt Initiative (RCI) and RMI have jointly formulated a specific standard for refiners called Cobalt Refiner Supply Chain Due Diligence Standard. This standard is designed to strengthen the due diligence efforts of companies and promote responsible production and sourcing along the cobalt value chain. It also facilitates compliance with the Responsible Sourcing requirements of the London Metal Exchange (LME) (RCI & RMI, 2022). This Standard follows the five step framework for risk-based due diligence from the Chinese Due Diligence Guidelines (CCCMC, 2015) and the OECD Due Diligence Guidance (OECD, 2016).

Lastly, the RMI define Responsible Mica Initiative, it incentivizes and improves supply chain on-site practices and due diligence in the mica value chain. The criteria in this document are used by an audit firm to assess whether a processor has implemented supply chain due diligence adapted to the circumstances of its mica supply chain, as well as site-level responsible workplace standards (RMI, 2022a).

3.4.2 RJC

The Responsible Jewellery Council (RJC) is a non-profit organization that was established in 2005 as a standard-setting and certification body. Its overarching goal is to establish a responsible global supply chain that fosters trust within the jewellery and watch industries worldwide. In order to achieve this, RJC has created two standards: the first is the RJC COP, which establishes a common standard for ethical, social, human rights, and environmental

[70] See RMI (2022).

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practices, and the second is the RJC CoC, which offers companies a methodology for managing and trading gold and platinum group metals, ensuring full traceability and responsible sourcing.

The RJC COP standard defines the requirements for establishing responsible business practices throughout the jewellery supply chain. COP certification is mandatory for all RJC commercial members and aims to provide a robust system for assuring stakeholders, shareholders, customers, and business partners that a company conducts its business in a responsible manner.

The RJC COP standard was developed in 2012 through a formal process overseen by the RJC Standards Committee, a multi-stakeholder body. This standard outlines the prerequisites for establishing a CoC for precious metals, ensuring that these metals are sourced, processed, and traded responsibly throughout the jewellery supply chain. Furthermore, the standard mandates that third-party verification be conducted at each stage of the process.

The process of RJC CoC certification comprises five stages (RJC, 2017): (1) The entity prepares and asks for a certification audit from an RJC-accredited auditor; (2) During the audit, the auditor verifies the entity has systems in place that conform to the RJC CoC Standard to source CoC materials and/or supply them to others in the jewellery supply chain; (3) Based on the auditor's report, the RJC certifies the entity, authorizing it to begin issuing CoC transfer documents for CoC materials; (4) Within 12 to 24 months, the auditor conducts a surveillance audit of the certified CoC entity to verify that the systems are operating effectively; and (5) After the three-year certification period, the entity renews the CoC certification through another certification audit.

3.4.3 ISO

The International Organization for Standardization (ISO) is a global consortium composed of national standards bodies, known as ISO member bodies. The responsibility of developing International Standards is typically carried out through ISO technical committees. Each member body that possesses an interest in a particular subject for which a technical committee has been established maintains the right to have representation on that committee.

The field of critical raw materials in ISO is very dynamic in this moment (June 2024), there are many working groups in parallel (traceability, sustainable mining), there are several votes at ISO level and proposals for merging groups.

Among the extensive array of ISO standards, the following three are emphasized in relation to traceability, secondary supply chain concepts and sustainable raw materials:

1. ISO 23664: 2021 - Traceability of REEs in the supply chain from mine to separated products: It describes a traceability system covering the REE supply chain between the originating mine and separated REE products. This document is intended to give supply chain members the ability to access information relating to REE materials or products as they pass through the supply chain (ISO, 2021). This information will include the identity of each company in the supply chain, which will allow buyers and suppliers of products to identify the companies processing a given shipment of material and the location of that material as it passes through the REE supply chain.

2. ISO/CD 59014 Environmental Management and Circular Economy- Sustainability and Traceability of Secondary Materials Recovery – Principles and Requirements (ISO, n.d.): It is under development and will replace IWA 19:2017 Guidance Principals for the Sustainable Management of Secondary Metals. It will cover sustainability principles and traceability (ISO, 2017c).
3. ISO/PC 348 Sustainable raw materials: This specifies criteria for sustainable raw materials in the industry and can be applied to the entire supply chain, from extraction to the final product.

Additionally, it is noteworthy that there exist ISO standards pertinent to sustainability, social and environmental responsibility[71] such as, ISO 20400: Sustainable procurement guidance, ISO 2600 Guidance on social responsibility, ISO 14001: Environmental Management System and ISO/TC 323 Circular economy. ISO standards for auditing, accreditation and risk management such as, ISO 19011: Guidelines for Auditing Management Systems, ISO/IEC: Conformity Assessment – Requirements for Accreditation Bodies Accrediting Conformity Assessment Bodies and ISO 31000: Risk Management. ISO standards for CoC and blockchain technologies such as, ISO 22095: 2020 Chain of Custody- General Terminology and Models and ISO/TR 6039: 2023 Blockchain and Distributed Ledger Technologies- Identifiers of subjects and objects for the design of blockchain systems. ISO standards for specific minerals such as Lithium: ISO/TC 333: Lithium.

3.4.4 Responsible Steel

Responsible Steel is a global, not-for-profit, multi-stakeholder standard and certification initiative. Its mission is to be a global driving force in the socially and environmentally responsible production of steel. They are dedicated to maximising the contribution of steel to a sustainable world by (Responsible Steel, 2022): Supporting the responsible sourcing and production of steel; Providing a multi-stakeholder forum to build trust and achieve consensus; Developing standards, certification, and related tools; and driving a positive charge through the recognition and use of responsible steel.

The ResponsibleSteel™ International Standard has been formulated to bolster the responsible sourcing and production of steel. It addresses a range of sustainability concerns, including emissions, pollution, responsible sourcing, human rights and labour standards, among others. The scope of the standard encompasses operational steel sites as well as related facilities engaged in processing raw materials for steelmaking or manufacturing steel products. The Standards are structured on 12 Principles (see Figure 8) with 370 associated requirements.

[71] See ISO (2017a, 2010, 2015, 2017b, 2018a, 2018b, 2020, 2023).

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Figure 8: The 12 Principles for "Certified Site". Source: Responsible Steel (2022).

In terms of T&T, ResponsibleSteel™ does not mandate the immediate establishment of fully traceable input materials. In other words, it does not require that individual shipments or components of a steel product be traceable back to the precise source of the raw material extraction. However, ResponsibleSteel™ recognizes and supports the gradual development of such traceability measures. It recognizes the challenges within the supply chain, given the steel sector's dependence on numerous materials and suppliers. Consequently, its Chain of Custody Framework does not establish a direct link between the physical input material and the corresponding paper trail.

3.4.5 The Copper Mark

The Copper Mark serves as an assurance standard designed to champion responsible practices within the copper, molybdenum, nickel, and zinc value chains. Its overarching vision is to foster a sustainable society by promoting responsible methods of metal production, sourcing, and recycling. Guided by core principles such as transparency, inclusiveness, collaboration, simplicity, and continuous improvement, the Copper Mark is committed to driving positive change.

The Copper Mark CoC Standard sets out the system rules as well as the tests required to demonstrate compliance with these rules. Conformance to the CoC standard is validated through the application of the Copper brand assurance process. The assurance process allows Copper Mark CoC-compliant sites at different points in the supply chain to make product-level claims related to "Copper Mark copper" in accordance with the Copper Mark Claims Guide. The CoC Standard applies to any site in the copper value chain that directly purchases Copper Mark copper or that purchases a product that contains Copper Mark copper and wishes to make assurance claims.

The main objectives of the CoC standard are to (The Copper Mark, 2022):

1. Increase transparency in copper supply chains.
2. Allow customers to be confident that their copper was produced responsibly.
3. To track eligible copper products as they move between responsible copper producers and processors.

4. Contribute to the uptake of responsible production practices and, in particular, the use of the Copper Mark Responsible Production Criteria (Copper Mark Criteria) and Assessment Process.
5. Contribute to the increased use of recycled material and support efforts to move to a circular economy.
6. Allow product-level claims of Copper Mark copper.

The Joint Due Diligence Standard for copper, lead, molybdenum, nickel and zinc has been established by the Copper Mark, the International Lead Association (ILA), the International Molybdenum Association (IMOA), the Nickel Institute (NI), the International Zinc Association (IZA) and RMI to enable responsible global supply chain management in the copper, lead, molybdenum, nickel and zinc industries (The Copper Mark et al., 2022).

The main standard objectives are (The Copper Mark et al., 2022):

(i) Support the application of OECD Guidelines for responsible mineral supply chains in copper, lead, molybdenum, nickel and zinc.

(ii) Facilitate adherence to market entry prerequisites, including the Brand Compliance requirement defined by the LME for LME Brands.

(iii) Promote compliance with criterion 31: Responsible Supply Chains of The Copper Mark, utilizing the Risk Readiness Assessment criteria from the RMI.

(iv) Encourage responsible sourcing from CAHRA without overtly excluding suppliers.

(v) Complement and recognize other standards that align with OECD principles, alongside existing third-party assurance programs.

(vi) Offer flexibility for multi-metal producers to include materials for non-principal metals in their metal product production.

3.4.6 ASI

The Aluminium Stewardship Initiative (ASI) is a non-profit, multi-stakeholder organization that exists to administer an independent third-party Certification program for the Aluminium value chain. This program ensures compliance with two standards: the ASI Performance Standard and the ASI Chain of Custody Standard. Both are voluntary for ASI members. The first standard defines environmental, social, and governance principles and criteria that address sustainability issues in the aluminium value chain, while the second standard complements the former and sets out the requirements for maintaining a Chain of Custody for CoC Material, specifying two starting points for ASI Aluminium: Primary and Recycled.

In particular, the ASI CoC Standard defines requirements for entities and facilities implementing Chain of Custody Management Systems, including systems for sourcing, accounting, and transfer of CoC Material (ASI Bauxite, ASI Alumina and ASI Aluminium) and Eligible Scrap. It aims to support a responsible supply chain by (ASI, 2023a): Providing a common Standard for ASI Members who wish to implement Mass Balance Chain of Custody systems in the Aluminium value chain; Establishing requirements that can be independently audited against Objective Evidence for the granting of ASI CoC Certifications; and Serving as a broader reference for the establishment and improvement of responsible production, sourcing, and stewardship initiatives in metals supply chains.

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To better understand how this standard is organized, Figure 9 shows the 11 sections it covers, grouped into 3 parts.

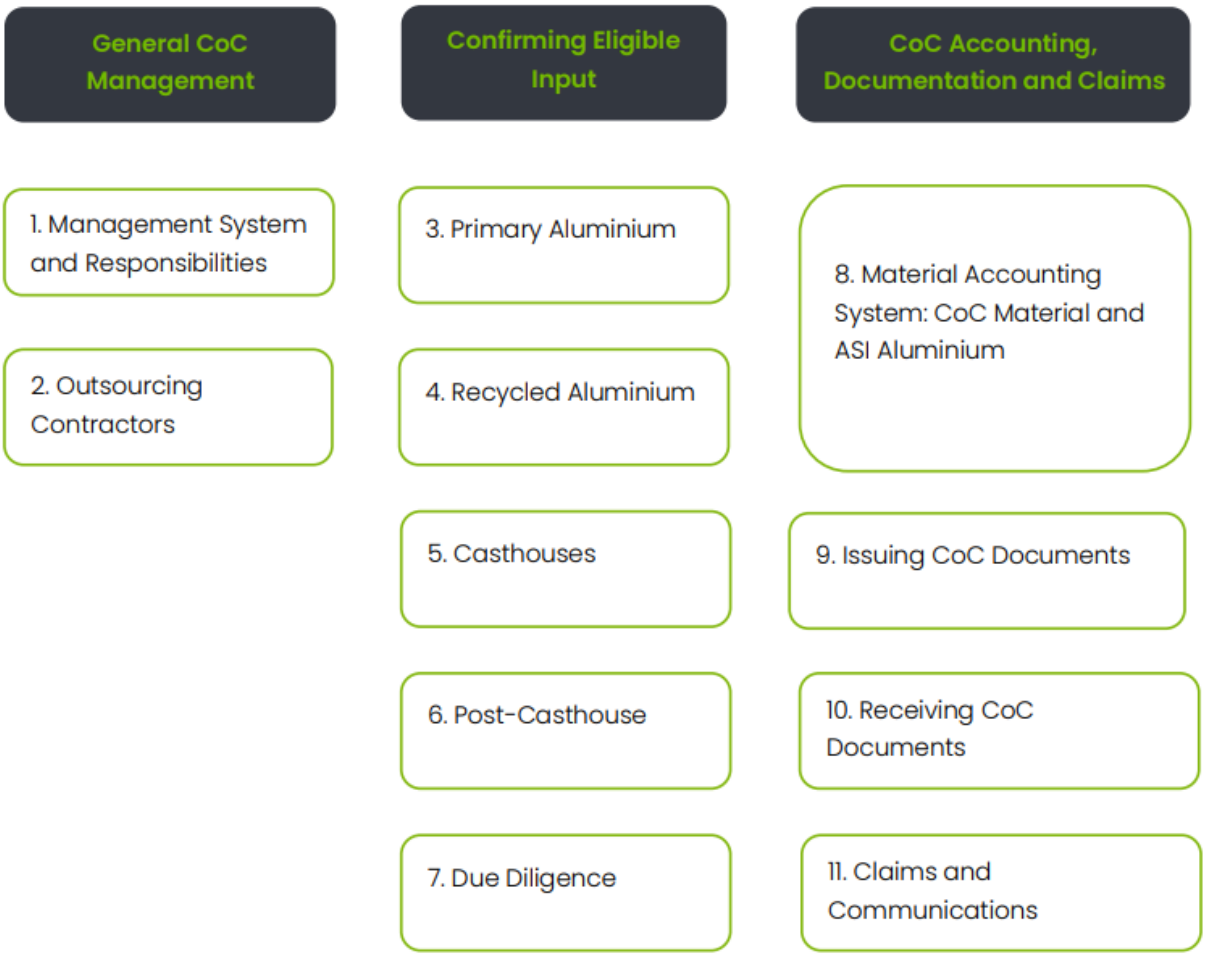

Figure 9: Sections contains in ASI CoC Standard. Source: ASI (2023).

3.4.7 WGC

The World Gold Council (WGC) serves as the industry development entity for the gold sector, aiming to lead the industry while fostering and maintaining demand for gold. In response to concerns surrounding the role of gold in funding armed conflict and human rights abuses in specific areas, the WGC introduced The Conflict-Free Gold Standard in 2012. This framework enables gold producers to evaluate and ensure that their gold extraction processes do not contribute to or benefit unlawful armed conflict, serious human rights violations, or breaches of international humanitarian law.

The core principle of this standard encompasses the requirement for thorough due diligence to verify that gold originates from sources free of conflict and human rights transgressions. Additionally, responsible practices pertaining to environmental protection and labour rights are endorsed.

The Standard is structured into five sections (WGC, 2019):

Part A-Conflict Assessment, assessing whether the area in which the mine is located should be assessed to be “conflict-affected or high-risk”;

Part B- Company Assessment, assessing whether the company has the appropriate systems in place to meet its corporate obligations and responsibilities in a "conflict-affected or high-risk area";

Part C- Commodity Assessment, assesses the processes in place to manage the movement of gold and gold-bearing material while in the company's custody, in order to mitigate the misuse of this material by groups associated with illegal armed conflict;

Part D- Externally Sourced Gold Assessment, when the mine acquires gold, this assesses the process that needs to be in place to ensure that appropriate due diligence is undertaken on this gold in relation to any potential involvement in causing or supporting unlawful armed conflict and;

Part E-Management Statement of Conformance, where management believe that the mine conforms with Parts A–D (as relevant), an appropriate statement needs to be provided to the next party in the chain of custody.

3.4.8 Fairtrade

Fairtrade Standard for Artisanal and Small-Scale Mining is a standard that focuses on promoting sustainable development and reducing poverty by improving equity in trading practices. The main objectives are to make changes in the conventional trading system that aim to benefit disadvantaged small producers and workers in the Global South and increase their access to markets. These actions can lead to improvements in small producer's social and economic well-being, as well as to their empowerment, environmental sustainability and promote (Fairtrade, 2018):

1. Legislation and public policies
2. improved environmental management (including mitigation the use of mercury and ecological restoration).
3. Social security
4. Gender equality
5. Child protection
6. Benefits to local communities in mineral-rich ecosystems
7. Improve governance within this sector

The standard wants to create opportunities for artisanal and small-scale miners and their communities by promoting the formalization of the ASM sector through the establishment of membership-based ASMO. The ASMO is responsible for Fairtrade certification and has the right to grant permits to miners to work under its coordination or has been appointed by the right holders to represent them in all matters related to Fairtrade certification.

The Fairtrade standard has four main chapters: The General Requirements, The Trade, The Production, and The Business and Development. In particular, The Trade mentions requirements for T&T to ensure that the authenticity of Fairtrade precious metal can be verified, traced back to the minerals through documentation, and that the product is physically separate and identifiable from non-Fairtrade products. Physician and/or documentary traceability requirements assure the customer that the correct quantity of Fairtrade Precious Metal was mined according to this standard by one or more ASMOs (Fairtrade, 2018).

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3.4.9 The Certification of raw materials (CERA 4in1)

The CERA 4in1 certification system (CERA 4in1) is the first and so far, only certification system that will prove sustainable development and transparency along the entire mineral raw material value chain – from exploration, through extraction and processing, manufacturing until end-products. In order to achieve the SDGs, CERA 4in1 was introduced as a scheme for the development of responsible mineral raw materials supply chains. It aims to provide requirements for the implementation of responsible production practices as well as for the traceability of responsibly sourced materials.

CERA 4in1 brings together four consecutive standards under one third-party certification scheme, with each considering a different aspect and stage of the mineral raw material value chain while building on each other:

Figure 10: Standards for each stage of the raw materials value chain.

CERA 4in1 Readiness Standard (CRS) covers the (pre-)investment and exploration phase until the operating stage of a project. It defines criteria for the standardized evaluation of exploration projects according to social, environmental, and economic (ESG) aspects.

CERA 4in1 Performance Standard (CPS) for upstream defines the ESG requirements for a production facility or a group of production facilities that cover the operations of mining, processing, smelting, and refining.

CERA 4in1 Performance Standard (CPS-II) for downstream defines the ESG requirements for a manufacturer and covers the manufacturing of semi-final products.

CERA 4in1 Chain of Custody Standard (CCS) applies to traded commodities and defines criteria for ensuring appropriate management systems for the traceability of responsibly sourced minerals, commodity-specific accounting methods, and chain of custody (CoC) material eligibility. This standard will ensure that all stakeholders in the supply chain meet the basic legal requirements concerning responsible sourcing and procurement.

CERA 4in1 Final Product Standard (CFS) establishes the criteria necessary to label consumer goods, empowering consumers to make well informed decisions. It defines the necessary certification requirements for the supply chain of the final product, enabling consumers to distinguish certified from uncertified products.

CERA 4in1 targets all kind of minerals, everywhere in the world and is applicable to any size of company. The main benefit of CERA 4in1 is to optimize the methods through which sustainability is defined and validated in the mineral raw material sector. It simplifies and streamlines the certification process for all actors in the mineral raw material value chain up

to the final product. CERA 4in1 has been designed to generate benefits and opportunities for all actors involved in the value chain. Proofing ESG compliance by CERA 4in1 e.g., reduces supply chain risks and insurance costs as well as improves the company's image, community involvement and stakeholder expectations.

3.4.10 Toward Sustainable Mining (TSM)

The Mining Association of Canada (MAC) is the national organization for the Canadian mining industry that promotes a strong, sustainable mining industry that benefits all Canadians and supports continued prosperity across the country. Among its initiatives is TSM, a standard that encourages continuous performance improvement in environmental and social mining practices (MAC, 2021). This program was established in 2004, and its main objective is to enable mining companies to meet the mineral needs of society, metals, and energy products in the most socially, economically, and environmentally responsible way possible. It is characterized by transparency, credibility, accountability, and measurability.

TSM provides a set of tools and indicators that drive performance and ensure responsible management of the main mining risks at participating mining and metallurgical facilities with a focus on three core areas: Communities and People (Indigenous and Community Relationships, Crisis Management and Communications Planning, Safety and Health, Preventing Child and Forced Labour), Environmental Stewardship (Tailings Management, Biodiversity Conservation Management, Water Stewardship, Exploration, Mine Closure), and Energy Efficiency (Climate Change).

In terms of TSM monitoring, this includes ongoing consultations with national Community of Interest advisory groups, independent multi-stakeholder groups of 12-15 people from indigenous groups, communities in which the industry operates, environmental and social NGOs, and labour and financial organizations.

3.4.11 IRMA

The Initiative for Responsible Mining Assurance (IRMA), founded in 2006 by a multi-stakeholder coalition, is a voluntary certification applied to all large-scale mining operations. Its objective is to establish an independently verified system for responsible mining assurance, with participation from multiple stakeholders.

IRMA Standard for Responsible Mining IRMA-STD-001 is a standard that establishes environmental and social criteria for responsible mining practices. It covers aspects such as environmental impact, labour conditions and community involvement with the objective of promoting sustainable and ethical mining operations. It is organized into four principles: (i) Business Integrity, (ii) Planning and Managing for Positive Legacies, (iii) Social Responsibility, and (iv) Environmental Responsibility.

The IRMA is guided by the belief that negative social and environmental impacts can be avoided if mines apply best practices (IRMA, 2020a). To initiate the implementation of these measures, a fundamental concern revolves around the concept of transparency. Transparency offers verifiable insights into the origins and consequences of the materials exchanged within the market. Addressing this imperative, the development of the IRMA Chain of Custody Standard for Responsibly Mined Materials ("IRMA CoC Standard") has come to fruition. This standardized framework establishes explicit prerequisites aimed at effectively monitoring the journey of IRMA-compliant, responsibly mined materials, from

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their extraction at the mine to their introduction into the market. This systematic approach empowers both entities within the supply chain and end users to make credible assertions pertaining to the utilization of IRMA-conformant responsibly mined materials. The principal objectives of the IRMA CoC Standard encompass the following facets: (a) Provide organizations in the chain of custody with a common standard for handling and making claims. (b) Formulating prerequisites that are amenable to external audit, thereby substantiating the verifiable flow of IRMA-compliant responsibly mined materials.

In terms of certification, the IRMA Chain of Custody Standard facilitates an autonomous and dependable validation mechanism. This mechanism serves to affirm that materials sourced from mining activities and traded within the realm of IRMA can be unequivocally traced back to a mine recognized by IRMA. Entities seeking certification under the IRMA Chain of Custody Standard undergo thorough assessments conducted by external auditors duly sanctioned by the IRMA (certification bodies). Furthermore, over the span of the three-year validity period of an IRMA Chain of Custody Certificate, these certified entities are subject to periodic surveillance audits to ensure ongoing compliance.

After completing the chain of custody certification process, the company will be able to start making claims on its invoices and shipping documents regarding the certification or achievement level of the materials extracted according to the IRMA standard (IRMA, 2020a). The IRMA system establishes four levels of achievement (see Figure 11). The first level is known as IRMA Transparency, which simply requires mines to be audited by an IRMA-approved auditing firm and to publish the results of these audits. The next levels are IRMA 50, IRMA 75 and IRMA 100. At the first two levels, mines must demonstrate that they have achieved 50% or 75% of the total score on all four principles of the IRMA Standard for Responsible Mining. At the highest level of compliance, all critical requirements are expected to be fully met (IRMA, 2022a).

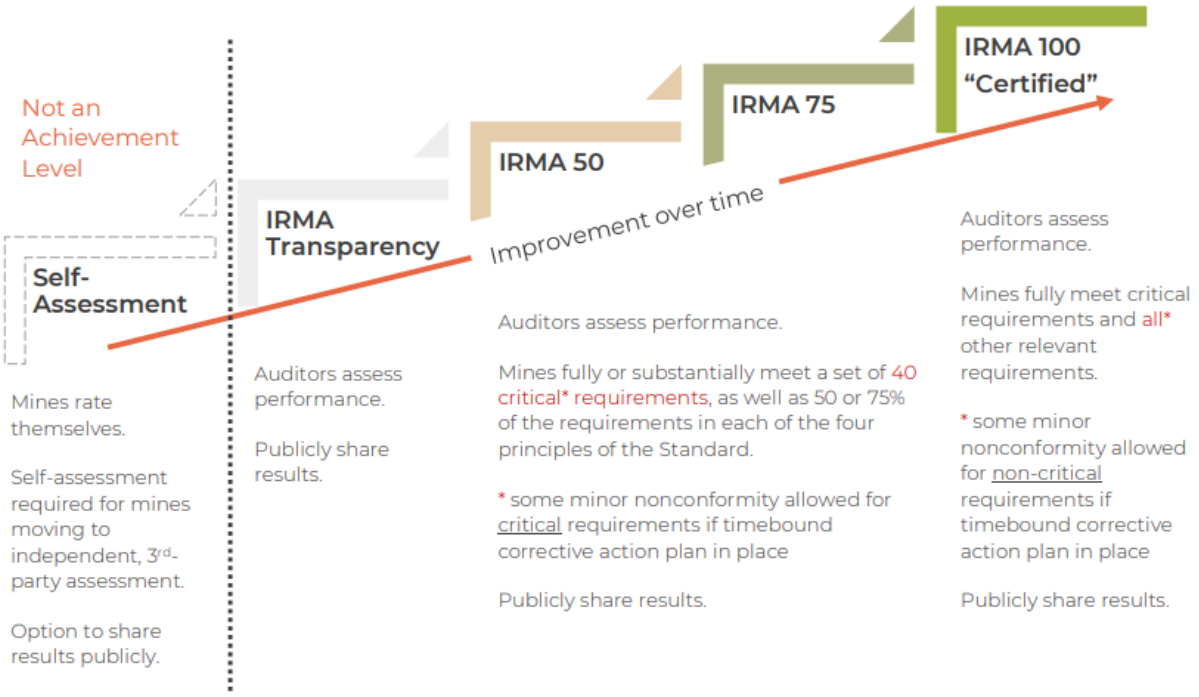

Figure 11: IRMA Achievement Levels. Source: IRMA (2022).

3.4.12 SERI

The Sustainable Electronics Reuse & Recycling (R2) Standard was developed by a multi-stakeholder group and establishes responsible reuse and recycling practices for the management and processing of used electronics globally (SERI, 2020). Attaining certification under this guideline via an impartial and accredited Certifying Body allows an R2 facility to assist asset managers, vendors of second-hand electronics, and prospective purchasers in making well-informed and conscientious choices, ensuring that used electronic equipment is handled in an ecologically responsible manner while safeguarding the well-being of workers and the general public. The stipulations encompassed by the R2 framework encompass practices pertaining to the environment, health, safety, and security of data.

The standard applies to all organizations, irrespective of size or location, that carry out different types of collection, repair, reuse, processing, etc. activities. And other activities that could be part of the recycling chain to reuse electronic equipment or components or recycle end-of-life materials. The materials that are of concern, as they merit greater care during the recycling, reconditioning, material recovery, energy recovery, incineration, and/or disposal processes due to their toxicity or other potential adverse effects on the health and safety of workers and the public are: PCBs, Mercury, CRT Glass, batteries, and Circuit boards.

3.4.13 e-Stewards

The e-Stewards Standard for Ethical and Responsible Reuse, Recycling and Disposition of Electronic Equipment and Information Technology and its third-party accredited certification program were initiated in response to the recycling and refurbishment industries' need to reduce their negative impacts, such as failures in the protection of human health and the environment or in data security (e-Stewards, 2022). This particular standard is distinguished by its endorsement of a conscious circular economy and advocates the idea of minimizing waste generation along with the value of awareness. The e-Stewards criteria are relevant for all companies and institutions engaged in substantial activities of recycling, repair, upgrading, and refurbishment of electronic products.

The standard establishes an operational structure encompassing a number of performance prerequisites aimed at: (a) Protect customer data and privacy; (b) Protect health and safety in the workplace and surrounding communities; (c) Prevent pollution; (d) Ensure fair labour practices; (e) Require proper disposal of hazardous e-waste; (f) Operate in compliance with laws, treaties and international agreements along the entire recycling chain; (g) Ensure that the above criteria extend downstream from the recycler and;(h) Verify performance through random inspections.

3.5 Summary of the main interventions related to the project

In previous sections, numerous interventions for due diligence in the supply chain have been mentioned, many of which focus on minerals and products in general, while others are specific. The MaDiTraCe project primarily focuses on critical raw materials used in five industries: magnets, batteries, automotive, photovoltaic, and microelectronics, where lithium, natural graphite, cobalt, and neodymium are considered relevant. The following highlights specific interventions for these critical raw materials.

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In the frameworks section, the **Cobalt Industry Responsible Assessment Framework** is crucial for assisting cobalt producers and purchasers in evaluating, mitigating, and reporting the risks associated with responsible production and sourcing within their operations and supply chains. This feature becomes particularly important as the global demand for cobalt increases, notably for the use in batteries and emerging technologies.

In the section on Laws and International Instruments, the **Regulation concerning batteries and waste batteries** stands out, which establishes mandatory requirements for the sustainability and safety of batteries within the EU, including minerals such as cobalt and lithium. Furthermore, the **Chinese interim measures New Energy Vehicle Power Batteries** is mentioned, which aims to improve the management of battery recovery and use, promoting the efficient use of resources, environmental protection, and human health.

In the activities and collaboration section, it's important to highlight battery-related initiatives such as the **GBA**, a public-private collaboration platform aimed at creating a sustainable value chain, and **Australia's National Battery Strategy**, which will guide the industry and governments towards a unified vision for the battery manufacturing sector. In the area of artisanal and small-scale mining, initiatives like **Better Mining** and the **Fair Cobalt Alliance** are significant. The former improves responsible sourcing practices through data collection and risk analysis, while the latter strengthens and professionalizes artisanal cobalt mining in the DRC.

Regarding specific projects in the battery domain, **CIRPASS** and **Battery Pass** focus on creating digital passports. **BATTRACE** concentrates on the traceability of metals, minerals, and materials for batteries, as well as optimizing production processes. The **Development of a trusted supply chain for Australian battery minerals and products** project aims to connect customers with reliable sources of battery minerals, developing tools and platforms to facilitate transparency within the supply chain. Pertaining to traceability-focused projects, **Trace4EU** and **Nordic Innovation-Sustainability Minerals: Traceability** highlight. The former designs and implements comprehensive solutions for product and data traceability, while the latter is developing a traceability technique to track metals throughout the global value chain. Other important projects worth mentioning focus on the recoverability of materials such as batteries, vehicles, and electrical items. For instance, **FutuRaM** is developing insights into the availability and recoverability of secondary raw materials within the European Union. **CE-RISE** aims to design and test an integrated framework for effectively reusing, recovering, and recycling materials. Lastly, the **CSyARES** project intends to develop a sustainability tracking tool for critical minerals, with a focus on rare earth elements and magnets.

In the Company Initiatives subsection, there are also initiatives related to the CRMs and minerals discussed in the project, such as **Fairphone** with its **Fairer Electronics** initiative, **Apple** with its **Blockchain traceability**, and **BMW** with **PartChain**. Finally, in the Technological and Chemical Solutions subsection, solutions are presented such as **Battery Passport** from **OPTEL GROUP**, **DPP** from **Circularise**, **Battery identification** from **MOBI**, **Battery Passport** from **Circulor**, and a platform for traceability from **ReSource**.

Finally, in the standards section, specific standards for the minerals included in the project can be found, such as the **Cobalt Refiner Supply Chain Due Diligence Standard** from RCI and RMI, the **Certified Trading Chains** from BGR for 3TG, cobalt, and coloured gemstones, the **ISO 23664** standard for the traceability of rare earth elements in the supply chain and

the Certification of raw materials (CERA 4in1), which will be the standard adopted and developed by the MaDiTraCe project. In addition, there are standards for the secondary supply chain like the **R2** from SERI, designed to help companies enhance the transparency and sustainability of the supply chain for materials such as PCBs, Mercury, CRT Glass, Batteries, and Circuit Boards, and the **e-Stewards** standard, which sets performance requirements specifically for the electronics recycling industry to ensure the highest levels of social and environmental protection.

3.6 Interventions focused on traceability in different sectors

In addition to the interventions presented in the previous chapters, the following chapter highlights significant traceability-focused interventions within the supply chain, primarily in the forestry, textile, and food sectors (Table 9). Although these interventions are not specifically targeted at the mining sector, they can serve as exemplary models to guide the efforts undertaken in this project. The main objectives of these interventions are to demonstrate responsible sourcing and ensure transparency throughout the supply chain.

Interventions	Year	Part of supply chain	Focus	Products	Scope
SFI™ Chain of Custody Certification	2019[1]	Overall	Sustainable forest management	Wood, paper and forest fibre	Companies
PEFC™ CoC of Forest and Tree Based Product	2020[1]	Overall	Sustainable forest management	Forest and tree-based products	Companies
FSC™ CoC Certification	2021[1]	Overall	Responsible Sourcing	Forest based product	Companies
Track Record Global	2023[2]	Overall	Transparency	Timber, Cotton, Recycled Plastic, Leather, Palm oil	Companies
Oritain	2008[3]	Primary	Origin of products and raw materials	Cotton, meat, coffee, fibres, dairy products, honey and medicines	Companies
Haelixa	2016[3]	Primary	Traceability solutions	Textile products	Textile sector
Asia Pacific Rayon (APR): Follow our Fiber	2019[2]	Primary	Traceability	Textile products	Textile sector

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TextileGenesis™	2019[2]	Primary	Traceability	Textile products	Fashion and Textile sector
The Aquaculture Stewardship Council CoC Standard Default version	2019[1]	Primary	Responsible sustainable aquaculture	Aquaculture products	Fishing and aquaculture sector
ISCC EU 203 Traceability and Chain of Custody	2021[1]	Primary	Material Traceability	Farms and Plantations	Companies
Marine Stewardship Council CoC Standard; Default Version	2023[1]	Primary	Ocean health	Seafood products	Companies
GLOBALG.A.P. Chain of Custody (CoC)	2023[1]	Primary	Transparency	Agricultural products	Farms

Table 9: Overview interventions focused on traceability in different sectors. 1. Standard update. 2. Year of services offered or product creation. 3. Year of foundation of the company.

Interventions focused on traceability in the supply chain are present in various sectors, including forestry, which adheres to standards like **the Forest Stewardship Council (FSC)**, **Programme for the Endorsement of Forest Certification (PEFC)**, and **SFI (Sustainable Forestry Initiative) CoC Certification**. The FSC, an international, non-governmental organization, is dedicated to promoting environmentally appropriate, socially beneficial, and economically viable management of the forests of the world (FSC, 2023). It has established a CoC standard to provide minimum management and production requirements, ensuring that forest-based materials and products purchased, labelled, and sold as FSC certified originate from well-managed forests, controlled sources, or reclaimed materials (FSC, 2021). The PEFC, also an international non-governmental and non-profit entity, focuses on advancing sustainable forest management through the rigor of independent third-party certifications. Its CoC standard enables organizations to provide accurate and verifiable information, ensuring that forest and tree-based products are sourced from PEFC certified sustainably managed forestry, recycled material, and PEFC controlled sources (PEFC, 2020). Finally, SFI CoC Certification ensures the traceability of wood, paper, and forest fibre content from certified responsible forests. Additionally, they provide independent audits for certification, enabling companies to make credible claims about sourcing sustainable forest products (SCS Global Services, 2023). In addition to these efforts, the European Union has established in 2023 the EUDR, which is a regulation aimed at combating deforestation and promoting the sustainable sourcing of wood-based products (Sheridan, 2024). Companies involved in the wood trade will need to establish a traceability system for the origin of the wood. Organizations such as FSC and SFI have responded to this measure by committing to meet the expectations of regulators and customers.

In the textile sector, traceability initiatives such as **Haelixa**'s "physical traceability" are making significant advances. Haelixa employs a method of marking raw materials with distinctive DNA markers to track products throughout the supply chain. This method ensures the traceability of materials, which is increasingly vital in complex and disrupted supply chains to maintain transparency (Haelixa, 2023b). In addition, **APR** has introduced the **Follow Our Fibre** initiative, a blockchain-based tracking platform that opens the door for traceability across the entire viscose fibre supply chain. It provides a complete picture of

the entire supply chain, providing opportunities for added efficiency measures (APR, 2023). Finally, **TextileGenesis™** (TextileGenesis, 2023), a Hong Kong-based start-up, has been using blockchain technology to ensure traceability of textiles from fibre to production and distribution. It has a digital platform for TENCEL™ and LENZING™ ECOVERO™ branded fibres, providing customers, partners, and consumers with an overview of the entire textile supply chain.

In the food sector, various interventions ensure the traceability and integrity of products from origin to consumer. **The Aquaculture Stewardship Council (ASC)** CoC Standard is one such measure that maintains traceability and segregation of certified aquaculture products throughout the entire supply chain. This standard ensures that, from the certified farm to the final product, seafood is sourced responsibly and sustainably (ASC & MSC, 2019). Similarly, **the Marine Stewardship Council (MSC)** contributes to ocean conservation and the secure future of seafood supplies with its CoC standard, mandating requirements for organizations that seek MSC CoC certification (MSC, 2023). This certification confirms that seafood products are traceable through the supply chain and originate from well-managed and sustainable sources.

Further supporting traceability in the food sector**, the ISCC EU 2023 Traceability and Chain of Custody** document (ISCC, 2021) outlines the requirements for preserving the integrity of sustainable materials throughout the supply chain. This document is applicable to any organization involved in the handling or trade of certified products, focusing on the complete traceability of sustainable materials from their origin to the end consumer. In addition, **GLOBALG.A.P**. offers a CoC standard that enables supply chain actors to demonstrate management systems that protect the segregation, identification and traceability of products (GLOBALG.A.P, 2023). Certified products are aligned with safe, socially and environmentally responsible agricultural practices.

In addition to the interventions already mentioned, there are also more general approaches. **Track Record Global**, for instance, improves the transparency, consistency and verification of ESG data across its supply chains, encompassing products such as timber, cotton, recycled plastic, leather and palm oil. The services offered are: Recommended risk assessment protocols compiled by specialists and tailored to your policies; Training for your suppliers to map their supply chains and verify their claims; Documentary evidence checks; Risk ratings – with mitigation recommendations; Monitoring of legislation changes; Annual reassessments to ensure your data is always up to date (Track Record Global, 2023). On the other hand, **Oritain**'s audit method uses forensic science and data to detect naturally occurring elements in a product or raw material, which they call an Origin Fingerprint for items such as cotton, meat, coffee, fibres, dairy products, honey and medicines. Once an Origin Fingerprint has been created, it can be used to audit products at any point in the supply chain – to clearly differentiate the legitimate from the fraudulent (ORITAIN, 2023).

3.7 Gaps and needs

The frameworks, laws, activities and collaborations and standards mentioned before have been designed to improve due diligence throughout the supply chains of multiple CRMs, focusing primarily on sustainable and responsible sourcing. This encompasses issues such as human rights, child labour, forced labour, conflict minerals, and environmental protection (see Figure 12). Although various aspects of due diligence in the supply chain of materials have been studied, these features are analysed separately, lacking interventions that encompass them in their entirety.

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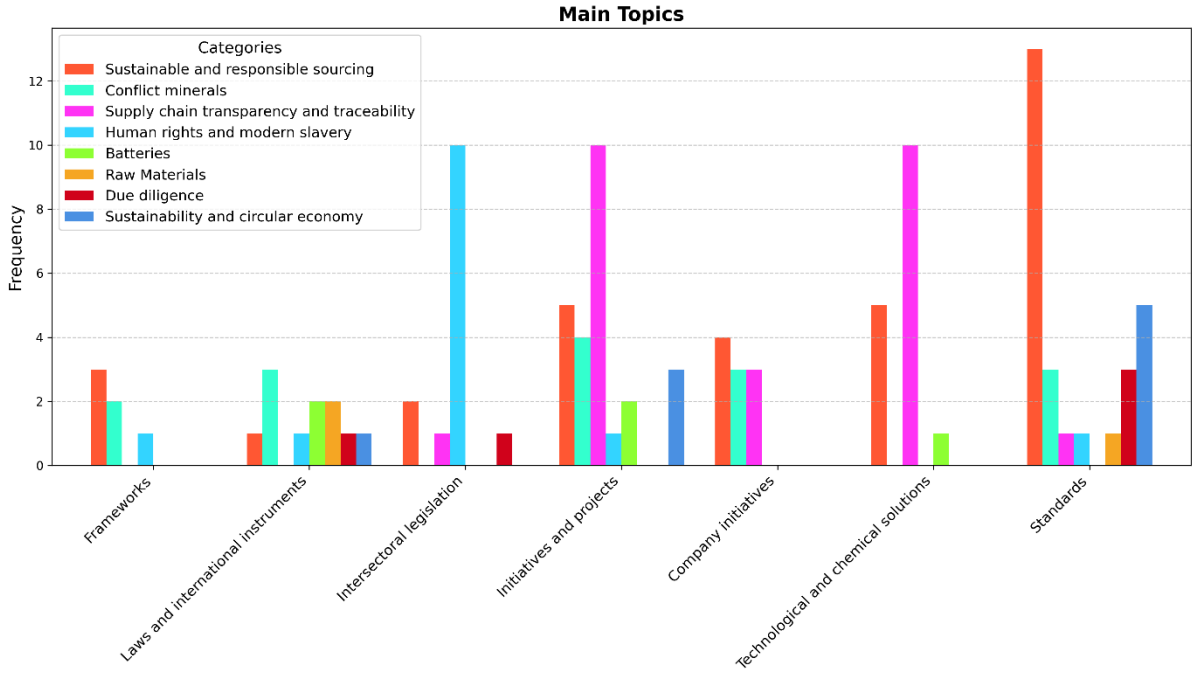

Figure 12: Main topics covered in the interventions.

Regarding the frameworks for due diligence in the supply chain - which form the basis for the creation of laws, initiatives, and standards - there are gaps in harmonization and coherence related to due diligence. The pursuit of harmonization is a critical discussion topic for companies committed to responsible sourcing and transparency of their operations. These companies face the dilemma of adopting a framework that is influenced by multiple factors such as the geographical location of operations, the type of raw materials used, regulatory pressures, and stakeholder expectations (OECD, 2016). This highlights the need for more detailed and contextualized guidance for effective implementation.

In relation to the content of these frameworks, there is a notable absence of specific details concerning particular sectors, particular products, and considerations for secondary raw materials. For instance, the UN Human Rights Office of the High Commissioner (OHCHR) (2011), although fundamental in establishing a baseline for human rights in the business context, may require adaptations or supplements to address the specific challenges and complexities of the mining sector, where operations can have significant and distinctive impacts on human rights that need to be managed in a specialized manner. Similarly, ICMM (2015) and CCCMC (2022) focus on the mining sector but are not specific to concrete raw materials, resulting in a lack of detailed complementary material.

In regard to due diligence, it is observed that not all frameworks comprehensively cover its essential aspects. For example, "financial transparency" is thoroughly addressed only in OECD (2016). As for "audit or third-party", which is fundamental to the company review process, only some frameworks discuss it extensively, while others merely suggest it as a recommended practice without imposing obligations. Similarly, "grievance mechanisms", crucial for assessing business impact and demonstrating corporate transparency, are primarily elaborated by OECD (2016) and UN Human Rights Office of the High Commissioner (OHCHR) (2011), with other documents treating them as mere recommendations without detailed instructions for their implementation.

Finally, the fact that these documents have not been updated for more than five years highlights a deficiency in reflecting current and emerging trends in due diligence. This situation imperatively underscores the need for systematic and regular reviews to ensure that the frameworks retain their applicability and effectiveness in an ever-evolving environment.

In terms of laws and instruments, it is important to consider that certain regulations are exclusive to specific regions. This particularity represents a challenge for international companies, which must navigate and adhere to a conglomerate of often conflicting legislations across different jurisdictions, thus complicating compliance. In addition, when due diligence is mentioned, there is a need to include more areas and to have a global approach and not be limited only to minerals such as the 3TG. In relation to the content presented in section 3.2.1, it addresses a series of objectives ranging from sustainable and responsible sourcing and conflict minerals to sustainability and circular economy (see Figure 12). Although these issues are intrinsic components of due diligence, only two documents encompass their entirety: the "Regulation laying down supply chain due diligence for Union importers", which covers a more exhaustive range of elements, and the "Proposal for a Directive on Corporate Sustainability Due Diligence", that the legal text is currently in the process of being written at a technical level, pending a definitive date due to the complexity of the European legislative process.

Legislative documents stipulate a series of requirements that companies must integrate into their operations, and these are linked to sanctions. However, for the EU legislation, the application of such sanctions is at the discretion of the executing member country. This discretion means that each member country may interpret and enforce these sanctions differently, potentially leading to inconsistencies in how the legislation is applied across the EU. As a result, there can be a lack of uniformity in enforcement, making it challenging for companies to predict how regulations will be applied in different countries. Such variability can undermine the overall effectiveness and predictability of the legislation, as companies might find it difficult to uniformly comply with the requirements across all member states. Clarity in sanctions is essential for companies to develop effective compliance strategies and avoid infractions. Ambiguity in the consequences of non-compliance with the law can lead companies to face difficulties in risk management, resource planning, and adapting to regulatory frameworks.

Regarding the obligations and responsibilities of the different actors in the supply chain, in the documentation, they are primarily categorized as the roles of operator and supplier. The regulations should detail the specific responsibilities of each participant, including governments and civil society, to ensure transparency, accountability, and sustainability. An effective and ethical supply chain requires that each actor assumes a clear and active role in implementing responsible practices, and laws should promote this comprehensiveness to strengthen compliance and oversight at all levels. This is particularly relevant in the context of traceability, where each actor within the supply chain must share information and be transparent, something that must be stipulated by law.

In the context of due diligence, the concept of "risk management" plays a pivotal role. It is essential for identifying, evaluating, and mitigating risks within business activities. However, it is observed that not all legislative documents address this aspect adequately. For example, the "Chinese Interim Measures for New Energy Vehicle Power Batteries" omit this point, while proposals like the "Regulation on Ecodesign for Sustainable Products" and the

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"Regulation on Prohibiting Products Made with Forced Labour" only cover risk identification without delving into its management. It is important to highlight that the documents which mention the topic, focus exclusively on corporate risk assessment processes. This perspective is limited and should be expanded to benefit not just companies, but also potentially affected groups. According to various stakeholders, there is a need to modify the approach of documents dealing with due diligence, directing them towards a risk assessment that encompasses not only companies but also potential impacts on society and the environment (European Commission, 2020b).

Regarding "financial transparency", it is mentioned in some documents only as a recommendation, and in others, it is not considered at all, including the "Proposal for a Regulation on Ecodesign for Sustainable Products", the "EU Principles for Sustainable Raw Materials", and the "Directive on Corporate Sustainability Due Diligence". Concerning "human and labour rights", there are documents that do not mention them, and others that merely suggest that companies should comply with due diligence criteria for human rights, without specifying.

As for "compliance evaluation mechanisms", like audits and grievance mechanisms, the majority set requirements for audits, but leave grievance mechanisms either undetailed or as simple recommendations. Furthermore, when grievance mechanisms are mentioned, they tend to be internal without describing how external stakeholders can report non-conformities. It would be beneficial to have clearer and more detailed guidelines for the practical implementation of due diligence, including specific steps, information requirements, and guidance for improving transparency.

In the sectoral context, the main gaps are that current regulations only cover a fraction of the aspects of due diligence, focusing on human rights and addressing issues such as slavery, human trafficking, corruption, and forced and child labour. However, only a few include concerns like environmental impacts, exemplified by laws and international instruments like the RBC – Responsible Gold Agreement, the IRBC agreements for the metallurgical sector, the CORE Act, the Swiss RBI initiative, the Belgian proposal on Duty of Care, the Norwegian Transparency Law, the Bill on the Protection of Human Rights, Sustainability, and Due Diligence, and the Law on Corporate Due Diligence Obligations in Supply Chains. This lack of uniformity can lead to gaps in the implementation and effectiveness of due diligence across different industries. There is a need to integrate these aspects into a holistic approach that considers human rights and sustainability as interdependent and fundamental to the strategy and operation of companies.

Another important aspect is the accessibility of information. Although regulations are developed for internal use within countries and, therefore, in local languages, they should be readily available and accessible to a broad audience. This indicates the need to translate these documents into an international language, as well as into formats that are comprehensible. Additionally, it is crucial to ensure the security of data storage. This involves implementing robust data protection measures to prevent unauthorized access and to maintain the integrity and confidentiality of information, especially when handling translations and multiple formats that may increase vulnerability to cybersecurity risks.

It is crucial to consider that most of these laws are in the initial stages of application or still in design. This demonstrates more reactive than proactive approaches, implying that there must be a shift in legislative culture and stakeholder expectations, from reacting to crises to

an integral and preventive risk management. Moreover, this development phase represents a significant challenge to ensure compliance and effectiveness. During this process, it is essential to establish clear and feasible implementation mechanisms that consider not only the operational realities of companies but also jurisdictional differences. Additionally, stakeholder participation in the design of these laws is fundamental, including collaboration with companies, NGOs, human rights and environmental experts, to ensure that the regulations are both pragmatic and ambitious.

In terms of existing activities and collaborations, it is essential to address their level of development. While a large portion of these initiatives are in an advanced phase, with interventions that are in the process of implementation or have already concluded, many are still under development. This is particularly true in areas linked to emerging trends such as circularity, recycling of materials, integration of new technologies, and solutions to improve traceability in the supply chain. It is imperative that EU projects, especially those that present the potential to be implementable solutions, consider a long-term vision. Also, evaluating the current progress of certain initiatives and projects is crucial, and should be carried out using success indicators and case studies, as well as monitoring and evaluation mechanisms that provide valuable feedback on the activities developed. The effective integration of solutions between academia and industry is fundamental to strengthen these relationships. This intersectoral collaboration would not only amplify the impact of the proposed interventions but also fosters a continuous flow of knowledge and resources. The importance of expanding international collaboration beyond the borders of the EU is emphasized, in search of comprehensive solutions for due diligence, considering that supply chains transcend borders and, in particular, many of the minerals used in Europe come from other countries. Therefore, it is essential to consider the integration of all stakeholders involved in the supply chain of CRM, thus ensuring effective and responsible cooperation. This integration not only implies the active participation of all parties but also the provision of adequate training and education.

In relation to company initiatives, it is imperative to establish clear and objective metrics that allow for the accurate verification and quantification of the real benefits derived from these actions. The implementation of constant oversight, both in audits and in compliance with regulations, is crucial to ensure sustained accountability throughout the entire supply chain. Likewise, it is essential to develop specific guides that encourage effective collaboration among companies involved in the supply chain. This collaborative approach not only improves the efficiency and sustainability of operations but also promotes mutual benefits for all stakeholders. These guidelines should focus on creating a framework that facilitates cooperation and the exchange of best practices, aligning the interests of different companies with the goals of sustainability and social responsibility.

Finally, in regard to **technological and chemical solutions**, it is essential to ensure that these technologies are accessible and easy to adopt for all stakeholders. This implies guaranteeing that they comply with relevant legal regulations and that they have a global scope, allowing their integration not only in large corporations but also in smaller companies and actors. It is crucial that these solutions are designed considering the diversity of needs and capabilities of different users, promoting universal and effective adoption.

Regarding the **standards**, which play an essential role in promoting responsible and sustainable practices within the supply chain. In recent years, significant changes have been

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observed in the evolution of these standards, particularly highlighting efforts to achieve harmonization with other regulations and international frameworks. This harmonization represents a crucial step to avoid confusion among companies when selecting appropriate practices and certifications. Therefore, it becomes necessary to continue working to achieve greater coherence and compatibility among the different standards (Erdmann & Franken, 2022; Kickler & Franken, 2017).

Regarding the deficiencies identified in the standards, the lack of inclusivity stands out. Many standards do not fully cover the supply chain or adapt to all companies, regardless of their size. Similarly, there are standards, such as RBS, TSM, and IRMA that cover a wide range of minerals, but lack specificity regarding the particularities of each industry. This lack of specificity means that while these standards provide a broad framework for responsible sourcing and environmental management, they may not address the unique challenges and requirements of different mineral industries. For example, mining and processing practices, environmental impacts and social implications can vary significantly between industries such as lithium, cobalt or rare earth minerals, and in particular in the case of lithium there are differences between extraction from hard rock and salt flats. Another significant deficiency is the lack of flexibility in these standards. This refers to the rigidity in adapting the norms to specific contexts and situations, which hinders their application in different industrial or geographical scenarios.

Current standards seem to be strict or general, and do not consider the peculiarities and unique challenges of each supply chain, reducing their effectiveness and applicability in multiple cases. This is observed in a low number of certified companies, which highlights the importance of adapting requirements to specific needs and increasing the visibility of these standards in the sector, to facilitate greater adoption and compliance. Moreover, in the face of complex supply chains, most standards do not offer clear solutions nor establish effective requirements for their management. Additionally, the dynamics within supply chains can further be complicated as different customers demand compliance with varying standards. This variability requires logistics to adapt flexibly, yet most standards do not provide the necessary frameworks to manage these differing demands effectively. Finally, regarding audit processes, the disclosure of results is usually internal, limiting the availability of information for external interested parties.

In relation to the identified needs, it is crucial to establish requirements that not only encourage commitment to local communities but also their active participation in certification processes. An effective measure would be to establish grievance mechanisms for communities to report non-compliance, thus ensuring ethical practices. Standards covering various aspects, such as ISO standards, are urged to be leaders in including communities in the global discussion of social responsibility in CRM supply chains. Additionally, a greater focus of standards on economic aspects is needed, such as employability, economic responsibility, financial aspects, fair trade, supply chain management, economic risk management, anti-corruption, and economic impacts. It is vital to ensure that staff and stakeholders are adequately informed and trained about the standards. Moreover, the incorporation of technology is essential, as it can significantly improve transparency, traceability, and efficiency in supply chains, through more accurate and real-time monitoring, facilitating problem identification and resolution, and ensuring that standards are met more effectively. Finally, the lack of alignment with specific regulations is an aspect to consider, although standards indicate their conformity with local regulations, they often do not detail their compliance with specific legislations.

In terms of **transparency**, significant progress has recently been made through the implementation of traceability systems for CRMs throughout the supply chain. These systems collect detailed information about the properties of minerals, their country of origin, quantities, and whether they come from conflict zones. In particular, technologies like blockchain, known for their immutable record of transactions, have gained popularity. However, it is crucial to consider certain aspects before their application. According to Calvão & Archer, (2021), the lack of interoperability between different blockchains can hinder information exchange. Additionally, the application of blockchain could lead to a shift in the oversight of supply chains towards systems controlled by a limited group of companies, restricting transparency and the democracy of the process. Moreover, the technological and financial demands of blockchain technology can create barriers for smaller, artisanal companies, potentially excluding them from the system and putting them at risk of marginalization (Calvão & Gronwald, 2019). These systems can perpetuate power inequalities, as only those with sufficient resources can access them. These characteristics indicate that, despite recommendations for implementing these systems, it is necessary to proceed with caution and study them further.

Other aspects to consider in these traceability systems include data security, given that these systems handle sensitive and often confidential information. It is crucial to ensure that these data are protected against unauthorized access, manipulation, and loss. Within the same aspect, many of the proposed interventions do not adequately address the challenges associated with resistance to sharing information along the supply chain, which may be due to concerns about confidentiality, competitiveness, or data security. Therefore, it is essential to design strategies and systems that encourage greater openness and collaboration. Another critical aspect to consider is the expansion of the traceability capabilities of these systems, to include not only the origin of the material but also aspects related to labour rights and environmental impact throughout the supply chain.

Regarding other aspects of transparency, it is essential for companies to improve communication and disclosure of the results obtained through due diligence and audits. Making these results public would not only increase transparency but also reinforce commitment to stakeholders (European Commission, 2020b).

3.7.1 Secondary raw materials

The main difficulties in collecting information lay in finding specific data for secondary raw materials (see Figure 13). Regarding due diligence frameworks, data was found for both primary and secondary raw materials (Overall), although these documents primarily focus on the primary aspect, lacking specific information for the secondary part. The same applies to legislation, where there are no specific laws or proposals for the sector, and those attempting to cover it do not delve into it or are more focused on primary materials, with no clear connection to secondary ones. Concerning initiatives and standards, recent efforts have highlighted the analysis of secondary materials separately from primary ones, concentrating on responsible sourcing, reuse, recycling, and disposal of electronic products.

As for the gaps in current interventions, there is a need for further development in establishing standardized recycling and disposal practices that ensure safe handling of electronic waste, and enhance the quality of secondary materials. The recycling sector's needs revolve around ensuring secure and environmentally responsible recycling of

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electronic waste. It is imperative that existing standards delve deeper into data security in electronic product recycling.

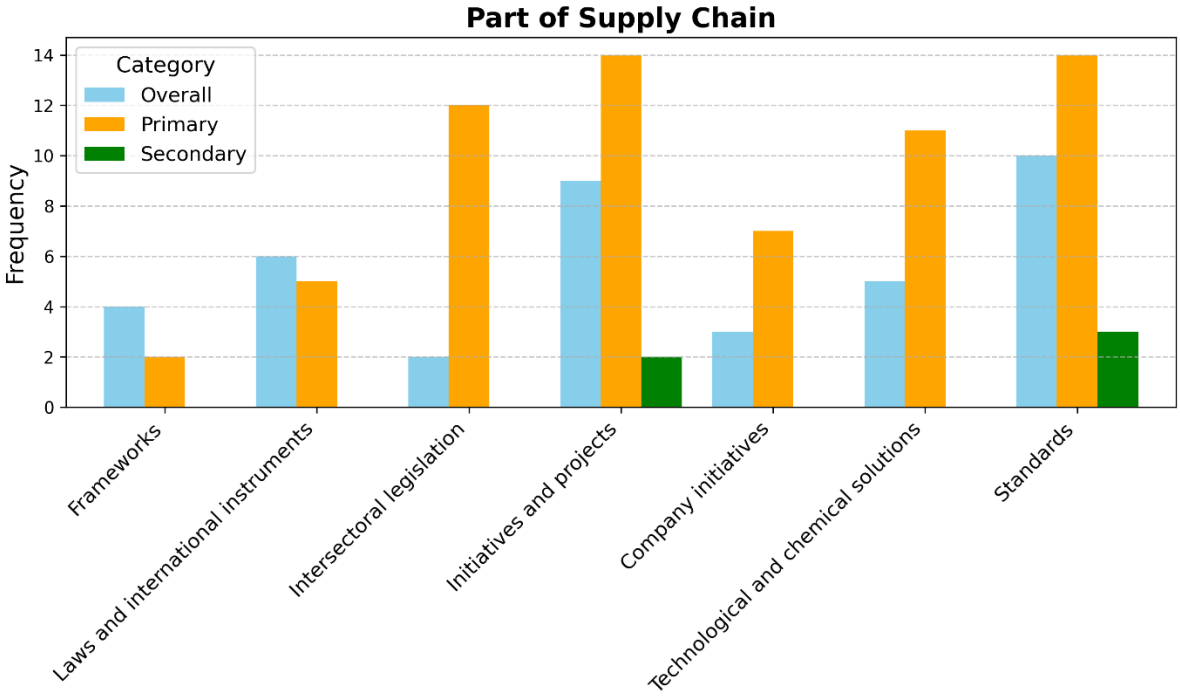

Figure 13: Frequency with which the documents cover primary raw materials, secondary raw materials, or both categories.

4 SWOT analysis of the main due diligence standards

In Chapter 3, current interventions in the field of due diligence were reviewed, organizing the information into four main categories: frameworks; laws and international instruments; activities and collaborations; and standards. The standards are particularly important as they establish the requirements for complying with due diligence in the supply chain, drive performance in Environmental, Social, and Governance (ESG) matters, and guide companies and stakeholders to ensure responsible sourcing. Therefore, the chapter 4 will focus on identifying the SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis of nine key standards, selected in consultation with experts from the MaDiTraCe project. These key standards include: 1) CERA 4in1; 2) the Responsible Jewellery Council (RJC) standards; 3) The Initiative for Responsible Mining Assurance (IRMA) standards; 4) The Aluminium Stewardship Initiative (ASI) standards; 5) the Copper Mark standards; 6) The World Gold Council (WGC) standards; 7) the RCI and RMI Cobalt standard; 8) the Responsible Minerals Initiative (RMI) standards; 9) The Sustainable Electronics Reuse & Recycling (R2) standard.

In the following subsections, the results obtained from the prioritisation of the SWOT criteria using the AHP method and the evaluation of the sustainability criteria using the LancsBox[72]

[72] Brezina, V., McEnery, T., & Wattam, S. (2015). Collocations in context: A new perspective on collocation networks. *International Journal of Corpus Linguistics*, 139–173. https://doi.org/10.1075/ijcl.20.2.01bre

tool are mentioned, showing more information for the prioritised criteria. Based on the above results, the SWOT analysis the standards are shown below.

4.1 Prioritisation of criteria through AHP

The following subsection aims to present and analyse the main results obtained from the prioritization of criteria using the AHP method. This analysis is essential for evaluating the standards in a structured and objective manner, in relation to their strengths, weaknesses, opportunities, and threats.

The overall AHP results (see Table 10), which correspond to the comparison of all criteria among themselves, show that opportunities and threats are key elements that we must consider to evaluate the standards. In particular, opportunities "O3" and "O2" and threat "T2" are the most important. O3 refers to the growing interest or demand from consumers or investors for companies to adhere to certain sustainability practices, and O2 to the partnerships or alliances that can be established to facilitate or improve the implementation of a standard. Regarding T2, it refers to how legislative changes could affect the adoption of the standard. This reflects the importance of responding to market expectations and stakeholder demands. Furthermore, it reflects the acceptance of standards in a constantly evolving regulatory environment.

Code	Criteria	AHP position obtained
O3	Growing Demand from Consumers or Investors	1
T2	Changing regulatory	2
O2	Strategic collaboration	3
SW42	Recognition OECD Due Diligence Guidance and UN Guiding Principles on Business and Human Rights	4
O7	Development of training programmes or resources	5
O8	Alignment with Corporate Social Responsibility Trends	6
O6	Advancement in technologies	7
O4	Scalability	8
O5	Market Differentiations	9
T7	Credibility	10
T4	Challenges in sustainability and social responsibility	11
O1	Emerging trends	12

Table 10: Final results of the prioritisation through the AHP method.

When comparing criteria by categories, within strengths and weaknesses (see Table 11), the most prominent criteria were SW2 and SW4, highlighting the importance of compliance with international standards and the ability of standards to adapt to local and international regulations. Additionally, criterion SW32 stands out, which is crucial since the clarity and availability of these guidelines facilitate the adoption and implementation of standards. Regarding audits, the type of audit (SW51) and the disclosure of its results (SW53) play a fundamental role. Standards that include rigorous and third-party verified audits are perceived as more robust and reliable, while standards that promote clear and accessible

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disclosure of results demonstrate a commitment to transparency and accountability. These results indicate that standards that best meet these criteria are perceived as more robust and reliable.

Code	Criteria	AHP position obtained
SW42	Recognition OECD Due Diligence and UN Guiding Principles	1
SW44	Regulatory alignment	2
SW32	Guidelines how to implement	3
SW51	Type of audit	4
SW53	Disclosure of audit results	5

Table 11: Results of the prioritization within the Strengths and Weaknesses group using the AHP method.

When comparing criteria by categories within opportunities (see Table 10), O2 and O3 were the most important, as mentioned earlier. But O7 Developing of training programmes or resources, also stands out because they can help companies better understand the requirements of the standard and implement sustainable practices more effectively. O8 Alignment with Corporate Social Responsibility Trends, also stands out, which is essential to ensure that standards remain relevant and attractive to companies seeking to improve their sustainability profile.

Regarding threats (see Table 12), the importance of T2 was previously mentioned, but T7 also stands out, given that it is a fundamental aspect, as any doubt about the integrity or rigor of the standards can erode trust and reduce their positive impact. Similarly, T4 is a key aspect, as the challenges not only include meeting these requirements but also effectively demonstrating that they are being met. Finally, another criterion to highlight is T6, the need for continuous innovation in response to new technological developments and changes in the industry presents a constant threat. Standards that cannot adapt or incorporate innovations may become obsolete and lose relevance compared to those that do.

These criteria highlight the need to seize key opportunities to mitigate risks and capitalize on the growing market interest in sustainable and responsible practices, thus ensuring their long-term competitiveness and sustainability. Additionally, they emphasize the importance of flexibility, credibility, and the ability to innovate so that standards can effectively face threats and maintain their relevance and effectiveness in a dynamic environment.

Code	Criteria	AHP position obtained
T2	Changing regulations	1
T7	Credibility	2
T4	Challenges in sustainability and social responsibility	3
T6	Innovation	4

Table 12: Results of the prioritization within the Threats group using the AHP method.

The results of the SWOT analysis presented in the following section used this prioritization to recognize strengths, weaknesses, opportunities and threats.

4.2 SWOT analysis details

This section describes in detail the SWOT analysis performed for nine main standards selected. The information for strengths and weaknesses is separated in: General characteristics of the standards; Performance Standard and if available Chain of Custody.

4.2.1 CERA 4in1 Performance Standard (CPS)

CERA 4in1 Performance standard is one of the 4 standards of CERA4in1 (TÜV NORD, 2024a), which aims to define requirements for environmental and social responsibility and corporate governance (ESG).

Strengths	**General characteristics of the standard and Performance standard**
• Strong multi-stakeholder governance and capacity for continuous updating, backed by broad collaboration and regular triennial renewal. • Applicability to all types of companies and commodities, with a wide geographical scope and a high level of compliance with social and environmental aspects. • Clear and detailed guidelines for implementation, with supporting documentation and a focus on transparency and information disclosure. • Compatibility with numerous key international standards and regulations, recognising global due diligence and human rights frameworks, as well as complying with ISO standards. • Robust approach to high-level audits with third-party verification and certification, including specific on-site verifications, and allows for rapid certification and re-certification with a high level of disclosure of audit results.	
Chain of Custody	
Under development	

Table 13: Strengths of the CERA 4in1 CPS standard.

Weaknesses	**General characteristics of the standard and Performance standard**
• Voluntary character, lack of ISEAL membership and is relatively new, first developed in 2020. • Information is only available in English, which makes it difficult to understand globally, and it lacks a system for complaints and denunciations of non-compliance.	

Table 14: Weaknesses of the CERA 4in1 CPS standard.

Opportunities
• Holistic Coverage: CERA 4in1 is the only certification covering the entire minerals value chain, from exploration to final product, facilitating transparency and sustainability, and differentiating it from fragmented certifications. • Growing Interest in Sustainability: CERA 4in1 may become the certification of choice for mining and mineral processing companies, attracting those committed to ESG criteria. • Strategic Collaborations: Significant benefits from strategic collaborations with governmental entities and major corporations, validated by successful pilot projects with a leading German automobile manufacturer and a cobalt mining company in the Democratic Republic of Congo (TÜV NORD, 2024b). • Training Programs: Development of training programs that include courses on ESG criteria in mining, practical conformity assessment exercises, and the creation of expert networks (TÜV NORD, 2024b), strengthening the implementation of standard.

Table 15: Opportunities of the CERA 4in1 CPS standard.

Threats

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• Competition from other Standards: The existence of other standards such as ASI, WGC, RMI, RCI, and IRMA that cover the same minerals and share similar objectives, which could be preferred due to their targeted or established approaches. • Geopolitical, Economic, and Industrial Instability: Challenges in these areas can affect the implementation and attractiveness of CERA 4in1, especially for conflict minerals like gold, cobalt, and 3TG. • Technological Adoption: The lack of emphasis on adopting the latest technologies may make the standard less attractive to the industry and the public. • Regulatory changes with stricter or different requirements: o Changes in Human Rights and Labour Laws, given that the CERA 4in1 incorporates references to the Universal Declaration of Human Rights (UN, 1948) and the principles of the International Labour Organization (ILO) (ILO, 2022). In addition, CERA 4in1 will address the conflict minerals supply chain: the Modern Slavery Act 2015 (Government UK, 2015). In addition, the Corporate Sustainability Due Diligence (European Commission, 2022a) is at the stage of translating the agreement into a legal text, therefore all changes made could have consequences on this standard. o Changes with more stringent requirements or different requirements from environmental protection regulations could introduce stricter controls on mining emissions and waste management: EU Mining Waste Directive (European Commission, 2006), U.S. Clean Water Act (EPA, 2023b) and U.S. Clean Air Act (EPA, 2023a). o Changes in Trade Regulations and Sanctions, which could influence the CERA 4in1 standards: Dodd-Frank Act: Section 1502 (U.S. Congress, 2010), EU Supply Chain Due Diligence proposal (European Commission, 2022a) and The Kimberley Process (Kimberley Process, 2003);Changes in fair trade policies: Fair Trade Commission Act (Federal Trade Commission, 2006) and EU Trade policy (European Commission, 2021a).

Table 16: Threats of the CERA 4in1 CPS standard.

4.2.2RJC standards

RJC has two standards: the RJC Code of Practices Standard (COP) (RJC, 2019) and the RJC Chain of Custody (CoC) (RJC, 2017). The first promotes ethical, social, human rights, and environmental practices, while the latter focuses on traceability and responsible sourcing practices.

Strengths	**General characteristics of the standards**
• Broad membership, more than ten years of experience and membership in ISEAL reinforce the credibility and acceptance of the RJC standard. • Comprehensive inclusion, encompassing all types of companies within the gold and platinum group chains, addressing the entire supply chain from extraction to recycling, and is applicable on a multinational and geographically wide basis. • Transparency with respect to its management structure and includes robust and well-structured complaints and grievance mechanisms. • Recognition of other standards, reaching the highest level of mutual linkage with IRMA, TSM and RMAP, according to Erdmann & Franken (2022). • Robust approach to high-level audits with third-party verification and certification, including specific on-site verifications, and allows for rapid certification and re-certification with a large number of companies certified to the CoP standard.	
Strengths	**RJC COP**

• The RJC CoP is mandatory for its members, consolidated since its first version in 2009, continuously incorporating new topics and developing with broad multi-stakeholder collaboration. • High development in the compliance of governance, environmental, social and economic aspects. • Clarity and Support, providing clear guidance on how to implement the requirements with specific documents, offers supporting documentation and clarity on the same, including definitions and translations in five languages. • International Compliance, recognizes international due diligence and human rights frameworks such as the OECD and UN Guiding Principles, complies with existing ISO standards and ensures compliance with all applicable laws and regulations, and expects the same from its members.
Strengths **RJC COC**
• Consolidated standard since its first version in 2012, continually incorporating new topics and is developed with extensive multi-stakeholder collaboration. • The RJC CoC addresses some guidelines on how to address data security risks when implementing the GDPR. • Clear guidance is provided on how to implement the requirements with the specific CoC Guidance document, supported by comprehensive documentation that includes definitions and is available in five languages. Additionally, for CoC transfer documents, a clear definition of disclosure requirements is specified. • Recognition of international frameworks for due diligence and human rights, such as the OECD Due Diligence and UN Guiding Principles, and conformity with existing ISO standards. • Extensively addresses traceability concepts and incorporates an efficient traceability system with detailed information and supporting documentation.

Table 17: Strengths of the RJC standards.

Weaknesses	**General characteristics of the standards**
• The governance structure of the standards is an industry lead initiative. • According to Erdmann & Franken (2022), the level of mutual linkage with the Copper Mark and ASI reaches the lowest level, that of 'Reference or superficial alignment. • The audit reports are concerning, as they provide only superficial results, with small number of companies certified to the CoC standard.	
Weaknesses	**RJC COP**
• The RJC COP is voluntary for non-members and is renewed every five years. • The RJC COP does not specify how members should disclose information.	
Weaknesses	**RJC COC**
• The RJC CoC is voluntary for both members and non-members, features only a moderate level of multi-stakeholder collaboration during implementation, and has a long renewal period of five years. • The RJC CoC does not address how to deal with resistance to intra-company data sharing and lacks guidelines on managing complex supply chains. • The accounting method for material control is not adequate, identity preservation should prevail over material segregation.	

Table 18: Weaknesses of the RJC standards.

Opportunities
• The role of RJC as a leading authority on responsible jewellery standards positions it advantageously compared to competitors, offering the potential to influence the industry, establish recognized standards, and advocate for ethical and sustainable practices.

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• The growing interest in ethical and sustainable practices in the jewellery industry provides RJC Standards with an opportunity to become the gold standard, attracting companies looking to enhance their reputation and appeal to a more conscious market. • Incorporating new technologies for traceability would enhance the CoC standard. • Developing a Standard for Recycled Products positions the RJC at the forefront of sustainability innovation, enhancing credibility and broadening market appeal to include recycled materials companies. • Numerous companies in jewellery production and promotion mark themselves as strategic sector partners. The ongoing extension of the partnership of the RJC with the World Diamond Council (WDC) (RJC, 2021), a key player in ethical diamond industry practices, forms part of its strategy to develop new markets. • Development of training workshops for artisans and small businesses on the benefits of RJC certification and how to become certified. • Collaborating with major retailers to encourage a preference for RJC-certified suppliers can incentivize standard adoption across the supply chain. The ongoing expansion of a partnership between RJC and Dhamani Jewels (RJC, 2022), the first UAE retailer to sign up, exemplifies this strategy.

Table 19: Opportunities of the RJC standards.

Threats

• Competition with WGC, could reduce market share in adoption of the standard.
• The credibility of the RJC is threatened by its ability to maintain transparency and consistency in the application of its standards. The long period of review of the standards, which takes place every 5 years, and the lack of transparency in the publication of assessment results, which provide only superficial results, can seriously undermine confidence in these standards. This situation could lead to a decline in adoption of the standard and negatively impact the reputation of the RJC within the responsible jewellery industry.
• Regulatory changes with stricter or different requirements:
  ○ Changes in Human Rights and Labour Laws, given that the RJC incorporates references to the Universal Declaration of Human Rights (UN, 1948) and the principles of the International Labour Organization (ILO) (ILO, 2022);
  ○ Changes in environmental regulation, as the RJC seeks to promote responsible and sustainable practices in the jewellery industry: U.S. Clean Water Act (EPA, 2023b), U.S. Clean Air Act (EPA, 2023a) and EU Mining Waste Directive (European Commission, 2006);
  ○ Changes in Trade Regulations and Sanctions, which could influence the RJC standards: Dodd-Frank Act: Section 1502 (U.S. Congress, 2010), EU Supply Chain Due Diligence proposal (European Commission, 2022a) and The Kimberley Process (Kimberley Process, 2003);Changes in fair trade policies: Fair Trade Commission Act (Federal Trade Commission, 2006) and EU Trade policy (European Commission, 2021a).

Table 20: Threats of the RJC standards.

4.2.3 IRMA standards

IRMA has two standards, the IRMA standard for Responsible Mining IRMA-STD-001, which defines best practices for responsible industrial-scale mining (IRMA, 2024) and the IRMA Chain of Custody, designed to provide baseline requirements for tracing material from any IRMA-audit mine through the downstream processing of mineral intro products (IRMA, 2023a).

Strengths	General characteristics of the standards
• More than ten years of experience of the standard owner, membership in ISEAL, a governance structure based on a multi-stakeholder board and flexibility in the application of regulatory requirements, with four levels of compliance allowing for progressive adaptation. • Multinational standards with a broad geographic scope. • Clear information on the management structure and a robust complaints system accessible to all stakeholders for complaints related to certifications and decisions of auditors. • According to Erdmann & Franken (2022), the level of mutual linkage with TSM, RJC and Responsible Steel reaches the highest level, that of "Recognition". • Robust approach to high-level audits with third-party verification and certification, including specific on-site verifications, and allows for rapid certification and re-certification with the result of the audit report available to the public.	
Strengths	**IRMA standard for Responsible Mining IRMA-STD-001**
• New issues are incorporated into updates and there is extensive multi-stakeholder collaboration during development and implementation. • High development in the compliance of governance, environmental, social and economic aspects. • Clear guidance for implementing requirements with specific documents, available supporting documentation, IRMA-STD-001 standard translated into five languages, and recommendations for information dissemination. • Recognition of international frameworks such as OECD due diligence and the UN Guiding Principles, compliance with ISO standards, and endorsement by legislators as a basis for responsible mining practices.	
Strengths	**IRMA CoC**
• New topics are incorporated into updates with extensive multi-stakeholder collaboration. • Clear guidance for implementing requirements with specific documents, supporting documentation available, IRMA CoC standard and definitions translated into five languages. • Recognition of international frameworks such as OECD and UN Guiding Principles, and compliance with ISO standards. • It addresses traceability with clear requirements, promotes proprietary systems, includes accounting guidelines and considers technologies such as Blockchain.	

Table 21: Strengths of the IRMA standards.

Weaknesses	General characteristics of the standards
• Low number of members of the standard owner (83), considering that there is a large number of mining companies and that it covers all minerals. • According to Erdmann & Franken (2022), the level of mutual linkage with IFC, The Copper Mark and ASI reaches the lowest level, that of 'Reference or superficial alignment. • The number of certified companies for each standard is not publicly specified.	
Weaknesses	**IRMA standard for Responsible Mining IRMA-STD-001**
• IRMA-STD-001 is voluntary, emerging since 2018, and has a long renewal period of five years.	
Weaknesses	**IRMA CoC**
• The IRMA CoC is voluntary, emerging from 2020, and has a long renewal period of five years.	

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• Guidance on dealing with risks to data security, resistance to data sharing, and the complexity of multi-tier supply chains is omitted. • The IRMA CoC standard is only available in English and does not specify how members should disclose information. • The IRMA CoC does not mention alignment with the regulation. • The IRMA CoC standard does not have a transfer document template.

Table 22: Weaknesses of the IRMA standards.

Opportunities
• As pressure for responsible mining increases, IRMA can establish itself as the essential standard for companies wishing to meet the sustainability and social responsibility expectations of consumers and investors. • Incorporating new technologies for traceability would enhance the CoC standard. • Integrating artisanal and small-scale mining into the IRMA Standard presents an opportunity to broaden its scope and inclusivity. • Recognizing different levels of achievement allows mines to be recognized for continuous progress, offering an opportunity to differentiate themselves in the marketplace and show commitment to constant improvement in responsible practices. • Community engagement in IRMA audits provides an opportunity to strengthen mineral resource governance through greater inclusion and participation of mining-affected communities, exemplified by the communities affected by the Unki mine (LEDS LAC, 2021). • IRMA has developed training programs and educational resources, including self-assessment tools and detailed mine assessment manuals (INNOVATION, 2023). These initiatives help companies apply IRMA standards and improve transparency and communication among stakeholders. • Expansion of sustainability in supply chains through the influence on leading companies like BMW to enforce IRMA standards compliance among their suppliers (BMW GROUP, 2020). • Possibility of improving social responsibility and cultural adaptation by identifying and addressing the specific needs of local communities, as demonstrated by lithium producers such as Albemarle (Albemarle, 2023) and SQM (SQM, 2023) and mining companies such as Anglo American (IRMA, 2022c, 2023b), Carrizal Mining S.A. de C.V. (IRMA, 2020b) and Livent Corporation (IRMA, 2022b).

Table 23: Opportunities of the IRMA standards.

Threats
• Competition with RMI and CERA4in1 standards, could hinder the adoption of the standard and reduce its market share. • Regulatory changes with more stringent requirements or different requirements from environmental protection regulations could introduce stricter controls on mining emissions and waste management: EU Mining Waste Directive (European Commission, 2006) , U.S. Clean Water Act (EPA, 2023b) and U.S. Clean Air Act (EPA, 2023a). In addition, the Corporate Sustainability Due Diligence (European Commission, 2022a) is at the stage of translating the agreement into a legal text, therefore all changes made could have consequences on this standard. • Challenges in managing relationships with local communities, particularly in securing and sustaining their support and consent. This is especially pertinent in regions where mining operations significantly impact local livelihoods and environments. • Ensuring high standards of occupational health and safety in the hazardous environments typical of mining is critical. Any lapse in maintaining these standards can significantly undermine the credibility of the standard.

• Mining in areas of high environmental or cultural value presents risks of legal challenges and community resistance. This undermines the credibility and acceptance of the standard and contradicts IRMA's commitment to environmental responsibility and sustainability. • The credibility of IRMA faces significant challenges due to the revision of its standards every 6 years, which could reduce their effectiveness and relevance. This extended interval may result in outdated practices and undermine stakeholder confidence, which could decrease the adoption of IRMA standards and damage its reputation.

Table 24: Threats of the IRMA standards.

4.2.4 ASI standards

ASI has two standards: the ASI Performance Standard (ASI, 2023b) and the ASI Chain of Custody. The first defines environmental, social, and governance principles and criteria, which address a broad range of sustainability issues in the aluminium value chain. The ASI Chain of Custody standard creates a link between the company's practices and responsible sourcing of products by connecting certified suppliers and customers while accounting for material flow (ASI, 2023a).

Strengths	**General characteristics of the standards**
• Detailed specifications for aluminium, backed by more than ten years of experience with ISEAL membership and modern technologies for improved documentation and certification. • Includes all types of companies in the aluminium sector, regardless of size. Multinational standards with a broad geographical scope covering the entire supply chain, from extraction to recycling. • Clear information on management structure. Robust whistle-blower mechanism, accessible to employees, auditors or ASI, and grievance mechanisms for auditor decisions. • Robust approach to high-level audits with third-party verification and certification, including specific on-site verifications, and allows for rapid certification and re-certification with the result of the audit report available to the public.	
Strengths	**ASI Performance Standard**
• Mandatory for companies in the ASI membership classes "Production and Transformation" and "Industrial Users". Consolidated standard since 2014, updated with focus on biodiversity, climate and human rights. High multi-stakeholder collaboration in its development and implementation. • High development in the compliance of environmental, social and economic aspects. • Clear guidance is provided to implement the requirements with specific documents (ASI Performance Standard Guidance). Availability of supporting documentation. Clear standard, with definitions and documents translated into seven languages, and recommendations on disclosure of information. • Recognition of international frameworks for due diligence and human rights (OECD and UN Guiding Principles). Compliance with ISO standards. ASI clarifies that organizations must comply with applicable laws, and members must ensure this compliance.	
Strengths	**ASI CoC**
• Mandatory for companies making claims related to the production or sourcing of materials. Updates include new topics and multi-stakeholder collaboration during development and implementation. • Clear guidance is provided to implement the requirements with specific documents (ASI CoC Standard Guidance). Supporting documentation available. Clear standard,	

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with definitions and documents translated into seven languages, and provides guidelines for reporting inputs and outputs. • Recognition of international due diligence and human rights frameworks, such as the OECD Guidelines and the UN Guiding Principles, is mentioned. Compliance with existing ISO standards. • Addresses traceability in detail, with a system that guarantees the origin of bauxite and provides verified documentation throughout the supply chain. It includes criteria for handling control material and a proper accounting method to track material without the need for physical segregation at each stage.

Table 25: Strengths of the ASI standards.

Weaknesses	**General characteristics of the standards**
• Low number of members of the standard owner (348), considering that aluminium is a key material in industries such as automotive, construction, aerospace, electronics, and packaging. • According to Erdmann & Franken (2022), the level of mutual linkage with IRMA, and RJC reaches the lowest level, that of "Reference or superficial alignment". • Small number of companies certified to the standards.	
Weaknesses	**ASI Performance Standard**
• Long renewal period of the standard, every five years. • Low development in the compliance of governance aspects.	
Weaknesses	**ASI CoC**
• Optional for ASI members. It is an emerging standard, with the first version developed in 2017 and a long renewal period, every five years. • Data security risk guidance is omitted. The ASI CoC standard lacks sufficient guidelines on information-sharing resistance along the supply chain. • ASI CoC does not consider the use of emerging technologies for traceability.	

Table 26: Weaknesses of the ASI standards.

Opportunities
• The uniqueness of the ASI standard focused on the aluminium supply chain brings specificity and represents a unique opportunity to establish leadership in sustainable and responsible practices in this sector. • Growing awareness in the aluminium industry and related sectors, as evidenced by the European Aluminium initiative (European Aluminium, 2023), presents a significant opportunity for the expanded adoption of ASI certifications. • ASI benefits significantly from strategic collaborations with major corporations and organizations in the aluminium value chain. Notable examples include its partnerships with major aluminium producers and users such as Hydro (Hydro, 2021), BMW, Audi, Nespresso, Heineken and Apple. As well as with the International Aluminium Council (IAI) and the European Aluminium Association (Sustain case, 2022). • Understanding and adoption of the standard through an ASI e-learning platform, which provides training modules, workshops and webinars on key topics such as greenhouse gas emissions reduction and waste management. This platform empowers companies to implement ASI standards effectively, improving transparency and compliance in the aluminium value chain (ASI, 2024a, 2024b). • Encouraging the inclusion of small and medium-sized companies in the implementation of the ASI standard by providing technical and financial assistance can significantly expand the impact and adoption of these sustainable practices in the aluminium industry.

• Demonstrating the business value of ASI certification through case studies and ROI analysis can incentivize more companies to adopt these standards, underscoring their effectiveness in improving efficiency and corporate reputation.

Table 27: Opportunities of the ASI standards.

Threats

• Competitiveness with standards that include all minerals as they can be more convenient and easier to apply as there are no sector-specific requirements.
• Companies that do not follow the ASI standard may offer aluminium at lower prices, which could put companies that do comply with these standards at a competitive disadvantage, especially in markets where consumers and customers do not value sustainability.
• The credibility of ASI is at risk if it does not maintain transparency and consistency in its certification processes. Revising its standards every 5 years can be a disadvantage, as this long interval can lead to outdated practices, reducing effectiveness and stakeholder confidence in the standards.
• The lack of updating to the latest traceability system technologies could result in the adoption of the standard not being perceived as innovative, limiting its relevance and effectiveness in a market in constant technological evolution.
• Regulatory changes with stricter or different requirements:
  ○ Changes with stricter environmental requirements in Europe, such as changes to the Green Deal (European Commission, 2023h), in Australia changes to the Environment Protection and Biodiversity Conservation Act 1999 (Australian Government, 2019).
  ○ Stricter supply chain policy requirements, for example when the EU Supply Chain Due Diligence Act becomes law in Europe (European Commission, 2022a), which will require companies to ensure that their supply chains are free of human rights and environmental violations and stricter updates to the Dodd-Frank Act in the US (U.S. Congress, 2010).

Table 28: Threats of the ASI standards.

4.2.5 The Copper Mark standards

The Copper Mark has three standards: The Copper Mark Criteria for Responsible Production, the Joint Due Diligence Standard, and the Copper Mark Chain of Custody. The first sets out requirements for responsible metal production across copper, molybdenum, nickel, and zinc value chains. The Joint Due Diligence Standards enables due diligence for copper, lead, molybdenum, nickel and zinc producers and traders, meeting responsible sourcing requirements. Finally, the Copper Mark Chain of Custody promotes transparency in the copper supply chain by enabling product-level claims about responsibly sourced copper.

Strengths	**General characteristics of the standards**
• ISEAL membership. • Companies of all sizes are included in copper chains to build capacity and mitigate potential risks of adverse impacts. Multinational standards with a broad geographic scope covering the entire supply chain, from mining to the recycling process. • Clear information on management structure. Copper Mark has implemented and maintained a complaints and grievance mechanism in line with the Effectiveness Criteria of the UN Guiding Principles for Non-Judicial Grievance Mechanisms.	

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• Robust approach to high-level audits with third-party verification and certification, including specific on-site verifications, and allows for rapid certification and re-certification.
Strengths **The Copper Mark Criteria and the Joint Due Diligence Standards**
• New themes and additions are made in updates. There is extensive multi-stakeholder collaboration during development and implementation. The standard is renewed every three years. • High development in the compliance of governance, environmental, social and economic aspects. • Clear guidance is provided for implementing the requirements with specific documentation. Supporting documentation is also available. Standards are clear, with definitions and documents translated into three languages. • International frameworks for due diligence and human rights, such as the OECD Guidelines and the UN Guiding Principles, are mentioned. Complies with existing ISO standards and national legal requirements.
Strengths **The Copper Mark CoC**
• Broad level of multi-stakeholder collaboration during development and implementation. • Available supporting documentation and clarity on standards, including definitions and documents translated into three languages. • It addresses traceability concepts, provides requirements and guidelines for implementation, includes criteria for control material handling, uses the mass balance method and facilitates material transfer. In addition, it is attentive to technological developments such as blockchain for future additions.

Table 29: Strengths of the Copper Mark standards.

Weaknesses **General characteristics of the standards**
• Few members of the standard owner (93) despite its global reach. Less than ten years of experience of the standard owner. Industry-led governance structure. • The level of mutual linkage with RJC is low, according to Erdmann & Franken (2022), reaching a level of "Reference or surface alignment". With ICMM, IRMA, TSM, ASI and WGC, the level of mutual linkage is medium, according to Erdmann & Franken (2022), reaching a level of "Reference or surface alignment". • Audit results are published in summary form. Certification to the Copper Mark CoC standard does not guarantee certification of the material or its complete de-risking. There are a low number of sites certified to the standards.
Weaknesses **The Copper Mark Criteria and the Joint Due Diligence Standards**
• The Copper Mark standards are voluntary and emerging, with the first version of the Copper Mark Criteria developed in 2017 and Joint Due Diligence in 2021. • Lack of clear guidelines on disclosure of information. Although companies are required to report annually on their social and governance performance according to international standards, the method or process for this disclosure is not specified. • Joint Due diligence does not mention conformity with existing ISO standards.
Weaknesses **The Copper Mark CoC**
• The standard is voluntary and emerging, with the initial version of Copper Mark CoC developed in 2022. • The Copper Mark CoC does not mention how to address risks to data security and resistance to data sharing. Furthermore, it does not directly mention how to deal with the complexity in Multi-Tier. • The Copper Mark CoC lacks clear guidance for implementing requirements and lacks clear guidelines for information disclosure.

• The Copper Mark CoC does not mention recognition of the UN Guiding Principles, conformity with existing ISO standards, or alignment with regulations.

Table 30: Weaknesses of the Copper Mark standards.

Opportunities
• The Copper Brand demonstrates a proactive commitment to innovation, keeping up with emerging technological developments, particularly the incorporation of blockchain technology into its chain of custody. • Growing consumer awareness and demand for ethical and environmentally responsible products represents a significant opportunity for the adoption of the standards. • Numerous companies in the copper production sector mark themselves as strategic partners. Ongoing collaboration of the Copper Brand with the International Copper Association (ICA) and governmental entities globally forms part of its strategy to promote responsible copper production and sustainable development (ICA, 2024). In addition, partnerships in initiatives such as the United Nations United for Efficiency (U4E) program exemplify its commitment to sustainability across the copper supply chain (The Copper Mark, 2024). • Expansion of training programs and educational resources to train companies in ESG criteria, strengthening transparency and sustainability in the copper value chain (The Copper Mark, 2024). • The specific focus on metals such as copper, lead, molybdenum, nickel and zinc present a unique opportunity to establish leadership and specialization in the supply chains for these metals. This specialization allows for the development of highly tailored and efficient standards. • The flexibility of the Copper Mark standard to include multiple metals represents a strategic opportunity to establish sustainable and responsible practices in a more diverse range of metallurgical operations. • Strengthening and sustainable development in small-scale mining, through funding for technical improvements and other aspects, represents a significant opportunity to drive sustainability and efficiency in this sector. This reinforces the reputation of the standard as committed to continuous improvement and support for mining communities.

Table 31: Opportunities of the Copper Mark standards.

Threats

• Competition with IRMA and CERA 4in1, could reduce market share in adoption of the standard.
• Regulatory changes with stricter or different requirements:
  ○ Inclusion of Copper on the Critical Materials List: The European Commission has proposed changes to its list of critical materials, adding copper and nickel (Blenkinsop, 2023), which could increase regulatory attention and expectations around copper production and supply.
  ○ Industrial Emissions Directive (IED): The IED regulates pollutant emissions from industrial facilities (Copper Alliance, 2023). Future changes to this directive could impose stricter requirements that impact companies that follow The Copper Mark standards.
  ○ Proposed EU Mining Code: The proposal of the European Commission to implement new rules for raw material mining in the EU, in response to Europe's dependence on third countries for these materials (L. Cartier & Zimmermann, 2022), could establish stricter requirements for waste management and rehabilitation of mining areas, which would increase the requirements and

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challenges to achieve and maintain compliance with current Copper Mark standards. • The potential for some suppliers to resist implementing the due diligence practices required by Copper Mark may hinder the uniform and effective adoption of the standards, affecting the integrity and overall effectiveness of system of its system. • Threat of reliance on outside contractors can complicate oversight and assurance that all operations comply with established standards and potentially affect the reputation and credibility of the standard. • The credibility of The Copper Mark relies on its ability to demonstrate transparency and effectiveness in certifying responsible copper production practices. Publishing only summarized assessment results can compromise this transparency, potentially undermining stakeholder trust and confidence in the reliability of certification.

Table 32: Threats of the Copper Mark standards.

4.2.6 WGC standards

WGC has two verification documents: The Responsible Gold Mining Principles and the Conflict-Free Gold standard. The first sets expectations for consumers, investors, and the downstream gold supply chain as to what constitutes responsible gold mining (WGC, 2023b). The Conflict-Free Gold standard addresses potential links between gold and unlawful armed conflict and operationalizes the OECD's Due Diligence Guidance for Responsible Supply Chains for Minerals from Conflict-Affected and High-Risk Areas (WGC, 2023a).

Strengths	**General characteristics of the standards**
• The standard owner has more than ten years of experience. • WGC boasts multinational standards with broad geographical coverage, encompassing the entire supply chain from extraction to recycling. • Gold Mining Principles undergo third-party verification, including on-site verification for a rotating sample of mine sites, verified annually.	
Strengths	**The Responsible Gold Mining Principles and the Conflict-Free Gold standard**
• The Conflict-Free Gold standard was consolidated in 2012, following broad multi-stakeholder collaboration during development. • High development in the compliance of governance, environmental, social, and economic aspects. • Clear guidance is provided for implementing requirements, supported by specific documents such as Guidance for implementing companies and examples. Support documentation is available, and the documentation is clear, including definitions and translations into three languages for the Conflict-Free Gold standard and five languages for the Gold Mining Principles. • Recognition of international frameworks for due diligence and human rights, such as the OECD Due Diligence and UN Guiding Principles, is acknowledged. Conformity with existing ISO standards and compliance with local and international regulations are also emphasized.	
CoC	
• It has no chain of custody. In particular the chapter "Control of gold in the operation" suggests within the specific management systems a traceability system for the flow of gold and gold-bearing material from the point of origin to the point of shipment.	

Table 33: Strengths of the WGC standards.

Weaknesses	General characteristics of the standards
• The WGC standard faces challenges due to a low number of members (32) despite its global scope, the absence of ISEAL membership, and a governance structure led by the industry. • The Gold Mining Principles and Conflict-Free Gold Standard may be impractical for artisanal and small-scale mining due to criteria beyond their capacity. • Undefined management structure and lack of formal complaint and whistleblowing mechanisms, although companies are encouraged to establish feedback processes. • According to Erdmann & Franken (2022), the level of mutual linkage with ICMM and TSM reaches the medium level, that of "Equivalency Benchmark". • Small number of companies have implemented Conflict- Free Gold Standard and Gold Mining Principles.	
Weaknesses	**The Responsible Gold Mining Principles and the Conflict-Free Gold standard**
• The Gold Mining Principles are voluntary for WGC Members and are in an emerging stage, with the first version developed in 2019. Tracking implementation progress is difficult due to decentralized implementation. Both the Gold Mining Principles and the Conflict-Free Gold standard are in their initial versions. • The Conflict-Free Gold Standard and Gold Mining Principles require companies to disclose information without specifying how, leaving guidelines for disclosure ambiguous. • The WGC standard does not mention conformity with existing ISO standards.	

Table 34: Weaknesses of the WGC standards.

Opportunities
• The WGC standard can be an effective tool to promote ethical and environmental relationships with small-scale miners, strengthening their formalization and improving sustainability in the gold industry. • The growing demand for ethical products offers the WGC standard the opportunity to stand out and attract companies seeking to comply with the Principles for Responsible Gold Mining, raising its profile and relevance. • Numerous organizations in the gold production sector mark themselves as strategic partners. The collaboration of WGC Conflict-Free Gold Standard with international NGOs, industry groups, and the UK Department for International Development (DFID) forms part of its strategy to enhance trust and transparency in the gold supply chain (WGC, 2024b). These partnerships validate the standard and promote responsible gold production. • The growing awareness of conflict funded gold mining gives this standard an opportunity to be widely adopted by companies wishing to assure their consumers and investors that their gold is conflict free. • Development and expansion of implementation and training guides for companies and assurance providers, facilitates understanding and compliance with the standard (WGC, 2024a, 2024b). • The WGC standard provides a comprehensive approach to addressing environmental, social and governance aspects, making it an essential tool for companies wishing to effectively manage these aspects in their gold supply chain. Implementing the WGC standard can improve efficiency in the use of resources such as water and energy, which benefits companies by reducing costs and improving their reputation in terms of sustainability.

Table 35: Opportunities of the WGC standards.

Threats

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• Competition with IRMA, CERA 4in1, RJC, Fairmined and Fairtrade could reduce the market share in the adoption of the standard.
• The lack of updates to the latest traceability system technologies could result in the adoption of the standard not being perceived as innovative, limiting its relevance and effectiveness in a market in constant technological evolution.
• The lack of certification systems undermines the credibility and effectiveness of the WGC standard in the gold supply chain.
• The lack of a traceability system, such as Chain of Custody, limits the ability to ensure transparency and traceability in the gold supply chain.
• For the WGC, maintaining credibility is crucial to ensure that certified gold does not fund conflicts. Relying on a single version of the standard and principles, coupled with a lack of transparency in publishing detailed assessment results, can undermine confidence in the reliability of certification.
• Regulatory changes with stricter or different requirements:
  ○ Environmental Regulations: Changes that impose more stringent environmental standards, such as the EU Waste Mining Regulation (European Commission, 2006).
  ○ Reporting and Transparency Requirements: Changes in legislation that mandates detailed reporting on social and environmental impact, such as, the EU Directive on Non-Financial Reporting (European Commission, 2014) and the Modern Slavery Act 2015 (Government UK, 2015).
  ○ Climate Change Legislation: Laws aimed at combating climate change could require mining companies to adopt low-carbon technologies and practices, such as, the European Green Pact (European Commission, 2023h) and the Paris Agreement on climate change (UNFCCC, 2023).
  ○ Changes in due diligence: The Corporate Sustainability Due Diligence (European Commission, 2022a) is at the stage of translating the agreement into a legal text, therefore all changes made could have consequences on this standard.

Table 36: Threats of the WGC standards.

4.2.7 RCI and RMI Cobalt standard

The SWOT analysis will be applied to the Cobalt Refiner Due Diligence Standard which aims to establish clear requirements for the due diligence and assurance activities of cobalt refiners, encouraging responsible sourcing and avoiding duplication of assessments (RCI & RMI, 2022).

Strengths	**General characteristics of the standard and Standard**
• RMI stands out with more than 500 members and a multi-industry governance structure that updates the standard every 1-2 years. • It includes all companies in the global cobalt chain, focusing on social and economic aspects. • It provides clear documentation and detailed guidelines, as well as a robust complaint mechanism for effective implementation. • Recognized by international frameworks such as the OECD and the UN, and aligned with ISO standards and local legislation. • Assurance through third-party verified audits that include site-specific controls.	

Table 37: Strengths of the RCI and RMI Cobalt standard.

Weaknesses	**General characteristics of the standard and Standard**
• The Cobalt Due Diligence standard is voluntary and was initially developed in 2018, with no multi-stakeholder collaboration during its formation. Its audit system focuses	

primarily on downstream refiners, leaving less oversight on key concentrators and processors for upstream due diligence. • The tools developed do not adequately reflect the reality on the ground in the DRC, which limits the scope and transparency of the mining industry in the region, especially in the early stages of the supply chain. • There is a lack of clear information on the management structure of the standard, and it is only available in Chinese and English, which could limit its accessibility and understanding for stakeholders who are not native speakers of these languages. • The assurance process lacks a material certification assessment, which is a key part of ensuring integrity and accountability throughout the cobalt supply chain.

Table 38: Weaknesses of the RCI and RMI Cobalt standard.

Opportunities
• It is the only standard in the market that focuses on cobalt and includes and encourages community participation and support for artisanal and small-scale producers, which can improve community relations and support sustainable practices. • The global approach to the standard in conflict-affected countries and high-risk areas, aligned with the OECD due diligence guidelines and the Chinese guidelines for responsible mineral supply chains, presents a key opportunity to benchmark international practices. • The standard requires annual reporting on supply chain due diligence can be used as a marketing tool to demonstrate transparency and corporate responsibility. • The forecast increase in demand for cobalt, driven by the growth of the electric vehicle industry (Cobalt Institute, 2022), positions the standard as a key tool for ensuring responsible and sustainable practices in an expanding market. • Expansion of the online training academy and organization of in-person workshops to train companies and auditors on due diligence and best practices, enhance the implementation of standards and transparency in the minerals supply chain (RMI, 2024). • The increase in cobalt production in emerging countries such as Indonesia, projected to increase tenfold (Cobalt Institute, 2022), presents an opportunity for the cobalt standard, marking its importance in guiding and ensuring responsible practices in these new supply chains. • The secondary supply of cobalt through recycling is expected to continue to grow (Zeng et al., 2022), representing an opportunity for the cobalt standard to play a key role in promoting and regulating sustainable practices in the metal recycling sector.

Table 39: Opportunities of the RCI and RMI Cobalt standard.

Threats
• Competition with IRMA, could reduce the market share and the adoption of the standard. • The lack of updating to the latest traceability system technologies could result in the adoption of the standard not being perceived as innovative, limiting its relevance and effectiveness in a market in constant technological evolution. • Inadequate documentation for a chain of custody system threatens the cobalt standard, potentially undermining its credibility and acceptance in the industry. • The complexity and cost of implementing the requirements of the standard throughout the supply chain can be challenging for some companies, especially small and medium-sized companies. • Geopolitical or instability risks in key cobalt production areas, such as the DRC, could hinder the effective implementation of the standard in those regions.

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• Regulatory changes with more stringent requirements or different requirements: Changes in the new battery regulation (European Commission, 2023d) and the entry into force this year of the new law on critical raw material (European Commission, 2024b). In addition, the Corporate Sustainability Due Diligence (European Commission, 2022a) is at the stage of translating the agreement into a legal text, therefore all changes made could have consequences on this standard.

Table 40: Threats of the RCI and RMI Cobalt standard.

4.2.8 RMI standards

The RMI standards considered for the SWOT analysis are Global Responsible Sourcing Due Diligence Standard for Mineral Supply Chains All Minerals and Environmental, Social & Governance (ESG) Standard for Mineral Supply Chains.

Strengths	**General characteristics of the standard and RMI standards**
• RMI, with over 500 members and more than ten years of experience, implements multi-industry governance with multi-stakeholder collaboration and continuous updates. • The RMI standards include all types of companies in the mineral chains, spanning multiple nations and a wide geographic scope, with advanced development in compliance with governance, environmental, social and economic aspects. • The RMI standards provide a comprehensive framework with clear guidelines, detailed supporting documentation and a robust grievance mechanism to ensure effective implementation and follow-up. • RMI standards achieve a high level of mutual recognition with the RJC and are aligned with important international frameworks such as the OECD guidelines and the UN Principles, as well as complying with ISO standards and relevant local legislation. • They include audits with third-party verification and certification, integrating site-specific controls to ensure compliance and integrity throughout the certification process.	

Table 41: Strengths of the RMI standards.

Weaknesses	**General characteristics of the standard and RMI standards**
• The RMI standards are voluntary and emerging, with the first version for all minerals developed in 2022 and the ESG standard in 2021, indicating an early stage in implementation and possible lack of maturity. • There is a lack of clear information on the management structure of the RMI, and the standards are limited to availability in English only, which may restrict access and global understanding. • It does not certify materials, but establishes criteria and procedures for due diligence in the minerals supply chain, with an average level of disclosure in the results of audits.	

Table 42: Weaknesses of the RMI standards.

Opportunities
• The adoption of responsible mineral extraction practices in accordance with RMI standards positions these standards as a catalyst for improving corporate image with consumers, investors, and business partners interested in sustainability and business ethics. This approach enhances the value of RMI standards, facilitates entry into new markets, and creates business opportunities for entities that adopt them. • RMI standards provide a framework for companies to actively engage in local capacity building in conflict-affected and high-risk areas. This opportunity increases the value of RMI standards in terms of social and community impact. • Expansion of the online training academy and organization of in-person workshops to train companies and auditors on due diligence and best practices, enhance the

implementation of standards and transparency in the minerals supply chain (RMI, 2024). • Adherence to RMI standards can facilitate the formation of strategic alliances with NGOs, government agencies, and other companies committed to responsible sourcing. In this way, RMI standards become a bridge for collaboration and continuous improvement in the industry.

Table 43: Opportunities of the RMI standards.

Threats
• Competition with IRMA and WGC, could hinder the adoption of the standard and reduce its market share. • Implementing these standards can add complexity to company operations, especially concerning mineral traceability and supply chain management. This may require changes to existing processes and the adoption of new systems. • The lack of updating to the latest traceability system technologies could result in the adoption of the standard not being perceived as innovative, limiting its relevance and effectiveness in a market in constant technological evolution. • The credibility of RMI standards hinges on demonstrating responsible practices through transparent and consistent audits. However, publishing only summary assessment results can undermine confidence in these standards, threatening stakeholder trust and the perceived reliability of the certification process. • Regulatory changes with stricter or different requirements, such as updates to the OECD Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas (OECD, 2016), changes in the Dodd-Frank Act Section 1502 (U.S. Congress, 2010) and changes in the European Union Conflict Minerals Regulation (European Union, 2017). In addition, the Corporate Sustainability Due Diligence (European Commission, 2022a) is at the stage of translating the agreement into a legal text, therefore all changes made could have consequences on these standards.

Table 44: Threats of the RMI standards.

4.2.9 The Sustainable electronics Reuse & Recycling (R2) Standard

The SWOT analysis for the R2 standard, which establishes responsible reuse and recycling practices for the management and processing of used electronics worldwide, is presented below.

Strengths	**General characteristics of the standard and R2 standard**
• R2 is a specific standard for the used electronics sector, established in 2008, with 1076 members and a multi-stakeholder governance structure. It is regularly updated to include technological advances and environmental concerns. • It includes all types of companies in the recycling chain, with a multinational and geographically wide scope. R2 establishes specific criteria for the security of sensitive data and waste management, being highly developed in governance, social and environmental aspects. • It provides clear information on its management structure and offers detailed guidelines for implementation. The documentation, which includes definitions and translations in six languages, is accessible and complements internal standards such as the Code of Practices. • R2 effectively integrates external standards and ISO norms to avoid redundancies and remain relevant and up-to-date. It requires legal compliance assessments in importing, transit, and exporting countries.	

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• The assurance process includes audits with third-party verification and certification, with site-specific controls. Certification and recertification audits are conducted in short periods, and a large number of companies are certified under the R2 standard.
Chain of Custody
They do not have a chain of custody, since R2 integrates a chain of custody component.

Table 45: Strengths of the R2 standard.

Weaknesses	**General characteristics of the standard and R2 standard**
• The R2 standard is voluntary and has a long renewal period of every five to seven years, with no ISEAL membership, which may limit its global recognition and acceptance. • There is a lack of whistleblowing and grievance mechanisms, and guidance on how to implement the requirements of standard is omitted, which could complicate its effective application. • R2 does not recognize international frameworks for due diligence and human rights such as the OECD Due Diligence and UN Guiding Principles. • R2 does not specify the publication of audit results, which may affect transparency and trust in the compliance of standard.	

Table 46: Weaknesses of the R2 standard.

Opportunities
• As the most widely adopted standard on responsible practices for used electronic products in the world, its recognition offers the potential to encourage wider use of the standard in the future. • Increased recycling-based solutions could expand the use of the standard for other products. • Increased market for batteries, thus increasing interest in battery recycling and adoption of the standard. • In the cell phone market, companies such as Samsung and Apple are leading the move towards recycling (Apple, 2022a; Samsung, 2023), expanding the use of recycled materials. This progress could encourage the adoption of the R2 standard. • Implementation and expansion of online training programs and in-person workshops to train professionals in electronics recycling and reuse (Kazdin, 2023), enhancing sustainability and safety practices • Pressure from original equipment manufacturers (OEMs) on processors to obtain R2 certification can be leveraged to establish strategic partnerships with these OEMs, improving the supply chain for recycled and reused electronics.

Table 47: Opportunities of the R2 standard.

Threats

• Competition with e-Stewards, could reduce market share in adoption of the standard.
• Regulatory changes with stricter or different requirements:
  ○ Change in the regulation of batteries, such as, the new EU regulation on batteries (European Commission, 2023d). R2 must be adapted to the new requirements.
  ○ Changes to the EU Waste Electrical and Electronic Equipment (WEEE) Directive (European Commission, 2012), which establishes the collection and recycling of electronic devices in EU member countries.
  ○ Changes in the General Data Protection Regulations (GDPR) (European Commission, 2016), with implications for the recycling of electronic devices containing personal data.
• Activities such as testing and/or repairing used electronics for reuse necessitate an extra quality management system certification. This can pose an extra hurdle for

organizations aiming to comply with the R2 standard, as it requires more effort and resources. • Proper management of focus materials, which include hazardous or special care materials, poses a major challenge. Failure in this management could lead to legal, health and environmental risks and thus damage the reputation of the standard. • The lack of updating to the latest traceability system technologies could result in the adoption of the standard not being perceived as innovative, limiting its relevance and effectiveness in a market in constant technological evolution. • In the e-recycling sector, the credibility of the R2 standard depends on transparency and consistency in the application of responsible recycling practices. The publication of assessment results only internally and the existence of long review periods of 5 to 7 years can undermine confidence in the certification process, negatively affecting the adoption of the standard.

Table 48: Threats of the R2 standard.

4.3 Needs and challenges

4.3.1 SWOT analysis and prioritization of criteria

The SWOT analysis reveals several **strengths in the standards** analysed, according to the evaluation criteria. Regarding "Standard owner and Standard," the long track record and experience of the standards owner stand out, with over ten years for almost all. Additionally, the incorporation of new topics with each update becomes a central strategy for the standards. This is further enhanced by their ISEAL membership for most, ensuring credibility and trust in adherence to social and environmental practices. This is reinforced by the governance structure, which, in most standards, adopts a multistakeholder approach. Specifically, Figure 14 allows for the comparison of standards against each other with respect to the evaluation criteria of strengths and weaknesses, as described in Section 2.2.1. The method used to generate this image involved counting the number of criteria that are strengths for each standard, where the "Standard owner and Standard" category was evaluated on a scale from 1 to 9; "Standard content", "Documentation and support" and "System of traceability" on a scale from 1 to 6; "Assurance Process" on a scale from 1 to 5; "Recognition and conformity" on a scale from 1 to 3. Based on these results, RMI and ASI stand out in the "Standard owner and Standard" category.

The characteristics of the standard are complemented by the "Standard content," where the standards cover a broad geographic scope, a feature present in all evaluated norms. Additionally, a high level of compliance is observed regarding sustainability topics (governance, social, environmental, and economic). Standards such as RJC, The Copper Mark and WGC stand out for these characteristics (see Figure 14). All these characteristics are supported by "Documentation and Support," where most standards present a clear management structure with grievance and whistleblowing systems to report complaints about the standards. This is accompanied by supplementary documentation that provides clear guidelines (with definitions and translations into different languages) and practical advice on how to implement the requirements of standards. IRMA and ASI provide clear documentation and mechanisms for effective information disclosure and complaints (see Figure 14).

Regarding "Recognition and Conformity," there is alignment with international frameworks and conformity with other relevant standards, which reinforces their validity and applicability in global contexts. There is no one standard that stands out from another. In

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terms of the "Assurance Process," most standards include audit processes with third-party verification and certification. These processes not only ensure certification through specific controls at operational sites but also apply frequent and rigorous assurance mechanisms, thus maintaining a high level of control and reliability over relatively short periods. CERA 4in1, IRMA and ASI stand out for their rigorous certification and verification processes (see Figure 14). Finally, The Copper Mark leads in "System of traceability", reflecting a robust approach to traceability throughout the supply chain, with integration of advanced technologies and detailed documentation for material control.

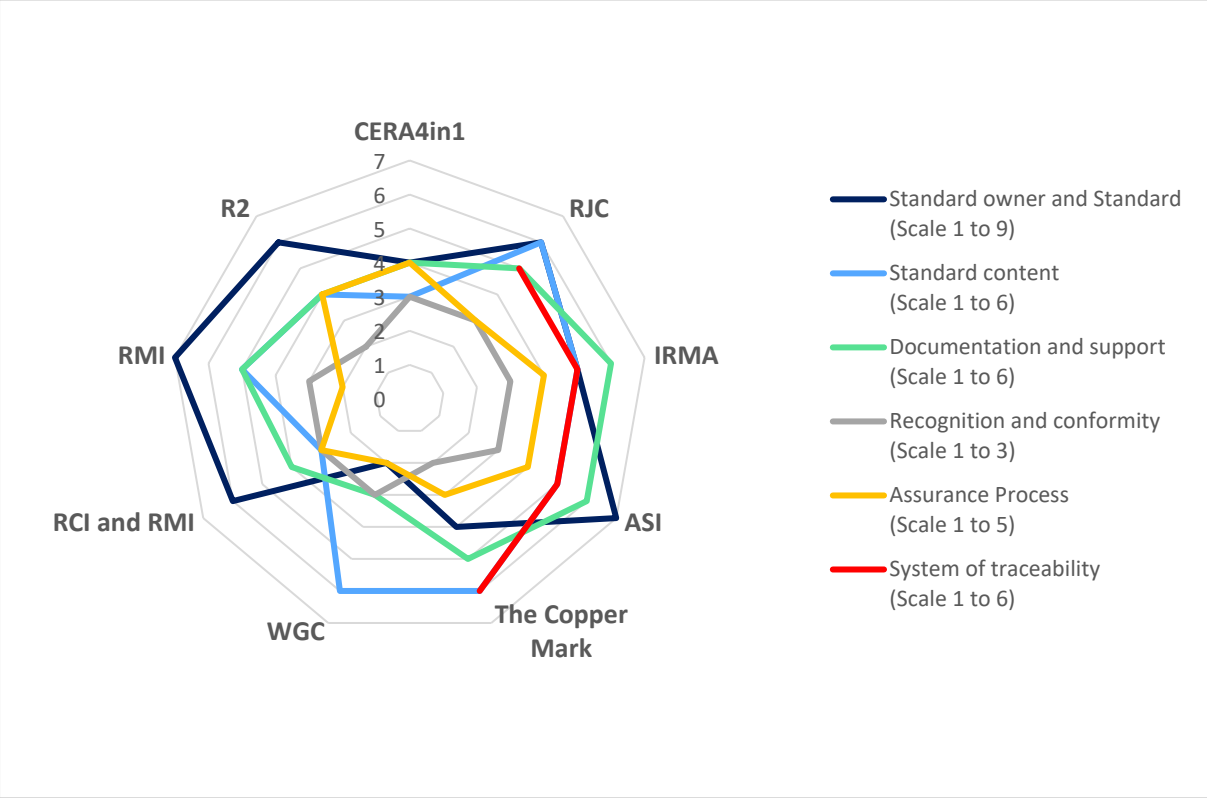

Figure 14: Strengths with respect to the criteria evaluated by standard. "System of traceability" only applies to RJC, IRMA, ASI and The Copper Mark.

However, the analysis also identifies **significant weaknesses**. The number of members of the standard owners is low, which limits their influence and representation in decision-making. The voluntary nature of some standards, along with the long renewal periods that can extend up to five years or more, poses significant issues of consistency and updating. Additionally, some of the standards are in their initial versions and most of them are emerging, still in the process of evaluation, adaptation, and learning how to implement their objectives. Furthermore, stakeholder participation throughout the development and implementation of the standard is not homogeneous, as they only participate in some cases in one of these two phases. Figure 15 uses the same method as Figure 14, but this time counting the number of weaknesses for each standard, using the same scale. Based on this, WGC has significant deficiencies related to these issues. Another important characteristic is the lack of guidelines for disseminating information, compounded by the lack of transparency in publishing audit results, whose incomplete and detailed disclosure can undermine trust in the certification processes. WGC again excels in these weaknesses (see Figure 15). Lastly, the limited number of companies currently certified according to these standards not only questions their effectiveness but also limits their impact on improving

sustainable and responsible practices in the industry. WGC and RMI show significant weaknesses, as WGC itself does not have a certification system and RMI does not deal with certification of materials (see Figure 15).

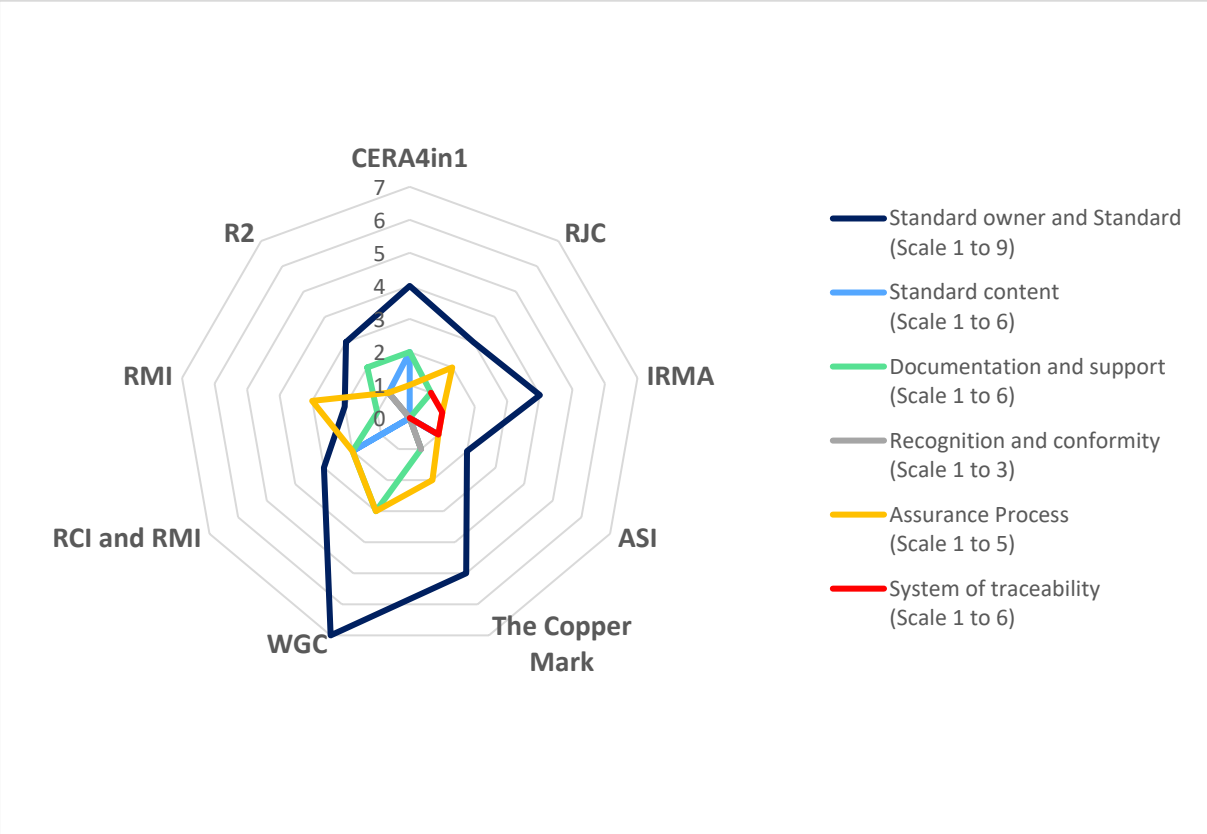

Figure 15: Weaknesses with respect to the criteria evaluated by standard. "System of traceability" only applies to RJC, IRMA, ASI and The Copper Mark.

In terms of opportunities, there is significant potential to improve the public perception and acceptance of these standards. This could be achieved through marketing campaigns focused on sustainability and social responsibility in the mineral supply chain. Such campaigns should highlight the tangible benefits of the standards for both businesses and society at large, promoting greater awareness and support. Strategic collaborations with governmental entities and large corporations can validate and expand the global application of the standards. This synergy between the public and private sectors could create a more robust and coherent regulatory framework, facilitating the widespread adoption of responsible practices in the industry. Additionally, offering incentives for certification could significantly boost the adoption of these standards. The development of training programs on ESG criteria and practical conformity assessment exercises strengthens the implementation of the standards, by forming professionals capable of supporting and advising on global certification projects. Furthermore, promoting the inclusion of artisanal and small-scale mining through the implementation of learning platforms and training in sustainable practices not only broadens the reach and impact of the standard but also fosters widespread adoption by facilitating the transition of these miners to responsible practices. This improves the reputation of the standard by demonstrating a genuine commitment to sustainability and social responsibility. Finally, promoting transparency and traceability as central aspects of the standards not only makes

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them more attractive to businesses but also responds to the increasing demands of consumers and stakeholders.

The identified threats include competition from other standards that cover the same minerals and share similar objectives, which represents a significant threat. The preference for more specific standards for certain minerals or those with greater experience can divert adoption and interest towards other standards, reducing the attractiveness of the standards in question. Additionally, the ability of the standards to withstand geopolitical, economic, or industrial challenges is crucial, as instability in these areas can affect their implementation and effectiveness, especially with minerals considered conflict minerals like gold, cobalt, and 3TG. The lack of adoption of the latest technologies also represents a significant threat, as it can make the standard less attractive to the industry. Regulatory changes with stricter or different requirements, in human rights, labour laws, and environmental protection, can introduce more rigorous controls that impact the adoption of the standard. Additionally, changes in trade regulations and sanctions could negatively influence the implementation of the standard. The credibility of these standards is at risk if transparency and consistency in the application of their certifications are not maintained, which can undermine confidence in them. Finally, ensuring that all personnel and stakeholders are adequately informed and trained on the standards can be a challenge, especially in large or geographically dispersed organizations, which poses a risk to consistent compliance and the overall effectiveness of the standard.

4.3.2 Assessment of sustainability criteria

Considering the frequency results provided by the LancsBox tool, regarding **Governance issues**, the issue “Business practices" is rarely mentioned across all standards. Most attention in this area is focuses on sub-issues such as “bribery” and “corruption”. Sub-issues like “Shareholder value” and “Fair competition” are not mentioned at all. In contrast, "Management practices" receive much more attention. Although the issue itself is seldom mentioned directly, its sub-terms have an above-average frequency of mentions. Judging by this, the most important topics appear to be “Grievance mechanisms”, “Stakeholder engagement”, and “Policy”. Some standards focus more on these issues than others. Figure 16 shows the distribution of mentions of governance-related issues (A), social issues (B) and environmental issues (C) across various sustainability standards. The data are expressed in terms of frequency per 10,000 words to allow for fair comparisons between documents of different lengths. According to this, the ASI Performance standard has the highest number of mentions, followed by RMAP ESG (see Figure 16A). The Principles for Responsible Gold Mining make only minor mentions of them.

Regarding **Social issues**, "Health and Safety" appears to be an important topic. It is consistently mentioned by all standards, though it is often not specified with sub-terms. "Human rights" is among the most frequently mentioned issues. While most standards do not explore its sub-terms in depth, it is consistently present in all of them. The issue of "Employment" shows moderate to low frequencies, with most mentions occurring in the "Training" sub-issue. "Local Communities" as an issue is rarely mentioned. However, there is a significant attention towards “Cultural heritage”, and “Conflict-Affected and High-Risk Areas”. Sub-terms such as “Free, Prior and Informed Consent (FPIC)” and “Indigenous rights” are not mentioned at all. "Local value added" has very low values and the sub-issue "Community development" is most frequency mentioned. As illustrated in Figure 16B, RJC

CoP, ASI Performance standard, and The Copper Mark stand out with more mentions to social issues.

Regarding **Environmental issues**, "Energy" has low frequencies except for the Copper Mark Criteria. "Water" is noted as the most-mentioned issue in the analysis. “Air emissions” is primarily mentioned by IRMA-STD. Concerning, the issue of “Noise" IRMA-STD and The Copper Mark stands out with high frequencies. "Waste" is another highly mentioned category and may be considered a strength. "Climate change" records very low frequencies in some standards, which might present an opportunity for all standard-makers. Regarding environmental issues in general, IRMA-STD, The Copper Mark and ASI Performance Standard are prominent.

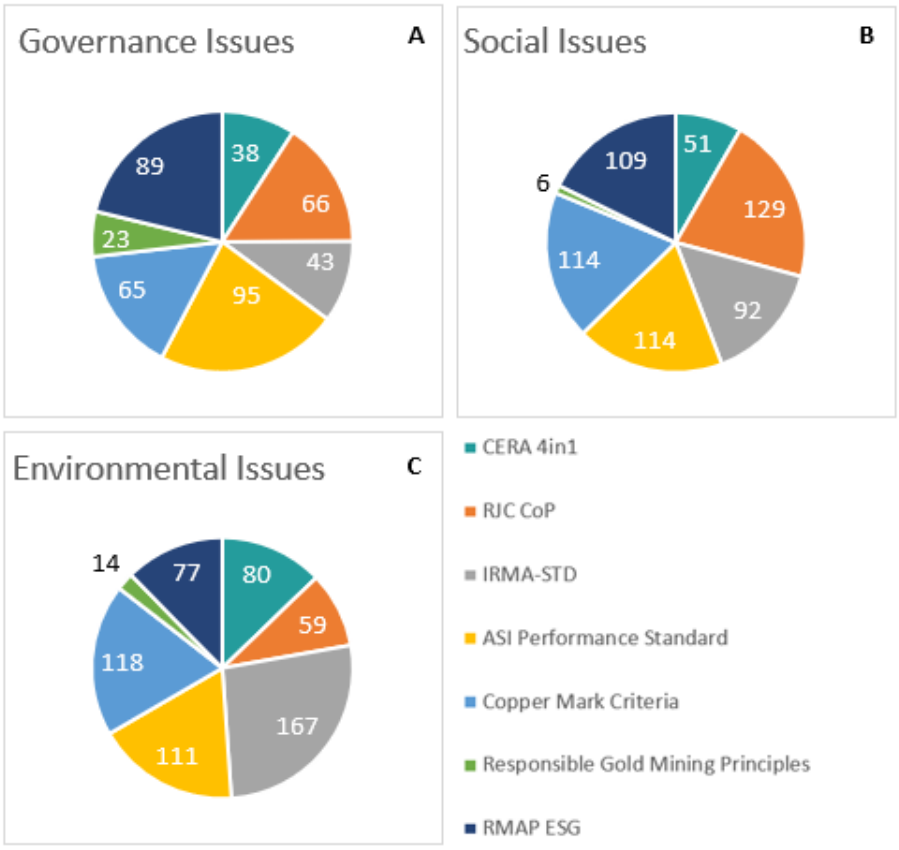

Figure 16: LancsBox frequency result. A. Governance issues. B. Social issues. C. Environmental issues.

Finally, there are important issues such as "Responsible sourcing" categorized in both social and environmental issues, that receive very low mentions. This can be attributed to the fact that these issues are often addressed separately in the corresponding Chain of Custody standards. Furthermore, **it should be noted that this analysis is based on frequency**, i.e., it refers only to the number of mentions of issues and sub-issues and does not assess the quality of the content within the text. Thus, the results show that the standards vary significantly in terms of the amount of attention they devote to governance, social and environmental issues. However, it is crucial to understand that the greater frequency of terms related to these issues does not necessarily indicate a more comprehensive approach or more effective implementation of related policies and practices. Standards with a higher number of mentions may simply be using more redundant language or include more

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statements of intent without corresponding concrete actions. Therefore, this quantitative analysis should be complemented by qualitative assessments that consider the actual depth and impact of the content discussed in each standard. Another important point to highlight about the simple analysis conducted is that performing a very detailed analysis of the compliance of the standards with sustainability requirements might not provide clear benefits, given that the degree of implementation of the required criteria in practice is unknown. Currently, there is much debate about the true impact of certification, as the degree of rigor and coherence with which the standards' requirements are actually applied or even "translated" into practice and independently verified is often not well understood (Kickler & Franken, 2017).

5 Conclusion

This report has provided an overview of due diligence in the CRM supply chain by delivering an inventory of the current state of regulations, frameworks, available standards, certification schemes, and technological solutions for primary and secondary raw materials within the industry, civil society, and policy development. This includes an analysis of the strengths and weaknesses of the most relevant standards and certification methods. Through detailed analysis, numerous areas have been identified where significant action is required to improve due diligence practices.

Comprehensively addressing the various gaps and needs identified in the due diligence frameworks in CRM supply chains is of vital importance. A lack of harmonization and coherence has been observed, highlighting the need for more detailed and contextualized guides for their effective implementation. Although these frameworks address important issues such as human rights, child labour, forced labour, conflict minerals, and environmental protection, they often analyse these features separately, without integrating them as a whole. Additionally, there is a notable absence of specific details in them about particular sectors and products, especially in the mining sector, suggesting the need for specific adaptations or supplements. Regarding due diligence, not all frameworks comprehensively cover essential aspects such as financial transparency, auditing or third-party verification, and grievance mechanisms, with the latter mostly treated as mere recommendations without detailed instructions for implementation. Finally, the lack of updates in these documents for over five years highlights a deficiency in reflecting current and emerging trends in due diligence, underscoring the urgent need for systematic and regular reviews to ensure that the frameworks maintain their applicability and effectiveness in an ever-changing environment.

Moreover, the report highlights the complexities that international companies face when navigating through a conglomerate of often conflicting legislations in different jurisdictions. This underscores the importance of detailing the specific responsibilities of each actor in the supply chain, including governments and civil society, to ensure transparency, accountability, and sustainability. It also identifies the need for more comprehensive approaches that consider human rights and sustainability as interdependent and fundamental components of corporate strategy and operation.

The development of clear and objective metrics to verify the actual benefits of corporate initiatives is crucial, along with the implementation of constant monitoring and effective collaboration between companies. This not only improves the efficiency and sustainability of operations but also promotes mutual benefits for all stakeholders. In terms of

technological and chemical solutions, the report underlines the need for these solutions to be accessible and easy to adopt for all actors, complying with relevant legal regulations and enabling their integration into both large corporations and smaller companies.

Regarding standards, there has been a significant evolution in the inclusion of ESG criteria and the recycling stage in the supply chain. Efforts have also been made to harmonize with other regulations and international frameworks. However, a lack of inclusivity and flexibility in current standards is identified, highlighting the importance of tailoring requirements to specific needs and increasing the visibility of these standards in the sector to facilitate greater adoption and compliance.

Due to the complex, dynamic, and opaque nature of global supply chains, traceability is a major challenge for companies aiming to conduct due diligence in the supply chain (European Commission, 2020b). Significant progress in implementing traceability systems for CRMs is encouraging. However, critical aspects such as data security and the expansion of traceability capabilities to include labour rights and environmental impact must be considered. The development of more comprehensive and coherent solutions that cover all these areas will improve the effectiveness and consistency in supply chain traceability, thus ensuring a more responsible and sustainable approach to managing responsible supply chain materials.

The SWOT analysis conducted in this report provides a clear and structured view of the strengths, weaknesses, opportunities and threats present in the standards assessed. This analysis has not only highlighted critical areas that require attention, but also identified possible avenues for growth and improvement. By recognising both internal challenges and external factors, it is possible to formulate more effective and holistic strategies that not only address current problems, but also prepare companies to adapt and thrive in an ever-changing marketplace. A focus on continually improving public perception and acceptance of these standards, along with the promotion of transparency and traceability, can significantly boost their adoption and effectiveness in the industry. In addition, the identification of threats such as competition from other standards and geopolitical and regulatory challenges highlights the importance of maintaining the credibility and adaptability of standards to ensure their long-term relevance and applicability.

Finally, regarding secondary raw materials, the main challenge in information gathering is the lack of specific data. Due diligence frameworks primarily focus on primary raw materials and do not provide sufficient information for secondary ones. Legislation reflects this trend, lacking specific laws for secondary materials. Nonetheless, progress is being made in the sector, as initiatives and regulations have recently been implemented that independently analyse secondary materials, emphasizing responsible sourcing, reuse, recycling, and disposal of electronic products. There arises a need to standardize recycling and disposal practices to safely handle electronic waste and improve the quality of secondary materials. Specifically, the recycling sector requires safe and environmentally responsible recycling practices, focusing on data security during the recycling of electronic products.

In summary, it is important to highlight that in the document, traceability solutions are presented in a segmented manner, each focusing on specific areas such as technology, fingerprinting, or certification. Although these solutions share a common goal, they lack an integrated holistic approach. This lack of integration represents a key opportunity that the MaDiTraCe project aims to address. MaDiTraCe proposes to

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develop more comprehensive and cohesive solutions that encompass all these areas simultaneously, thereby improving the effectiveness and consistency in the traceability of the supply chain. Moreover, the MaDiTraCe project must ensure that these solutions for traceability are applied sustainably and responsibly, following due diligence guidelines. To achieve this, it is essential to consider the identified gaps. This implies that the traceability mechanisms or systems must be detailed meticulously, including explanations about the technologies and methods to be employed. Furthermore, the solutions proposed by the project should extend beyond large-scale mining to include artisanal and small-scale mining (ASM), and go beyond solutions specific to a particular geography.

Figure 17 summarizes the above visually.

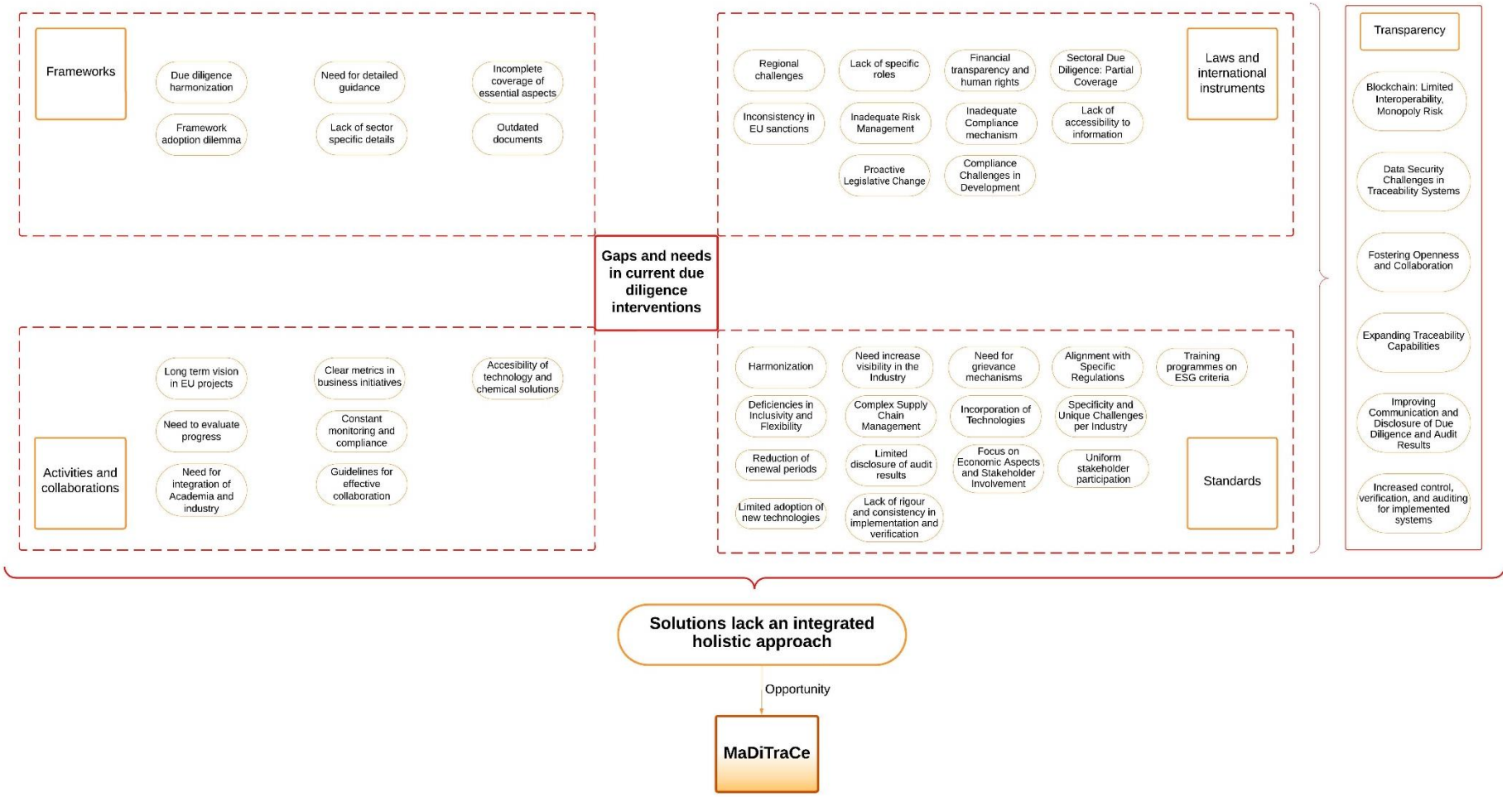

Figure 17: Summary of Gaps and Needs in Current Due Diligence Interventions.

6 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 (L. E. Cartier et al., 2018).

Chain of Custody[73]

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).

Primary raw materials

Unprocessed or minimally processed natural resources that are extracted directly from the earth or nature.

Recycling

Recycling encompasses a series of activities in which waste materials, previously utilized, undergo a transformation process, either for their original purpose or for alternative uses, excluding energy recovery.

Responsible Sourcing

Management of sustainable development in the supply or acquisition of a product, complying with environmental and social performance standards and criteria. It is often driven by end-user markets along with other stakeholders.

[73] Based on OECD (2016) and ISEAL Alliance (2016).

Secondary raw materials

Materials and products which can be used as raw materials by simple re-use or via recycling and recovery (Spooren et al., 2020).

Supply Chain

The term supply chain refers to the system of all the activities, organizations, actors, technology, information, resources and services involved in moving (primary and secondary) raw materials from the source to end consumers (OECD, 2016).

Upstream companies

Upstream companies are entities that operate upstream in a product's supply chain, specifically focusing on the segment from extraction sites to smelters and refineries.

Downstream companies

Downstream companies refer to entities that operate in the later stages of a product's supply chain, specifically the part that goes from the refineries to the final product.

Traceability[74]

The ability to authenticate the historical path, location or use of an item through documented and recorded identification. This encompasses verification of the sequence of events, movements and processing of a material from one point to another within a specific supply chain context.

Transparency[75]

Extent to which information on companies, suppliers, sourcing sites (including mines) and processing conditions (cutting and treatment processes) is available to end consumers and other companies in the supply chain.

[74] Based on ISEAL Alliance (2016) and IRMA (2020).
[75] Based on Schäfer (2023) and Cartier et al. (2018).

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8 Appendix

8.1 Assessment of sustainability criteria for SWOT analysis

Governance	
Issue	**Sub-issues**
Business Practices	Extortion
	Acquisitions
	Ethics
	Corruption
	Divestment
	Shareholder Value
	Fair Competition
	Bribery
Management practices	Economic Management
	Environmental Impact Assessment
	Performance management
	Legal compliance
	Grievance Mechanism
	Stakeholder engagement
	Policy
	Sustainability report
	Social impact assessment
	Production Plan
	Information management system
	Environmental Management

Table 49: Issues and sub-issues to analyse compliance of standards with governance topics.

Social	
Issue	**Sub-issues**
Occupational health and safety (OHS)	Workplace Hazards
	Personal Protective Equipment
	OHS Training
	Building & Transport Safety
	Electricity
	Emergency Preparedness
	Basic Supplies
	Medical Care
	Hazardous Substances
	Mercury Use
	Cyanide Use
	Silicate Exposure
Human rights	Child labour
	Forced labour
	Modern slavery
	Discrimination
	Diversity
	Disciplinary Practices
	Violence
Employment	Training
	Education

	Social Insurance
	Retrenchment
	Freedom of Association
Local Communities	Indigenous Rights
	Community engagement
	Free, Prior and Informed Consent (FPIC)
	Cultural Heritage
	Resettlement
	Medical Care
	Conflict-Affected and High-Risk Areas
	Conflict with Agriculture
	Conflict with LSM or Indigenous
Local value added	Local Workforce
	Local Procurement
	Community Initiatives
	Community Development Plan
	Institutional Capacity
	Support of nearby ASM
Responsible Source	Sustainable Sourcing
	Natural Resources Use

Table 50: Issues and sub-issues to analyse compliance of standards with social topics. The words highlighted in yellow apply to the extraction stage of the supply chain.

Environmental	
Issue	**Sub-issues**
Energy	Renewable
	Carbon
	Efficiency
	Consumption
Water	Management
	Conservation
	Groundwater
	Quality
	Efficiency
	Recycling
	Reduction
Land use	Conservation
	Prohibition
Biodiversity	Conservation
	Protected
	Ecosystem
	Endangered
	Habitats
Air emissions	Quality
	Monitoring
	Prevention
	Mitigation
	Reduction
	Greenhouse gas
Noise	Monitoring
	Prevention

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	Mitigation
	Reduction
Waste	Emissions
	Waste water
	Management
	Hazardous
	Recycling
	Chemical Waste Disposal
	Acid Mine drainage
	Land Application Disposal (LAD)
Rehabilitation	Restoration
	Closure
	Subsidence
	Backfilling
	Post-closure
	Historical Liabilities
Responsible Source	Sustainable Sourcing
	Natural Resources Use
	Material Stewardship
Climate change	Adaptation
	Mitigation
	Resilience

Table 51: Issues and sub-issues to analyse compliance of standards with environmental topics. The words highlighted in yellow apply to the extraction stage of the supply chain.

9 Annex

9.1 Chain of Custody Models and Definitions

Based on the ISEAL Alliance (International Social and Environmental Accreditation and Labelling Alliance), different CoC models are described, the understanding of which will be important for the project. CoC Models aim to authenticate the assertions regarding the sustainability standard-covered product, process, company or service. They establish checks on the transit of tangible goods and linked sustainability information from endorsed or certified enterprises through every phase of the supply chain. Consequently, the CoC system lays the groundwork for any assertions that can be formulated concerning the sanctioned or certified merchandise. The complementary system of assurance, encompassing auditing, supervision, reporting, and claims validation, is employed to validate the adherence of the involved entity to the CoC Standard and related policies.

There exists a spectrum of diverse CoC models, varying in terms of the extent and precision in identifying the product's origin and its sustainability attributes, as well as the intricacy of execution. The chosen model(s) will be influenced by the commodity type, industry, and the presence of any specific associated legal prerequisites.

The following is a description of the CoC models, according to information provided by ISEAL Alliance (2016):

- Identity Preservation (IP): An IP model ensures that certified product from a certified site is kept separate from other sources throughout the supply chain. The certified material cannot be physically mixed with other certified or non-certified material of the same commodity.

Figure 18: Example Identity preservation. Number represents a hypothetical unit or volume of product. Source: ISEAL Alliance (2016).

- Segregation: Certified product is kept separate from non-certified sources through each stage of the supply chain. It permits the mixing of certified products from a variety of sources certified to the same standards and must be documented accordingly.

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- Mixed IP: This model includes components of the identity preservation and segregation models. The exact origin/producer information of all volumes composing the mix and how much of which producer is the mixed volume remains available throughout the chain in the traceability system.

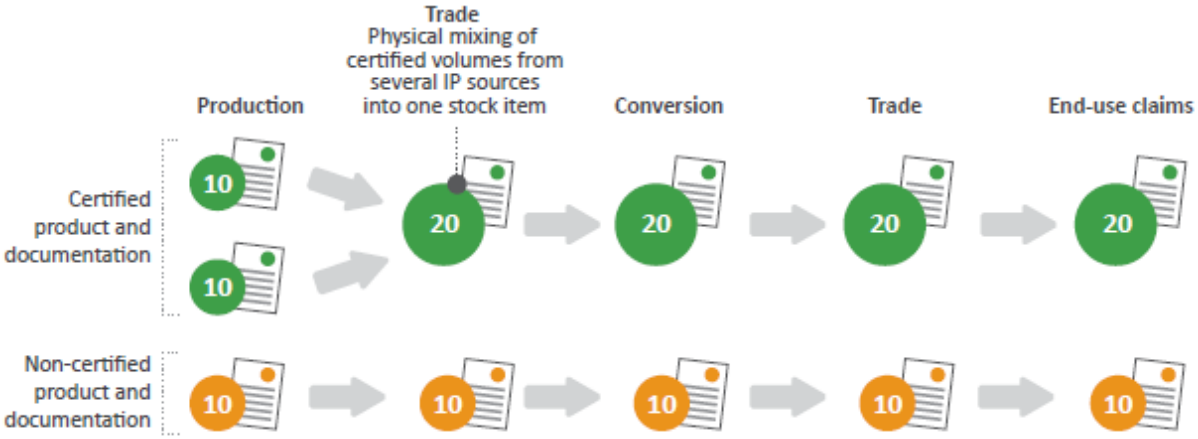

Figure 19: Example Segregation. Number represents a hypothetical unit or volume of product. Source: ISEAL Alliance (2016).

- Mass Balance: Certified physical product is not separated from and may be mixed with non-certified physical product at any stage in the production process, provided that the quantities are controlled and an equivalent volume of product leaving the operations can be sold as certified. The volumes can be balanced at the batch level, site level and group level. There is no guarantee that there is any certified content in each final product (except batch level mass balance where physical mixing occurs). Two variables related to the level of certainty that the product actually contains certified content must be considered, whether physical mixing of certified and non-certified content actually happens and what stage in the supply chain segregation is lost (i.e. where physical mixing or volume reconciliation happens) and how often.

    - Batch level mass balance: This model maintains segregation until the final point of blending or mixing for a specific batch of a product. Mixing with non-certified product is controlled and recorded, so the proportion of certified content in each final product is known. This type of mass-balance ensures the end-product contains at least a proportion of certified product, which allows specific end-use claims to be made.

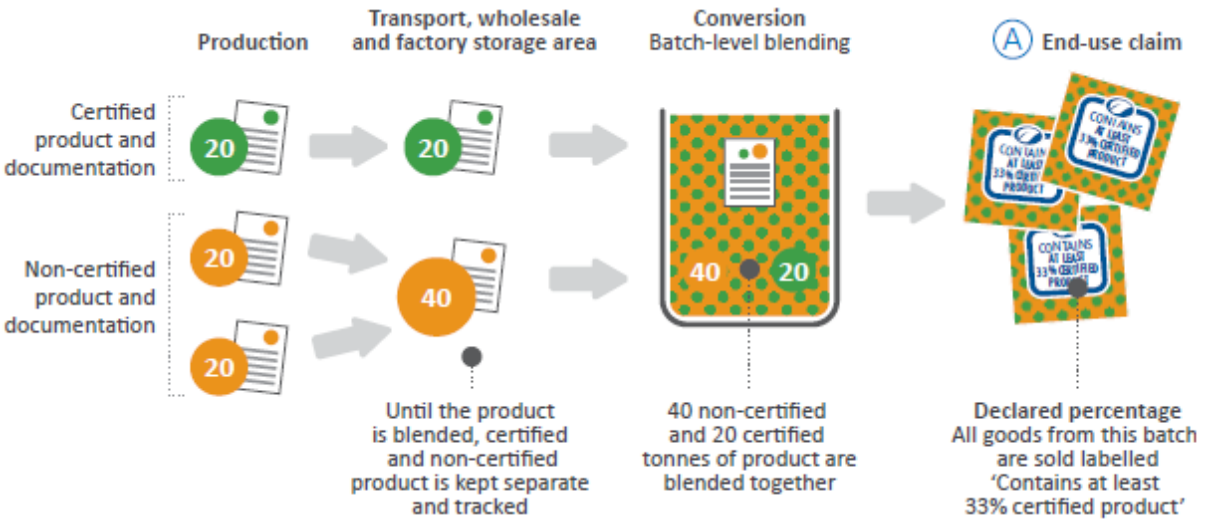

Figure 20: Example Batch-level Mass Balance. Number represents a hypothetical unit or volume of product. Source: ISEAL Alliance (2016).

- Site level mass balance: The model maintains segregation until the manufacturing or processing stage in the supply chain, when the certified product can then be mixed with non-certified product, and the proportions of certified and non-certified product at the overall site level are recorded and reconciled. The percentage of certified content actually contained in the final products is not known. Certified and non-certified components may be mixed within an actual product, or in numbers of products in the overall business. The reconciliation period (or 'trade-conversion trade cycle') can be shorter or longer depending on the commodity/product or systems, but would not normally exceed one year.

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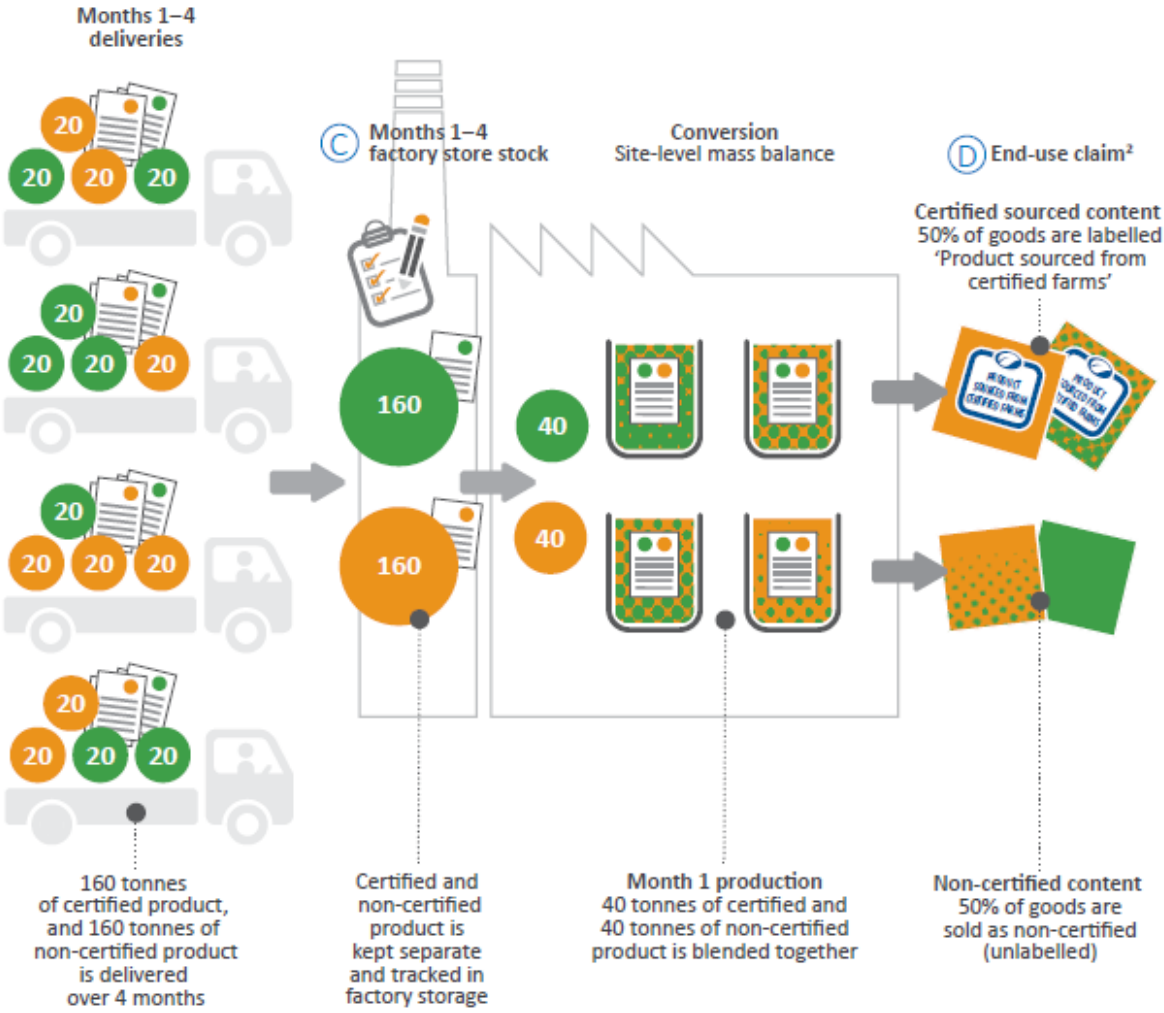

Figure 21: Example Site-level Mass Balance. Illustrates four-month reconciliation period. It is possible to see how the balancing in reconciliation scheme affects the output of goods at the factory gate on a month-by-month basis. Source: ISEAL Alliance (2016).

- Group level mass balance: "Group" may refer to a company with several sites, a country, or any other combination of more than one site where volumes are tracked. Physical mixing or volume reconciliation of certified and non-certified product is allowed at any stage in the production process provided that the quantities are controlled in documentation. The volume of certified product purchased by the group is controlled and an equivalent volume of product leaving the group can be sold as certified.

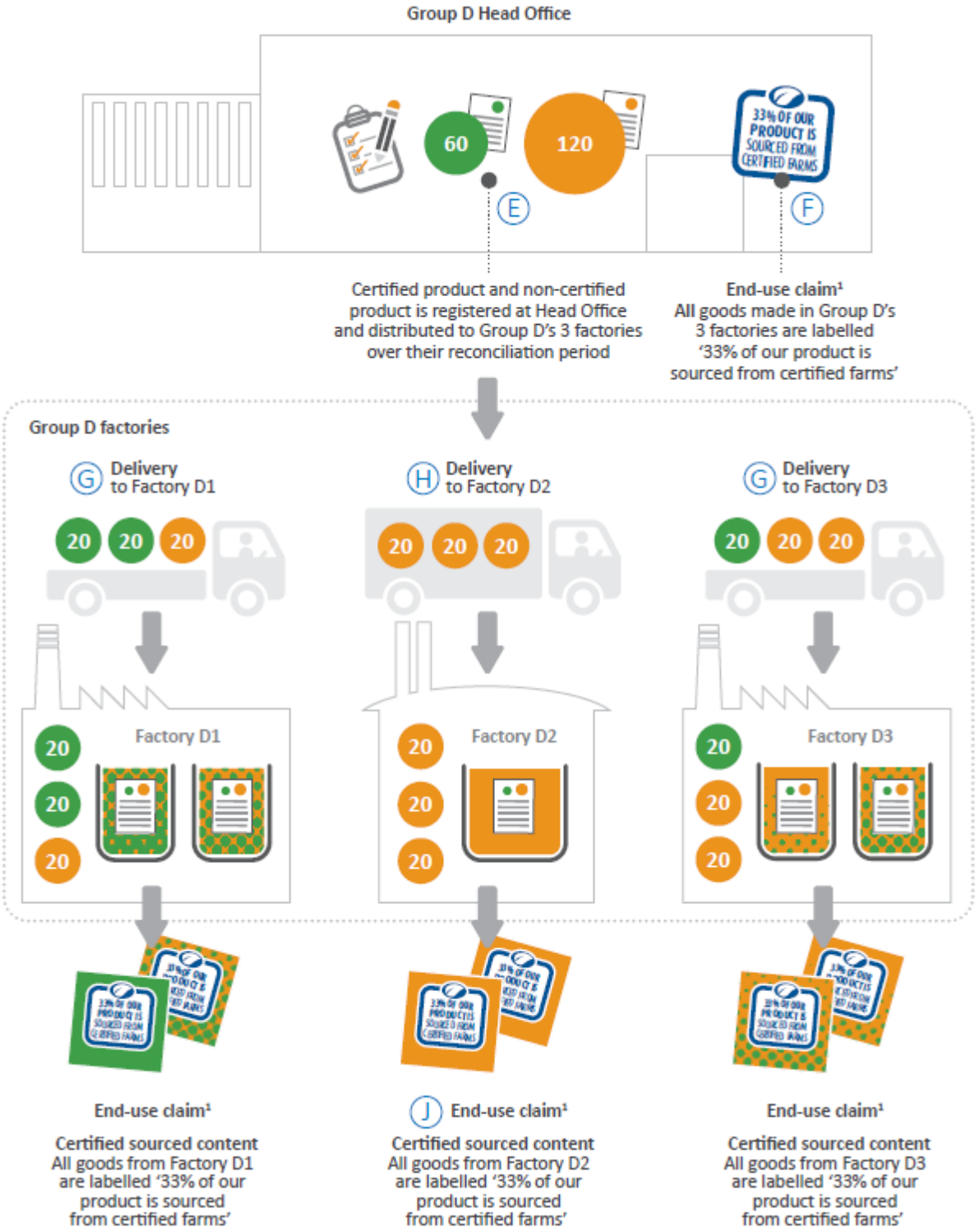

Figure 22: Example Group-level Mass Balance. Source: ISEAL Alliance (2016).

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- Certificate trading: Certified and non-certified products flows freely through the supply chain. Sustainability certificates or credits are issued at the beginning of the supply chain by an independent issuing body and can be bought by market participants, usually via a certificate or credit trading platform. However, it should be noted that certificate trading is not strictly a CoC model, because the end product contains no known certified product.

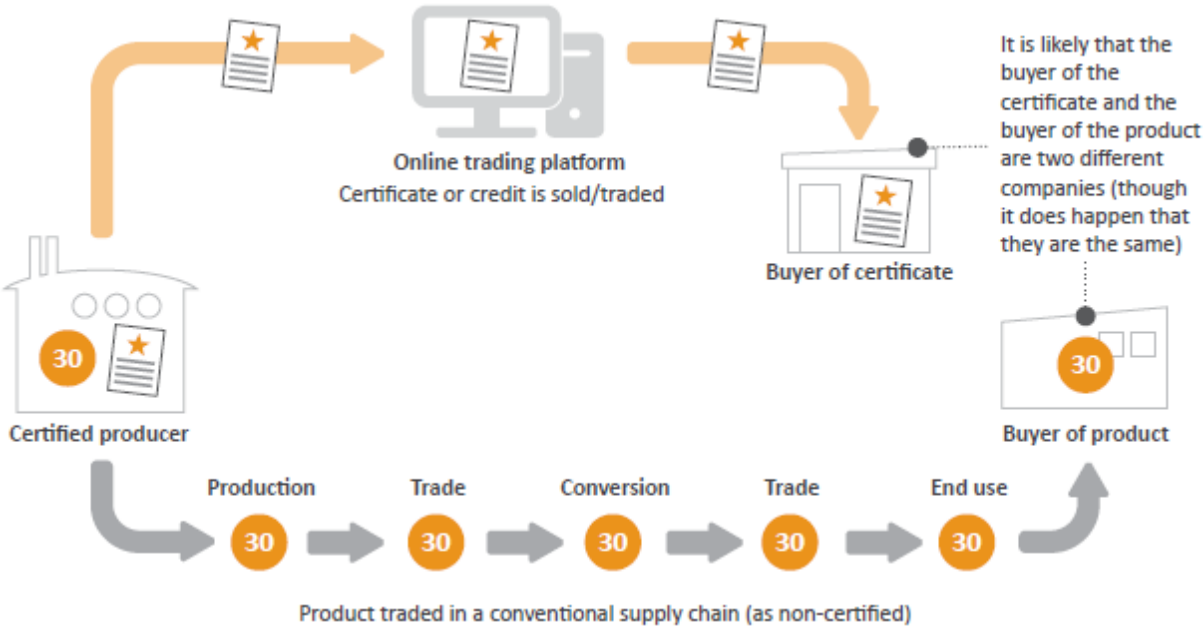

Figure 23: Example Certified trading. Source: ISEAL Alliance (2016).