EiQ by LRQA

The traceability context report: labor rights and due diligence in global supply chains

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GlobalTrace PROTOCOL

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OVERVIEW: THE GLOBAL TRACE PROTOCOL PROJECT

The Global Trace Protocol project (GTP) is funded by the U.S. Department of Labor to help reduce child and forced labor in global supply chains through traceability. It is implemented by LRQA, a leading global assurance partner,[1] with subaward partners Diginex (developing tool software), SLR Consulting, and the Responsible Mineral Initiative (RMI). The Project objective is to develop a tool and methodology that enables brands, suppliers and other stakeholders to trace products through the entire journey, with data on compliance regarding child and forced labor and other exploitative practices at each tier. The Project developed a traceability tool and methodology that it has been tested during pilots conducted in Pakistan's cotton sector and the Democratic Republic of Congo's cobalt sector. Using lessons from those pilots, the Project is refining and publicly sharing a commodity agnostic traceability methodology and tool.

The Project aims to ensure that the tool is:

- User-friendly and publicly available free as open-source software;
- Effective in applying labor rights *and* due diligence principles; and
- Sustainable by being cost-effective, interoperable, and usable by various stakeholders.

Supporting research, guidance, and Project background may be found at Global Trace - Addressing barriers in supply chain traceability | LRQA. After the first run of the Pakistan pilot, the Project produced The Pakistan Cotton Pilot: Results, Lessons Learned, and Next Steps for Sustainability Report (June 2024), which informed the second, improved test run in 2024-25. The Project also produced other supporting material, including the Traceability Glossary (January 2024). The commodity agnostic tool with user guidance and best practices is available on the U.S. Department of Labor's GitHub website.

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[1] The Cooperative Agreement was originally signed by ELEVATE Ltd., which was subsequently acquired by LRQA.

EXECUTIVE SUMMARY

This Report provides an overview of supply chain due diligence and traceability practices used to support the promotion of labor rights, including the elimination of child labor and forced labor in global supply chains. Supply chain traceability has grown in scope and depth in the past decade because governments, brands, investors, consumers, workers, and other civil society actors have demanded it. Governments have increased requirements for importers to verify that their products have not been produced through practices that violate fundamental labor rights.

The U.S. Customs and Border Protection (CBP) has ramped up enforcement of the prohibition against importing goods made by forced labor, and European countries are adopting laws that mandate due diligence consistent with international labor standards. In response to these enhanced requirements, companies have expanded due diligence and traceability to increase transparency and reduce risks related to production, legal liability, reputation, and other aspects of business. For some corporations, these changes accompany fundamental shifts in corporate vision and strategy.

In **Section One**, the Report explains key terminology and identifies drivers for traceability and transparency, including regulatory pressure, civil society demands, demands for improved efficiency and resiliency, and investor pressure.

In **Section Two**, the Report analyzes supply chain due diligence and risk assessment approaches for human rights, including labor rights, as well as the need to distinguish different levels of risk when operating in high-risk and conflict-affected areas. It also identifies guidance for conducting risk assessments in high-risk areas through various tools including remote sensing, due diligence monitoring, grievance mechanisms, and worker engagement tools.

Section Two also analyzes the role of choke points, which are key stages or points of transformation in supply chains, as well as upstream assurance mechanisms, particularly in the garment, footwear, agriculture, and timber sectors. It explains how to conduct mapping through various tiers from raw material sourcing to the final product, with illustrative flow charts for cotton, palm, gold, and cobalt. This section concludes with a discussion of supplier management and supplier visualization, supported by supplier self-assessment questionnaires, supplier management solutions, and supply chain visualization tools.

In **Section Three**, the Report analyzes the traceability landscape, addressing the goals and challenges of ensuring data transparency and the need to tailor traceability systems to meet specific requirements. It identifies key traceability stakeholders and discusses chain of custody (CoC) models, including:

1. ***Identity Preservation***, which requires that certified product inputs be packaged, processed, and traced separately from other certified or non-certified product inputs or modifications throughout the supply chain.
2. ***Segregation***, single or multi-country, which requires all materials or components of a product to be certified but permits the mixing of materials if they are certified.
3. ***Mass Balance***, which permits the mixing of certified and non-certified inputs but requires that certain volume and/or weight ratios are maintained.
4. ***Certificate Trading***, which allows for certified upstream producers to generate and sell claims to downstream operators, similar to carbon offsets purchasing.

The Report further reviews the commonly applied models used to trace goods, common practices related to data management for traceability, and approaches to product identification and product-data pairing.

Section Three also addresses CoC model selection criteria and describes key certification schemes and their approaches. It notes that the selection of the most effective CoC model for each business depends on the goals and requirements of the certification program the model supports, with the following questions:

- How “extended” is the supply chain in terms of geographical reach, size of markets, and number of actors in global production networks?
- What are the supply chain processing requirements and total number of processing facilities?
- What are the “clear and inherent product quality differences” between sustainably and non-sustainably produced products?
- What is the level of risk of human rights violations and/or adverse environmental impacts in the commodity’s supply chain?

Certification schemes apply different CoC models based on a variety of factors. Some mandate specific CoC models at specific points and tiers of the supply chain, while others require a single model throughout. Certification programs also maintain different audit and risk assessment requirements related to labor conditions.

Before choosing or creating their own certification program and verification procedure, corporations must review international labor standards to determine whether they are aligned with the company's policies and commitments.

Section Three addresses data standards allowing partners to efficiently manage trade data through a common standard. Traceability data can be both internal (processes within a company's own operations) and external (product information received from suppliers or provided to customers). Consistent documentation is necessary for efficiently sharing information in **interoperable systems**. Establishing the critical tracking events (CTEs) and key data elements (KDE) are integral aspects of developing a traceability system. The three "foundational" traceability principles, as promoted by the leading traceability not-for-profit **GS1**, include:

- **Identify**: Identify business objects and locations using standardized identifiers.
- **Capture**: Encode objects' identity and attributes, such as time, location, and other details, in a standard manner using a data carrier such as barcodes or radio frequency identification (RFID).
- **Share**: Share data using standardized semantics, in a standardized format, using common exchange protocols.

Blockchain, a form of "distributed ledger," with the ability to provide timestamping, digital asset creation, and business process integration, is briefly explained in the traceability context. Electronic Data Interchange (EDI) and data sharing models are also explored.

Section Four summarizes this Report's role in designing and piloting the Project's traceability tools aimed at promoting labor rights and reducing child labor and forced labor in global supply chains. It provides analysis and recommendations that may guide other similar efforts. The research demonstrates that there is not a one-size-fits all approach to traceability or supply chain risk management; rather, organizations need to design and adopt solutions that account for the complexities and risks of their supply chain, the financial and resource constraints they face, and the regulatory requirements that differ according to industry.

The Report identifies considerations and goals related to terminology, engaging stakeholders in design and implementation, and selecting a CoC model or models and data management. Traceability efforts will differ in effectiveness; a key goal moving forward will be to better identify the most successful characteristics, integrate them into traceability tools and protocols, and engage in a process of continuous improvement.

Annexes I and II provide details on technology solution providers and labor standards in certification programs.

NOTE ON METHODOLOGY

The Report includes findings published in reports and guidance from the U.S. Department of Labor (DOL), United Nations Economic Commission for Europe (UNECE), UN Centre for Trade Facilitation and Electronic Business (UN/CEFACT), U.S. Agency for International Development (USAID), Food and Agriculture Organization (FAO), U.S. Customs and Border Protection (CBP), U.S. Forest Service (USFS), International Labour Organization (ILO), Organisation for Economic Co-operation and Development (OECD), and the European Union (EU).

The Report reviews certification requirements, CoC guidance, and labor standards from certification or supply chain due diligence initiatives including the Responsible Minerals Initiative (RMI), the London Bullion Market Association (LBMA), Rainforest Alliance, Responsible Jewellery Council (RJC), Marine Stewardship Council (MSC), Roundtable on Sustainable Palm Oil (RSPO), International Tin Supply Chain Initiative (ITSCI), Better Cotton Initiative (BCI), the Global Organic Textile Standard (GOTS), the Responsible Mica Initiative, the Forest Stewardship Council (FSC), and Fairtrade International.

The Report also draws on the expertise of leading traceability academics, experts, and organizations in the field. Experts include GS1, FishWise, Fair Labor Association (FLA), the Global Reporting Initiative (GRI), Business for Social Responsibility (BSR), International Organisation of Standards (ISO), the World Economic Forum, Applied Blockchain, Natural Resource Governance Initiative, ISEAL, LRQA (formerly ELEVATE Limited), RCS Global, Earthworm Foundation, Know the Chain, Responsible Sourcing Network, The Copper Mark, Global Fish Watch, Future of Fish, and Gartner. Insights have also been captured from more than 20 different in-depth discussions with traceability solution providers and traceability experts.

1. TRACEABILITY OVERVIEW

Many companies throughout the world are using supply chain traceability to meet increasing demands to improve transparency and reduce business risks. Governments, investors, advocacy organizations, and consumers are, more than ever, holding global companies accountable for exploitative labor conditions throughout their supply chains. The complex nature of international supply chains, however, makes tracing the origin of products challenging, particularly when attempting to trace to the sub-component and raw material tiers with inputs sourced from remote, opaque, or conflict-affected areas.[2]

Traditionally, companies have focused much of their responsible sourcing efforts on tier 1 suppliers, with which they have direct contractual relationships. Alone, this approach does not support verification of or improvements in working conditions in their extended upstream and raw material supply chains. Indeed, workers in the early stages of a product's lifecycle often face the greatest risks of exploitation and forced labor.[3] To address these gaps, companies and other key stakeholders must gain visibility across tiers to identify rights violations, develop and collect risk indicators, and use this information to reduce and eliminate child labor, forced labor, human trafficking, and other forms of worker exploitation. Transparency thought the supply chain may also be needed to certify that a product meets a sustainability claim made about the product.[4]

1.1. TRACEABILITY DEFINITION[5]

The Global Trace Protocol project (GTP) applies the following definition of traceability:

*"**[T]he ability to identify and trace the history, distribution, location, and application of products, parts, and materials, to ensure the reliability of sustainability claims, which may include those in human rights, labor (including health and safety), the environment, and anti-corruption, among others**"*[6]

A version of this definition was first used in the United Nations Global Compact (UNGC) report, *A Guide to Traceability - A Practical Approach to Advance Sustainability in Global Supply Chains*. While many definitions of traceability exist, they all refer to a process where an asset moves through a supply chain to a final customer or consumer. This specific definition was chosen for our project for the following reasons:

- **Use by other projects and practitioners**: Traceability systems benefit from the use of consistent definitions and a common language across organizations. This Project intends to advance the adoption of best practices in traceability while creating a shared understanding of concepts. In addition to alignment with the identified UNGC report, this definition is referenced by many other key organizations, including the United Nations Economic Commission for Europe (UNECE) in its recent work on traceability standards for sustainable value chains.[7]
- **Builds on International Organization for Standards (ISO)**: This definition builds on language from the ISO, which is the largest developer of voluntary international standards facilitating world trade. ISO defines traceability as the "*ability to trace the history, application and location of that which is under consideration*." For products, they add that "*traceability can relate to the origin of materials and parts*" or "*the processing history*."[8] The selected definition uses important elements of the ISO definition, adding expanded language to make it fit-for-purpose for sustainability-focused traceability systems.

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[2] ILO Ending Forced Labour by 2030: A Review of Policies and Programmes, 2018, pp 8 and 71.
[3] U.S. Department of Homeland Security. What is Forced Labor?
[4] Product "certification" may reference either compliance with a third-party certification program or a company's product certification through a credible means to meet its own supply chain standards. The definition of traceability below explains the concept and connection to sustainability claims.
[5] LRQA, GTP Traceability Glossary at Glossary, 2024.
[6] United Nations Global Compact Homepage. And BSR, A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains, April 9, 2014.
[7] United Nations Economic and Social Council, Recommendation No. 46: Enhancing Traceability and Transparency of Sustainable Value Chains in the Garment and Footwear Sector, 2021.
[8] ISO, ISO 9000:2015, Quality Management Systems-Fundamentals and Vocabulary, 2015.

- **Supports the reliability of sustainability claims**: This definition includes the notion of the "reliability" of sustainability claims made through industry certification schemes, audits, and monitoring programs, as well as credible self-reporting mechanisms. Actors make a variety of claims regarding their conformance with recognized labor standards. Traceability is one way to ensure the reliability of, or identify the lack of support for, sustainability claims.

"Comprehensive traceability" is another term used to describe the type of traceability that collects data about a product that is simultaneously environmental, social, and economic in nature.[9] A **traceability system,** in the context of the GTP project, should be able to accommodate comprehensive traceability, by recording a trail of key information about the product, and the conditions of how a product was produced, through the entire chain. Both tracing (monitoring the history of an asset) and **tracking** (monitoring the present and future movements of the asset) should be possible to be most useful for management purposes.

Key Definitions:

Traceability: The ability to identify and trace the history, distribution, location, and application of products, parts, and materials, to ensure the reliability of sustainability claims, in the areas of human rights, labor (including health and safety), the environment, and anti-corruption, among others.

Sustainability Claim: Assertion about a characteristic of a product, or about a process or an organization associated with that product to support a required or desired aspect of sustainability.

Supply Chain Due Diligence: An ongoing, proactive, and reactive process through which enterprises can prevent and mitigate adverse impacts related to human rights, labor rights, environmental protection, and bribery and corruption in their own operations and in their supply chains.

Supply Chain Mapping: An exercise by which a company or a third party collects information on its suppliers and their sub suppliers to understand relationships and increase the visibility of the wider supply chain.

Chain of Custody Model: An approach taken to demonstrate the link (physical or administrative) between the verified unit of production and the claim about the final product.

Origin: Provenance and location of all products, parts, components, processes, and factories.

Value Chain: The full range of activities that firms and workers perform to bring a product from its conception to end use and beyond, including research and development (R&D), design, production,

The box above provides definitions for other relevant terms. Traceability is one essential aspect of supply chain due diligence but is not a substitute for due diligence.[10]

Each of these concepts is explored in detail throughout the remainder of this Report as they may also be utilized in different ways to support stakeholder demands depending on each specific context.

[9] Seafood Alliance for Legality and Traceability (SALT), Comprehensive Electronic Catch Documentation and Traceability (eCDT) Principles, February 2021.
[10] United Nations Global Compact Homepage. And BSR, A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains, April 9, 2014.

1.2. DRIVERS OF TRACEABILITY AND TRANSPARENCY

Expectations and requirements for companies to adopt and implement supply chain traceability and supply chain due diligence are growing. Companies are facing new regulatory requirements, investor pressure, and increased customer expectations that responsible sourcing practices extend upstream through the full supply chain, to those who produce the raw materials and component parts of products.

Achieving end-to-end traceability between raw materials and product assembly is beneficial, and in some cases required, for managing environmental and social risks and responding to stakeholder demands. Full visibility into product supply chains also ensures companies have the appropriate evidence to support product sustainability claims including those relating to child labor and forced labor. Supply chain visibility also allows companies to optimize their supply chains, enhance resilience, and build efficiencies.

1.3. LEGAL AND REGULATORY PRESSURE FOR SOCIAL RESPONSIBILITY

The supply chain regulatory landscape is rapidly creating additional expectations for companies to understand their supply chain and disclose efforts taken to address labor rights and other social responsibility risks. A growing number of supply chain laws and regulations require companies to disclose their practices, conduct due diligence, and conform with human/labor rights import requirements. Failure to demonstrate compliance can lead to reputational harm, legal judgments, fines, loss of sourcing contracts and even seizure of goods.

Social responsibility legislation and regulations can be categorized as:

1. **Disclosure-only**, requiring covered companies to disclose data or compliance activities and methodologies;
2. **Due diligence compliance**, requiring companies to take steps to assess and address risks and adverse impacts and take corrective action;
3. **Trade and customs based**, prohibiting the importation of goods that do not meet specified human/labor rights requirements, most particularly the prohibition of goods made by forced labor.[11]
4. **Procurement based,** such as purchaser driven standards required by national, state and local governments as well as private entities, often developed through ISO standards development organizations with public-private participation.

Some legislation focuses on a particular set of labor rights (e.g., forced and child labor) while other legislation covers all fundamental labor rights; some legislation covers only very large companies while others cover medium or even small ones. Certain legislation covers specific industries or products (e.g., minerals, textiles). Many sources reference the OECD Guidelines for Responsible Business Conduct.

1. Disclosure Requirements

Regarding disclosure requirements, the European Union's Corporate Sustainability Reporting Directive (CSRD), has a set of mandatory reporting requirements that cover a wide range of social and human rights as well as environmental rights and governance factors for "large undertakings" (average at least 250 employees annually with relatively high balance sheet requirements). Member States were required to transpose this Directive into national laws by July 6, 2024, though some states required more time.

In contrast, the focused California Transparency in Supply Chains Act (2012), requires large retailers and manufacturers doing business in California to disclose their "efforts to eradicate slavery and human trafficking from [their] direct supply chain for tangible goods offered for sale."[12] Other states, such as New York, Massachusetts and Washington State have similar passed or draft legislation.[13] The U.K. Modern Slavery Act requires covered companies to publish statements identifying steps it has

[11] Ropes & Gray LLP, Corporate Social Responsibility Legislation, A Summary of Selected Instruments, Aug/Sept 2024, pp i-iii (requires email confirmation to download).
[12] Harris C., California Department of Justice, The California Transparency in Supply Chains Act: A Resource Guide, 2015.
[13] Ropes & Gray LLP, Corporate Social Responsibility Legislation, A Summary of Selected Instruments, Aug/Sept 2024, pp18-33.

taken during the financial year to ensure that slavery and human trafficking are not taking place in any of its supply chains or in any part of its business.[14] Similarly, the Canadian Fighting Against Forced Labour and Child Labour in Supply Chains Act (2024) aims to increase industry awareness and transparency about forced and child labor and encourage responsible business practices with a set of public reporting requirements.[15] Australia's Commonwealth Modern Slavery Act (2018) aims to reduce modern slavery in supply chains through enhanced disclosure.[16]

Disclosure requirements can also be found in securities law. For example, The Dodd-Frank Wall Street Reform and Customer Protection Act (2010) requires publicly traded companies to disclose their use of minerals sourced from conflict zones, designated as "conflict minerals" (tin, tantalum and gold), if those minerals are "necessary to the functionality or production of a product" manufactured by those companies, which may have relied on labor rights abuses.[17]

2. Due Diligence Compliance Requirements

The European Union's Corporate Sustainability Due Diligence Directive (entered into force July 5, 2024) is perhaps the strongest driver for mandatory due diligence. The Directive aims to ensure that companies active in the EU contribute to "sustainable development" through the "identification, prevention and mitigation, cessation and minimization of potential and actual adverse human rights and environmental impacts" of their operations, subsidiaries and chain of activities.[18] The initial covered entities are very large companies, and the requirements cover a wide range of labor/human rights as well as environmental factors. EU member States were required to transpose the Directive into national law by July 26, 2024.

Many EU Members have had due diligence laws for years and are amending them, including The German Act on Due Diligence in Corporate Supply Chains (in force in 2023),[19] the French Corporate Duty of Vigilance Law of 2017,[20] Netherland's Child Labor Due Diligence Act (adopted in 2019, in force in 2022),[21] and Norway's Transparency Act (2021) (in force in July 2022),[22] among others.

In 2022, Japan also established due diligence guidelines to protect human rights in global supply chains for businesses operating in Japan.[23] By creating the guidelines, Japan's government aims to close the gap with the US and European countries, with Japanese companies facing the risk of being cut out of clients' supply chains if they fail to address human rights concerns.[24] The Guidelines call for adopting a human rights policy that includes labor rights in the ILO Declaration, conducting due diligence on it, and implementing grievance mechanisms to ensure its fair application. While the guidelines are voluntary, by September 2023, more than 65% of covered businesses established a human rights policy with the numbers implementing due diligence rapidly rising.[25]

3. Trade and Customs Requirements

The U.S., the EU, and Canada have been strengthening their trade and customs requirements to prohibit the importation of goods made with forced labor.

In the U.S., the main instruments prohibiting forced labor are the Tariff Act and the Uyghur Forced Labor Protection Act (UFLPA). The Tariff Act of 1930 (19 U.S.C. 1307) prohibits the importation of "*goods, wares, articles, and merchandise mined,*

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[14] Parliament of the United Kingdom, The Modern Slavery Act of 2015.
[15] Government of Canada, Public Safety: Forced Labour In Canadian Supply Chains
[16] Parliament of the United Kingdom, The Modern Slavery Act of 2018.
[17] Securities and Exchange Commission (SEC), Fact Sheet: Requiring the Disclosure of Conflict Minerals, 2022.
[18] EUR-Lex, The EU Corporate Sustainability Due Diligence Directive, (16) Preamble.
[19] European Center for Constitutional and Human Rights, German Parliament Passes Mandatory Due Diligence Law, 2022.
[20] Parliament of France, The French Law on the Duty of Vigilance: Theoretical and Practical Challenges Since its Adoption, 2021.
[21] Government of the Netherlands, Dutch Child Labor Due Diligence Act, 2022.
[22] United States Congress, The Transparency Act of 2021.
[23] Japan's Guidelines for Respecting Human Rights in Responsible Supply Chains, Sept. 2022 (unofficial English translation).
[24] Business & Human Rights Resource Centre, Japan: Govt. to Set Human Rights Due Diligence Guidelines for Companies Hoping to Close Gaps with US and European countries, February 15, 2022.
[25] Littler, Employers Rapidly Implement Japan's Guidelines on Business Human Rights, September 11, 2023.

produced, or manufactured wholly or in part" by forced labor.[26] In February 2016, the Tariff Act of 1930 was amended by the Trade Facilitation and Trade Enforcement Act, which ended the "consumptive demand" exception, which essentially had blocked enforcement where domestic production did not meet consumer needs for the goods.

In response to the amendment, the Department of Commerce's U.S. Customs and Border Protection (CBP) ramped up the detainment of goods through Withhold Release Orders (WRO) where they have a "reasonable suspicion" that the goods were made with forced labor. When the CBP issues a WRO, the burden shifts to the employer to rebut the suspicion. The importer may still export the goods within three months but if CBP issues a "finding" of forced labor production, the goods are forfeited and seized.[27] CBP maintains a dashboard for WROs and Findings.[28]

In 2021 the U.S. adopted the Uyghur Forced Labor Prevention Act, which requires importers of goods, wares, articles, or merchandise made in whole or part from Xinjiang, China to show by clear and convincing evidence that they were not produced using forced labor.[29] CBP enforces the "rebuttable presumption" that goods mined, produced, or manufactured wholly or in part in the XUAR, or by an entity on the UFLPA Entity List, are prohibited from importation. The most likely way to have a good removed from the list is to show that no part of the good is from or went through Xinjiang. CBP maintains a dashboard providing statistics on shipments subjected to UFLPA reviews and enforcement actions.[30]

The U.S. Global Magnitsky Sanctions, enforced by the U.S. Department of The Treasury's Office of Foreign Asset Controls has been invoked to block importation of goods involving the Xinjiang Production and Construction Corps (XPCC) for its connection to serious human rights abuse in Xinjiang, China.[31]

CBP also streamlines the importation of goods from organizations compliant with the Customs Trade Partnership Against Terrorism (C-TPAT), which requires demonstrated compliance with the prohibition of the importation of goods made by forced labor.[32]

The Canadian government also amended its tariff law to prohibit the importation of goods that are mined, manufactured or produced wholly or in part by child labor, effective in 2024. The prohibition of the importation of goods made by forced labor was adopted in 2020 as part of the U.S. Mexico Canada Free Trade Agreement.[33]

4. Government Procurement Requirements

National, state and local governments are implementing procurement requirements that encourage or require meeting certain labor rights and mineral sourcing requirements. These systems rely on purchaser standards, often developed through consensus-based ISO procedures that include the private sector.

The 2014 European Union procurement directives require EU member states to take appropriate measures to ensure that their covered contractors and suppliers comply with obligations under the ILO core conventions.[34] Implementation takes place under EU Member national law.[35]

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[26] Legal Information Institute, 19 U.S. Code § 1307 - Convict-made goods; importation prohibited.
[27] U.S. Customs and Boarder Protection (CBP), How does CBP Enforce 19 USC 1307?
[28] CBP, Withhold Release Orders and Findings List.
[29] CBP, Uyghur Forced Labor Protection Act 2022.
[30] CBP, Uyghur Forced Labor Prevention Act Statistics.
[31] U.S. Department of Treasury, The Global Magnitsky Sanctions, General License 2A,
[32] U.S. Customs and Boarder Protection, Customs Trade Partnership Against Terrorism (CTPAT) Guidance.
[33] See Government of Canada, Fighting Against Forced Labour and Child Labour in Supply Chains Act (Part 4).
[34] Art. 18(2) provides that "Member States shall take appropriate measures to ensure that in the performance of public contracts economic operators comply with applicable obligations in the fields of environmental, social and labour law established by Union law, national law, collective agreements or by the international environmental, social and labour law provisions listed in Annex II" See EU Public Procurement Directive 2014/24/EU. Annex II references the ILO conventions on freedom of association and collective bargaining, forced labor, child labor, discrimination and equal remuneration.
[35] For an analysis and critique, see G. Botta *The Interplay Between EU Public-Procurement and Human Rights in Global Supply Chains: Lessons from the Italian Legal* Context (undated).

U.S. Federal Acquisition Regulations (FAR) prohibit the federal government from acquiring products produced by forced or indentured child labor. U.S. government contracting personnel are required to check the Department of Labor's List of Goods Produced by Forced or Indentured Child Labor when issuing a solicitation for suppliers. Where the product appears on the List, the contractor must certify that it has made a good faith effort to determine whether such practices were used in producing the product (or not supply a good from a country on the List).[36]

The U.S. Federal government, some state and local governments as well as other national and local governments purchase electronic products primarily or exclusively that are compliant with the Electronic Product Environmental (and Social Responsibility) Assessment Tool (EPEAT) standards. Many private companies also use the EPEAT® registry for their purchases. EPEAT® includes mandatory and optional requirements on labor rights, occupational safety and health, and mineral sourcing, as well as environmental and energy management practices for compliance at Bronze (mandatory criteria only), Silver (mandatory plus 50% of optional) and Gold (mandatory plus 75% of optional) levels. The standards are continually updated through a process of consensus-based dialogue between U.S. government, private sector, academic, and other civil society stakeholders, per ISO practices.[37]

1.4. CONSUMER AND ADVOCACY GROUP DEMANDS

Consumer and advocacy groups also drive the demand for businesses to substantiate sustainability claims. Products can be labeled and/or certified to help consumers easily identify if a product was produced in alignment with a certain environmental, social, or economic standard. The claims, such as "organic" or "conflict-free," are used as a market differentiator. In recent years, consumers have become more skeptical of greenwashing, which occurs when a company makes misleading claims about the environmental, social, or economic benefit of a product to gain market share and a competitive advantage over rivals.[38]

In addition, advocacy groups, international NGOs, and civil society actors are increasing pressure on international companies, using legal and reputational tactics such as "naming and shaming." In recent years high profile lawsuits related to child labor have been filed against publicly traded companies connected to the cobalt mining sector in DRC,[39] the cocoa sector in Côte d'Ivoire,[40] and the fishing industry in Thailand.[41] In these cases, human rights organizations have filed class-action lawsuits against international companies on behalf of people in these geographies where labor violations are alleged. Clearly, human rights advocacy organizations will continue to use similar approaches in the future.

1.5. DEMANDS FOR GREATER EFFICIENCY AND RESILIENCY

According to a McKinsey & Company report, at least one in twenty companies every year suffer a supply chain disruption costing at least $100 million.[42] These disruptions are the result of a growing number of supply chain risks and vulnerabilities. Building resilient supply chains involves gaining full visibility into supply chain material flows. This level of visibility enables companies to understand their potential exposure to unforeseen events that could negatively impact their supply chain, such as natural disasters, economic shocks, cyberattacks, and supply chain shortages; as well as the possibility that goods are stopped at borders due to forced labor allegations.

Deeper insight into supply chain vulnerabilities can inform business decisions allowing for more effective mitigation and business continuity planning that can include diversifying sourcing countries or investing in key strategic suppliers to optimize production, reduce costs, and reduce supply chain vulnerabilities.

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[36] Acquistion.gov, FAR subpart 22.15 Prohibition of Acquisition of Products Produced by Forced or Indentured Child Labor.
[37] Global Electronics Council, EPEAT Registry. For a discussion of EPEAT standards' impact on migrant workers, see Wheeler, J., Global Social Policy, Expanding Worker Voice and Expanding Labor Rights in Global Supply Chains, 22(02), 2022, pp 385-391.
[38] Changing Markets Foundation, The False Promise of Certification, May 2018.
[39] Kelly, The Guardian, Apple and Google Named in US Lawsuit over Congolese Child Cobalt Mining Deaths, December 16, 2019.
[40] The Week Nestle, Mars Face Lawsuit Over Child Labour in the US, February 21, 2021.
[41] Business & Human Rights Resource Center, Nestlé lawsuit (re forced labour in Thai fishing industry), December 2015.
[42] Alicke, Barriball, Lund, and Swan, McKinsey & Company, Is Your Supply Chain Risk Blind—or Risk Resilient, May 14, 2020.

1.6. INVESTOR PRESSURE

Environmental, social, and governance (ESG) risks were previously considered "non-financial" company risks. Now they are considered material financial risks and opportunities with the potential to have a significant impact on a company's bottom line and shareholder value.

With increasing regulatory requirements related to forced labor, in particular, there has been increased pressure from both ESG-focused and traditional portfolio managers. For example, the organization Know the Chain, representing $6.2 trillion in assets, released an investor statement with actions referencing traceability,[43] and included a traceability and supply chain transparency indicator into its benchmark methodology. The benchmark measures and ranks companies based on their understanding of the practices of their suppliers, including if the raw materials they procure from suppliers are at high risk of being produced by forced labor and human trafficking.

Companies are being held accountable more than ever for exploitative labor conditions throughout their supply chains. The increasing number and scope of supply chain regulations, including recent U.S. WROs, have compelled companies to trace their supply chain to the point of origin to ensure raw materials used in their products are clean. Failure to demonstrate compliance with labor regulations can lead to reputational costs, fines, and the seizure of goods.

[43] Know the Chain, Benchmark Methodology – Apparel & Footwear Sector Version 3, August 2019.

2. SUPPLY CHAIN DUE DILIGENCE

To properly evaluate traceability approaches, it is essential to review the broader supply chain due diligence landscape. Businesses conduct due diligence as an investigatory process to identify and manage commercial risks, which cover all or part of their supply chains and are connected to enterprise supply chain management. **Supply chain due diligence** is defined by the Organisation for Economic Cooperation and Development (OECD) as an "*ongoing, proactive, and reactive process through which enterprises can prevent and mitigate adverse impacts related to human rights, labor rights, environmental protection, and bribery and corruption in their own operations and in their supply chains*."

An effective supply chain due diligence program incorporates multiple approaches to preventing and mitigating risks in supply chains, including traceability. Due diligence increases visibility through evidence-based information gathering. An enterprise's position in a supply chain and the risk environment informs traceability program design, including where traceability efforts are most needed and where other approaches from the broader due diligence domain may be warranted.

"**Value chain**" references the full range of value adding activities in a supply chain, including all firms and workers that bring a product from conception to end use and beyond. It includes research and development (R&D), design, production, marketing, and distribution to the final consumer.[44] In the sustainability domain, the term "value chain" may be used instead of "supply chain" to include external stakeholders such as communities and governments.[45]

2.1. HUMAN RIGHTS DUE DILIGENCE

The United Nations Guiding Principles on Business and Human Rights (UNGPs) state that companies are expected to avoid infringing on the human rights of others and address human rights harm they have caused, contributed to, or are linked to. This responsibility applies to a company's entire value chain, which includes its operations and extended supply chains. The UNGPs set the expectation that companies address human rights abuse by conducting human rights due diligence.

In 2011, the United Nations Human Rights Council unanimously endorsed the UNGPs, making them the first framework related to corporate human rights responsibility to be endorsed by the UN. The UNGPs serve as the foundation of regulatory and voluntary corporate responsibility standards and **due diligence frameworks** along with the guidance from the Organisation for Economic Co-operation and Development (OECD), including the Due Diligence Guidance for Responsible Mineral Supply Chains, the OECD Due Diligence Guidance for Responsible Business Guidance, the OECD Due Diligence Guidance for Responsible Supply Chains in the Garment and Footwear Sector, and the OECD Due Diligence Guidance for Agricultural Supply Chains. In recent years, the EU has also established due diligence regulations in specific industries.

The International Labor Organization's Fundamental Principles and Rights at Work establish a foundation for labor rights in human rights and trade.[46] The ILO also promotes the broader concept of "decent work."[47] The due diligence frameworks listed above include these rights and other related rights, such as the rights of migrant workers.[48] These frameworks provide detailed recommendations to help companies ensure respect for human rights using a risk management process. Effective implementation requires incorporating a risk-based approach to identify, prevent, mitigate, and account for how companies address adverse human rights impacts. The frameworks also establish expectations for due diligence management, due diligence policies, and public reporting.

2.2. RISK MANAGEMENT

Supply chain due diligence efforts align well with practices from corporate **risk management**. A proactive approach to risk management can support strategic decision making and operational effectiveness. Through risk management, disruptive events can be anticipated, and actions can be taken to reduce their likelihood of occurring or limit damage and costs if they do. Risks in global supply chains include "shocks" that impact delivery as well as reputational or compliance risks such as

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[44] Achieving decent work in global supply chains TMDWSC/2020, Report for discussion at the technical meeting on achieving decent work in global supply chains, ILO (Geneva, 25–28 February 2020), p 8.

[45] SustainAbility, UNEP and UNGC, Unchaining Value: Innovative approaches to sustainable supply, 2008, p 2.

[46] ILO, Declaration on Fundamental Principles and Rights at Work website.

[47] ILO, Decent Work.

[48] Achieving decent work in global supply chains TMDWSC/2020, Report for discussion at the technical meeting on achieving decent work in global supply chains, ILO (Geneva, 25–28 February 2020).

environmental, governance, or human rights risks. These risks include allegations of misconduct, labor violations, and sanctions violations.

Companies may implement due diligence proportional to the risk profile of their sources, based on **materiality** and **saliency** assessments, prioritizing resources for issues that matter most to a business and its stakeholders.[49] Risk-related topics that matter most to a business and their stakeholders are classified as "material" or "material-topic." The Global Reporting Initiative (GRI), which sets sustainability reporting standards, suggests that materiality can be determined by "*broader societal expectations, and by the organization's influence on upstream entities*." Different risks may be more or less material to different businesses.

Risk saliency is a related but distinct term used throughout the UN Guiding Principles Reporting Framework that focuses on risks to people instead of businesses. The framework requires companies to focus human rights risk management and reporting on areas where the most severe negative human rights impacts could occur.[50] In contrast to materiality, salient human rights issues are not defined in reference to any one audience or goal.[51]

Moreover, the definition of risk has grown to include the treatment of workers within numerous sourcing standards. For example, EPEAT, which serves as the widest used purchaser driver standard for the IT sector, sets forth labor criteria requiring an assessment of worker risks, including the likelihood of a violation and severity of impact on them, rather than just on the organization's liability.[52] The Global Electronics Council (GEC) has recently updated the Responsible Supply Chains Criteria for EPEAT, more clearly incorporating ILO and ISO standards.[53]

Risk assessments for labor rights violations can draw on risk modeling approaches to support the assessment of supply chain risks based on geography, sector, or issue. A data-centric approach to assessing risks may utilize reputable, third-party data sets and company data sets, such as supplier performance data. Doing so allows companies to evaluate social and geopolitical risks and historical performance to inform decisions based on current information.

Risk Management Guidelines: ISO 31000

ISO 31000 provides that management systems must have defined and documented processes with auditable standards following these steps:

- **Scope, Context, and Criteria Definition**: all risk management should be customized and tailored to the specific scenario.
- **Risk Assessment**: including risk identification, risk analysis, and risk evaluation.
- **Risk Treatment**: select an appropriate risk "treatment" to mitigate the risk, while making a risk treatment plan, which may include:
    - Avoiding the risk by deciding not to start or continue with the activity that gives rise to the risk;
    - Accepting or increasing the risk to pursue an opportunity;
    - Removing the risk source;
    - Reducing the likelihood of the risk occurring;
    - Changing the consequences;
    - Sharing the risk with another party(ies) (e.g., contracts and risk financing); and
    - Retaining the risk by informed decision.
- **Monitoring, Review, Evaluation**: monitor and review risks, and includes planning, gathering, and analyzing information, recording results, and providing feedback.

[49] KPMG, The Essentials of Materiality Assessment, 2014.
[50] UN Guiding Principles, Salient Human Rights Issues, September 2017.
[51] Shift Project, Introduction to Silent Human Rights, February 2016.
[52] EPEAT.
[53] Global Electronics Council (GEC), the Responsible Supply Chains Criteria for the Electronic Product Environmental and Social Responsibility Tool, EPEAT_RSC (February 2025). These criteria are currently optional, as they are often when first introduced. Through a process of continuous improvement, such criteria are generally reviewed to determine if and when they should be converted to mandatory criteria.

Open data and information from open data sets can also be used to inform traceability if reputable. Many organizations collect and make publicly available a broad range of data, including UN agencies such as the World Bank and World Health Organization, university research projects, and NGOs and non-profit advocacy groups. As open data is typically readily processable by a computer, easily accessed, and easily modified, it can be included in different systems efficiently. **LRQA's EiQ** solution is one such risk assessment software tool, utilizing LRQA audit data sets, coupled with bottom-up worker information, risk analytics, and open data disaggregated by country, region, and sector.[54]

2.3. RISK ASSESSMENT FOR HIGH-RISK AREAS

In high-risk or conflict-affected areas, risk assessments may distinguish between levels of elevated risk, such as between "high-risk" and "ultra-high" risk. Collecting accurate and timely risk data in these contexts is one of the biggest challenges for risk-based due diligence systems, particularly for **commodities** sourced or processed in remote, hidden, or conflict-affected areas.[55] To properly assess and mitigate the risks of child and forced labor in such opaque high-risk environments, scaling-up collaborative solutions, with public, private, and/or civil society actors agreeing to act with complementary capabilities, can be more effective than individual stakeholder action.

Regardless of how risky an environment is deemed to be during risk assessment, populations depend on raw material production for income and businesses operating in such locations play an important role in supporting local livelihoods and improving working conditions. Risk assessments require site-specific and thoughtful approaches to prevent blanket bans on entire high-risk geographies. Known as "de-facto embargos," risk assessments that lead to the exclusion of entire regions or countries can be harmful to local economies and people and can lead to a further deterioration of human rights and labor conditions. In these cases, frequent risk monitoring may be preferred to (or combined with) regular audits, as annual audits do not capture ongoing performance, which can be highly variable in these settings. New and innovative approaches are also increasingly used to supplement traditional audit programs and traceability efforts, that can improve visibility into working conditions and supply chains.

Approaches to risk monitoring include remote sensing using satellite imagery, field monitoring, and online worker engagement tools or grievance mechanisms. Digital tools can rapidly collect data that can influence supplier management decisions in real time. This allows companies to supplement audits, which provide a snapshot of a site's performance at a moment in time. For traceability initiatives, risk assessments from these approaches may help prioritize where expanded real-time monitoring or traceability may be appropriate. There are a variety of different technology-driven tools on the market, detailed in Annex I, that can be incorporated into corporate risk management activities.

Remote sensing using satellite imagery can be combined with machine learning to detect risks such as deforestation, illegal fishing, or forced labor. Satellite imagery provides spatially explicit and scalable data for efficient risk analysis. Spatially explicit models specify the location of objects within a landscape.[56] Research has demonstrated that remote sensing can detect forced labor risks by observing dynamic behavior. For example, high-risk behavior in fishing vessels can be linked to distance from port, number of voyages per year, or average daily fishing hours.[57]

Remote sensing can also support the identification of at-risk locations using risk indicators. Initiatives in the remote sensing space have typically developed risk indicators for forced labor based on on-the-ground or expert knowledge of high-risk locations. For example, certain types of vessels, kilns, or mines, are known to be at higher risk of forced labor than others, with characteristics that might indicate forced labor. Machine learning techniques can use data to build a predictive model that identifies high and low risk sites.[58]

Artificial intelligence (AI) can be used in conjunction with satellite imagery to identify high-risk behaviors based on predefined criteria. Combining satellite imagery with a supply chain map can provide insight into the risk of such practices. Based on this information, sites can be targeted with focused support, enforcement actions, or development programs. AI

[54] More information can be found at LRQA's EIQ webpage.
[55] ILO Ending Forced Labour by 2030: A Review of Policies and Programmes, 2018.
[56] Dunning, Stewart, Danielson, Noon, Root, Lamberson, and Stevens, Ecological Applications, Spatially explicitly population models, February1995.
[57] McDonald, Costello, Bone, Cabral, Farabee, Hochberg, Kroodsma, Mangin, Meng, and Zahn, Proceedings of the National Academy of Sciences, Satellites can Reveal Global Extent of Forced Labor in the World's Fishing fleet, January 2021.
[58] Jackson, Bales, Owen, Wardlaw, and Boyd, Journal of Modern Slavery, Analysing Slavery through Satellite Technology: How Remote Sensing Could Revolutionise Data Collection to Help End Modern Slavery, 2018.

may also be used to screen extensive data sets such as import, export, shipping, customs, bill of lading data, adverse media, and sanctions watchlists to flag potential risks in complex multi-tiered supply chains.

In comparison to remote sensing and AI, other forms of risk monitoring draw directly from human sources. These risk monitoring programs can seek to differentiate the on-the-ground risks between specific sites.[59] Monitoring human rights risks in this manner requires participation from individuals able to identify rights violations and gain access to sites. Information about conditions on the ground is typically provided by community members, CSOs, labor inspectors, or the staff of monitoring programs. This data can be linked to a traceability system as evidence about the production conditions of a product.

A complaint or grievance mechanism is a channel for individuals to raise concerns within companies for executives to review and respond to. Companies can require their suppliers to maintain these mechanisms as part of their supplier policies, to ensure the concerns of workers within their supply chains and members of adjacent communities are captured. In some instances, funded call center helplines have been established to capture regional complaints or grievances without private sector mechanisms.

Some companies operate complaint mechanisms and help lines in their global supply chains or implement third-party mechanisms to provide another channel to remedy worker concerns. Third-party mechanisms, such as the Amader Kotha Helpline in Bangladesh,[60] collect valuable data from supply chain workers to supplement audits and can be incorporated into data driven risk assessments. Worker organizations play a vital role in ensuring company compliance with standards through such mechanisms and related processes anchored in governmental, administrative, and judicial proceedings and potentially collective bargaining agreements between employers and unions. Indeed, worker organizations may be among the most effective for helping companies stay compliant with labor rights regulations because their trained worker representatives monitor conditions at workplaces, including, for example, health and safety compliance.

Risk mitigation, a term often used in the lexicon of due diligence in place of “risk treatment,” can use information captured in due diligence programs as the basis for selecting treatments or interventions. Targeted risk mitigation can support the progressive improvement of labor conditions. **Progressive improvement** recognizes that certain issues require commitment to continuous improvement, which may be more valuable to the well-being of the value chain than risk avoidance, as it advances towards best practice.[61] Risk mitigation strategies may also include the proactive termination of a specific supplier relationship or termination of sourcing from specific locations where other mitigation measures are not possible. Corrective action plans are commonly used to monitor the implementation of risk mitigation and treatment plans.

2.4. CHOKE POINTS AND UPSTREAM ASSURANCE MECHANISMS

A similarity among many due diligence frameworks is their focus on choke points (also known as control points) which are key stages, or points of transformation, in a supply chain at which there is greater visibility and control over production and trade upstream.[62] If management systems at a choke point allow for only approved and/or certified input materials to be used, it can be assumed that outputs produced after that choke point are less risky. Due diligence audits assess the robustness of due diligence management systems, including their risk management approach and how the system supports, tracks, and directs due diligence activities. Supplier mapping allows a company to identify the choke points in their supply chain. This allows them to confirm whether these choke points have been audited.

In certain industries, particularly those with strict compliance requirements, traceability for all inputs into defined choke points is a foundational and audited aspect of due diligence. In those industries, documented evidence of the consistent use of traceability systems, either internal or third-party, may be required. In these systems, traceability is required upstream of a

[59] These initiatives are distinct from large-scale child labor monitoring programs (CLM), such as those managed by ILO, UNICEF, and other leaders in the space. CLM programs often take an area-based approach to monitor of child labor in larger geographical areas, involving the identification, referral, protection, and prevention of child laborers through the development of a coordinated multi-sector monitoring and referral process that aims to cover all children living within a given geographical area.
[60] Amader Kotha Worker Helpline Homepage.
[61] The Alliance for Responsible Mining (ARM) and RESOLVE, CRAFT Code 2.0, Volume 2.A, 2020.
[62] OECD, OECD Due Diligence Guidance for Responsible Supply Chains in the Garment & Footwear Sector, 2017.

selected choke point, meaning it is applied only to high-risk tiers of a supply chain. In the minerals sector, traceability and monitoring is performed by "**Upstream Assurance Mechanisms**" which are a select and approved set of organizations.

The **Responsible Sourcing Network** led **Yarn Ethically and Sustainably Sourced (YESS) Standard** is used to scale due diligence management to choke points in the cotton and textile industry. The goal of YESS is to implement industry-wide due diligence to support the elimination of cotton produced with forced labor at yarn spinners and textile mills. The Standard focuses on nine high-risk countries: Benin, Burkina Faso, China, India, Kazakhstan, Pakistan, Tajikistan, Turkmenistan, and Uzbekistan. The Standard audits due diligence management systems and material control systems to ensure reconciliation of all cotton inputs within a facility. Upstream traceability will play an essential role in YESS assessments.[63] Ultimately, with this approach, all inputs are to be verified by a **"**farm-level scheme" such as the Better Cotton Initiative, Cotton Made in Africa, the e3 Sustainable Cotton Program, and Fairtrade, all of which use traceability, and will be used upstream of choke points.

In the agriculture sector, the OECD Due Diligence Guidance for Agriculture Supply Chains have not been widely implemented at the original time of this report in 2022. The Guidance includes less established due diligence regulatory frameworks and industry standards for commodities such as soy, sugar, cocoa, palm oil, and beef. There is, however, considerable forward momentum. In 2019, the OECD and FAO released a public call to action around the need to scale-up due diligence for responsible agricultural supply chains. In a 2020-2022 workplan, they noted a set of priorities, including the integration of OECD-FAO recommendations on due diligence into regulatory frameworks and industry standards and conducting alignment assessments of certification schemes from selected industries.[64]

In the timber sector, the EU Timber Regulations take a risk-based approach to due diligence and traceability requirements. These regulations focus on importers to the EU market, requiring actors who place timber products on the EU market to exercise due diligence. If a risk of illegal practices is identified during a risk assessment, the operator is required to take mitigation measures and conduct a new risk assessment, or refrain from placing that timber on the EU market. Record-keeping requirements related to traceability are mandated and used as part of the risk management process.

2.5. SUPPLY CHAIN TIERS

Risk assessments can help determine when, where, and how traceability can be established. Prior to implementing traceability or tracking, companies should first map their supply chains. Doing so makes it possible to identify the geographies, product inputs, and/or business relationships in their supply chain. In high-risk areas, companies may conduct more detailed mapping of the suppliers, to identify where engagement or focus is most necessary.

At a high level, supply chain mapping allows a company to better understand its extended supply chain and supplier network. The Fair Labor Association (FLA) defines supply chain mapping as "*an exercise by which a company or a third party collects information on its suppliers and their sub-suppliers in order to understand relationships and increase the visibility of the wider supply chain.*" And supply chain mapping is *"in support of demonstrating the relationships among the entities in a supply chain through which a product, item, or material flows."*[65] Furthermore, the FLA notes that mapping is a key step in designing a traceability system and can be considered part of supply chain due diligence.

A supply chain is a complex network of intersection points. Understanding the structure and relationship between stakeholders within a supply chain is essential for coordinating suppliers and enabling traceability. Multiple actors may provide the various materials and components that make up a finished good. Stages within a supply chain are known as "**tiers**," which are described in terms of their one-up, one-down supplier relationship. Understanding the potential tiers is essential prior to developing a supply chain map. Actors that only perform logistics services – such as traders or warehouses - are not typically considered or listed when inventorying tiers of sub-suppliers. They, however, are important to the value chain and to a traceability system's success and should be documented.

A tier-1 supplier is a directly contracted upstream supplier of product inputs.[66]

A tier-2 supplier supplies product inputs to a tier-1 supplier.

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[63] Responsible Sourcing Network, YESS Standards for Spinning & Fabric Mills, 2019.
[64] OECD-FAO, Guidance for Responsible Agricultural Supply Chain Implementation Plan 2020-2022, 2020.
[65] Fair Labor Association, Supply Chain Mapping and Traceability Glossary, 2018.
[66] A supplier can be a manufacturer, fabricator, distributor, materialman, or vendor.

The chain extends upstream through suppliers and as many existing tiers to the point of primary production of raw materials used in a final product. There are cases when a single actor performs multiple roles in a supply chain, in what is known as **vertical integration**. For example, a company performing both primary refining and secondary refining, or a facility that has integrated spinning and knitting processes.

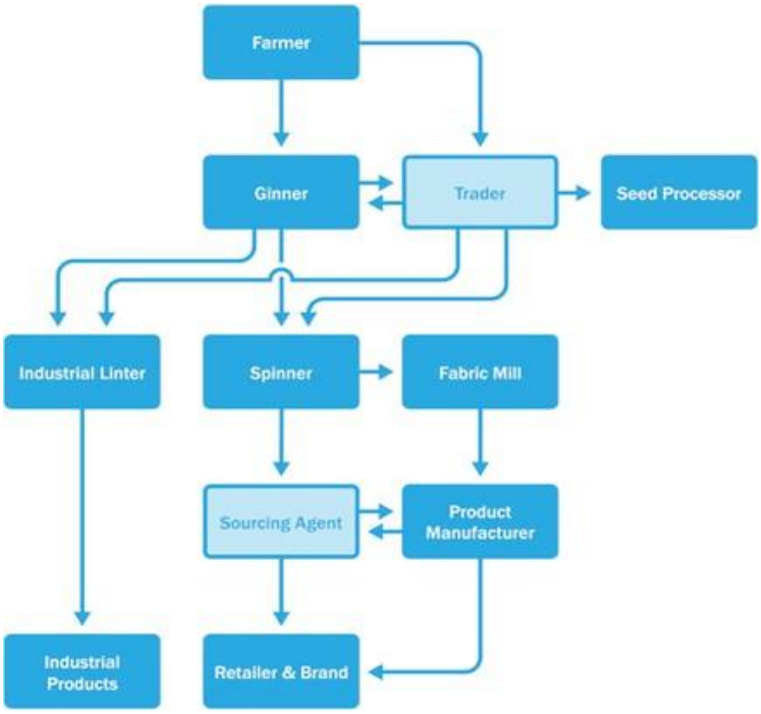
The segments and actors in a supply chain are described as upstream, midstream, or downstream. The upstream refers to primary producers such as farmers, miners, growers, and fishermen, as well as the processors operating in the same country or region as the primary producers, such as crude smelters or ginners. Midstream typically refers to secondary or value-added processors, such as fine refiners, fabric mills, chemical manufacturers, or component manufacturers. The downstream refers to final manufacturers, finished goods, and retailers.

Four simplified examples of commodity supply chain maps are included in the figures below (figures 1–4). These figures illustrate common processes and relationships between tiers in different commodities. Common tiers are in dark blue, while the logistic or trade partners, who do not provide a production, essential aggregation, or transformation process to a good, are in light blue.

While there are some commonalities among supply chains, each is different. Additionally, these maps do not reflect the supply chains of actual businesses in the sectors, reinforcing the need for each company to understand and account for the specificities of their specific supply chains, including vertical integration and processing steps, as part of due diligence. Each company should map their own supply chain with as much specificity as possible, particularly to understand all choke points in their extended supply chain.

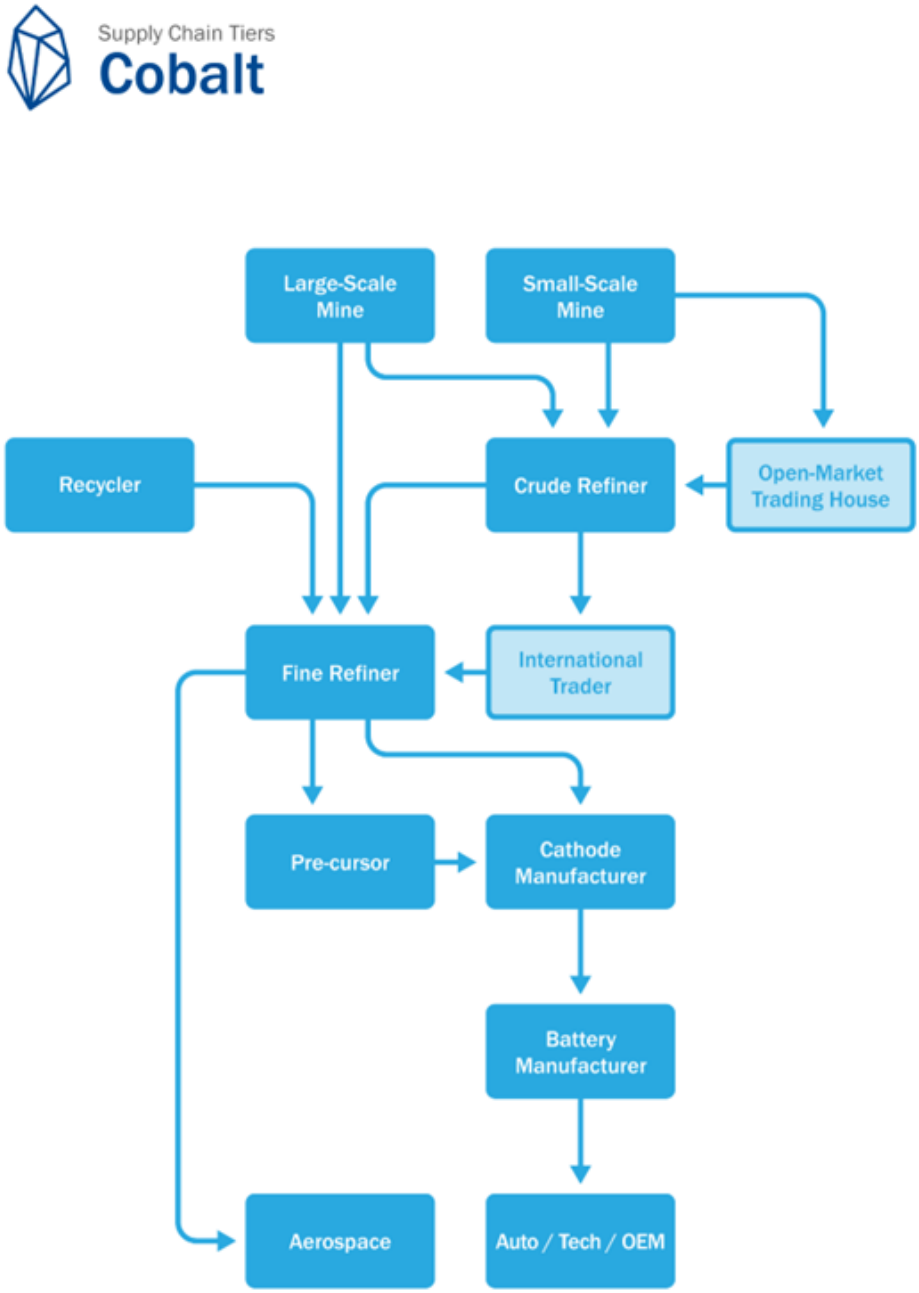
> *"While perspectives of companies further upstream in the supply chain from tier-2 suppliers to mine sites are typically more difficult to capture, they will also provide valuable insights into risks, impacts, and mitigation strategies that can inform an organization's due diligence system and reporting."*
>
> Global Reporting Initiative & Responsible Minerals Initiative

Figure 1: Illustrative Cotton Supply Chain Tiers



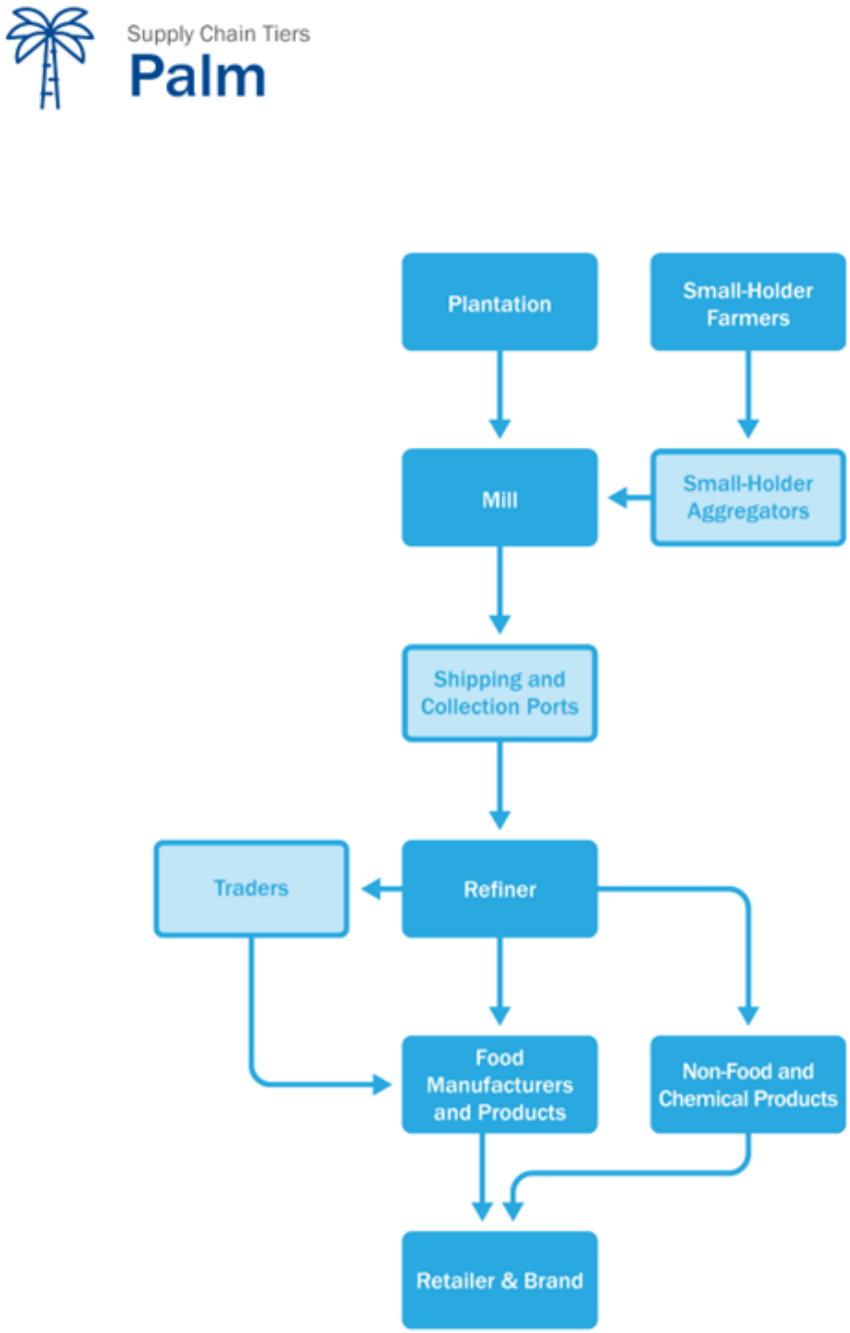
Key Choke Points: Ginner and Spinner

Figure 2: Illustrative Cobalt Supply Chain Tier



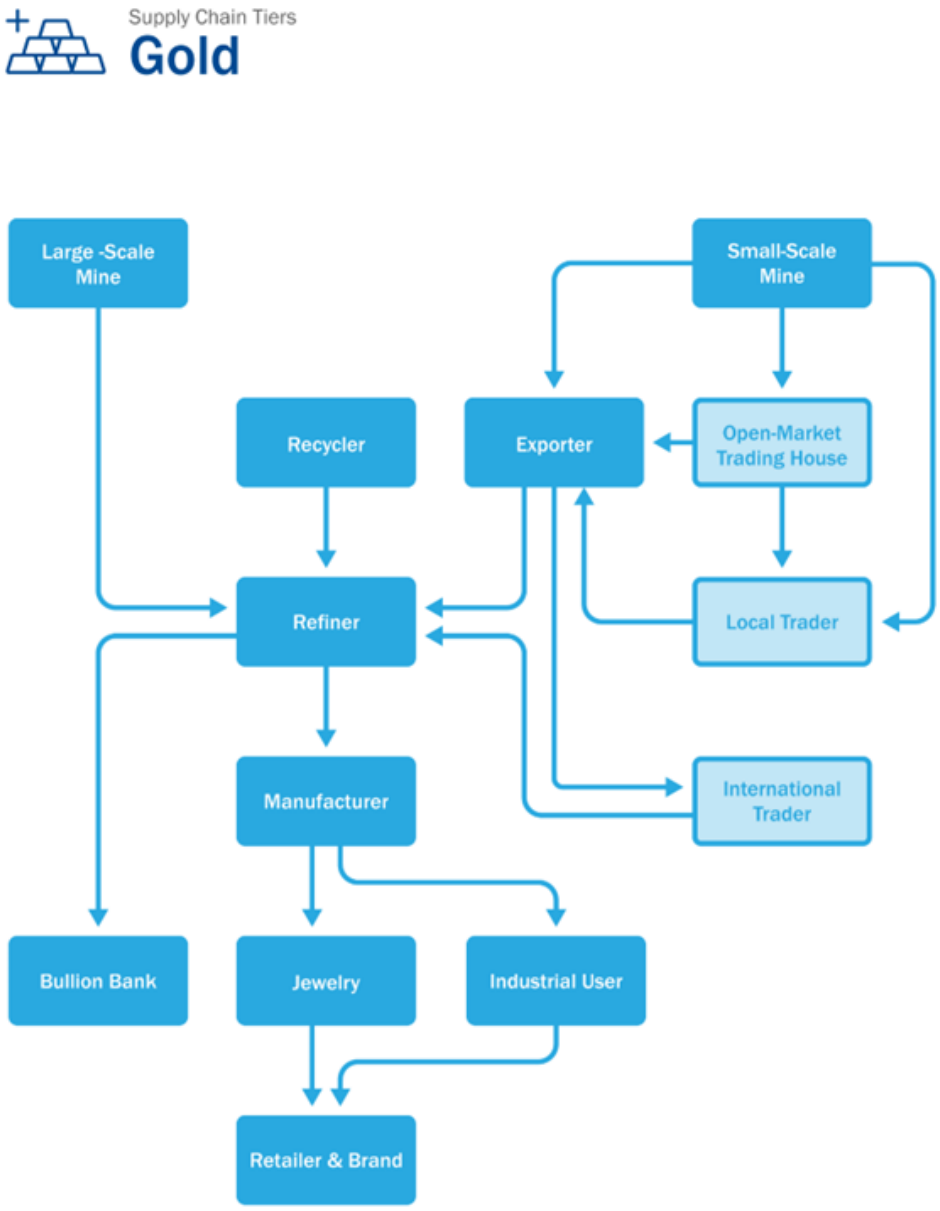
Key Choke Points: Crude Refiner and Fine Refiner

Figure 3: Illustrative Palm Oil Supply Chain Tiers



Key Choke Points: Refiner

Figure 4: Illustrative Gold Supply Chain Tiers



Key Choke Points: Refiner

2.5.1. SUPPLIER MANAGEMENT AND VISUALIZATION

Supply chain mapping requires interaction, communication, and requests for information from business partners throughout an extended network of companies. Proactive engagement with suppliers using supplier management tools can be a starting point to gain valuable insights needed to develop a supply chain map.[67]

Engagement includes requests for supplier information, including supplier names, locations of sites manufacturing component parts, and/or production processes. Engagement with upstream suppliers can be done through consultation or negotiation processes, or through questionnaires or interviews. Mapping can be led by an individual company or through an industry initiative.[68] Common tools used for supplier engagement include:

Supplier Self-Assessment Questionnaires (SAQs) and other supplier reporting questionnaires are templated supplier request forms. These support the identification of suppliers and conditions within a supply chain. Typically, these templates request information from suppliers that have been in a supply chain in previous years or are continuous suppliers. They also seek to support the determination of the origin of product components. Different SAQs request varying levels of detail about a supplier's sourcing practices. Common and formatted reporting templates exist in different industries, such as the Drive Sustainability SAQ[69] for the automotive sector and the Conflict Minerals Reporting Template (CMRT)[70] for the technology sector.

Supplier management solutions are offered by numerous consulting and technology firms in the supplier management space. Supplier requests, such as SAQs, can be managed through these specialized, technology-enabled services. These platforms automate supplier questionnaires and allow for efficient storage and management of information. In some instances, they can support the management of remote audits or audit follow-up procedures. Supplier data must be collected at the extended tiers of a supply chain to the point of raw material production. Companies extend this process through their tier-1 suppliers by requiring tier-1 suppliers to engage their direct suppliers to collect tier-2 supplier data and so on.

Information requests are most frequently completed when they are part of a downstream brand's supplier requirements and written explicitly into supplier and sub-supplier contracts, which can help to clarify expectations in a proactive manner. It is vital for platforms to include robust data verification protocols to ensure that information collected is truthful and accurate. This includes the need for local language translation, understanding(s) of production workflows, and both human-centered and computer-based verification mechanisms.

Supply chain visualizations provide graphic representations of the one-up and one-down relationships in a supply chain for a specific product. A variety of supply chain visualization software solutions are used by companies to support their transparency goals. Additional information, such as social and environmental information, can be captured in these visualizations based on predetermined requirements. Sometimes, a supply chain visualization is built into other supplier management solutions. These visualizations can be helpful for public communication purposes (e.g., for a corporate website or report) or for internal management purposes, including contributing to a wider risk management toolkit, or to highlight where information gaps exist.

Figures 5–7 below provide examples of different approaches to supply chain visualization. Differences between the visualizations include whether georeferenced tier locations are included, whether they provide details on the processes of or other contextual details about the tiers, and whether they provide details related to the products themselves. These examples highlight the wide range of possibilities that exist when visualizing linkages in a supply chain.

[67] GRI and the RMI, Advancing Reporting on Responsible Mineral Sourcing, 2019.
[68] The Responsible Mica Initiative members, for example, commit to supply chain mapping as an entry standard.
[69] Drive Sustainability, SAQ 4.0 to be updated to SAQ 5.0 in 2022.
[70] RMI, Conflict Minerals Reporting Template.

Figure 5: Web-based Map Using SourceMap[71]

VF Corporation, an American apparel and footwear company, used SourceMap to map and visualize its supply chain. SourceMap is a U.S. company that specializes in dynamic supply chain visualizations to support sustainability management and communications. VF Corporation's supply chain maps were publicly hosted on their sustainability website until December 2021. The maps included details about sustainability certifications for each tier in their supply chain, details about VF Corporation's labor initiatives, and statistics about supplier facilities such as their number of workers. The display included georeferenced points and lines representing the flow of material they source.

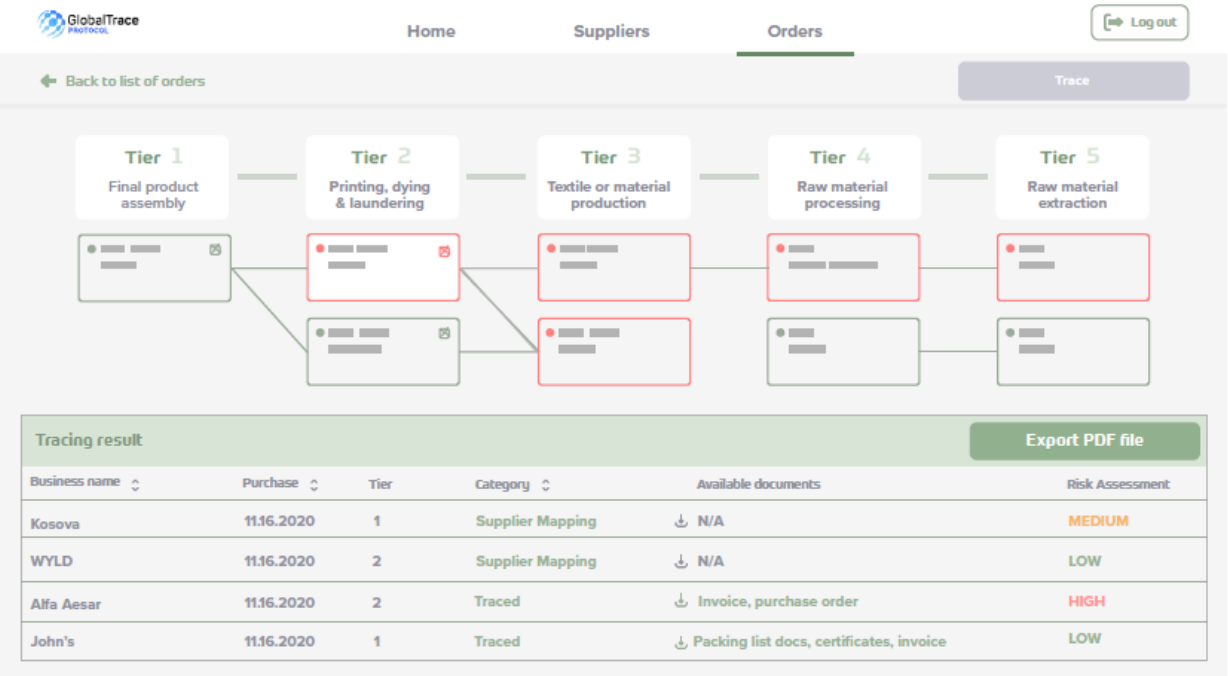
Figure 6: Logical Branch Map Using ChainPoint

ChainPoint, a German software company, provides comprehensive traceability services to certification programs around the world. ChainPoint has managed the traceability systems for the Better Cotton Initiative, iTSCi, the Rainforest Alliance, RSPO,

[71] Found at https://www.vfc.com/responsibility/product/traceability.

and Responsible Soy, among others. ChainPoint provides traceability solutions to support all chain of custody models (Section 3). While not core to their business model, ChainPoint also offers a mapping feature so users can easily see linkages between supply chain actors.[72] Maps can be created quickly and allow users to toggle between logical displays and georeferenced maps. Lines with arrows indicate how suppliers are connected.

Figure 7: Logical Tree Diagram Using the GTP Tool



The Global Trace tool includes supply chain mapping visualization that shows the flow of the supply chain as a horizontal tree diagram. Global Trace distinguishes between product inputs that are actively tracked from known suppliers and those from which detailed traceability information has not been collected. Maps created by the tool include details about each tier, trade partner names, risk assessment rankings, and dates. A more comprehensive review of traceability service providers from across the supplier management space, based on first person interviews and desk research, is found in Annex I.

[72] Screenshot from April 2021 discussion with ChainPoint. More information can be found at https://chainpoint.org/.

3. THE TRACEABILITY LANDSCAPE

Experts have debated which data is required for a traceability system to have "true" transparency with visibility and access to accurate information across supply chains.[73] The amount of information collected in a traceability system, however, is not fixed. Some experts assert that a fully visible supply chain requires access to "*fully available information about products, processes, and performance*."[74] Others assert that traceability must capture data on all material inputs used in a product with unique identifiers assigned to all of the product's material inputs and outputs.[75] These definitions remain inadequate for guiding the selection of traceability data elements, and especially when selecting elements and indicators related to "comprehensive" traceability, which could include supplier labor conditions or ESG performance.

These debates highlight the possibility that, if not managed carefully, traceability systems can be overbuilt or underbuilt or can collect information that is not useful for their intended purpose. It is worth considering GTP's definition of traceability: "*the ability to identify and trace the history, distribution, location, and application of products, parts, and materials, to ensure the reliability of sustainability claims, which can include human rights, labor (including health and safety), the environment, and anti-corruption, among other areas,*" which is distinct from some definitions of traceability. With any system, there is a risk of designing something that does not support an intended goal. As stated by Jamie Barsimantov below,[76] traceability must be done in a fit-for-purpose manner with specific goals in mind. In some instances, other approaches to supplier management may be more appropriate than comprehensive traceability.

The remainder of this section discusses the technical elements of traceability and data management. The approaches described can help readers design a fit-for-purpose traceability system. These include chain of custody models, unique identifiers, key data elements for comprehensive traceability, and approaches to data sharing.

3.1. TRACEABILITY STAKEHOLDER IDENTIFICATION

Traceability can accomplish a variety of goals and meet the demands of diverse groups of stakeholders. These stakeholders often have divergent perspectives on or expectations of traceability. A traceability or due diligence system can be more or less

> *"The term "traceability" is used too broadly, without first identifying the specific goal or underlying reason to engage the supply chain. This can lead companies to over-collect data, spend too much time setting up complex systems, and sometimes even collect the wrong data. We find that companies have the most success in understanding and addressing risks in their multi-tiered supply chains by first gaining basic mapping visibility into key materials. It is amazing how easy it is to layer on information requests and more granular information based on an initial level of transparency and technology-based engagement."*
>
> Jamie Barsimantov, COO, SupplyShift

robust, with different data requirements depending on the needs and goals of stakeholders. Three stakeholder groups – companies, consumers, and regulators – may have the following requests and perspectives:

- **Companies**: Different functional teams will have varied and competing priorities within a company and may interact with a traceability system in different ways. These functions may include procurement, risk management, or sustainability/corporate social responsibility teams, among others. Cross-functional teams are often assembled to deploy traceability. In addition to supply chain social responsibility and sustainability, the teams may be focused on efficient inventory controls, maximizing profitably, or diversifying their supplier base.

[73] GS1, Global GS1 Global Traceability Standard, 2017.
[74] Cetinkaya, Cuthbertson, Ewer, Klaas-Wissing, Piotrowicz, and Tyssen, Sustainable Supply Chain Management Practical Ideas for Moving Towards Best Practice, 2011.
[75] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.
[76] Quote provided to the report authors by Jamie Barsimantov in May 2021.

- **Consumers**: Consumers are interested in the reliability of producers' sustainability claims. These claims can inform and influence consumer purchasing decisions. A traceability system can support communication around these product claims, including sustainability commitments. Obtaining useful and reliable data about supply chain conditions – including those at the primary producer level such as farmers, miners, growers, or fishermen – is essential to these efforts.
- **Regulators and government**: Regulating bodies have distinct requirements that may impact the design of a traceability system. Examples of U.S. regulations that require some form of traceability include the U.S. Lacey Act, Section 1502 of the Dodd-Frank Act, the Food and Drug Administration (FDA) Food Safety Modernization Act (FSMA),[77] the Drug Supply Chain Security Act and the Seafood Import Monitoring Program (SIMP).[78] A traceability system developed to meet these regulations may differ from one built for management traceability or consumer traceability, because companies and their suppliers will be required to meet submission, data storage, and data security protocols. They may require the disclosure of a company's purchase orders, the invoices between supply chain members, packing lists with shipper and product descriptions, details about production processes, the production records for all components of a product, and the location of origin of input materials.[79] In some cases, traceability data must be submitted to regulators via portals such as the Automated Commercial Environment (ACE) or the FDA Interoperability Web Service portal.

The needs of stakeholders are not mutually exclusive, and the same data can often be used for multiple purposes. A company's ability to meet these needs is determined in part by the resources a company has to develop and maintain the traceability system.

3.2. CHAIN OF CUSTODY MODELS AND CERTIFICATION PROGRAMS

Experts also have different views on how to distinguish "**chain of custody**" (CoC) from traceability. Some assert that CoC relates only to documentation related to the possession of goods,[80] while traceability is the ability to demonstrate CoC.[81] Others use the term interchangeably, assuming there is no fundamental difference between them. One definition of CoC says that it is the "*documentation showing the transfer of ownership of a product every time that product changes ownership and/or is altered or repacked.*" Certifiers often require partners to adhere to a specific chain of custody protocol to move products labeled "certified" through the supply chain."[82]

CoC requirements are often driven by certification or "ecolabel" programs that establish "CoC standards" and set specific rules for said standards.[83] Certification standards, also referred to as sustainability standards, require data to be collected related to the movement of goods from certified businesses at each stage of the supply chain.[84] ISEAL Alliance, a global membership association for sustainability standards, has led or participated in defining the CoC practices for numerous leading certification standards, including Fairtrade International, Rainforest Alliance, Textile Exchange, Marine Stewardship

[77] The FDA Food Safety Modernization Act (FSMA) section 204 (21 U.S. Code § 2223) requires high-risk foods have additional recordkeeping requirements to protect public health. FDA developed a Risk-Ranking Model for Food Tracing ("the Model"), a data-driven science-based decision support tool, to assist the Agency in the process of designating a Food Traceability List.
[78] The Seafood Import Monitoring Program (SIMP) was established to prevent illegal, unreported, and unregulated (IUU) products from entering U.S. commerce. SIMP requires the importer of record to report key data, including event and location data, at the point of entry into U.S. commerce. It also requires the importer of record to maintain certain traceability documents, which can be used as evidence during audits.
[79] Solar Energy Industries Association, Solar Supply Chain Traceability Protocol 1.0, 2020.
[80] Experts have differing views on distinguishing CoC and traceability, with some suggesting that CoC relates only to the documentation related to possession of the goods. See UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.
[81] ISEAL Alliance, Chain of Custody Models and Definitions, 2016.
[82] Future of Fish, FishWise, and Global Food Traceability Center, Seafood Traceability Glossary.
[83] Borit and Olsen, Seafood Traceability Systems: Gap Analysis of Inconsistencies in Standards and Norms. FAO. 2016. Note: Melania Borit and Petter Olsen, two leading academics in the study of traceability extensively discuss differences between the terms, writing "with ecolabel type CoC, there is one particular set of properties that it is desired to protect, retain and document (i.e., dolphin-safe, organic) while other sets are not given importance."
[84] ISEAL Alliance, Chain of Custody Models and Definitions, 2016 with updated draft guidance in 2024.

Council (MSC), Better Cotton Initiative (BCI), Roundtable on Sustainable Palm Oil (RSPO), and the Forest Stewardship Council (FSC).

The term **chain of custody model** is less ambiguous and is used to "d*emonstrate the link (physical or administrative) between a verified unit of production and a claim about the final product*."[85] The four basic chains of custody models used by leading certification programs are: 1) identity preservation (IP), 2) segregation, 3) mass balance (and controlled mass balance) and 4) certificate trading. These models vary considerably in their ability to verify sustainability claims for specific batches of goods.

CoC models use different approaches to physical and administrative traceability, which impacts whether certified and non-certified batches can be mixed. Identity preservation and segregation models prohibit the mixing of certified and non-certified inputs. Administrative models, such as mass balance and certificate trading, may allow for controlled mixing of inputs and are based on the reconciliation of inputs and outputs during processing.

3.2.1. IDENTITY PRESERVATION

Figure 8: Identity Preservation[86]

The identity preservation model is the most rigorous, credible, and resource heavy CoC model. It requires goods to come from a single location and for each batch, quantity, or consignment of a certified product to be packaged, processed, and traced separately from other certified or non-certified products. This is true both in terms of a physical product and its associated documentation. To utilize this model, product identifiers and physical controls are needed to preserve the certified status of a good.

Identity preservation is commonly applied when there is extremely high consumer or regulatory interest in a specific origin. It is also used in supply chains where there are clear or inherent product quality differences.[87] Identity preservation can be challenging to implement, as production facilities, refiners, and processing factories may need to develop specific lines of production to ensure product materials remain segregated.[88]

Table 1: Examples of Identity Preservation in Certification or Due Diligence Programs

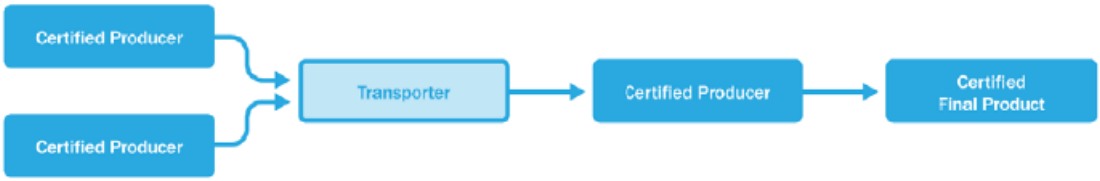
Good	Example Use - Identity Preservation Model

[85] IBID.
[86] In each image, logistic and transport partners, who do not provide a production, essential aggregation, or transformation process to a good, are represented in light blue.
[87] ISEAL Alliance, Chain of Custody Models and Definitions, 2016.
[88] CSIS Human Rights Initiative, New Approaches to Supply Chain Traceability Implications for Xinjiang and Beyond, 2020.

Gold	Swiss Better Gold Association
Gemstones	Responsible Jewellery Council
Coffee	Rainforest Alliance - Identity Preserved

3.2.2. SEGREGATION

Figure 9: Segregation



The segregation model is somewhat less strict than identity preservation, as it allows for the mixing of batches among certified sources. Certified products must be kept separate from non-certified products both physically and in documentation.[89] Batch segregation from non-certified material occurs during all receiving, processing, packaging, storage, and transportation stages of the supply chain. Mixing makes claims about specific origin more difficult, as mixed batches may come from multiple upstream origins. So, while the full product content is certified, it can come from different certified sources. Claims should be reliable, as long as all inputs have been certified prior to mixing.

Segregation requires documentation from certified sources to be maintained, and records and identifiers related to inputs and outputs captured. This model is useful in supply chains where upstream processing is common to accommodate multiple small-scale producers. Cotton gins, for example, may be utilized by dozens or hundreds of small-holder farmers making identify preservation impractical in some cases. A robust and trustworthy approach to certify all upstream producers and verify inputs at points of processing is required.

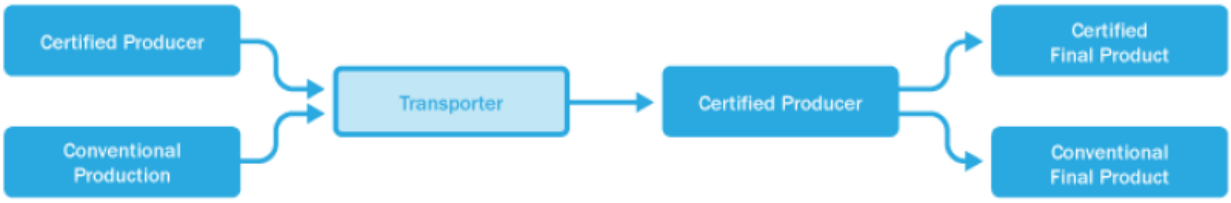
Table 2: Examples of Segregation in Certification Programs

Good	Example Use - Segregation Model
Cotton	Global Organic Textile Standard (GOTS)
Fish	Marine Stewardship Council (MSC)
Chocolate	Rainforest Alliance - Segregation
Gold	LBMA Good Gold Guidance

[89] ISEAL Alliance, Chain of Custody Models and Definitions, 2016.

3.2.3. MASS BALANCE

Figure 10: Mass Balance



The mass balance model accommodates the mixing of certified and non-certified sources during processing. Mass balance has historically allowed for two distinct types of sustainability claims. The first is that a good contains a specific ratio of certified to non-certified ingredients/material, such as "50% mass balance certified". The second claim, which has proven in recent years to be more controversial in the marketplace[90], is shown in the graphic above. In this model, a portion of the final batches are claimed to be certified while the rest of the batch is considered conventional. Controlled mass balance builds upon the basic mass balance by adding specific requirements for non-certified materials, which could include minimum performance standards or verification procedures.[91]

In this model, producers sell their goods to downstream businesses that accept both certified and non-certified goods. As assets move through the supply chain, an exact account of volume and weight ratios is kept at each tier.[92] Close documentation and oversight of all inputs and outputs is required to determine percentages of certified sources in newly created batches accounting for all processing, conversion processes, and receipts.[93] Accounting procedures ensure that the volume of inputs processed meets or exceeds the volume required for output products.[94] Mass balance accounting is typically audited, at each tier over a defined period of time. This period allows for the reconciliation of inputs and outputs and can be as long as a year."[95]

The mass balance model, unless controlled, cannot guarantee that a final product is made without human rights violations, as non-certified sources will have been mixed into the product. It also cannot make claim to a specific origin. The model is, however, economical and efficient for large-scale operations. It is also argued that mass balance can support the increased use of certified material in a supply chain as a whole.[96] Mass balance is best used in environments where there is no mandate to explicitly exclude non-certified material in processing, where the risk-environment is low enough to warrant the model, or where it is deemed the only sensible and/or economically viable model.

Table 3: Examples of Mass Balance in Certification or Due Diligence Programs

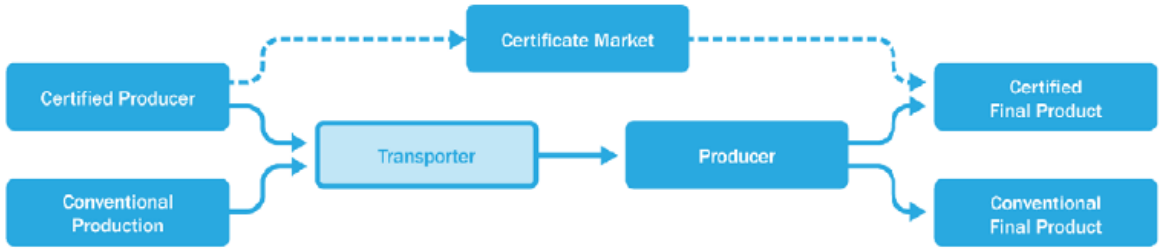
Good	Example Use - Mass Balance Model or Due Diligence Program

[90] Ecotextile News, BCI Admits 'Mass Balance' System Could Go, December 1, 2020
[91] ISEAL Alliance, Supporting EUDR, 2024.
[92] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.
[93] United Nations Global Compact and BSR, A Guide to Traceability: A Practical Approach to Advance Sustainability in Global Supply Chains, 2014, p 85.
[94] Borit and Olsen, FAO, Seafood Traceability Systems: Gap Analysis of Inconsistencies in Standards and Norms, 2016.
[95] ISEAL Alliance, Chain of Custody Models and Definitions, 2016.
[96] CSIS Human Rights Initiative, New Approaches to Supply Chain Traceability Implications for Xinjiang and Beyond, 2020.

Cocoa Powder	Rainforest Alliance – Mass Balance
Cotton	US Cotton Trust
Cocoa, Sugar, Fruit Juice, Tea	Fairtrade USA[97]
Fish	ASC - feed sourcing requirements
Cotton	BCI – Spinner to Brand Requirement

3.2.4. CERTIFICATE TRADING

Figure 11: Certificate Trading CoC Model



The certificate trading model allows for certified upstream producers to generate and sell claims to downstream operators. This administrative accounting model allows the downstream actor to make sustainability claims without the need for physical traceability. This approach is similar in some ways to purchasing carbon credits, in that they can be used to offset an amount of otherwise non-certified products in a supply chain. These credit transactions take place on an electronic trading platform managed by a central authority, usually from a certification program, who monitors the accounting of sustainability claims, comparing the volumes and weights specified on certificates issued and those being traded.[98]

With this model there may be no actual physical relationship between inputs in a product and the amount of sustainable content claimed. In some instances, identity preservation or segregation may be required up to a specific choke point in the supply chain, where the certificate trading model takes over and physical traceability ends. As with mass balance, the model allows producers to claim a degree of certifiability in situations where it may otherwise not be possible.

Table 4: Examples of Certificate Trading in Certification or Due Diligence Programs

Good	Certificate Trading Model
Cotton	Better Cotton Initiative

[97] Fairtrade USA state that the words “made with” or “contains” may not be used on a package where mass balance was used to ensure transparency for consumers.
[98] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.

Soy	Roundtable on Responsible Soy
Palm	Roundtable on Sustainable Palm Oil
Cotton	US Cotton Trust

Table 5: CoC Model Overview

CoC Approach	Physical Traceability	Batch or Lot Mixing Allowed	Mixing Certified and Non-Certified Sources	Specific Origin Determination Possible
Identity Preservation	Yes	No	No	Yes
Segregation	Yes	Yes	No	No single specific location. A set of certified locations or regions of origin can typically be claimed
Mass Balance	To point of blending	Yes	Yes	No
Certificate Trading	No	Yes	Yes	No

3.3. CHAIN OF CUSTODY MODELS AND CERTIFICATION

The selection of a suitable chain of custody (CoC) model depends on the goals and requirements of the program the model supports. Both certification schemes and independently implemented corporate sourcing programs can mandate specific CoC requirements. While all CoC models seek to bring reliability and acceptance to the claims they make, many considerations are important when selecting a CoC model, including:

- How "extended" a supply chain is in terms of its geographical reach, the size of its market, and the number of actors in its global production networks.
- The processing requirements and total number of processing facilities in a supply chain.
- The "clear and inherent product quality differences," or perceived quality differences, between sustainably and non-sustainably produced products.[99]
- The level of risk in a supply chain, including risks of human rights violations and/or environmental impacts in a supply chain.

Businesses may also need to consider regulatory requirements when selecting a CoC model. Certification schemes, and their use for corporate sourcing and regulatory traceability, are explored in more detail in the following subsections.

3.3.1. CERTIFICATION SCHEMES

Certification schemes audit the implementation of CoC model's, often with the support of standard alignment bodies, such as ISEAL Alliance, based on a variety of factors. Some schemes, such as the Better Cotton Initiative, mandate separate CoC

[99] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.

models for each distinct tier of a supply chain. Others, such as Global Organic Textile Standard (GOTS), require a single CoC model to be used throughout an entire supply chain. Some certification programs, such as the Marine Stewardship Council (MSC) and the Rainforest Alliance, use risk assessments to develop a unique set of CoC requirements for each segment of a specific supply chain including specific audit requirements. Low risk environments may have less onerous audit or traceability requirements. Certification programs dictate the CoC model and traceability requirements, which are typically audited. The following table describes the basic CoC models used by leading certification programs, and how they build risk into their standard.

Table 6: Certification Program CoC Approach

Certification or Program	Commodities	Risk-Based Approaches Used	CoC Model and Traceability Requirements
Rainforest Alliance[100]	Tree crops (including coffee, cocoa), tea, fruits (including bananas, coconuts and pineapples), nuts (hazelnuts) and cut flowers.	The Supply Chain Risk Assessment (SCRA) is an onboarding requirement done at least every three years. For supply chain certification, it is applicable to certificate holders that present a high risk for social and labor items. These high-risk parties must comply with additional requirements, including a commitment to assess-and-address child labor and forced labor.	Different requirements according to which standard is being met. Products are labeled as either "certified" or "mass balance." Certified products must be segregated from non-certified products at all production stages, including transport, storage, and processing. "Mass balance" uses administrative accounting rules and is only used for certain crops at certain production stages.[101]
Better Cotton Initiative (BCI)[102]	Cotton and textiles.	Limited risk-based language is found in the standard, however mass balance as a model is only acceptable from the spinner onwards. As such the high-risk farming tier has more strict traceability requirements.	BCI certified cotton must be segregated from conventional cotton between the farm and gin supply chain tiers and must come from BCI registered farmers. BCI farmers must harvest, store, transport, and gin separately from conventional cotton, and cannot mix or substitute cotton until spinning, when product segregation requirements are no longer applicable and mass balance and

[100] Rainforest Alliance, Sustainable Agriculture Standard, Supply Chain Requirements and Annex S6: Traceability, 2020.
[101] Mass balance is allowed at the "supply chain certificate holder level" (first buyer and beyond) in cocoa, orange juice, and flowers. In hazelnuts, palm oil, and coconut oil mass balance can be applied at the supply chain as well as "farm certificate holder level". Rainforest Alliance state in their Mass Balance Guide that the higher cost of segregation (such as separate tanks and silos) can divert funds away from investing in more sustainable farming practices.
[102] Better Cotton Initiative, BCI Chain of Custody Guidelines V1.4, 2020.

			certificate trading (Better Cotton Claim Units) is used.
Forest Stewardship Council (FSC)[103]	Legally harvested forest products and recycled materials from reclaimed timber and wood products.	FSC certification applies different CoC standards according to risk. Products imported from specific locations are considered to have "negligible" risk, which carry less requirements.	For the FSC 100% Standard claim, all inputs must be 100% segregated. For Mass Balance claims products are labeled with the percentage claimed.
LBMA Responsible Gold Guidance[104]	Gold	Origin and whether gold has been transported via conflict-affected or human rights abuse high-risk area is considered. High risk can trigger enhanced due diligence	Guidance for refiners asks them to have ability to identify origin of material. They state this can be accomplished by either traceability (e.g., bag and tag[105] or electronic system to physically trace minerals) or CoC (a range of documents that identify the provenance of minerals and their transport routes). The guidance states that traceability should align inputs and outputs via unique reference numbers.
Global Organic Textile Standard (GOTS)[106]	Organic fiber, yarns, fabrics, garments, textile toys, home textiles, bedding.	Certified entities are expected to undertake testing (for organic nature) in accordance with a risk assessment. No fibers shall be used which originate from projects which show evidence of a persistent pattern of gross violations of the ILO core labor norms.	GOTS is a segregation model standard. Blending organic and conventional fibers of the same type in the same product is not permitted. Followers of the standard must trace: a) the origin, nature and quantities of organic and additional (raw) materials and b) the flow of goods within the unit (processing/ manufacturing steps performed, recipes used and stock quantities) and c) the composition of manufactured products.
Marine Stewardship Council (MSC)[107]	Fish	Organizations are exempt from certain requirements if they are	Certified products need to be traceable back to a certified supplier, fishery, or farm. If

[103] Forest Stewardship Council, FSC Chain of Custody Certification V 3.1, 2021.
[104] LBMA, Responsible Gold Guidance V8, 2018.
[105] "Bag and Tag" is a reference to a widely used security feature in the metals and minerals industry where certified materials are placed in a bag or a container and sealed with a tamper-proof seal. Typically, the seal includes a data carrier, such as a barcode.
[106] Marine Stewardship Council, MSC Chain of Custody Standard: Default Version V5, 2019.
[107] Ibid.

		lower risk for forced and child labor violations according to the Country Labor Risk Scoring Tool. The Country Labor Risk Scoring Tool assigns a risk rating to countries based on items such as ratification of UN conventions and whether it is found on the US DOL List of Goods Produced by Child Labor or Forced Labor.	processing or repacking occurs, records shall allow conversion rates for certified outputs from certified inputs.

Verification of conformance with certification standards, including documentation of CoC compliance, is often represented by a physical or digital certificate.[108] Certificates are commonly used (or requested) as evidence that a product has been traced through its supply chain and is free of rights and/or environmental infractions and that its inputs come from specific points of origin in a supply chain. While some certification programs have been successful, there are noted **limitations of certification** programs as a full solution to traceability across commodities. These include:

- **CoC model selection**: Each CoC model varies in its ability to verify the origin of product inputs. Mass balance and certificate trading models do not require physical traceability, so it is not possible to verify the labor standards of non-certified suppliers involved in a product's supply chain.[109] This could allow a commodity produced with forced labor to enter the market.
- **Verification processes for claims**: Certification programs have different levels of reliability. This includes varying levels of auditors' ability to identify non-compliances. Processes to remediate non-compliances also vary depending on the program.[110]
- **Lack of coverage**: Certified production sites are typically audited by third parties; however other sites, often nearby, are not. This can leave a vacuum with no support related to social issues or traceability in these nearby locations.[111]

> *"The challenges of working in remote areas—common to commodity certification generally—may reinforce this gap in coverage. Weakness in "traceability" appears to be the most critical. Buyers are often unable to determine the exact origin of produce, creating a loophole for nonparticipating farmers to sell through certified neighbors.... In remote areas, programs also have trouble auditing and enforcing standards."*
>
> USAID Climate Links

[108] Borit and Olsen, FAO, Seafood Traceability Systems: Gap Analysis of Inconsistencies in Standards and Norms, 2016.
[109] Lehr, CSIS Human Rights Initiative, New Approaches to Supply Chain Traceability Implications for Xinjiang and Beyond, 2020.
[110] Whoriskey, Washington Post, Chocolate companies sell 'certified cocoa.' But some of those farms use child labor, harm forests, October 23, 2019.
[111] USAID, Productive Landscapes: The Role of Governments in Making Certification Effective: A Synthesis of the Evidence and a Case Study of Cocoa in Côte d'Ivoire, December 2020.

3.3.2. COC PROGRAMS FOR COMPANIES

Many companies collect certification documentation from producers in their supply chain. This allows companies to supplement their own policies with leading industry and/or commodity-specific standards to mitigate the increased risks and complexities common with a specific industry or commodity supply chain. Doing so allows companies to use their collective influence to improve working conditions by requiring suppliers to comply with one set of standards and jointly invest in site improvements.

Some companies with significant leverage have established their own CoC requirements, standards for labor, and associated audit requirements for high-risk commodities. For example, the **PepsiCo Palm Oil Traceability Protocol** requires tier-1 palm suppliers to provide a palm traceability report, in a templated manner, to PepsiCo each quarter.[112]

Risk assessments determine the nature of audits required at sites. The traceability report suppliers provided to PepsiCo requires a list of all palm oil mills, geo-coordinates, certification or verification status of sub-suppliers, and total percentage of traceable oil to the palm oil mill tier. Acceptable certifications in PepsiCo's Protocol include RSPO, Indonesian Sustainable Palm Oil (ISPO), Malaysian Sustainable Palm Oil (MSPO), International Sustainability Carbon Certification (ISCC), and Rainforest Alliance.

Before a company chooses to accept a certification program for its suppliers, it must review its own labor standards, policies, and commitments to ensure they are aligned with international labor standards and domestic laws.

3.3.3. LABOR STANDARDS IN CERTIFICATION PROGRAMS

The USAID-funded Seafood Alliance for Legality and Traceability (SALT) Project outlines three phases of traceability system development. These are:

- **Initiate**, which includes early research, goal setting, and stakeholder engagement.
- **Design**, which includes identifying technology, assigning responsibilities, and creating the systems to support the program; and
- **Implement**, which includes piloting the program, adaptively managing, and scaling it.

CoC models are designed to support product claims about the conditions in which a product is made or about the materials used in a product (i.e., labor conditions, environmental impact). Several different certifications may be required to ensure materials and products are harvested, extracted, and produced in alignment with international labor standards. International labor standards are usually incorporated in government regulations to help protect workers' rights. They may also be included in corporate policies to help companies define and respect the rights of their workforce, as well as the workers in their global supply chains.

Annex II of this report provides information on essential ILO Conventions and explains how specific certification programs align with these conventions.

3.3.4. CERTIFICATION PROGRAMS FOR COMPLIANCE

In most cases, certification programs will not satisfy all demands for traceability and documentation that is demanded of companies for compliance purposes. For many certification programs, the approaches utilized were never intended to be the only due diligence solution used across an entire commodity. In fact, representatives of certification programs interviewed for this report clarified that while their program can support compliance, it is not their intention or desire to be used widely in this manner.[113]

In some cases, however, as with FSC, a program may be widely used by a company to meet regulatory requirements. For the EU Timber Regulations, FSC's public documentation state that "competent authorities do see FSC certification as a useful part of a due diligence system – a contribution to risk assessment and risk mitigation. But precisely how much one can rely on

[112] PepsiCo, Palm Oil Traceability Protocol, April 2019.
[113] Conversation with cotton sector certification body in April 2021.

a certificate varies from case to case and authority to authority."[114] Businesses wishing to use certification programs for compliance purposes must consider how closely each certification program will align production with regulatory requirements on a case-by-case basis.

3.4. DATA MANAGEMENT AND STANDARDS

Traceability data can be "external" and "internal" in nature. **Internal traceability** is the processes within a company that identify the inputs and outputs of the goods it manufactures. **External traceability** is the product information that an operation receives from suppliers or provides to customers. Typically, external data is sourced from a company upstream flowing to a downstream company. Traceability relies on a commitment between trading partners to share information with each other.[115]

Consistent documentation is necessary for the efficient sharing of information between trading partners. For systems to communicate efficiently, they should be **interoperable**, which is when different computers can exchange, and use exchanged information. Interoperability is crucial for minimizing transaction costs and facilitating efficient sharing. Data standards are required for systems to be interoperable.

3.4.1. DATA STANDARDS

Data standards establish a shared digital language allowing partners to manage trade data more efficiently. This includes trading partners or other actors who wish to access traceability data in an automated manner using back-end IT systems.

The not-for-profit **GS1** has developed the most widely used set of traceability data standards, which provide a foundation for interoperability. GS1 was originally developed in 1973 by industry leaders who sought to create a universal code for product identification.[116] This led to the GS1 Barcode Standard which is still widely used today. Today more than two million companies use GS1, drawing from the GS1 Core Business Vocabulary (CBV), a library and glossary of traceability terminology. Found in these standards are the three "foundational" GS1 traceability principals which are:

- **Identify**: Supply chain partners identify business objects and locations using standardized identifiers.
- **Capture**: Supply chain partners capture an object's identity and additional attributes, encoded in a standard manner, using a data carrier such as barcodes or RFID. The time (when) and location (where) are captured, as well as other data (who and what).
- **Share**: Data is shared using standardized semantics, in a standardized format, and using standard exchange protocols.

The following sections provide examples of these three principles.

3.4.2. IDENTIFICATION OF BUSINESS OBJECTS, LOCATIONS, AND PROCESSES

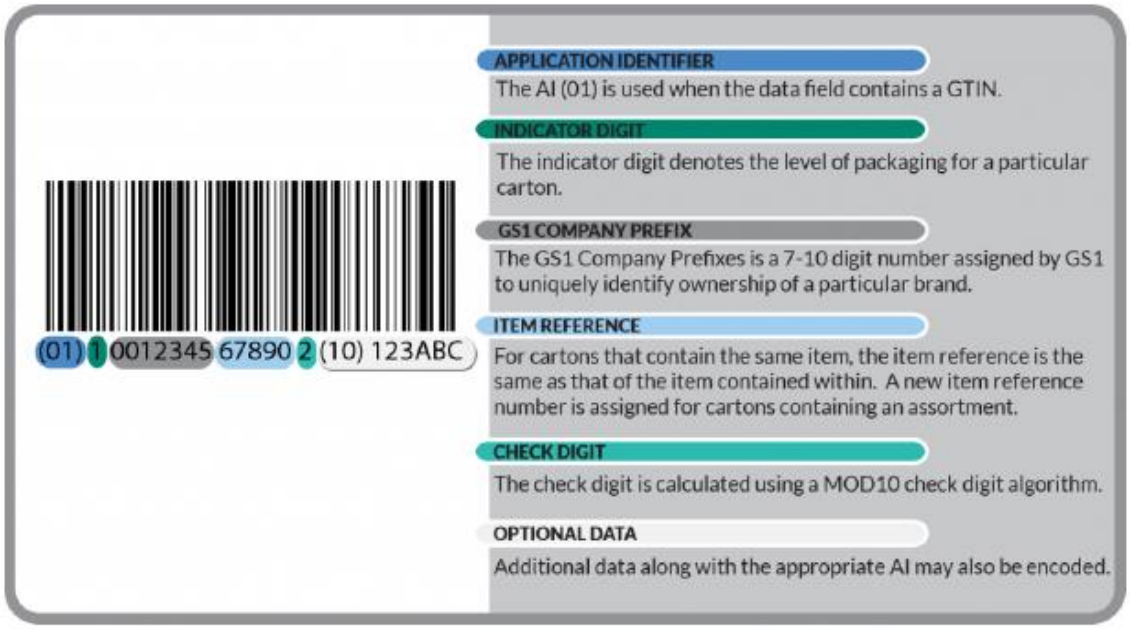
Unique, standardized identifiers should be assigned to all traceable assets. As captured in our Project's definition of traceability, traceable assets are any product, part, or material that needs to be traced along a supply chain. **Unique identifiers** can be assigned to parts, individual products, batches, or lots. The objectives of the traceability system should determine the level of identification.[117] Unique identifiers should also be assigned to all enterprises in the supply chain. Unique identifiers help parties avoid ambiguity, inconsistency, or mistaken attribution.[118]

Common identification structures include those created by GS1, as well as Universal Product Codes, DUNS IDs, and European Article Numbers. If none of these commonly used identification structures are used in a specific supply chain, it may be suitable to use a universally unique identifier (UUID), a 128-bit number used to uniquely identify objects or entities, which are

[114] FSC, EU Timber Regulation – Implementation Guide for Companies Trading FSC-Certified Materials in the EU Revised Version, February 2018.
[115] GS1, Global GS1 Global Traceability Standard, 2017.
[116] More on the history of GS1 can be found on its About webpage.
[117] GS1, Global GS1 Global Traceability Standard, 2017. GS1 also state that for low-risk situations, part level IDs can be used (Class level) instead of product level.
[118] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.

also globally unique.[119] Other initiatives are working to establish common, unique identification structures or attribute values as detailed in the table below.

Figure 12: Identifier Use on Data Carrier



The graphic above[120] describes how GS1 data standards are used on a commonly used barcode data carrier (GS-128). IDs in this example include the Application Identifier (GTIN), GS1 Company Prefix, and Item Reference. This barcode type also provides room for additional optional encoded information[121]. Different barcodes have varying capacities for data storage.

Table 7: Notable Identification or ID Management Initiatives

Name	Description
Open Supply Hub (OSH)	OSH is a non-profit organization that "[identifies] apparel factories and their affiliations by collating disparate factory lists into one central, open-source map, listing factory names, addresses, affiliations and a unique OSH ID." The OSH ID is a unique 15-character identifier assigned to each facility in the OSH database.
Responsible Minerals Initiative – Responsible Minerals Assurance Process (RMAP) Smelter Identification Number (CID) and Blockchain	RMI is a non-profit organization that established the Smelter Identification Number system (CID) for mineral supply chains. RMI assigns a unique identification number to smelters or refiners. The RMAP is expanding to cover aluminum, alumina, bauxite, cobalt, copper, gold, graphite, iron ore, lead, lithium, mica, molybdenum, nickel, platinum, rare earth elements, silver, steel, tantalum, tin, tungsten, and zinc. RMI has worked to align data sharing standards in their 2020 RMI Blockchain Guidelines.
Global Textile Scheme Initiative (GTSI)	GTSI, a for-profit initiative, is developing an ID management schema/catalogue called the Global Textile Language. GTSI seeks to develop IDs for an expansive set of inputs used in textiles, from raw materials to production materials, to finished products. All

[119] The Internet Society, A Universally Unique Identifier (UUID) URN Namespace, 2005.
[120] Found at Bar Code Graphics GTIN-14 Data Structure.
[121] Such as expiration date or other

	inputs are broken into types, subtypes, and classes. GSTI was developed out of the belief that harmonization and coding of all relevant master data should be the basis for automation.
GS1 US Apparel and General Merchandise Initiative's Raw Materials Workgroup	This working group developed a common language for specifying attribute values for raw materials. The language includes attribute values for knit fabric, woven fabric, leather, and synthetic material, with additional categories of thread, printed labels, and RFID inlays. For example, conventional cotton fiber is given an ID of BQ, while organic cotton fiber is given an ID of BR. It is hoped that this common language can support the evaluation of material sustainability and make sustainability assessment tools more interoperable.

3.4.3. PRODUCT-DATA PAIRING

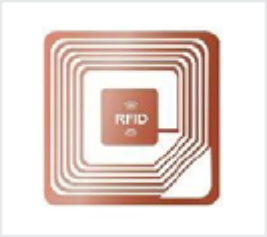
Product-data pairing links a physical product to information about that product using a **data carrier**. With pairing, the asset can be labelled or marked and physically traced throughout the supply chain. The use of a product identifier supports the credibility of traceability data, security, and fraud prevention across stages of internal and external traceability.[122]

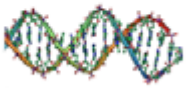
Product identifiers may be embedded in labels, tags, or markers. It has become common for traceability solutions to use multiple product identifiers throughout a supply chain, as different identifiers are better suited to different purposes. Product identifiers require the use of **hardware**, such as scanners, lasers, mobile phones, or lab testing equipment. Alphanumeric (human-readable) codes can also be used in certain instances. Common product identifiers and their usages are captured in table 8 below, along with traceability solution providers that utilize this type of product identifier.

Table 8: Data Carriers for Product-Data Pairing

Type of Data Carrier	Explanation	Solutions Utilized (Non-Exhaustive)
Barcode 	A barcode is a machine-readable representation of data usually describing something about the object it is affixed to. Information can include a manufacturer's identification number, an item's product code, or additional tailored information. Barcodes use varying widths of and spacings between parallel lines. A barcode cannot be modified and requires a clear line of sight to be read. Multiple items cannot be scanned at the same time. While less efficient, can be more reliable. The GS1 EPCIS - ISO/IEC 19987 standard, the Universal Product Code (12-digit), and EAN-13 identifiers are commonly used formats found on many trade items.	**ChainPoint** **Better Mining**

[122] Future of Fish, Five Core Business Functions of Robust End-to-end Traceability, 2016.

Quick Response 	A Quick Response (QR) code uses dots, rectangles, and other geometric patterns to store information about products. QR codes offer a high fault tolerance and fast readability. QR codes, however, cannot be read with a laser scanner which limits their usability in logistic settings. They are public domain and free to use, and there is a high understanding of how to use QR codes.	**Minespider** **TraceBale** **Global Trace**
Radio-frequency identification (RFID) 	RFID uses electromagnetic fields to identify and track tags attached to objects. RFID tags are commonly used on shipping containers. RFID readers can track container arrivals or departures. RFIDs are used for risk management, such as tracking vessel proximity to protected areas or hours at sea. Multiple RFID tags can be scanned at once. While this is efficient, it can be a disadvantage for specific uses where tracing small batches does not warrant multiple scans at one time. RFID tags can be modified which can make them less secure.	**OpenSC** **Optel**
Near-field communication (NFC)	Near-field communication (NFC) is a short-range wireless technology, which provides a more advanced version of RFID's electromagnetic induction for transmitting data. NFC is often seen as a sticker or an inlay. NFC-enabled devices can communicate with each other as long as they are close to each other. NFC devices can act both as a reader and as a tag. NFCs are more costly and difficult to embed, so best used for high value goods.	**Everledger**
Attribute Fingerprinting 	Attribute fingerprinting is used to identify the "fingerprint" of products by analyzing the natural attributes of a commodity or product itself. This includes analyses of the stable isotopes, composition of trace elements, or microbes found in or on a product or analysis of the crystallographic or molecular structure of the product. If genetic markers can be analyzed and entered into a database early in the supply chain (upstream) and confirmed to match again later (downstream) during the journey of the	**Oritain** **Phylagen** **Metalor** **IBM** **GemTrack**

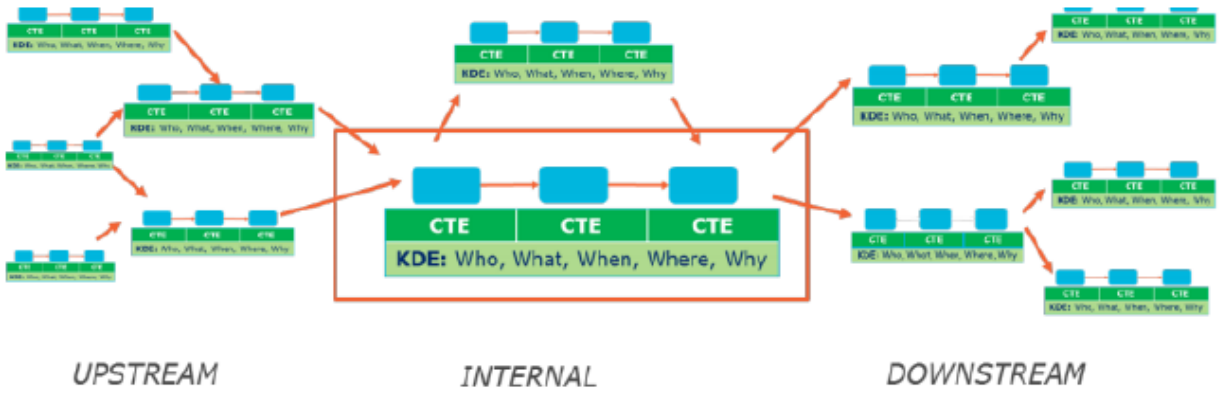
	good, with a defined margin of error, the product can be considered to be the same. Lab analysis can sometimes be a costly and/or lengthy process.	
Externally Introduced Forensic or Physical Markers 	Externally Introduced Forensic or Physical Markers work by adding a traceable forensic marker to a product and ensuring that marker is present in the product across multiple stages in a supply chain. This can be done with a non-deteriorating compound with a specific DNA, a luminescent pigment, or by creating another physical marker, such as a laser mark, to a stone.	**Haelixa** **SmartWater** **FibreTrace** **PhotoScribe Technologies**

3.5. DATA CAPTURE AND SHARING

When designing a traceability system, a company should determine the **critical tracking events** (CTEs) and **key data elements** (KDE) to capture. CTEs are specific and actual points, locations, or processes along a supply chain where data elements need to be captured. These include events such as receiving, processing, packing, shipping, or transporting. During transformation processes, it is essential to record data related to both a product's inputs and outputs.[123]

KDEs capture the who, what, where, and when of a product as it moves through the supply chain. KDEs can include items such as dates, specific species, or purity. The Global Dialogue on Seafood Traceability (GDST) Standards and Guidelines for Interoperable Seafood Traceability Systems is an example of an industry-wide data standard and data capture alignment mechanism.[124] It requires data captured in the seafood industry to align with GS1 data requirements. Compliance with various standards requires the use of a mandated set of KDEs and CTEs. GDST-compliant businesses must be able to receive and/or transmit data between supply chain partners in digital files.

Figure 13: CTEs and KDEs[125]



[123] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.
[124] GDST, Standards and Guidelines for Interoperable Seafood Traceability Systems 1.2 Core Normative Standards, June 2023.
[125] Image from the GS1, Global GS1 Global Traceability Standard, 2017.

Table 9: Illustrative CTEs and KDEs

Industry	Illustrative CTEs	Illustrative KDEs (Examples Only)
Seafood	Farm (Harvest), landing, processor, aggregation, shipper, receiving, sale.[126]	Vessel name, vessel registration, unique vessel ID, catch area, species, GTIN, weight, date of Capture, landing location, date of landing.
Gold (Bars)	Mining, primary processing, aggregation, shipping, secondary processing, receiving, storage, sale.	Cooperative name, mining license, smelter ID, purity, weight, date of refining, LBMA audit ID.
Cotton/Textile	Farming, ginning, spinning, shipping, receiving, manufacturing, sale.	Farm location, bale ID, spinner OAR ID, bale weight, spinner certification ID, ginner certification ID, manufacturer OAR ID.
Cobalt/Li-Ion	Mining, primary processing, aggregation, shipping, secondary processing, receiving, packaging, sale.	Cooperative name, mining license, smelter ID, purity, weight, truck ID, date of refining.
Palm	Harvest, milling, storage, primary refinery, trader, manufacturer, sale.	Plantation location, batch ID, Fairtrade certification ID, batch size, date.

3.5.1. DATA SHARING

The exchange of interoperable data has historically relied on **electronic data interchange (EDI)**. EDI facilitates the computer-to-computer exchange of data among multiple business trading partners in standard, machine readable formats through a business-to-business communication network. Unfortunately, a standardized format is not available for all industries, and most EDI systems are **industry specific**.[127] GS1 uses EDI, which means that the majority of electronic international trade transactions are implemented using EDI standards. However, many emerging web platforms exchange data using complimentary or alternative approaches to business-to-business data exchange.[128]

Information can also be exchanged using an **application programming interface (API)**. APIs are computing functions that allow applications to access data and interact with external software components, operating systems, or microservices. APIs

[126] GDST, Standards and Guidelines for Interoperable Seafood Traceability Systems 1.2 Core Normative Standards, June 2023.
[127] UN ECOSOC, Recommendation No. 46: Enhancing Traceability and Transparency of Sustainable Value Chains in the Garment and Footwear Sector, 2022.
[128] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.

can integrate data with existing **databases,** web-based applications, and blockchain applications. The use of APIs to exchange data is rapidly gaining popularity for traceability. Gartner's 2021 report on Supplier Sustainability Applications states that "*product roadmaps reveal how the majority of vendors are planning to invest in bidirectional API integration with other procurement legacy systems and develop stronger capabilities to support buyer-supplier collaboration within their platforms*."[129]

The "procurement legacy systems" mentioned in the Gartner quote is largely in reference to **Enterprise Resource Planning (ERP)** systems.[130] These centralized systems integrate specific business functions, such as procurement, inventory and supplier management, and accounting. However, many ERP systems remain siloed for specific business functions and often have conflicting ways to identify assets and business partners. Reconciling information is labor-intensive because many of the systems were not designed to facilitate data sharing. This is one of the issues that standardized identifiers are seeking to address. There are three models for how data can be shared in a traceability system:

- The **one step up-one step down model** is where businesses keep traceability data in their respective systems. Information and associated documents are exchanged between immediate trading partners upstream or downstream.
- The **centralized model** is where businesses share traceability data and associated documents in a central repository and send information requests to it. This includes repositories operated by regulatory authorities and trade groups.
- The **networked model** is where businesses keep traceability data in their own local system and provide all supply chain partners (not only immediate trading partners) with the ability to pull data from it.

Ideally, traceability data should flow both upstream and downstream and exchanges should accommodate "*document-equivalent and business-process-driven data snippets*" and be able to differentiate between them.[131] Lastly, there needs to be a way to verify data at the product or company-level at any point in the supply chain.[132] Data verification, whether through a certification process or an audit, is critical for proving the legitimacy of traceability data.

3.6. BLOCKCHAIN FOR TRACEABILITY

Blockchain technology can enhance the security, legitimacy, and connectivity of supply chain traceability efforts. A blockchain is a type of **distributed ledger**, or decentralized database, that records transactions so they can be shared and accessed across sites and geographies by multiple participants.[133] Due to its distributed nature, the ledger is visible to all approved parties in a synchronized manner.

Transactions recorded on a blockchain are append-only, meaning they cannot be modified after their creation. Therefore, no single party can change transactions recorded on a blockchain, as the ledger is copied and distributed among users.[134] Permissions related to those who can view, browse, or audit transactions are flexible and can be determined by those who establish the blockchain.[135]

There are three main ways blockchains can be used to support traceability:

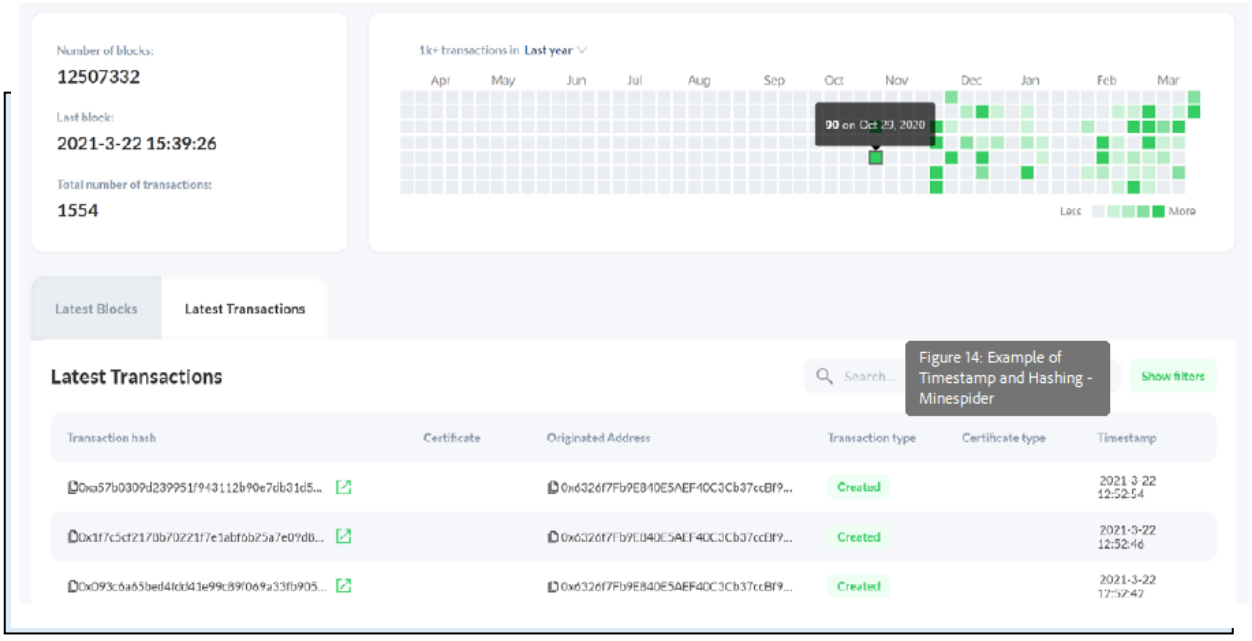
1. **Digital asset creation**: A digital representation of an asset, called a token, can be created to represent items, such as an ounce of gold, on a blockchain. Tokens can be created using the Ethereum blockchain, which has widely used rules for the creation of tokens.[136] However other blockchains can also be used. In the commodity space, a blockchain can be

[129] Gartner, 2021 Gartner Market Guide for Supplier Sustainability Applications, April 2021.
[130] Market leaders in the development of ERP systems used for procurement purposes are Oracle and SAP. Many companies have developed their own ERP systems or use different providers for internal purposes.
[131] UNECE, Traceability and Transparency in the Textile and Leather Sector, Part 1: High-Level Process and Data Model, 2021.
[132] Future of Fish, Five core business functions of robust end-to-end traceability, 2016.
[133] IBM, What is Blockchain?
[134] US Department of Commerce, Draft NISTIR 8202, Blockchain Technology Overview, 2018.
[135] NRGI GovLab, The Practice and Potential of Blockchain Technologies for Extractive Sector Governance, September 2020.
[136] The ERC-20 (Ethereum Request for Comments 20) and ERC-721 being two of the most widely used set of token structure rules. Details can be found at https://ethereum.org/en/developers/docs/standards/tokens/erc-20/.

used to create a record of ownership for an asset that can be exchanged as it changes hands.[137] In traceability, this process of exchange can be a useful mechanism for providing trade finance.

2. **Time stamping:** A record, called a cryptographic hash,[138] of the time an activity took place can be created on a blockchain providing "evidence" that traceability requirements regarding a product were met. A hash typically does not reveal anything about an activity itself other than establishing a unique record that it occurred at a point in time. These records can be useful for tracking approvals, such as those required during shipping and receiving events. If multiple parties need to agree that contract conditions were met, a hash capturing the time of their agreement can be created. Time stamps using hashes can be useful for audits, dispute resolution, or accounting purposes. This model is illustrated in Figure 12.
3. **Business process integration**: Blockchain requires different actors to interact using a standardized data model. This forces synchronization of business processes between companies to use the same blockchain system. It also provides opportunities for cross-organization automatization based on a set of coded requirements. Automating transactions in blockchain is commonly referred to as a **smart contract**. Smart contracts are self-executing contracts, with the terms and requirements of a contract between buyer and seller directly written into lines of code.[139] Smart contracts can be used in supply chains to facilitate the execution of business transactions with less human intervention in the pursuit of efficiency gains.

Figure 14: Example of Timestamp and Hashing - Minespider



[137] OECD and KPMG, Is there a role for blockchain in responsible supply chains?, 2019.
[138] Applied Blockchain, 4 Pragmatic Blockchain Design Patterns for Business, September 2020.
[139] BSR, Win-Win-Win: The Sustainable Supply Chain Finance Opportunity, 2018.

While blockchain technology shows promise for use in traceability and global trade, there are barriers to its widescale adoption as the governance of shared blockchain networks can be time and resource intensive. Blockchain relies on a degree of interconnection among data sources and stakeholders. Creating a standard data model for value chains would require lengthy engagement between users about data security, data privacy, and data access. Blockchain projects have shown to move faster when a previously agreed upon data model exists.[140]

From a cost perspective, blockchain implementation for traceability competes with other company resources allocated for similar purposes. Companies have limited resources and tend to allocate them to systems that provide the most immediate value. For many companies, centralized (non-blockchain) traceability solutions may adequately meet their needs. However, with rapid changes in technology, blockchain may lose its value, for example with the development of quantum computing that can crack blockchain cryptography.[141]

> *"Under the caveat that companies have already mapped out their entire supply chain, a blockchain layer connecting all the parties could provide a near-real time overview on all transactions occurring throughout the supply chain, thus allowing for better control in localising risk hot spots and performing risk mitigation. However, this will only apply for those parties who can actually be connected to the blockchain. Informal actors along a supply chain will be difficult to integrate in such a system, meaning that tracking RBC risk information associated with upstream activities in the supply chain will remain a challenge."*
>
> Is there a role for blockchain in responsible supply chains? OECD KPMG 2019

[140] NRGI GovLab, The Practice and Potential of Blockchain Technologies for Extractive Sector Governance, 2020.
[141] See for example, The Hashtag Insight, Quantum Computing vs. Blockchain: Who Will Win the Security Battle? , Nov. 12, 2024.

4. RESEARCH IMPLICATIONS AND CONCLUSIONS

This Report is to provide guidance for the Global Trace design and piloting and organizations designing and implementing their own traceability tools for labor rights and other goals. A clear lesson in the research phase has been the need to establish common definitions of key concepts when developing a traceability system. GTP has developed a Glossary of terms, pulling from commonly used definitions, to be shared with stakeholders.

To the greatest extent possible, stakeholders seeking to establish a traceability system should be engaged in early-stage goal setting, which should include information gathering, supply chain mapping, and risk model development in the geographies the system will cover. It should also consider how the traceability system will interact with other transparency or traceability programs operating in their project's geographies and sectors.

Actors from local government agencies, communities, business, and civil society must be engaged when designing a traceability system. These actors in the value chain will be needed to manage the traceability system beyond the life of the Project. Worker groups and monitoring bodies should also contribute to traceability efforts.

Research to support supply chain mapping should begin at the conceptual level and then focus on the needs of supplier networks. Once the tiers within targeted supply chains are understood, administrators should engage suppliers to determine their sub-suppliers, the production processes these actors perform, and their geographic locations.

Designers of a traceability system must also determine what data is required, and the level of verification and documentation needed, to support the reliability of the traceability claims they seek to make. These decisions will have major impacts on a project's technology tools, the project's budget, and project team member's roles and responsibilities. The designers of the system should focus on the following questions, among others:

- Sustainability claims. What level of claim must be met and where will they come from?
- Verifiability. Will the system need to be audited by parties other than those responsible for implementing it?
- Accuracy. How accurate does the system have to be, and is there room for a margin of error?
- Sustainability and budget. How will the system be sustainably operated, and costs covered, in the long term?
- Document control. How will documentation be stored and shared when necessary.
- Data requirements. To what extent will relevant data be recorded in the system? What information will be gathered about a traceable asset, including how a commodity has been transformed, moved, or stored, by which actors, at which locations, in which processes, and at which times?

Indicators for success. How will users of the system monitor and evaluate whether goals are being met?
These questions must be answered during tool design and reviewed after launch for improvement. The codebase for the open-source Global Trace tool can be found on the US Department of Labor's GitHub.

ANNEX I – TECHNOLOGY SOLUTIONS REVIEW

Annex 1 presents an overview of technology solution providers or technology-enabled organizations in the traceability, mapping, supplier management, worker feedback, and monitoring spaces. Table 14 provides details on a select set of blockchain providers, as a way to show differences in the use cases for blockchain in trade. These platforms constantly evolve, and the overviews are as of the time the review and represent a snapshot in time.

Table 10: Traceability and Supplier Management Tools

X - Primary tool provided by solution

*- Ancillary or additional tool the solution provides beyond primary tool

Solution Provider	Overview / Office Locations	Traceability System	Mapping & Visualization	Supplier Management	Monitoring	Forensic or DNA Tracing
BanQu www.banqu.co	Traceability solution providing unique tokenized rewards to parents for their children's school attendance. Used in agriculture, recycling, mining sectors. US.	X				
Better Mining SLR Consulting	Mine site monitoring program for first mile traceability. Uses approved RMI Upstream Assurance Mechanism. Active in cobalt/3TG sectors in DRC & Rwanda. UK.	*	*		X	
Bext360 www.bext360.com	Traceability solution used in coffee, seafood, and timber. APIs enable embeds in websites and links to supply chain management and point-of-sale systems. US.	X				
BSI Supplier Compliance www.bsigroup.com	Supplier management software that includes supplier ratings, audit management, and the ability to manage audit-based supplier corrective action plans. UK.			X		
CertainT (Applied DNA Sciences) www.adnas.com	Provides molecular and genomic testing services enabled by our expertise in DNA-based sciences and technologies. US.	X				*

Chainparency chainparency.com	Traceability solution for tracking and tracing commodities at a granular level using GS1-aligned key data elements and critical tracking events. US.	X				
ChainPoint www.chainpoint.com	Traces multiple commodities including cotton, palm, cocoa, and minerals to assess compliance with BCI, RA, and RSPO certification programs. Germany.	X	*			
Circulor www.circulor.com	Traceability solution piloted in minerals, plastics, and agriculture sectors. Used as part of the Trafigura/DRC Government EGC cobalt pilot. Blockchain-supported. UK.	X				
Everledger www.everledger.io	Traceability solution using NFC RFIDs and Hyperledger Fabric blockchain. Used in gems, apparel, wine, and minerals sectors. UK.	X	*	*		
FarmForce www.farmforce.com	Traceability supporting FairTrade and Rainforest Alliance certification management for small farmers. Includes a mobile platform. Norway.	X				
FibreTrace www.fibretrace.io	Solution that applies a luminescent pigment on fiber. A hardware device scans and reads the pigment signature for tracing purposes, linked to their platform. Singapore.	*	*			X
GemFair www.gemfair.com	Traceability and monitoring for small-scale gemstones. Numerous pilots in Africa. Focus on working conditions and market connections. DeBeers Group owned. UK.	X			*	
GemTrack www.ssef.ch	Lab analysis-based solution for gemstone industry. Creates a fingerprint of gem based on the stones crystallographic, structural, chemical features. UK.	*				X
GenuTrace genutrace.com	Support proving the origin of products and raw materials using forensic science and advanced data analytics, ensuring	X				

	compliance, authenticity, and traceability throughout the supply chain.					
Haelixa www.haelixa.com	DNA-marking solution applied at batch level to support other traceability and audit programs for cotton, gold, cashmere, gems, and silk. Switzerland.	*	*			X
IPIS Ipisresearch.be	NGO providing open-source, map-based data on mine sites and trade hubs in conflict affected areas including DRC and the Central African Republic. Belgium.		*		X	
Isotech (Stratum Reservoir) stratumreservoir.com	Forensic technology solution analyzing natural variations in molecules to distinguish regional cotton profiles based on geographic origin. US.					*
Re-Source www.kryha.io	Traceability solution developed for largescale cobalt actors including CMOC, ERG, Glencore, and Umicore. Netherlands.	X				
Kumucaya earthworm.org	Web-based monitoring tool developed by the Earthworm Foundation to provide independent and community-based information about palm sector labor conditions. UK.				X	
Minespider minespider.com	Traceability solution to manage shipment-level certificates using Ethereum timestamping. Piloted from regional smelter to international buyer for tin in Rwanda. Germany.	X	*			
OpenSC Opensc.org	Traceability solution using RFID and machine learning to identify risks across commodities using Ethereum timestamping in partnership with WWF/BCG. Australia.	X	*		*	
Optel optelgroup.com	Traceability solution utilized across multiple industries including aluminum, pharmaceuticals, and barley/beverages. Canada.	X	*	*		
Oritain www.oritain.com	Solution that analyses the isotopes of a product to determine its likely geographic origin within a margin of error. New Zealand.	*				X

Phylagen Origin www.phylagen.com	Company that traces products through a supply chain by determining its “microbiome signature” based on the microscopic dust found on a product. US.	*				X
Provenance www.provenance.io	Traceability solution linking labor-related data to certifications and audit information on Ethereum-based platform. UK.	X				
Retraced www.retraced.co	Textile supplier management solution with mapping and visualization support piloted with Artistic Milliners and WWF in Pakistan. Germany.	*	*	X		
SafeTraces safetraces.com	Marking solution applying seaweed DNA to food products, including palm, to creates a record that can be referenced later in the supply chain. US.	*				X
SmartWater CSI smartwatercsi.com	Liquid forensic asset marking system. Visible under UV light. Smartwater is given a forensic ‘code’, which is registered to a location in a database and tracked. US.					X
Source Intelligence www.sourceintelligence.com	Supplier management program supporting compliance regarding conflict minerals, labor rights, and human trafficking through supplier questionnaires and remote audits. US.			X		
SourceMap Sourcemap.com	Mapping solution that visualizes product supply chains and provides information about labor conditions and supplier certifications at each tier. US.		X			
SupplyShift Supplyshift.net	Supplier management solution that enables engagement, monitoring, and assessments among supply chain actors, including data analysis and supplier scoring. US.		*	X		
TextileGenesis textilegenesis.com	Traceability solution that tokenizes textile assets in alignment with GS1. Collaborating with the US Cotton Trust and the Textile Exchange on pilot projects. Hong Kong.	X	*			
TraceBale	Traceability solution focused on farms, ginners, and spinners in China, India, and Pakistan. UK.	X	*		*	

Tracebale.com/						
Trace Register Traceregister.com	Traceability solution supporting SIMP ACE compliance for seafood/fishing sector. Emphasizing interoperability including with GDST aligned systems. US.	X		*		
TrusTrace Trustrace.com	Traceability mapping and supplier solution focused on fashion/textile and food sectors. Extracts data from transaction and scope certificates. Sweden.	X	*	*		

Table 11: Remote Sensing Solutions

Company/Tool Name	Description
Environmental Market Solutions Lab (emLab) Global Fishing Watch Map	emLab uses satellite data supplied by the Global Fishing Watch's (GFW) vessel monitoring system, which enables vessels to broadcast their position to avoid collisions. emLab analyzed vessel behavior using machine learning techniques to build a predictive model that discriminates between high and low risk vessels based on ILO forced labor indicators.[142]
ASM Spotter The European Space Agency ASMSpotter	ASMSpotter is a remote sensing solution led by the machine learning firm Dida and minerals experts Levin Sources. It can continuously identify, monitor, and assess the direct, indirect, and cumulative environmental impacts of artisanal and small-scale mining (ASM) over large geographic regions. The solution works by automating the identification of ASM sites through machine learning and satellite imagery.
Rights Lab at the University of Nottingham Nottingham.ac.uk	The Rights Lab at the University of Nottingham led research using cloud sourcing, remote sensing, and satellite imagery to identify brick kilns in the Punjab region of Pakistan baring a high risk of forced labor.
Global Forest Watch	Global Forest Watch (GFW), led by the World Resources Institute, is an interactive, online forest monitoring and alert system that collects information for managing and conserving forests. The platform offers data

[142] McDonald, Costello, Bone, Cabral, Farabee, Hochberg, Kroodsma, Mangin, Meng, Zahn, Satellites Can Reveal Global Extent of Forced Labor in the World's Fishing Fleet, 2020.

Globalforestwatch.org	about forest cover losses and gains around the world. GFW is used by international companies to support risk management.[143] It is also used to design policies, enforce forest laws, and detect illegal forest clearing.[144]

Table 11: Due Diligence Monitoring Solutions

Company/Tool Name	Description
Kumucaya Earthworm.org	Kumucaya, created by Earthworm Foundation, is a deep monitoring platform that allows CSOs and community members to anonymously report labor rights incidents in the palm oil, pulp, and paper sectors in Southeast Asia. It has also been piloted in the mining sector. The incident data supports evidence-based dialogue between the private sector and CSOs. Data includes a description of an incident, the commodity, a GPS point, and supporting evidence. The platform allows trend analysis including identifying where further investigation and/or mitigation is needed.
Better Mining SLR Consulting	The RCS Global mine site monitoring program is currently active in the cobalt, tin, tungsten, and tantalum sectors in DRC and Rwanda. In certain instances, it is coupled with first mile “bag and tag” traceability, allowing for segregated mineral supply chains. Better Mining is an approved RMI Upstream Assurance Mechanism, meaning it can be used to support smelter due diligence and audit compliance.
IPIS Ipisresearch.be	IPIS is a Brussels-based NGO that collects and manages a large set of open-source monitoring data. Their API-centric approach supports mapping and collects mine site and trade hub data providing contextual details about the conditions and certification status of specific mine sites. IPIS focus on conflict-affected areas including DRC/CAR and has partnered with other data providers and worker voice technologies.
iTSCi www.itsci.org	ITSCI is a mine site certification program that logs and reports on-the-ground developments affecting mineral production and trade. The program involves local communities in risk identification and mitigation measures. It sends email alerts to its entire user base if a severe risk is identified during monitoring operations. ITSCI also manages a whistleblower mechanism used by local stakeholders. Traceability is also coupled with the system, which is managed at the international level by ChainPoint.

[143] World Resources Institute, Companies Can Now Quickly and Accurately Monitor Deforestation Around the World, June 2019.
[144] Climate Links, Global Forest Watch (GFW) and GFW Climate, December 2015.

Table 12: Worker Engagement Tools

Company/Tool Name	Description
Clear Voice worker helplines	These helplines build on Laborlink (operated by LRQA), established in Bangladesh to enable workers to use their mobile phone to answer multiple-choice surveys about their working conditions. Workers are provided with educational content, employer updates, rights and services announcements, training messages, and sometimes survey results. Workers report workplace-based problems, such as safety hazards, forced overtime, failure to pay or provide benefits. Its successor Amader Kotha helpline operates in Bangladesh. Hamari Awaz operates in Pakistan.
International Labor Rights Forum (ILRF) IM@Sea Laborrights.org	The IM@Sea pilot aimed to advance a worker-driven approach to corporate human rights due diligence in the seafood industry. The project sought to represent migrant workers in the Thai fishing sector through worker connectivity while at sea, improved forced labor risk assessments, the verification of workplace compliance, and the development of a worker-driven grievance mechanism. IM@Sea designed package of data collection technologies to provide a cost-effective way to assess forced labor risk by combining worker reporting tools and electronic video monitoring. At port, Burmese workers completed a comprehensive survey that monitored indicators of forced labor and Thai regulatory violations. At sea, the workers used smartphones connected to onboard wi-fi to provide near real time information on working conditions via satellite. Workers and vessel owners were interviewed by ILRF and its local partner, the Migrant Workers Rights Network. Vessel owners signed agreements that guaranteed workers' access to ILRF's tool, committed to addressing grievances, and agreed to not retaliate against participating workers. Worker data was cross-referenced against data from other sources to generate labor risk assessment reports for each fishing vessel.
Issara Institute Inclusive Labor Monitoring System / Golden Dreams Issarainstitute.org	The Issara Institute's Inclusive Labor Monitoring system aims to empower workers across extended supply chains. Issara uses multiple channels to engage current and prospective Burmese, Cambodian, and Thai migrant workers in Thailand. It does so through social media, hotlines, and its Golden Dreams Burmese language Android app. The app allows users to exchange opinions about employers, recruiters, and service providers via its rate and review platform; access lists of employers and recruitment agencies; review polling data from migrant workers; report a problem or seek immediate assistance from the Issara team.
Mobile Accord GeoPoll Geopoll.com	GeoPoll uses multi-modal surveys on labor rights violations to obtain information from customers in 40 or more countries where data has traditionally been difficult to obtain. The platform sends surveys to workers through SMS or IVR which are free for the user, do not require internet connectivity, and includes a small incentive for completion. Aggregated data are displayed on an interactive dashboard that is automatically updated as new data comes in. Personal identifying information is not shared with partners. Although mainly focused on income generating private-sector work, GeoPoll also conducts surveys to support partners such as USAID, the World Food Programme, other UN agencies, and the Gates Foundation. In 2016, it conducted

	pilot surveys with mining and fishing communities across the DRC, Ghana, Kenya, and Tanzania to gauge workers' willingness to report labor violations in their supply chains.
Ulula Ulula.com	Ulula's software provides multi-language tools to support supply chain management, stakeholder engagement, and monitoring and evaluation. These are intended to help brands, suppliers, auditors, and governments manage human rights risks in their supply chains. Ulula runs worker engagement projects in 15 countries across Africa, Asia, and Latin America. Ulula uses different communication channels depending on context, including SMS, social media messenger apps, custom apps, and message apps. Its services include automated pulse surveys sent to elicit feedback from workers and community members.

Table 13: Example Uses of Blockchain in Commodities and Traceability

Company Name	Primary Blockchain Use	Blockchain Protocol	Overview
E-Livestock Global Elivestockglobal.com	Timestamp	Mastercard Provenance	E-Livestock Global has created a livestock traceability system to compile information concerning all the life occurrences of animals including changes in ownership. It was piloted in Zimbabwe using Blockchain timestamps.
Everledger Everledger.io	Timestamp, Digital Asset, and Business Process Integration	Hyperledger Fabric	Everledger is a blockchain platform used to trace diamonds, gemstones, and luxury goods, etc. and track certificates. Everledger data is divided into privacy "channels" so stakeholders can choose to withhold sensitive data attributes and disclose others based on their preferences. It uniquely uses NFC technology to track high value goods.
FishCoin www.fishcoin.co	Digital Asset	Ethereum	FishCoin is a token system that has been piloted in the seafood industry. Supply chain stakeholders, such as fishermen and processors, receive tokens in exchange for providing data useful to the system.
Minespider Minespider.com	Timestamp	Hyperledger Fabric	The Minespider solution allows due diligence certificates and documents to be created and shared us in QR codes to display "public layer" information about commodities, including the name and unique ID of a seller, the name of buyers, the date of a transaction, a transaction hash, the materials of the shipment, and any other public and downloadable documents. Piloted in tin. Used by a Rwandan regional smelter to European buyer data management.

TextileGenesis www.textilegenesis.com	Timestamp, Digital Asset, and Business Process Integration	Ethereum	TextileGenesis is a Hong-Kong based, GS1-aligned company that digitizes textile assets and provides asset traceability solutions. Its approach allows for the use of different CoC models according to their client's need. TextileGenesis is collaborating with the US Cotton Trust and the Textile Exchange on pilot projects, as well as with private companies like Lenzing which manages a fabric certification system.

ANNEX II – FUNDAMENTAL LABOR RIGHTS SUMMARY

The International Labour Organization's (ILO) Declaration on Fundamental Principles and Rights at Work establishes five categories of labor principles and rights: 1) freedom of association and the effective recognition of the right to collective bargaining; 2) the elimination of forced or compulsory labor; 3) the abolition of child labor; 4) the elimination of discrimination in respect of employment and occupation; and 5) a safe and healthy working environment.[145] Worker rights and principles are defined in the following fundamental ILO Conventions:

1. **Freedom of association and the effective recognition of the right to collective bargaining**

- Freedom of Association and Protection of the Right to Organize Convention, 1948 (No. 87): Provides workers the right to establish and join organizations of their own choosing without prior authorization or interference from their employers. The right to organize enables workers to form, join, or assist labor organizations in negotiating for better wages, benefits, and to address other work-related issues.
- Right to Organize and Collective Bargaining Convention, 1949 (No. 98): Defines collective bargaining as the process of negotiation between organizations of workers and their employer(s). The goal of the negotiations is to reach a collective agreement on the terms and conditions of employment and the rights and responsibilities of the parties.

2. **The elimination of forced or compulsory labor**

- Forced Labour Convention, 1930 (No. 29): Defines forced labor as all work or service exacted from any person under the menace of any penalty and for which the said person has not offered himself voluntarily.
- Abolition of Forced Labour Convention, 1957 (No. 105): Prohibits the use of any form of forced or compulsory labor.

3. **The abolition of child labor**

- Minimum Age Convention, 1973 (No. 138): Defines the general minimum working age as 15 years old, the minimum working age for light work as 13 years old, and the minimum age for hazardous work as 18 years old. It also defines allowances for the minimum working age to be 14 where the economy and education facilities are insufficiently developed.
- Worst Forms of Child Labour Convention, 1999 (No. 182): Defines a "child" as any persons under 18 years old. It establishes that the worst forms of child labor includes all forms of slavery or practices similar to slavery, such as the sale or trafficking of children, debt bondage and serfdom, or forced or compulsory labor, including forced or compulsory recruitment of children for use in armed conflict; the use, procuring or offering of a child for prostitution, for the production of pornography or for pornographic purposes; the use, procuring or offering of a child for illicit activities; and work which, by its nature or the circumstances in which it is carried out, is likely to harm the health, safety or morals of children.

4. **The elimination of discrimination in respect of employment and occupation**

- Equal Remuneration Convention, 1951 (No. 100): Defines renumeration as the minimum wage or salary and any additional compensation the employer pays the worker directly or indirectly in exchange for a worker's employment and requires equal remuneration for male and female workers for work of equal value without discrimination based on gender.
- Discrimination (Employment and Occupation) Convention, 1958 (No. 111): Defines discrimination to include any "distinction, exclusion or preference made on the basis of race, color, sex, religion, political opinion, national extraction or social origin, which has the effect of nullifying or impairing equality of opportunity or treatment in employment or occupation."

5. **A safe and healthy working environment**

- The Occupational Health and Safety Convention, 1981 (No. 155), establishes the core framework for OSH management at both national and workplace levels, introducing a dynamic national policy approach to OSH.
- The Promotional Framework for Health and Safety Convention, 2006 (No. 187), introduces an integrated approach to OSH standards, enhancing their coherence, relevance, and impact.

[145] ILO, ILO Declaration on the Fundamental Rights and Principles of Work.

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