European Commission

JRC TECHNICAL REPORTS

Social assessment of raw materials supply chains

A life-cycle-based analysis

Mancini, L; Eynard, U.; Eisfeldt, F.;
Ciroth, A.; Blengini G. Pennington, D.

2018

Joint Research Centre

EUR 29632 EN

Contact information
Name: Lucia Mancini
Address: via E. Fermi 2749, 21027 Ispra, Italy
Email: lucia.mancini@ec.europa.eu
Tel.: +39 0332 78 5428

JRC Science Hub
https://ec.europa.eu/jrc

JRC112626

EUR 29632 EN

PDF	ISBN 978-92-79-99074-8	ISSN 1831-9424	doi:10.2760/470881
Print	ISBN 978-92-79-99073-1	ISSN 1018-5593	doi:10.2760/782634

Luxembourg: Publications Office of the European Union, 2018

How to cite this report: Mancini L., Eynard U., Eisfeldt F., Ciroth A., Blengini G., Pennington D., *Social assessment of raw materials supply chains. A life-cycle-based analysis*, EUR 29632 EN, Publications Office of the European Union, Luxembourg. 2018 ISBN 978-92-79-99074-8, doi:10.2760/470881, JRC112626

Contents

Acknowledgements

We are grateful to Dr. Alessandra Zamagni for her valuable suggestions and for having reviewed this report.

Authors

Lucia Mancini, JRC, Land Resources Unit

Umberto Eynard, JRC, Land Resources Unit

Franziska Eisfeldt, GreenDelta

Andreas Ciroth, GreenDelta

Gian Andrea Blengini, JRC, Land Resources Unit

David Pennington, JRC, Land Resources Unit

Abstract

The supply chains of raw materials and semi-finished products can create both positive and negative impacts affecting various stakeholders. Raw materials have also a strategic importance for enhancing the competitiveness of the European industry, and creating employment (EC - European Commission, 2017a). At European level, the secure and sustainable supply of raw materials from domestic sources and international markets are key objectives of the Raw Materials Initiative (EC - European Commission, 2008).

The relationship between low security of supply and poor governance in supplier countries is acknowledged and captured in the list of Critical Raw Materials for the EU (EC - European Commission, 2017b). Internationally, many of the Sustainable Development Goals (UN General Assembly, 2015) address, directly or indirectly, the social dimension of sustainable development and, hence, are linked to the supply of raw materials, under several aspects (Mancini et al. 2018).

In the context of sustainability assessment, Life Cycle Thinking is a well-known concept. Social Life Cycle Assessment (SLCA) evaluates social and socio-economic impacts along the life cycle of products (from the raw materials extraction, processing, manufacture, use, end of life) using a mix of generic and site specific data. Studies can be focused on a specific supply chain, or they can look at different sectors in an entire economy.

Given that EU policy on raw materials aims at a sustainable supply of raw materials (both from domestic sources and from international markets), the selection of appropriate metrics for monitoring the sustainability at sector level is key. However, the task is particularly challenging for what concerns the social dimension of sustainability, which is less advanced from a methodological point of view (Boström, 2012).

In this study, we used a SLCA database for assessing and comparing the social risks associated with the supply chain of raw materials sectors at the macro-scale in EU, and in a set of extra-EU countries. Negative social impacts are expressed in terms of potential risk to be exposed to negative social conditions while potential positive contributions are expressed using an opportunity evaluation.

The economic sectors under investigation are mining and quarrying, forestry and logging, manufacture of basic metals, non-metallic minerals, paper and paper products, wood and of products of wood. A set of social aspects (called categories, or areas of concern) was selected from those available in the database, according to criteria of relevance, data quality, etc. These include aspects affecting workers (health and safety; freedom of association and collective bargaining; child labour; fair salary; working time), local communities (respect of indigenous rights and migration), actors in the value chain (corruption) and society as a whole (contribution to economic development). While the latter category include an indicator on a positive impact, the others are negative impacts occurring in the value chain.

The results of the analysis compare social risk in the European raw materials supply chain with those of six extra-EU countries, for the set of selected social aspects. The contribution analysis shows social hotspots within a supply chain, highlighting sectors and locations that are mostly contributing to social risk. Data quality and sources of uncertainty are also discussed. Given the granularity of the data used to assess social aspects (mostly at country, or macro-sector level), specific features of raw materials sectors and sub-national variability are not captured in this analysis.

This macro-scale assessment demonstrates the potential and the limitations of social data combined with input-output models for assessing social risk in supply chains. It provides a first-screening assessment of supply chains, which can be used for prioritizing areas for more detailed investigation. One of the strengths of this approach is to show social performance in various social categories and in different stakeholders, over the entire life cycle worldwide, thus has the capability of detecting trade-offs and burden shifting. Results, however, suggest that the current use of these models in e.g. policy analysis should be applied with some caution due to the uncertainty derived by the combination of

input/output models with social data. As the governance indicators used in the criticality assessment, social risk results could be suitable for macro-scale assessment of material trade flows, in order to estimate, for instance, social implications of a high import reliance, or evaluate consequences of changes in trading partners for the EU.

1. Introduction

In 2015, the United Nations set out a vision for global sustainable development (UN General Assembly, 2015). The framework includes seventeen Sustainable Development Goals (SDGs) with specific targets to be achieved by 2030. Many of these SDGs address, directly or indirectly, the social dimension of sustainable development. Nine goals directly focus on social issues, addressing themes like poverty (Goal 1), health (3) and education (4) and two of them concern the governance of the transition towards sustainable development. Other goals are indirectly linked to social conditions, such as sanitation (goal 6) and energy affordability (7).

The concern about social impacts in global supply chains has increased in recent years. Severe human rights abuses in the production of minerals in Democratic Republic of Congo and the collapse of the Rana Plaza building in Bangladesh[1] are just two examples that contributed to raising the attention of civil society and policy makers around social sustainability in supply chains. In both cases, goods produced in dangerous and undignified conditions in developing countries ended up to be consumed in European and other developed countries. Such social impacts (as well as environmental ones) occurring in the upstream phases of the supply chain are completely hidden to the final consumer.

Similar to other sectors, the production of raw materials and semi-finished products can create both positive and negative impacts in society, local communities, consumers, and workers. At European level, the high import dependence for some materials is a factor of risk not only from an economic point of view, but also because it could imply an externalization of negative impact in countries with poor governance and weak social and environmental legislation. The secure and sustainable supply of raw materials is therefore a key objective, and has a strategic importance for enhancing the competitiveness of the European industry, increasing the security of supply, promoting responsible sourcing and creating employment (EC - European Commission, 2017a).

In the context of sustainability assessment, Life Cycle Thinking is a well-known concept to help identify impacts along the supply chains, in order to compare management alternatives and avoid unintentional shifting of burdens. A standardized methodology has been developed for the "traditional" Life Cycle Assessment (LCA), taking into account mainly impacts that derive from environmental interventions; namely resource extractions and emissions (ISO 14044, 2006). The consideration of social and socio-economic aspects, however, is a more recent advancement in this context.

Social LCA (SLCA) assesses social and socio-economic impacts found along the life cycle (from the raw materials extraction, processing, manufacture, use, end of life) using generic and site specific data. In SLCA, life cycle stages are associated with geographic locations and impacts refer to potentially affected stakeholders. In order to support assessments, at least at a national or sectorial level, and to highlight hotspots in the supply chains, generic databases and modelling tools have been developed: for example the Social Hotspot Database (SHDB) (Benoit-Norris et al., 2012) and the Product Social Impact Life Cycle Assessment (PSILCA) database (Ciroth and Eisfeld, 2016).

Other approaches include the calculation of social footprints for specific social aspects like, e.g., inequality, labour, human rights, etc. (Čuček et al., 2012). They are usually based on Multi-Regional Input-Output models (Lenzen et al., 2013) and applied at macro scale.

From a business perspective, avoiding that a product is associated with unsustainable practices and negative impacts is also a reputational as well as a risk management issue. Companies are increasingly adopting Corporate Social Responsibility (Jenkins and Yakovleva, 2006) and supply chain due diligence in order to guarantee consumers about their responsible behaviour. In the case of extractive industries, public acceptance of the sector is particularly low and mitigating social and environmental impacts is one of the

[1] https://en.wikipedia.org/wiki/2013_Savar_building_collapse

factors influencing the so-called Social Licence to Operate (e.g., Litmanen et al., 2016; Moffat et al., 2016; Parsons et al., 2014; Prno, 2013).

The European Union is strongly committed to the improvement of social conditions and to sustainable development. With the European Pillar of Social Rights (EC - European Commission, 2017c), the EU set out a number of key principles and rights to support fair and well-functioning labour markets and welfare systems. The Social Pillar is deemed to be also essential for building more resilient economic structures. Among other initiatives, the EU has expressed its vision towards the achievement of the SDG's through the communication "A Global Partnership for Poverty Eradication and Sustainable Development after 2015" (EC - European Commission, 2015a) and ""Next steps for a sustainable European future European action for sustainability" (EC - European Commission, 2016a).

Raw materials industries are particularly interesting from a sustainability point of view. Being at the base of any supply chain, they are essential for modern societies and contribute to the achievement of many Development Goals. Direct contributions include, for instance, the provision of materials for infrastructure and housing. Besides, some metals are fundamental for low-carbon energy technologies, and therefore allow for boosting energy efficiency and reducing greenhouse gas emissions. On the other side, the production of materials can generate severe social impacts, especially in case of poor governance and weak institutional and legal frameworks. An analysis from the Columbia Center on Sustainable Investment (CCSI) mapped the linkages between mining and SDGs, highlighting how these principles can be integrated into core business (UNDP et al., 2016). A review of social impacts of mining and the indicators frameworks used to assess them in different contexts is presented in Mancini and Sala (2018). In Mancini et al. (2018) the analysis of the contribution to the SDGs is extended to the entire value chain of both biotic and abiotic raw materials, thus including other sectors in addition to the extractive one (forestry, raw materials manufacturing, materials' end-of-life sectors).

The European Union adopted a Raw Materials policy and strategy in 2008. This aims at ensuring a fair and sustainable supply of raw materials from global markets; boosting a sustainable domestic supply; and improving resource efficiency and supply of secondary raw materials through recycling (EC - European Commission, 2008). From a trade perspective, the import of minerals from conflict affected-areas is an issue of concern for policy and downstream operators trying to sustain legitimate trade. The EU regulation on conflict minerals requires companies to perform supply chain due diligence, in order to ensure that suppliers are not involved with conflicts, human right violations, illegal trade, etc. (European Union, 2017). The EU Regulation is based on the OECD "Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas" (OECD, 2016).

An additional challenge related to raw materials is their security of supply. To address this challenge, the European Commission published a list of Critical Raw Materials (CRMs), based on their economic importance for EU industrial sectors and their supply risk (EC - European Commission, 2017b). Governance is a key factor in this methodology. In order to support the EU raw materials policy, the European Commission is also developing the Raw Materials Information System (RMIS) and issued the Raw Materials Scoreboard (EC - European Commission, 2016b, 2018).

1.1. Goal and structure of this report

The EU raw materials policy has the objective of ensuring a sustainable supply of raw materials (both from domestic sources and international markets). This study points at the social dimension of sustainability and aims at answering the following questions: can we quantitatively assess social performances of raw materials supply chains, using a life-cycle based approach? Can SLCA databases provide meaningful insight into the distribution of social impacts among countries and sectors involved in a certain supply chain?

This study applies SLCA databases for a macro-level analysis of supply chains worldwide. Raw materials sectors under investigation are those within the scope of the EU Raw

Materials Policy, i.e. non-energy, non-agricultural raw materials. The aim of the study is to analyse feasibility, potential and limitations of these approaches and databases, especially for supporting policies and decision making. The analysis has a life-cycle based approach, therefore it assesses not only the performance of a certain sector in a certain country/region, but encompasses the contribution of the upstream sectors supplying the sector under investigation (e.g. energy, equipment, parts, construction materials etc.). Indeed, also in the extractive sector, which is typically considered to be the starting phase of a value chain, uses inputs coming from other economic sectors from other countries/regions. These complex interactions are typically reflected in economic models like the Input/output tables (Lenzen et al., 2013), used also in the SLCA modelling.

This report is organized as follows. Section 2 describes the European strategy on raw materials, introducing the main policy initiatives of interest for this study. Section 3 introduces the concepts of social sustainability, its definitions and available assessment methodologies. Session 4 provides an overview of relevant issues concerning the social sustainability of raw materials sectors along their life cycle, i.e. forestry, mining and quarrying, materials manufacturing and end-of-life phase. Section 5 describes the general features of the SLCA methodology and modelling approaches; section 6 explains how SLCA databases are built; section 7 explains how the PSILCA database was used to perform this analysis, including the selection of countries, sectors and relevant impact categories. Section 8 presents the results, both in terms of international comparison and contribution analysis within the supply chains. Section 9 discusses sources of uncertainty affecting the study and analyses the results in terms of data quality. The last section discusses the strengths and limitations of this approach and provides suggestions for further research.

2. European strategy on raw materials

In this section we describe the European policy strategy in the raw materials field. While the Raw Materials Initiatives has the objective of supporting the industrial sector through a secure and sustainable supply of raw materials (2.1), the trade policy on conflict minerals aims at ensuring that imported minerals and metals are responsibly sourced.

2.1. Raw Materials policy

Over the last years, the raw material markets showed a strong growth in demand, especially from emerging countries. In addition, raw materials supply to the EU was affected negatively by trade barriers. Due to the economic importance of manufacturing sectors and their sensitivity to hindered trade of raw materials, the European Commission adopted in 2008 the Raw Materials Initiative (RMI) (EC - European Commission, 2008).

The RMI is a communication from the EC which strives for securing reliable and undistorted access to raw materials to sustain and improve the competitiveness and growth of the EU economy. Therefore, ensuring secure sustainable access to these raw materials is crucial to the success of the Lisbon Partnership for growth and jobs[2] and to achieve the objectives of the Europe 2020 strategy (EC - European Commission, 2010a). It covers all non-agriculture non-fuel raw materials used by EU industry. The RMI proposes the establishing an integrated strategy with three pillars which aim to ensure:

- Fair and sustainable supply of raw materials from global markets
- Sustainable supply of raw materials within the EU
- Resource efficiency and supply of "secondary raw materials" through recycling

In addition, the EC regularly publishes a list of critical raw materials (CRM), based on their economic importance and supply risk. The first list was published in 2011 and revised in 2014. In 2017, a third list of CRM was published based on a refined methodology (EC - European Commission, 2017b). One of the indicators used in the criticality assessment methodology is an average of the Worldwide Governance Indicators (Kaufmann, et al. 2010). It is assumed, indeed, that weak governance can negatively influence the security of supply of raw materials. Indeed, conflicts, strikes (due to negative labour conditions), accidents, political instability, which can cause supply disruption, are more likely to in countries with low governance.

The third pillar of the RMI is strictly linked with the Circular Economy Action Plan (EC – European Commission 2015b), which established a concrete and ambitious programme that will stimulate Europe's transition towards a circular economy, by contributing to 'closing the loop' of products life cycle. The action plan aimed to simultaneously boost EU competitiveness, foster sustainable economic growth and generate new jobs.

In order to count on a sound and continuously updated knowledge base for the support of the raw materials-related EU policies, the European Commission is developing the Raw Materials Information System (EC RMIS 2.0)[3]. The EC RMIS is a reference web-based knowledge platform on non-fuel, non-agricultural raw materials from primary (e.g. extracted through mining) and secondary sources (e.g. recycled, recovered from mining waste). It supports EU policy, gathering and organizing EU level data and information on raw materials. Moreover, knowledge from different sources like Member States, industry representatives, and other stakeholders, is going to be available in the RMIS.

The Commission also produces biannual updates of the Raw Materials Scoreboard (EC - European Commission, 2016b, 2018). The RM Scoreboard is a monitoring tool that aims at providing reference information and data to follow on the challenges of the EU raw

[2] EC (2005): Common Actions for Growth and Employment: The Community Lisbon Programme, COM(2005) 330 final

[3] http://rmis.jrc.ec.europa.eu/

materials industry, along their value chain. These challenges cover a comprehensive set of topics which include, among others, environmental and social sustainability.

The RM Scoreboard is an initiative of the European Innovation Partnership on Raw Materials (EIP-RM)[4], which aims to contribute to relevant industrial policies (EC - European Commission, 2010b) and initiatives by ensuring the sustainable supply of raw materials to the European economy whilst increasing benefits for society as a whole. It is prepared in collaboration between DG Internal Market, Industry, Entrepreneurship and SMEs and the Joint Research Centre.

The Scoreboard consists of a set of indicators (24 in 2016 and 26 in the 2018 version) grouped into five thematic clusters: the global context, competitiveness and innovation, framework conditions for mining, circular economy and recycling and environmental and social sustainability. All indicators are based on best-available data, considering the 'RACER criteria' (relevant, accepted, credible, easy to compute and understand and robust), and are the results of an iterative and participatory process, with the involvement of public and private stakeholders and policy makers (around 30 experts representing a balanced range of interests). Two indicators concern the social sustainability of raw materials sectors: rate of non-fatal accidents at works (comparison among EU sectors) and number of companies performing sustainability reporting, within the Global Reporting Initiative (comparison among sectors, and world regions).

2.2. Trade policy on Conflict Minerals

In conflict zones and politically unstable countries, forced labour and human rights abuses can occur in the extraction of metals and minerals. Moreover, minerals trade can finance armed groups and contribute to perpetuate wars and corruption. Conflict minerals came into public attention in the 1990s and 2000s, when some NGOs denounced that the growing demand for mobiles and other electronic products, as well as jewellery, was fuelling violence and atrocities in several African countries. In 1998, Global Witness published an alarming report on the role of diamonds in the Angolan conflict (Global Witness, 1998). The attention grown until reaching the UN General Assembly where the issue of "conflict diamonds" was more specifically discussed, leading to the formulation of its definition[5] and establishment of sanctions in 2000. In 2003, outrageous situations were described in Sierra Leone by the non-governmental organisation Partnership Africa Canada (PAC)[6]. In general, this media coverage proved that the illicit trade of diamonds funded brutal wars also in numerous African countries, including also the Central African Republic, Democratic Republic of Congo and Liberia, resulting in the death and displacement of millions of people. Similar situations have been later described in reports published by other NGOs on, among others, gold, and the mineral ores that produce the metals tantalum, tin and tungsten (often referred as 3TG).

In response of the conflict diamonds issues, the Kimberley Process Certification Scheme[7] was set up in 2000 as a tripartite initiative, hence gathering governments, the diamond industry and civil society organisations. The objective is to prevent the flow of conflict diamonds, while helping to protect legitimate trade in rough diamonds.

Concerning conflict minerals (3TG), the EU Regulation (European Union, 2017) aims at stopping conflict minerals and metals from being exported to the EU; preventing the use of conflict minerals in EU smelting and refining industries; avoiding the abuse of mine workers, and supporting local development.

[4] https://ec.europa.eu/growth/tools-databases/eip-raw-materials/en/content/european-innovation-partnership-eip-raw-materials.

[5] "Rough diamonds which are used by rebel movements to finance their military activities, including attempts to undermine or overthrow legitimate governments" United Nations, general Assembly Resolution 55/56, December 2000.

[6] In 2017, PAC changed its name to IMPACT.

[7] https://www.kimberleyprocess.com/en/kpcs-core-document

The EU regulation, that will take effect in 2021, applies to companies importing tin, tantalum, tungsten and gold (in the form of mineral ores, concentrates or processed metals) from high-risk and conflict-affected areas. Guidelines for the identification of these areas are currently under development. The Regulation requires that EU companies in the supply chain ensure they import these materials responsibly and from conflict-free sources only. It is built upon the OECD Due Diligence Guidance for responsible mineral sourcing (OECD, 2016). The due diligence is an "on-going, proactive and reactive process through which companies can ensure that they respect human rights and do not contribute to conflict". It is considered as the international benchmark for supply chain due diligence.

The European Commission is establishing a support system for Small and Medium Enterprises (SME) who will need to perform due diligence in their supply chain.

3. Social sustainability and social impacts assessment

The sustainable development concept usually refers to humanity's ability of meeting "*the needs of the present generations without compromising the ability of future generations to meet their own needs*", as stated in the Brundtland Report of the World Commission on Environment and Development (UN, 1987). While this definition leaves space for many different interpretations, it is nonetheless customary to describe sustainable development as the composition of three pillars, representing economy, environment and society (or also as 3P: Profit, Planet, People). This approach, also called the Triple Bottom Line (Elkington, 1998), originates within a business context, and focuses on the need of adding social and environmental considerations into financial corporate reporting. The relationships among these three dimensions are generally assumed to be compatible and mutually supportive (Littig and Griessler, 2005). However, how the integration of these elements should be operationalized is still unclear.

Another way of representing the three sustainability pillars uses three concentric spheres, where the social and economic dimensions are embedded in the environmental one, and thus constrained by ecological limits (fig. 1). Some authors outlined the limitations of the three pillars approach by adding more components, like culture, institutions, etc. (e.g. (Bendell and Kearins, 2005; Godschalk, 2004; Inayatullah, 2005; Seghezzo, 2009). However, other authors criticise the "pillars approach" as a whole. They argue that forcing complex socio-environmental problems into a certain number of distinct containers means approaching environmental, economic, and social issues separately and therefore giving separate solutions (Milne and Gray, 2013; Peterson, 2016; Vanclay, 2004).

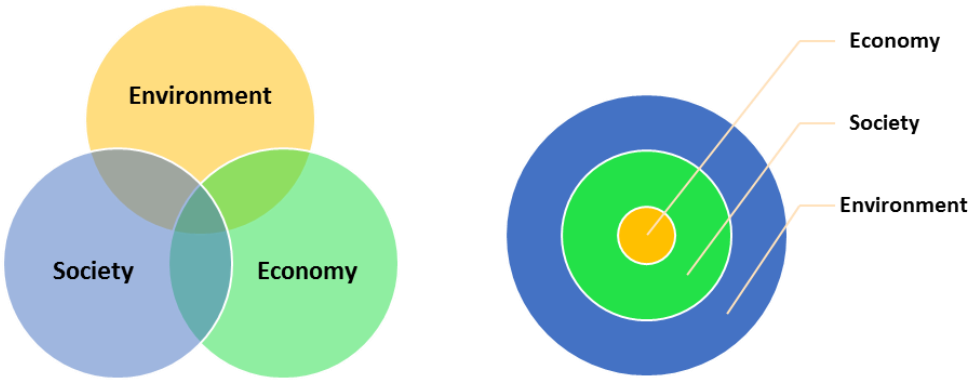

Figure 1 Models for representing the interrelations between environmental, social and economic sustainability

A common consideration emerging from the literature on sustainability is the fact that the social dimension of sustainability, so far, garnered less attention than the environmental and economic ones. Only in recent years, studies from different disciplines (e.g. urban and regional planning, sociology, anthropology, political science, economics, ecology, etc.) have started exploring social sustainability both from a conceptual and an operational point of view. Many scholars argue that a universal definition of social sustainability does not exist, but it is rather a dynamic concept, that can change over time and depending on the context of an application. Such conceptual imprecision and the flexibility in the interpretation can be seen both as a strength (because it facilitates communication among different actors and disciplines) and as a weakness (as it needs to be defined every time the term is used) (Boström, 2012).

Many studies address the theoretical and conceptual definition of social sustainability, trying to respond to the question of what social sustainability is, what should be measured and what are the main themes to be addressed. Table 1 presents an overview of key themes characterizing the social sustainability concept, according to different authors.

While the list is not comprehensive, it highlights the variety of aspects that can be considered as relevant within the social sustainability umbrella. Within the list, equity/equality and livelihood are recurrent concepts mentioned by several authors.

In addition to the issues listed in table 1, most of the authors agree on some features characterizing social sustainability, such as:

- Importance of the local context and the local governance, attention to local needs and values
- Integration of different perspectives (e.g. through the consideration of different stakeholders and community engagement)
- Need for an integrated vision of sustainability (Peterson, 2016).

Peterson et al. (2016) also stresses the importance of integrating governance into sustainability. In the introduction to a special issue of a journal dedicated to social sustainability, Peterson resumes the idea expressed by different authors "[…] *that truly integrated sustainability is not just an issue to address through governance and decision-making; sustainability underlies and makes governance possible. In this way, the framework moves beyond environmental, economic, and social issues to realize that good governance is sustainability and vice versa*".

Another conceptual framework (Eizenberg and Jabareen, 2017) points at risk as the ontological foundation for sustainability and social sustainability. According to the "risk society" theory (e.g. Beck, 1992), modern societies are increasingly occupied with preventing and managing risks that they themselves have produced. In this context, the authors propose that social sustainability "*comprises socially oriented practices intended to address major social issues to cope with the risks of climate change and environmental hazard*" (ibidem).

Table 1 Key themes for the operationalisation of social sustainability

Reference	Features
Chambers and Conway, 1992	Livelihood – Equity – Capability to withstand external pressure – Safety nets
UK Department for International Development (DfID), 1999	Inclusion – Equity – Poverty - Livelihood
Sachs, 1999	Equity – Democracy - Human rights - Social homogeneity - Equitable income distribution - Employment - Equitable access to resources and services
Hans-Böckler-Stiftung, 2001	Paid and voluntary work - Basic needs - Social security - Equal opportunities to participate in a democratic – Society – Enabling of social innovation
UK DfID, 1999; Thin et al., 2002	Social justice – Solidarity – Participation – Security
Omann and Spangenberg, 2002	Education – Skills – Experience – Consumption – Income – Employment – Participation
Godschalk, 2004	Development – Property - Resource - Liveability
Chiu, 2004, 2003	Social limits - Ecological limits - Equality
Baines and Morgan, 2004; Sinner et al., 2004	Basic needs - Personal disability - Needs of future generations - Social capital – Equity - Cultural and community diversity - Empowerment and participation
Shinn and Magis, 2008	Human wellbeing – Equity – Democratic government – Democratic civil society
UNEP/SETAC Life Cycle Initiative, 2009	Human rights – Working conditions – Health and safety – Cultural heritage – Governance – Socio-economic repercussions
Cuthill, 2010	Social justice and equity - Social infrastructure - Engaged governance - Social capital
Vallance et al., 2011	Development social sustainability - Bridge social sustainability - Maintenance social sustainability
Mani et al., 2016	Equity – Safety - Health and welfare – Philanthropy – Ethics - Human rights
Missimer et al., 2017b, 2017a	Trust - Common meaning – Diversity – Capacity for leaning – Capacity for self-organization
Eizenberg and Jabareen, 2017	Equity – Safety – Sustainable urban forms – Eco-prosumption

So far, despite its relevance, the evaluation of social sustainability performance has been conducted by adopting a variety of approaches and indicators (Mancini and Sala, 2018).

In the case of social impacts, according to Macombe et al. (2013) they can be defined as consequences caused by changes, which entail a certain effect. When these effects cause phenomena that are experienced by people, or groups of people, these are social impacts (Fig. 2). Social impacts can relate to changes in, e.g., life expectancy, well-being, health, and social status. It is therefore important to distinguish among the evaluation of social performances, effects, and impacts. When information about social effects is not available, it is useful to apply the concept of risk (fig. 2). This notion implies that it is neither possible nor necessary to know for certain the social impacts of the production of specific goods or services, but it suffices to know with which probability a certain product is associated with an externality (Sala et al., 2015).

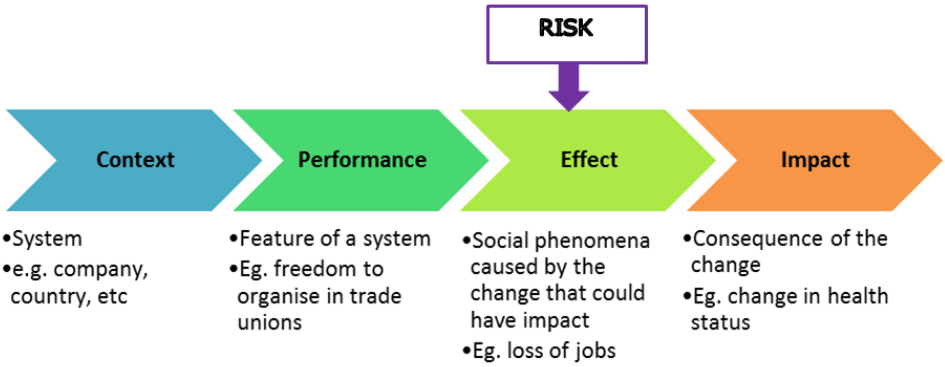

Figure 2 Differences among performance, effect and impact (Adapted from Macombe et al. 2013). Positioning of risk evaluation within the impact pathway.

Table 2 presents the main available techniques and tools for performing a social assessment at different levels (project, product, organization, community). Among others, the most relevant ones (for the purpose of this study) are described below:

- **Social Impact Assessment (SIA)**, developed in the 70s for managing the social issues associated with planned interventions (Esteves et al., 2012; Vanclay, 2004). Nowadays, SIA is widely practiced internationally in a number of fields, such as natural resource management, disaster preparation, international development cooperation, in peace-building and conflict initiatives, conflict management and in due diligence processes (Dendena and Corsi, 2015).
- **Social Life Cycle Assessment**, aims at assessing social impacts in product life cycles from the resource extraction to final disposal (UNEP/SETAC Life Cycle Initiative, 2009). This methodology is described in detail in section 4.1.
- **Social Accountability** (SA8000:2014): an auditable certification standard that encourages organizations to develop, maintain, and apply socially acceptable practices in the workplace. This was developed in 1997 by Social Accountability International, an advisory board consisting of trade unions, NGOs, civil society organizations and companies. The SA8000's criteria were developed from various industry and corporate codes to create a common standard for social welfare compliance.
- **Corporate Social Responsibility (CSR)**: a form of corporate self-regulation integrated into a business model. CSR policy functions as a self-regulatory mechanism whereby a business monitors and ensures its active compliance with the spirit of the law, ethical standards and national or international norms.
- **ISO 26000:** guidance on social responsibility is launched from the International Organization for Standardization (ISO). ISO 26000 is an International Standard providing guidelines for social responsibility (SR) named ISO 26000 or simply ISO SR, released in 2010. Its goal is to contribute to global sustainable development, by encouraging business and other organizations to practice social responsibility to improve their impacts on their workers, their natural environments and their communities.
- **Supply chain due diligence:** a holistic concept to proactively manage supply chains, reducing the likelihood of severe social impacts, e.g. the use of conflict minerals or human rights abuses. In many countries and in the EU, due diligence obligations are required by law for companies importing metals (Tin, Tungsten, Tantalum, Gold) from high-risk and conflict-affected areas (European Union, 2017). The OECD has published guidance for performing due diligence in minerals supply chains (OECD, 2016).

- **Human Rights Impact Assessment:** a process for systematically identifying, predicting and responding to the potential human rights impacts of a business operation, capital project, government policy, or trade agreement. It is designed to complement a company or government's other impact assessment and due diligence processes and to be framed by appropriate international human rights principles and conventions (Monash University, 2008).

Table 2 Social assessment toolbox

		Level of assessment			
		Project, intervention or facility	**Product**	**Organization**	**Community**
Type of technique or tool	**Analytical tools**	- Social Impact Assessment (SIA) - Health Impact Assessment (HIA) - Human rights Impact Assessment (HRIA) - Sustainability Appraisal (SA)	- Social Life Cycle Assessment (SLCA)	-Social Accountability - Social footprint - Value chain assessment Etc.	- Participatory action Research - semi-directed and open interviews - Questionnaire, survey, Focus groups, etc.
	Procedural and management tools	SA 8000	Life Cycle Management	- Standards and certifications (e.g. Fair trade certification) - Guidelines (e.g. ISO 26000; OECD guidelines for multinational enterprises) - Performance measure (e.g. Corporate Social Responsibility) - Due diligence	Local Agenda 21
	Monitoring tools	Social follow up	Social Audits	Social Audits	Evaluation
	Communication tools	Certification	Product certification	- Sustainable development reports - Labelling - Sustainability/ Social indexes	Campaigns
	Reporting tools			- Global Reporting Initiatives guidelines - Social reporting indicators	Political systems

4. Social considerations in raw materials sectors

This section describes the raw materials sectors under investigation, focusing on the main characterizing social issues.

4.1. Mining and quarrying sector

Quarrying and mining are typically referred to as extractive industries. Whereas differences exist, mostly based on legal definitions, quarrying typically refers to the extraction of stone or construction materials or most of industrial minerals. On the other hand, mining is typically associated to the extraction of metals and some industrial minerals (usually from an ore body, lode, vein, seam, reef or placer deposits).

Mining is one of the most ancient activities, since pre-historic times. The sector has evolved tremendously in the last century, and is now often characterized by a high level of mechanization and technological innovation and the presence of a globalized mining industry of large multinational corporations. Obviously, social conditions and impacts linked to this sector have also changed a lot in comparison to the XIX century industry in many cases. However, they largely vary from country to country (e.g. in developed vs. developing countries) and in large scale vs. small scale mining.

In a recent review on social impacts of mining (Mancini and Sala, 2018), the social impacts occurring in the sector and documented in literature are clustered in the following six macro-areas:

- **Economy, income and security**: can be both positive and negative. Mining can give stimulus to the local economy and increase population income and business opportunities, also in other sectors. On the other hand, an unfair distribution of the benefits coming from resource extractions and corruption due to the bad management of mineral wealth can trigger social tensions. Conflicts can also arise between companies and illegal/artisanal miners, as well as anti-mining activists. Increased poverty can also occur, if e.g. local populations lose traditional means of livelihood, and when governments fail in reinvesting revenues from mining.
- **Employment and education**: the creation of jobs (both in the mining sector and indirectly in other sectors) is a positive impact of the mining activity documented in several studies. Educational opportunities offered by the company and employee skill development are further potential positive outcomes. Negative impacts relate to the occurrence of child, forced and compulsory labour, but also to the quality of jobs (including poor working conditions, low wages, substandard housing provided to workers, lack of freedom in organizing trade unions activities). In some cases, increased unemployment is documented, explained by the increasing mechanization of mining operations.
- **Land use and territorial aspects**: land competition can arise when mining projects are developed, endangering wellbeing of local populations and leading to their impoverishment. Almost 30% of the scrutinised studies report land expropriation, displacement and resettlement of local communities (Mancini and Sala, 2018). A further impact linked to land use regards the limited access to land for the rural population, which implies a negative impact on livelihood and consequent food insecurity. The presence of a mine in the territory can, however, also contribute to local development, when mining companies engage in providing and improving local infrastructures (e.g. road network, power and water supply) which in turn allows local populations to access health and education services.
- **Demography**: the mining activity is likely to attract workers from other regions causing migration flows and a change in the local demographic structure. A gender imbalance can emerge due to the prevalence of male workers, undermining social cohesion and spreading problems of a psychological or behavioural nature (e.g. alcoholism, drug addiction, prostitution, etc.). Inflation and rising accommodation costs can also negatively affect the local population's wellbeing. In one study,

however, population growth was perceived as a positive consequence of the mining activity.

- **Environment, health and safety**: Dangerous working conditions, accidents and fatalities can affect employees but also safety problems can touch local communities (e.g. through damage caused to dwellings by explosives and injuries during mine activities). Work environmental and health impacts are extensively documented in the literature and more quantitative studies are available on these issues. Environmental impacts can affect human health in local communities and of workers directly (e.g. having toxic or carcinogenic effects) or indirectly through e.g. reduced water supply or contamination (and consequential prevention of fisheries and loss of means of livelihood). The reviewed studies do not report any positive impacts within this category.
- **Human rights**: violation of human rights can have different forms, including discrimination of vulnerable groups, lack of stakeholder inclusion and respect of indigenous populations, human rights abuse and impacts on cultural and aesthetic resources.

In addition to the issues mentioned above, the mining sector in developing countries is characterized by a high degree of informality and small-scale/artisanal mining. Artisanal and small-scale mining (ASM) refers to mining by individuals, groups, families or cooperatives with minimal or no mechanisation, often in the informal (and illegal) sectors of the market (Hentschel et al., 2002). ASM is very heterogeneous in terms of scale, legality, demographics and seasonality; operations exploit marginal and small deposits, are labour intensive and have poor access to markets and support services, have low standards of health and safety and significant environmental impacts. According to World Bank estimates, ASM employs from 20 to 30 million people globally, representing 15-20% of the global minerals and metals production (Buxton, 2013). Practiced in about 50 countries, it is believed to provide a livelihood for over 100 million people, almost all of whom live in developing countries.

The outcome of the EU H2020 projects outlines a list of challenges for the mining sectors (and specifically for the ASM) and the main contributions to economic development (table 3) (Schüler et al. 2016).

Given the specificity of the mining sector, one of the main sustainability reporting scheme, the Global Reporting Initiative[8], developed a set of sector-specific aspects and indicators that should be monitored when performing sustainability reporting (see table 15 in the appendix).

[8] https://www.globalreporting.org/information/sector-guidance/sectorguidanceG4/Pages/default.aspx

*Table 3 List of contributions to economic development and socio-economic challenges in mining (adapted from Schüler et al. 2016. Text with * is of specific relevance for ASM).*

Mining contribution to economic development		
Job generation		
Infrastructure development		
Technology and knowledge transfer		
Public revenues		
Socio-economic challenges in mining		
Workforce	Child labour	Freedom from child labour*
	Forced labour	Freedom from forced labour
	Working conditions	Adequate working hours & leave
		Fair wages
		Non-discrimination in hiring & employment
		Social insurance against loss of income*
	Workplace health & safety	Protection from injuries & occupational diseases*
		Freedom from physical and mental harm*
		Emergency preparedness*
		Hygienic workplace & sanitary facilities*
		Access to safe drinking water*
	Labour rights	Freedom of association
		Collective bargaining
Local communities	Community health	Emergency preparedness
		General community health & safety
	Social & cultural rights	Free, prior and informed consent
		Displacement & resettlements
		Loss of livelihood*
		Preservation of cultural heritage
		Social tensions & increase in crime*
	Community Safety	Responsible use of force and firearms
		Crisis & conflict mitigation
	Local development	Infrastructure development
		Procurement of local goods & services
Society at large	Economic development	Income generation
		Job creation
		Attraction of foreign investment
		Procurement of national goods & services
	Governance issues	Corruption*
		Money-laundering*
		Tax evasion
		Fraud
	Armed conflicts	Finance & support of conflicts*

4.2. Forestry

According to the Food and Agricultural Organization (FAO), the forest sector includes all economic activities that primarily depend on the production of goods and services from forests. These economic activities, among others, include growing of standing timber, growing of coppice and pulpwood, logging (felling of timber and production of wood), forestry service activities (forestry inventories, timber inventories, forest management), transport of logs within the forest, production of charcoal, and gathering of wild growing forest materials[9]. However, some countries have their own national or regional classification of economic activities in the forest sector.

The International Labour Organization (ILO) highlights that the forestry sector and its three-subsectors (logging, wood processing, pulp and paper sector) employ globally some 13.7 million of formal workers, equivalent to 0.4% of the total labour force[10]. The forest sector is characterized by a high degree of informality, especially in developing countries.

Although it creates employment and benefit to the economy, the forestry sector is prone to several conflicts such as illegal logging (the harvesting of timber in contravention of the laws and regulations of the country of harvest[11]) and land grabbing which may subsequently cause environmental and socio-economic implications to the local community. The Timber Regulation (EU No 995/2010) lays down the obligations of operators who place timber and timber products on the market:

- It prohibits the placing on the EU market for the first time of illegally harvested timber and products derived from such timber;
- It requires EU traders who place timber products on the EU market for the first time to exercise 'due diligence';
- It requires the economic operator to keep records of their suppliers and customers.

Accidents at work seem to be particularly relevant to forestry. As described in the Raw Materials Scoreboard (EC - European Commission, 2016b, 2018), forestry has the highest rate of non-fatal accidents, among the European raw materials sectors (which include mining, manufacturing of metals, non-metallic minerals, wood products and paper).

The ten rules for responsible forest management of the Forest Stewardship Council (FSC) certification include the following social aspects[12]:

- The Organization shall maintain or enhance the social and economic wellbeing of workers.
- The Organization shall identify and uphold Indigenous Peoples' legal and customary rights of ownership, use and management of land, territories and resources affected by management activities.
- The Organization shall contribute to maintaining or enhancing the social and economic wellbeing of local communities.
- The Organization shall efficiently manage the range of multiple products and services of the Management Unit to maintain or enhance long term economic viability and the range of environmental and social benefits.

Similarly, the Programme for the Endorsement of Forest Certification (PEFC) includes the following social requirements for best practice in sustainable forest management:

- Workers' rights and welfare are protected
- Local employment is encouraged

[9] http://www.fao.org/docrep/007/ad493e/ad493e05.htm
[10] FAO, 2004, Trends and current status of the contribution of the forestry sector to national economies, http://www.ilo.org/global/industries-and-sectors/forestry-wood-pulp-and-paper/lang--en/index.htm
[11] http://ec.europa.eu/environment/forests/illegal_logging.htm
[12] https://ic.fsc.org/en/what-is-fsc-certification/principles-criteria/fscs-10-principles

- Indigenous peoples' rights are respected
- Operations are undertaken within the legal framework and following best practices.

4.3. Basic materials manufacturing

Within the scope of this study, materials manufacturing includes the production of paper, wood products, non-metallic minerals and metals. Non-metallic minerals include a wide range of materials, used, e.g. for construction (e.g. cement, concrete, glass, etc.); as fertilizers (phosphate, nitrogen, etc.); or for ornamental scopes (e.g. marble slab, etc.)

Metal production encompasses the activities of smelting or refining ferrous, non-ferrous, and precious metals from ore or scrap, using metallurgic techniques. It also includes the production of metal alloys and super-alloys by adding certain chemical elements to pure metals. The applications of metals are extremely various: some materials, like iron, steel and copper are ubiquitous and are central to meeting basic needs such as housing and mobility. Others, like precious and specialty metals are used in specific technological applications (for instance, Lithium in batteries; Gallium, Germanium, Indium in flat screens). Even if their markets are generally smaller, their demand is rapidly growing, according to the spread of the end-use technologies.

In general, in the manufacturing sector, one of the main concerns for workers' health is chemical exposure at the workplace (ILO, 2005). Occupational health hazards can arise from inhaling chemical agents in the form of vapours, gases, dusts, fumes, and mists, by dermal contact, or by inadvertent ingestion from hand-to-mouth contact. Chemicals at the workplace may have acute narcotic effects, cause reproductive harm or cancer. After intake, chemicals may enter the bloodstream and reach internal organs or a developing fetus (Hellweg et al., 2005). In the metals production sector, occupational exposure to solvents in dry-cleaning and in the metal-degreasing industry can be significant (Von Grote et al., 2003).

A further concern relates to the risk of injuries in the workplace that according to the International Labour Organization are generally higher in basic metal production, due to the presence of hazards such as molten metal (ILO, 2005).

Health impacts can also interest local communities, due e.g. to emissions of hazardous chemical substances to air, soils and water bodies. For instance, the emissions of dioxin can cause reproductive and developmental problems, damage the immune system, interfere with hormones and also cause cancer. Dioxins are unwanted by-products of a wide range of manufacturing processes including smelting, chlorine bleaching of paper pulp, etc. (WHO, 2016).

The Global Reporting Initiative[13] gives sector-based guidance for the primary metal processing (including smelting, recycling and basic fabrication). Social aspects to address in sustainability reporting and correspondent indicators are shown in table 15 (in appendix).

[13] https://www.globalreporting.org/information/sector-guidance/sectorguidanceG4/Pages/default.aspx

5. Social Life Cycle Assessment

This section describes the main features of the Social Life Cycle Assessment (SLCA) methodology and how it can be applied to study supply chains and social impacts of products and services. Two modelling approaches (top-down and bottom-up) are possible, as described in section 4.3.

5.1. The background: life cycle-based methodologies

The sustainability assessment community uses different methodologies to evaluate impacts in production and consumption systems. One of them is Life Cycle Assessment (LCA), a methodology defined by the international standards ISO 14040 and 14044, aiming at analysing impacts in product systems. In the introductory part of international standards ISO 14040 LCA is defined as follows: "*LCA studies the environmental aspects and potential impacts throughout a product's life (i.e. cradle to-grave) from raw material acquisition through production, use and disposal. The general categories of environmental impacts needing consideration include resource use, human health, and ecological consequences*." (ISO 14044, 2006). This definition refers to the "traditional" LCA that, however, includes also impacts on the social sphere (e.g. human health). A more recent definition describes LCA as a methodology assessing the impacts (of environmental, economic or social nature) due to environmental interventions along a supply chain, i.e. due to the extraction or emission of physical substances (Mancini et al., 2016).

The ISO standards identify four phases for conducting an LCA: Goal and Scope; Life Cycle Inventory (LCI); Life Cycle Impact Assessment (LCIA) and Life Cycle Interpretation.

This framework can be used as a backbone for similar analyses in other fields, like the social and economic ones. Corresponding methodologies in these fields are Life Cycle Costing (LCC), Working Environmental LCA (WE-LCA) and Social and socio-economic Life Cycle Assessment (SLCA).

Life cycle costing is a compilation and assessment of all costs related to a product, over its entire life cycle, from production to use, maintenance and disposal. LCC can address the economic impact of a product whose environmental performance is scrutinized in an E-LCA.

As stated by Poulsen and Jensen (2004), Working environmental LCA methods aim at compiling and evaluating potential working environmental impacts on humans of a product system throughout its life cycle. Working environmental issues were traditionally not assessed in detail through E-LCA because the focus of the technique was to assess the potential impacts on the external environment. WE-LCA allows to examine whether environmental product improvements are implemented at the expense of a deteriorated working environment. Some WE-LCA methods include the assessment of subjects that may be included in an SLCA, such as work accidents and work atmosphere. When conducting both an SLCA and a WE-LCA, attention should be given to the choice of WE-LCA methodology and/or choice of SLCA inventory indicators and subcategories in order to avoid double counting (UNEP/SETAC Life Cycle Initiative, 2009).

5.2. SLCA methodology

Social LCA is grounded in Life Cycle Thinking (LCT). This approach seeks to capture the environmental/social impacts of goods or services "from the cradle to the grave", thus considering all the steps in their life cycle and avoiding shifting of burdens among geographic areas or supply chain steps. There are also a number of important dissimilarities between both approaches. One of them being that social concerns are diverse and their importance is more subjective to the context (Sala et al., 2015).

A Social Life Cycle Assessment (SLCA) is an impact assessment methodology that aims to assess the social and socio-economic aspects of products and their potential positive and negative impacts along their life cycle. SLCA can either be applied on its own or in combination with e.g. E-LCA (UNEP/SETAC Life Cycle Initiative, 2009).

In the context of SLCA, social impacts are defined as "the consequences on human populations of any public or private action that alter the ways in which people live, work, play, relate to one another, organise themselves so as to meet their needs and generally cope as members of societies" (ICGP, 1995). Social impacts are therefore consequences of positive or negative pressures on social areas of protection (i.e. well-being of stakeholders). As the cause-effect chain is not well defined and a proper impact assessment method hasn't been developed yet, often the term "social risk" is adopted. Social risk refers to the potential for one or more parties to be exposed to negative social conditions that, in turn, undermine social sustainability (Pelletier et al., 2013). Positive social impacts "hidden" in product supply chains are also taken into account in the SLCA methodology, even though their theoretical definition and implementation in the methodology is still under debate (Di Cesare et al., 2016). As stated in Di Cesare et al. (2016) in a review on positive impacts in SLCA, the definition of positive impact should not be limited to the utility of a product, which, in economic terms is "the well-being that a given good or service is able to provide to a person as it is suitable to satisfy a desire or fulfil a need". Instead, the concept of positive impact should refer to the so-called "win-win" situations, in which all parties involved in the initiative have a benefit (or are not damaged) in terms of value created in their favour.

Regarding this specific methodology, recognised internationally standards do not exist yet as for E-LCA, but guidelines have been produced in the document "Guidelines for social life cycle assessment of products" realised by UNEP/SETAC Life Cycle Initiative (UNEP/SETAC Life Cycle Initiative, 2009). This document has been written by several experts in diverse fields such as sustainability, LCA methodology, social science etc., according to its multidisciplinary nature. The UNEP/SETAC guidelines provide a reference set of stakeholders and impact subcategories to consider in an SLCA study (Table 4). "The Methodological Sheets for Subcategories in Social Life Cycle Assessment" (SLCA)" (Benoît-Norris et al., 2013) were issued to provide a structure and basis for developing research and studies using social indicators.

Table 4 Stakeholder categories and subcategories as in UNEP/SETAC Guidance (2009)

Stakeholder categories	Subcategories
WORKERS	Freedom of Association and Collective Bargaining
	Child Labour
	Fair Salary
	Working Hours
	Forced Labour
	Equal opportunities/Discrimination
	Health and Safety
	Social Benefits/Social Security
CONSUMERS	Health & Safety
	Feedback Mechanism
	Consumer Privacy
	Transparency
	End of life responsibility
LOCAL COMMUNITY	Access to material resources
	Access to immaterial resources
	Delocalization and Migration
	Cultural Heritage
	Safe & healthy living conditions
	Respect of indigenous rights
	Community engagement
	Local employment
	Secure living conditions
SOCIETY	Public commitments to sustainability issues
	Contribution to economic development
	Prevention & mitigation of armed conflicts
	Technology development
	Corruption
VALUE CHAIN ACTORS (not including consumers)	Fair competition
	Promoting social responsibility
	Supplier relationships
	Respect of intellectual property rights

5.2.1. Modelling approaches with SLCA

As the other Life Cycle methodologies, the SLCA developed as a product-oriented methodology, seeking to appraisal impacts of a certain good or service from a life cycle perspective and making the comparison among alternatives possible (EC - European Commission, 2013). The Social Organizational LCA uses the organization, instead of the product, as a reference unit. It has been proposed as a new approach to overcome some challenges of SLCA, i.e. the difficulty in allocating social impacts of an organization to a single product (Martínez-Blanco et al., 2014). The following sections explains two main modelling approaches used to analyse supply chains.

5.2.1.1. Bottom-up approaches

Traditionally, SLCA have a micro-economic focus, as they investigate a specific supply chain looking at the organization and/or product, and the suppliers involved in that particular supply chain. This modelling approach imply a site-specific data collection for the most relevant phases of the supply chain. Field investigation is usually conducted to collect inventory data on different social aspects. This can be performed through questionnaires, surveys, or through participatory approaches that allow a more direct stakeholder involvement (Mathe, 2014). Stakeholders groups can also be involved in the selection of

impact subcategories, in order to take into account issues of importance for the different actors.

In order to gather the whole life cycle of a product, all the upstream and downstream phases of the supply chain (as defined in the system boundary) should be taken into account and subject to the social investigation. For instance, if the product under investigation is a notebook PC, the extraction phase of all the used materials, the manufacturing of single components and their assembly should be investigated. As a notebook consists of thousands of parts, a complete data collection is unfeasible with these methods. In order to overcome this challenge, two different, and sometimes complementary paths are possible:

- Apply a sharp simplification of the supply chain, taking into account only some of the most relevant steps
- Integrate the assessment with generic data or risk values on a sector and/or country level from the available SLCA databases (see section 5.2).

The main phases of a SLCA study are the following:

- ***Goal and scope***

This phase includes a clear statement of purpose, the goal, describing the intended use and the goal pursued. The study will then be defined to meet that purpose, within any constraints. The second step is to define the scope, which include the definition of the function and the functional unit of the product (i.e. the quantified performance of a product system for use as a reference unit in a life cycle assessment study). The scope phase defines the depth of the study and decisions about data collection (i.e. which phases of the supply chain will require direct data collection, which ones uses secondary data from literature or generic databases). In order to define the depth of the study, activity variables[14] (such as worker hours or value added) may be used. This phase includes the modelling of the product system and the system boundaries, i.e. defining which stages and upstream phases in the value chain are under investigation. The selection of stakeholders (the actors who will be affected by the positive or negative consequences of social impacts) and impact subcategories (social issues affecting each stakeholder), is also performed in this phase.

- ***Social-Life Cycle Inventory (SLCI)***

The inventory phase of a SLCA aims at collecting data on possible drivers of impacts, for each stage of a product life cycle. Inventory indicators can be quantitative or qualitative, and must measure in the most direct way the social aspect of the corresponding impact category and stakeholder. Data collection can be performed in different ways, from literature review and web search to field investigation and site specific data collection, through surveys, interviews, focus groups, etc. As the collection of primary data for in all the stages of the supply chains is likely to be unfeasible (due to the high number of production processes involved), a prioritization of the most relevant phases can be applied. For this purpose, an hotspot analysis can be performed with the SLCA databases, and they can be used also to complement primary data collection for the phases of the supply chain that are not subject to in-depth field investigations (UNEP/SETAC Life Cycle Initiative, 2009).

- ***Social-Life Cycle Impact Assessment (SLCIA)***

The SLCIA phase consists of the three mandatory steps identified in ISO 14044 (2006) for LCIA, which allow to trace the Inventory data through the relevant social and socio-

[14] An activity variable is a measure of process activity or scale which can be related to process output. Activity variables, scaled by the output of each relevant process, are used to reflect the share of a given activity associated with each unit process. Thus, for attributes concerning labor conditions, a relevant activity variable is worker-hours. Process-specific coefficients of worker-hours per unit of process output are used to estimate the share of total life cycle worker-hours associated with each unit process (UNEP/SETAC 2009).

economic mechanisms to define a social and socio-economic impact. Those three steps are: selection of impact categories and methods and models; linkage of inventory data to particular SLCIA subcategories and impact categories (classification); as well as determination and/or calculation of subcategory indicator results (characterization).

- ***Social-Life Cycle Interpretation***

Life Cycle interpretation is the process of assessing results in order to draw conclusions. In accordance with the goal and scope of the study, this phase has several objectives: to analyse the results, reach conclusions, explain the limitations of the study, provide recommendations and report adequately.

Results from bottom-up studies are particularly suited to support business decision-making, in particular they may help companies to identify major risk sources and to implement optimization strategies in their production processes and in their supply chains. Scaling up these results to, e.g. the sector level, can have serious limitations, as social conditions can change considerably from a company to another and are not connected to design and production technologies. Therefore, their use for supporting policy decision making pose some challenges.

5.2.1.2. Top-down approaches

While most of the SLCA studies adopt a bottom-up approach and are applied at micro scale, social assessments at meso (sector) and macro (country/global) scale are also possible. These top-down analysis allows to screen the global supply chains using SLCA databases, repository of social indicator data relevant for a set of thematic areas. While originally intended for microscale, product-level assessment, these databases have been applied also at macro scale social dimensions of production and consumption (Benoit-Norris et al., 2014, 2012), in international commodity trade (Pelletier et al., 2016) and to support human rights due diligence (Benoit-Norris et al. 2018). In this study, this approach is applied to identify social hotspots in the raw materials sectors.

The available SLCA databases are the Social Hotspot Database (SHDB)[15] and the Product Social Impact Assessment Database (PSILCA)[16].

Section 6 explains how these databases are structured, their modelling approaches, and the methodology used in this study.

[15] https://www.socialhotspot.org/
[16] https://psilca.net/

6. Methodology

This section describes how the SLCA databases are structured, how these data are modelled in a life-cycle analysis, and how the Product Social Impact Life Cycle Assessment (PSILCA) was applied to study the supply chains of raw materials. The third part of the chapter describes the choice of countries and sectors under investigation, and the selection of relevant social aspects to assess.

6.1. Key elements of the SLCA databases and modelling

The currently available SLCA tools feature a similar structure. They include three main components: a database on social aspects (social inventory); an Input/output model; and a Worker-Hours model. The sections below provides a brief description of the SLCA database and Input/output plus Worker Hours modelling, while section 6.2 highlights distinctive features of the currently available databases.

6.1.1. Social inventory

The main component of the SLCA databases are information sheets on social aspects for each Country-Specific Sectors (CSS). CSS are combinations of economic sectors in a specific country (e.g. mining in France; manufacture of metals in Canada, etc.). The SLCA databases contain thousands of CSS, as they cover the global economy. For each CSS a set of social aspects and indicators are detailed. The classification of social aspects is based on the identification of affected stakeholders (e.g. workers); impact subcategories (e.g. health and safety) and related indicators (e.g. number of fatal accidents). International data providers such as International Labour Organization, World Bank, etc. are used to compile these lists of indicators with quantitative and qualitative data (raw values) (see fig. 3).

Based on the indicator values, risk levels are assigned to the CSS for each social aspect. For instance, if the number of fatal accident per 100k employees in the French mining sector is lower than 7.5 the risk level is "very low". These levels can be based on laws and international standards, when available.

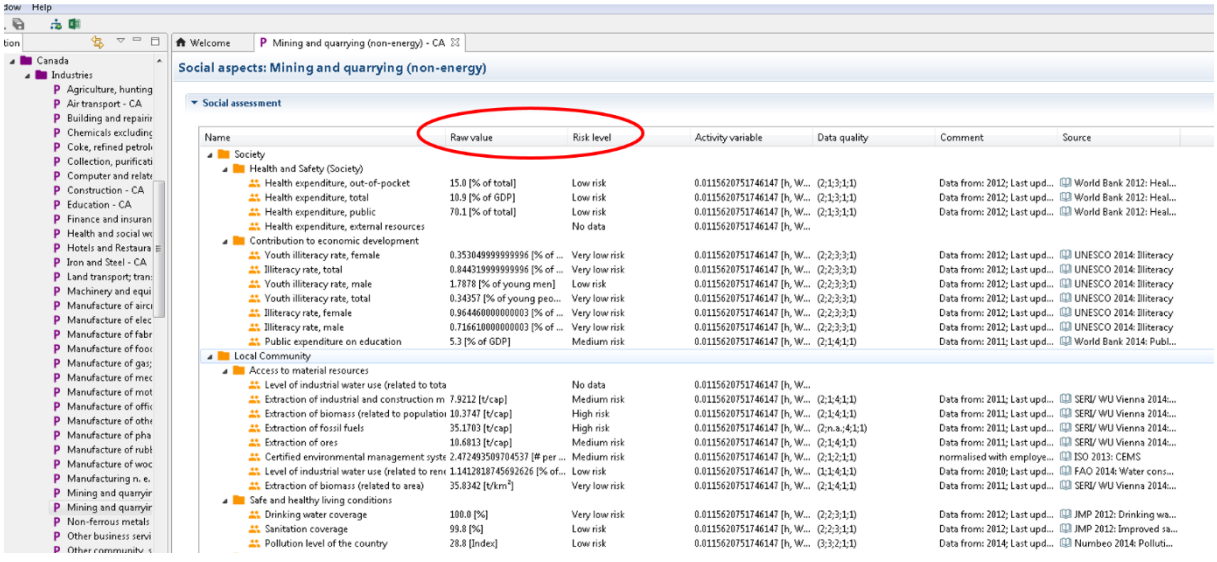

Figure 3 Screenshot showing an example of social database structure in SLCA databases

6.1.2. Life cycle modelling

A characterization model is applied to convert risk levels of each social indicator in quantitative values. For instance, low risk level=1; high risk=100. This step allows the aggregation of risk values along the different steps of the value chain and is repeated for each country-sector combination and for all the social indicators.

In order to allow a life-cycle based assessment, a model representing the structure of the economy (for instance Global Trade Analysis Project, GTAP or a Multi Regional Input/Output model, MRIO) is combined with social data. These models represent the global supply chains, as they specify how each economic sector supplies other sectors, in monetary values. Therefore, they allow to know the upstream sectors that are contributing to the final output, based on their purchases and demand for inputs.

A worker hours model allows the aggregation of social risks occurring at different points of the supply chains in terms of a common activity variable, worker hours i.e. the number of worker hours along the supply chain that are characterized by a specific social risk. This model divides total wages paid out by a country and sector per dollar of output based on the input-output model (Norris, 2006) (fig. 4).

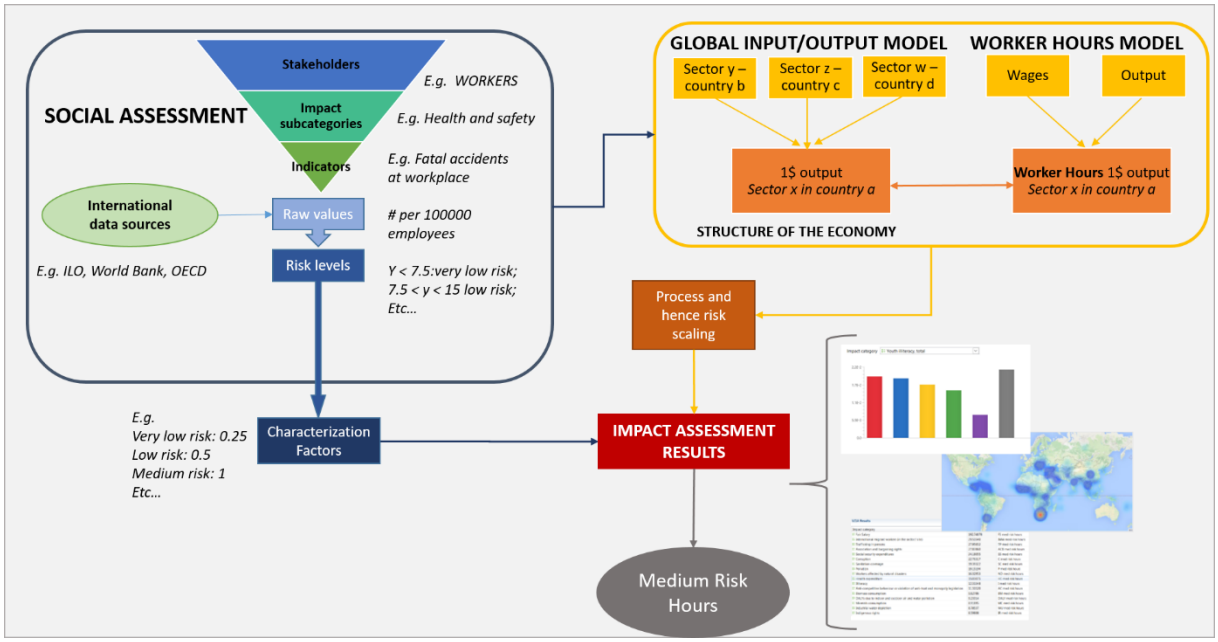

Figure 4: Social database and modelling framework

6.2. Description of available SLCA databases

The currently available SLCA databases are PSILCA (the Product Social Impact Life Cycle Assessment database) and SHDB (Social Hotspot Database). In this section we describe the main features of both, providing more details for PSILCA, which was used for analysing social risk in raw materials sector supply chains. The underlying reasons for this choice are the following:

- most updated available data source
- transparent documentation of original data sources and risk assessment
- provision of data quality assessment.

The SHDB is used in this report to compare the results of the assessment from PSILCA, evaluate possible sources of uncertainty and discuss the robustness of the analysis (section 8).

6.2.1. PSILCA Database

PSILCA - the Product Social Impact Life Cycle Assessment database - is a repository of data for Social LCA developed by GreenDelta GmbH. It provides information on social aspects of products over their life cycles. Similar to the SHDB, it integrates social indicators with also a global input/output model representing the structure of the world economy.

The EORA Multi-Regional Input/Output (MRIO) database (Lenzen et al., 2013) is used as input–output model. It represents the interdependencies between different branches of a national economy or different regional economies (Raa, 2009). Eora database covers 187 countries with a list of 15,909 sectors and uses monetary flows, expressed in US dollars, to link processes among different sectors and countries.

Since PSILCA provides comprehensive data for a broad range of industry sectors worldwide it is also relevant for the application in the field of sustainability policies. Governments can reveal potential social risks in specific sectors of their trading partners or identify high-risk contributing sectorial flows to production in individual countries (Sala et al., 2015).

- ***Stakeholders, impact subcategories and indicators in PSILCA***

PSILCA provides social indicators for a set of stakeholders and impact subcategories, based on the list from the UNEP/SETAC Guidelines (Table 5). Each subcategory is accounted by a set of social indicators, for a total of 88 qualitative and quantitative indicators, applied to the whole set of Country-Sector combinations available in the Eora database. Definitions, units of measurement, data sources of each indicator are described in detail in a documentation of PSILCA (Ciroth and Eisfeld, 2016) that is available also online[17].

[17] https://www.greendelta.com/

Table 5 PSILCA database structure: stakeholders, subcategories and indicators

Stakeholder	Subcategory	Indicator
WORKERS	Child labour	Children in employment, male
		Children in employment, female
		Children in employment, total
	Forced labour	Goods produced by forced labour
		Frequency of forced labour
		Tier placement referring to trafficking in persons
	Fair salary	Living wage, per month
		Minimum wage, per month
		Sector average wage, per month
	Working time	Hours of work per employee, per day
		Hours of work per employee, per week
		Standard daily hours
		Standard weekly hours
	Discrimination	Occurrence of discrimination
		Women in the labour force
		Men in the labour force
		Gender wage gap
	Health and Safety	Accident rate at workplace
		Fatal accidents at workplace
		Occupational risks
		DALYs due to indoor and outdoor air and water pollution
		Presence of sufficient safety measures
		Workers affected by natural disasters
	Social benefits, legal issues	Social security expenditures
		Evidence of violations of laws and employment regulations
		Workers with a contract
	Workers´ rights	Trade union density
		Right of Association
		Right of Collective bargaining
		Right of Collective bargaining
		Existence of standard rates
		Number of labour unions
VALUE CHAIN ACTORS	Fair competition	Presence of anti-competitive behaviour or violation of anti-trust and monopoly legislation
		Presence of policies to prevent anti-competitive behaviour
	Corruption	Public sector corruption
		Active involvement of enterprises in corruption and bribery
	Promoting social responsibility	Presence of codes of conduct that protect human rights of workers among suppliers
		Membership in an initiative that promotes social responsibility along the supply chain
	Supplier relationships	Interaction of the companies with suppliers
SOCIETY	Contribution to economic development	Economic situation of the country
		Contribution of the sector to economic development
		Public expenditure on education
		Adult illiteracy rate (15+ years), male
		Adult illiteracy rate (15+ years), female
		Adult illiteracy rate (15+ years), total
		Youth illiteracy rate, male
		Youth illiteracy rate, female
		Youth illiteracy rate, total
	Health and Safety	Health expenditure, total
		Health expenditure, public
		Health expenditure, out-of-pocket
		Health expenditure, external resources
		Life expectancy at birth
	Prevention and mitigation of conflicts	Risk of conflicts with regard to the sector
LOCAL COMMUNITY	Access to material resources	Level of industrial water use (related to total withdrawal)
		Level of industrial water use (related to renewable water resources)
		Extraction of biomass (related to area)
		Extraction of biomass (related to population)

Stakeholder	Subcategory	Indicator
		Extraction of fossil fuels
		Extraction of industrial and construction minerals
		Extraction of ores
		Certified environmental management systems (CMEs)
		Description of (potential) material resource conflicts
	Respect of indigenous rights	Presence of indigenous population
		Human rights issues faced by indigenous people
		(Company´s) respect of indigenous rights
	Safe and healthy living conditions	Pollution level of the country
		Contribution of the sector to environmental load
		Drinking water coverage
		Sanitation coverage
		Management effort to improve environmental performance
	Local employment	Unemployment rate in the country
		Work force hired locally
		Percentage of spending on locally based suppliers
	Migration	International migrant workers in the sector
		International Migrant Stock
		Net migration rate
		Emigration rate
		Immigration rate
		Human rights issues faced by migrants
CONSUMERS	Health and Safety	Violations of mandatory health and safety standards
		Presence of commissions or institutions to detect violations of standards and protect consumers from health and safety risks
		Presence of management measures to assess consumer health and safety
	Transparency	Presence of business practices that are deceptive or unfair to consumers
		Presence of certifications or labels for the product/sites sector
		Presence of a law or norm regarding transparency (by country and/or sector)
	End of life responsibility	Strength of national legislation covering product disposal and recycling

The database gathers data from a variety of sources. Among others, databases from international organizations like World Bank, International Labour Organization, World Health Organization and Organization for the Economic Cooperation and Development are frequently used. Other sources include governmental databases, public records on e.g., Environmental Health and Safety (EHS) violations, company or industry databases.

For all indicators, the raw, unassessed values are provided, together with an indication of its quality.

For some indicators only proxies are available and for others values have been conferred through normalization, attribution and extrapolation. Normalization is necessary when values are dependent on the size of the system. Attribution and extrapolation are used when there is a different level of detail between sources and Eora database (e.g. raw data is available for only a few sectors of a country existing in Eora database or raw data is not available for a country in Eora or in any its sectors).

- ***Risk assessment and data quality***

Each Country-Specific Sector (CSS) is characterized for the whole set of indicators, using raw data from various sources (e.g., "number of fatal accidents for Country x and Sector y"). In the database these raw values are associated to risk levels that are assigned based on risk assessment schemes.

There are, typically, 6 different levels distinguished on a negative scale: no risk, very low risk, low risk, medium risk, high risk, and very high risk. For some indicators, also a positive scale is used as the indicator result may reflect a positive social impact. In this case the

levels are high opportunity, medium opportunity and low opportunity. When data are not available and processes of attribution or extrapolation are not applicable because it could not make sense, "no data" assignment is given to indicators. The assignment of risk levels to the indicator values is based on international conventions and standards, labour laws, expert opinions but also own experience and evaluation. Due to the subjective nature and dependence on cultural and even individual evaluation and conventions, in PSILCA, the risk levels can be modified individually to better reflect e.g. specific goal and scope of a study.

For each data point, PSILCA provides information on the data quality, based on the reliability of the source, completeness, temporal, geographical and technical conformance (table 21 in Appendix). Data quality is based on the pedigree matrix that was introduced to LCA for quality assurance (Weidema and Wesnæs, 1996).

- ***Activity variables***

An activity variable is "*a measure of process activity or scale which can be related to process output. Activity variables, scaled by the output of each relevant process, are used to reflect the share of a given activity associated with each unit process. Thus, for attributes concerning labor conditions, a relevant activity variable is worker-hours. Process-specific coefficients of worker-hours per unit of process output are used to estimate the share of total life cycle worker-hours associated with each unit process*" (UNEP/SETAC Life Cycle Initiative, 2009). Therefore, activity variables are necessary to describe the relevance of impacts caused by a process in a life cycle (Norris, 2006).

So far, worker hours are the unique activity variable, but other options are under investigation. In PSILCA database, worker hours are related to 1 US$ of process (or sector) output. The worker hours were not directly available from an external source, but are calculated for the database, as follows:

$$Worker\ hours = \frac{Unit\ labour\ costs}{Mean\ hourly\ labour\ cost\ (per\ employee)}$$

$$Unit\ labour\ force = \frac{Compensation\ of\ employees(US\$\ per\ countryspecific\ sector\ and\ year)}{Gross\ output\ (in\ US\$\ per\ country-sector\ and\ year)}$$

Data for "compensation for employees" are from the Eora satellite accounts. The category follows the definitions of United Nations' System of National Accounts: "*compensation of employees is defined as the total remuneration, in cash or in kind, payable by an enterprise to an employee in return for work done by the latter during the accounting period*." (EC, OECD, 2008) From this definition, compensation of employees consists of two main components: wages, salaries in cash or in kind and social insurance. According to UN SNA, "gross output" is equal to the intermediate consumption plus value added for each group of producing unit (industry). The gross output for all sectors and countries was calculated from Eora.

Data on "mean nominal hourly labour cost per employee" are available from the International Labour Organization (ILO, 2015). Labour cost "*comprises remuneration for work performed, payments in respect of time paid for but not worked, bonuses and gratuities, the cost of food, drink and other payments in kind, cost of workers' housing borne by employers, employers' social security expenditures, cost to the employer for vocational training, welfare services and miscellaneous items, such as transport of workers, work clothes and recruitment, together with taxes regarded as labour cost*"

In some case, data for the mean labour costs was only available for years before 2011; in these cases, the most recent value available was chosen and extrapolated to 2011 assuming a wage increase of 3% per year. After that, all given values were converted to

US$, using a currency converter, usually with the currency exchange rate from 31.12.2011 (Ciroth and Eisfeldt, 2016). Eora sectors without an equivalent in the "Mean hourly labour cost per employee" were assigned a mean value (arithmetic mean) of hourly labour cost over all the other sectors within the country. There are some values extremely small belonging typically to sectors related to export or import; some values are rather high, but not completely unrealistic, e.g. for countries where mean hourly labour cost is very low.

A simple impact assessment method allows to summarise risk-assessed indicators. Users can also create their own impact assessment method.

6.2.2. Social Hotspots Database

Social Hotspot Database (SHDB) is a project centred at New Earth, a U.S. based not-for-profit company focused on information systems for sustainability. In 2009, New Earth developed the Social Hotspots database and in 2013 it was issued. It works in LCA software. Since 2013, New Earth has been working on updates and further development of the database and making it available with different product system models.

The SHDB system current Global IO model is based on the Global Trade Analysis Project Version 7, a global economic equilibrium model, with reference year of 2002.

The total database contains data for 57 different sectors, for each of 113 different regions; most of these regions correspond to individual countries while others are regions containing multiple countries. Thus, there are 6441 country-specific sectors in the database.

The labour intensity data were developed by converting GTAP data on wage payments into estimates of worker hours, skilled and unskilled, for each sector in each GTAP country/region. This was made possible by compiling and using wage rate data, for skilled and unskilled labour, by sector and region. These labour hour intensity factors are used together with the social risk level characterizations, in order to express social risks and opportunities in terms of work hours, by sector and country, at a given level of risk relative to each of over 22 social impact subcategories and nearly 150 different indicators. Only risk-assessed indicators are available in the database, the raw indicator values are not provided.

The risk data addresses five main impact categories:

- Labour rights and decent work
- Human rights
- Health and safety
- Governance and community

The SHDB project draws data sources ranging from the International Labor Organization, the World Health Organization, the U.S. Department of Labor and State, the World Bank, etc. Quantitative statistics and qualitative information by country and sector are used to develop characterization models. These models assign a risk (or opportunity) level to the data so that users can identify target areas in their supply chains to verify or improve social conditions.

The SHDB is based upon life cycle attribute assessment (LCAA), a methodology developed by Norris (2006). Each unit process (so called country-specific sector, CSS) has a number of different attributes, or characteristics, relative to a large set of social issues. The activity variable used in the SHDB is worker hours. Thus, the SHDB can be used to identify how many worker-hours are involved for each unit process in the supply chain, for a given final demand (final product or service output from the system). The socio sphere flows are expressed as worker-hours at a specified level of risk on a given risk indicator, per US $ of process output.

A social life cycle impact assessment method based on New Earth's Social Hotspots Index makes it possible to get results on 5 impact categories in addition to disaggregated results

by theme and indicator. Users also have the possibility to create and implement their own impact assessment method (Sala et al., 2015).

6.3. Application of PSILCA for the analysis of raw materials supply chains

In this study, the SLCA methodology was applied using a top-down approach. Data on social aspects and supply chains' structure are from PSILCA database. The following sections explain the choice of countries and sectors used for the international comparison, the selection of impact subcategories of interest, and how the European countries were aggregated in order to study the "EU supply chain" for various raw materials sectors.

6.3.1. Selection of countries and sectors for international comparison

The analysis of the social performance of raw materials supply chains includes the EU-28 and six extra-EU producing countries. The selected extra-EU countries are the main non-energy raw material producers, according to World Mining Data (Reichl et al., 2017):

- Australia
- Brazil
- China
- Russian Federation
- South Africa
- United States

For the selection of sectors, the focus of the analysis reflects the coverage of the European Raw Materials policy strategy, which includes non-energy, non-agricultural raw materials. Consequently, our choice of sectors included both abiotic and biotic resources (metals, non-metallic minerals, wood, paper) in the extractive and manufacturing stage (i.e. mining and quarrying, forestry and logging, raw materials manufacturing). The resulting list of sectors is the following:

- Mining and quarrying
- Manufacture of basic metals
- Manufacture of non-metallic mineral products
- Forestry and logging
- Manufacture of paper and paper products
- Manufacture of wood and of products of wood

We mapped these sectors with corresponding Country-Specific Sectors (CSS) available in PSILCA.

As explained above, PSILCA has a highly detailed list of CSS (as in the underlying Input/output model), therefore several PSILCA processes refer to a single sector from those identified in our list. For instance, in the case of Australia, the "manufacture of basic metals" sector can be mapped with a set of PSILCA processes including "Nickel", "Aluminium", "Copper, silver, lead and zinc", "precious metals".

6.3.2. Choice of relevant impact categories

In a review of social impacts in the mining sector (Mancini and Sala 2018), we identified the main thematic areas where social impacts were reported in the fifty selected studies. As outlined in fig. 5 according to this study the areas where impacts most frequently occur are: economy, income and security; employment and education; land use and territorial aspects. However, the study also discloses that the area "economy, income and security" is poorly represented in the SLCA databases, in particular with respect to positive impacts.

Looking at specific impacts, the 15 most reported in the studies under investigation are presented in fig. 6.

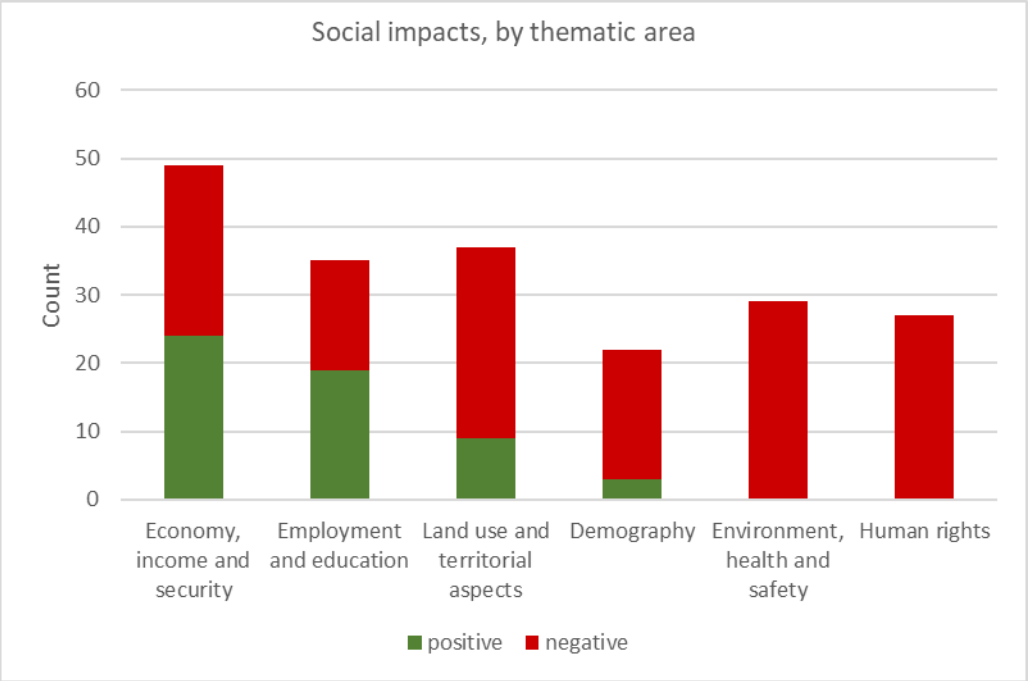

Figure 5 Number of positive and negative impacts in the selected studies, by macro area of impact (Mancini and Sala, 2018).

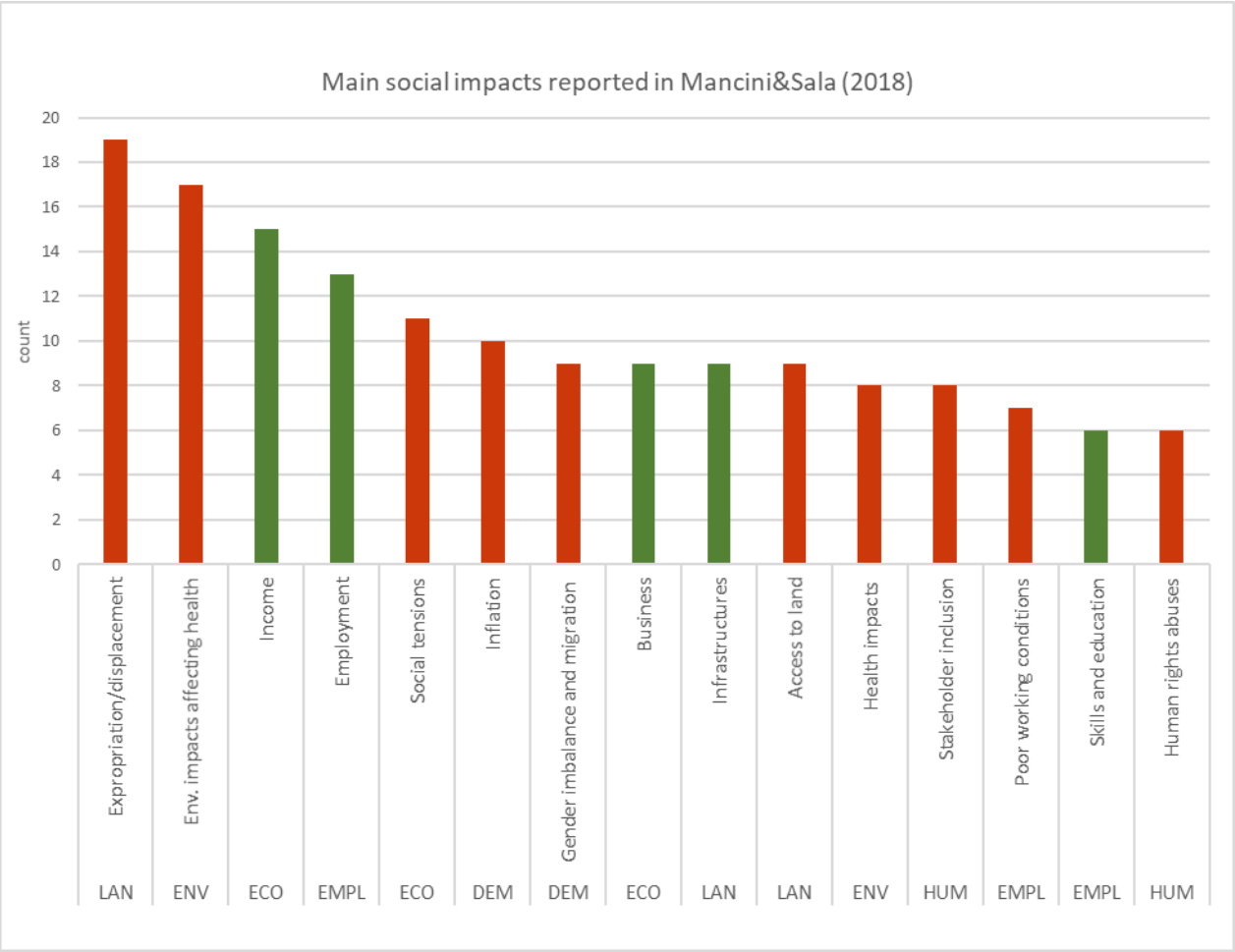

Figure 6 Most reported social impacts according to a literature review on mining (Mancini and Sala 2018). (Red bar: negative impact; green bar: positive impact; Legend of thematic areas: LAN: Land use and territorial aspects; ENV: Environment, health and safety; ECON: Economy, income, security; EMPL: Employment and education; DEM: Demography; HUM: Human rights)

In order to select the impact categories for the evaluation of social risk in the raw materials sectors from PSILCA, we developed a set of seven criteria (table 6). They refer to the relevance of the topic for the RM supply chains and policy, the quality and completeness of impact assessment method used to assess the social risk and the quality of the data available in the database.

Table 6 Set of criteria and references for the evaluation

CRITERIA		**Assessment scheme**
RELEVANCE	**1. Relevance for the RM supply chain:** each impact category is assessed based on its link with and pertinence to the RM sectors.	**GOOD**: the impact category is closely related to the sector performance and output **MEDIUM**: the topic of the impact category is pertinent to the RM sector, but not influenced by its performance **LOW**: the impact category is weakly related to the RM sector performance
	2. Policy relevance : each impact category is assessed based on the importance of the theme from a policy perspective (based on authors' judgement)	**GOOD**: the impact category represents a relevant issue for the EU policy, its meaning can be easily understood and accepted **MEDIUM**: the issue represented by the impact category has an average interest for policy **LOW**: the issue represented by the impact category has low policy relevance
IMPACT ASSESSMENT	**3. Link between topic and the indicators:** within each impact category, it is assessed if the indicators proposed in PSILCA have a direct link with the topic of the impact category	**GOOD:** The indicators properly represent and measure the issue described by the impact subcategory. **MEDIUM**: Partly proxy variables are used to measure the issue described by the impact subcategory. **LOW**: Weak link between the indicators and the issue described by the impact subcategory
	4. Basis for indicator risk assessment: for each indicator, it evaluates if the scheme used to assign the risk level is based on reference values used elsewhere or if it is based on own judgement	**GOOD**: Performance reference points are used for the assignment of risk levels. **MEDIUM**: Proxy variables are used for the risk assessment. **LOW**: Risk assessment is based on expert judgement or equal distribution of the values.
DATA QUALITY CRITERIA	**5. Reliability of the data sources:** for each indicator, it assesses if data providers are reliable sources	**GOOD**: Data are provided by recognized official statistical agencies or by primary data collection **MEDIUM**: Secondary data from official public or private sources **LOW**: Non-verified data partly based on assumptions or data from non-recognized sources or qualified estimates
	6. Appropriate geographic and technical resolution of the indicator data: it assesses if the indicators used in each impact category are country and sector specific	**GOOD**: Data is mainly country- and sector-specific or is at least derived from a similar sector (according to values 1 and 2 of PSILCA data quality assessment) **MEDIUM**: Data is mainly country-specific but represent mainly averages of similar sectors **LOW**: Data is rarely country-specific and mainly represent averages of different sectors

We evaluated the impact subcategories available in PSILCA based on the above described criteria, assigning single scores for each criterion (good=2, medium=1, low=0). All the criteria had the same weight. For criteria 3 and 4, a score was assigned to all indicators within the impact subcategory, and the average among the indicators scores was used for the corresponding impact subcategory (see table 16 in Appendix).

Nine subcategories with the highest rank have been selected for this initial assessment. From now on, we will call them just "categories". The * indicates categories emerged as important also in the literature review, as in fig. 6:

- Health and Safety *
- Freedom of association and collective bargaining
- Child labour
- Fair salary *
- Working time *
- Respect of indigenous rights *
- Migration *
- Corruption

- Contribution to economic development *

Out of nine, six of these categories are also within the list of most frequent impacts detected in the literature review (see figure 6 above). In particular, the contribution to economic development (in terms of income and employment creation from the sector) emerged as a very relevant aspect in the review. Demographic aspects were also flagged as important in the review (even though the specific data availability in the SLCA databases in field is limited), together with working conditions (in terms of health and safety of workers, working time, fair salary), and indigenous rights (relevant especially for the extractive sector, i.e. mining and forestry).

Table 7 presents the full list of impact categories and related indicators, unit of measurement and data sources used for the analysis. For each indicator, table 8 details the risk assessment scheme, i.e. the risk level (from very low, to very high) corresponding to the indicator value. Typically, 6 different levels are distinguished on a negative scale: no risk, very low risk, low risk, medium risk, high risk, and very high risk. For some indicators (in the selected set of indicators, only one indicator within the "contribution to economic development" category) an opportunity scale is used and planned as the indicator result may reflect a positive social impact. The levels used are high, medium and low opportunity. The assignment of risk levels to the indicator values is based on international conventions and standards, labour laws, expert opinions but also own experience and evaluation. Of course, as it is inherent in the nature of social LCA, this risk assessment is to some extent subjective and dependent on cultural and even individual evaluations and conventions. In PSICLA, therefore, the risk levels can be modified individually to better reflect e.g. specific goal and scope of a study.

Each risk/opportunity level is translated in a quantitative metric using characterization factors[18] (table 18 in Appendix). For instance, if the cases of fatal accidents in a certain sector and country are equal or exceed 40 in a year, the assigned risk level is "very high". The factor corresponding to very high risk level for fatal accidents is 10. The attribution of a quantitative factor allows the aggregation of supply chain segments along the value chain in terms of risk values. For each indicator, the final result represent the aggregated risk value of each country-sector included in the supply chain. The indicators belonging to the same impact category are then aggregated in order to get a single risk value for each category. In case of lack of data the applied factor is 0.1.

[18] Factor derived from a characterization model which is applied to convert an assigned life cycle inventory analysis result to the common unit of the category and/or subcategory indicator. ISO 14040 (2006)

Table 7 Selected impact categories with corresponding indicators, units of measurement and main data sources

Stakeholders	Impact category	Indicator	Unit of measurement	Main data sources
WORKERS	Health and Safety	Rate of non-fatal accidents at workplace	Cases per 100,000 employees and year	ILOstat 2017
		Rate of fatal accidents at workplace	Cases per 100,000 employees and year	
		DALYs due to indoor and outdoor air and water pollution	DALYs per 1,000 inhabitants in the country	WHO 2009
		Presence of sufficient safety measures	OSHA cases per 100,000 employees in the sector	United States Department of Labor (USDOL) 2014: Occupational Safety and Health Administration (OSHA)
		Workers affected by natural disasters	Affected persons as % of whole population between 2012 and 2014	EM_DAT – The International Disaster Database 2015
	Freedom of association and collective bargaining	Trade union density	% of employees organised in trade unions	ILOstat 2017
		Right of Association	Score of ordinal scale 0-3 scale	University of Amsterdam: ICTWSS: Database on Institutional Characteristics of Trade Unions, Wage Setting, State Intervention and Social Pacts in 51 countries between 1960 and 2013
		Right of Collective bargaining	Score of ordinal scale 0-3 scale	
		Right to strike	Score of ordinal scale 0-3 scale	
	Child labour	Child labour, total	% of all children ages 7-14	World Bank 2017
	Fair salary	Living wage, per month	USD	WageIndicator 2017
		Minimum wage, per month	USD	
		Sector average wage, per month	USD	ILOstat 2017
	Working time	Hours of work per employee, per week	H	
LOCAL COMMUNITIES	Respect of indigenous rights	Presence of indigenous population	Y/N	Wikipedia 2015; ; Office of the United Nations High Commissioner for Human Rights (OHCHR) 2015; ILO 1989: Indigenous Peoples Convention; UN Declaration of indigenous rights; United Nations Department of Economic and Social Affairs (UN-DESA)
		Human right issues faced by indigenous people	Score	
	Migration	International migrant workers in the sector	% (employed international migrant population related to total employed population)	ILO 2017
		International Migrant Stock	% (of total population)	World Bank 2017
		Net migration rate	% (= per 1,000 persons)	World Factbook 2017
VALUE CHAIN ACTORS	Corruption	Public sector corruption	Score (Corruption Perception Index score of the country)	Transparency International 2012
		Active involvement of enterprises in corruption and bribery	% of sector- related cases out of all registered foreign bribery cases	OECD 2014
SOCIETY	Contribution to economic development	Contribution of the sector to economic development	% of GDP	UNSTAT 2017
		Public expenditure on education	% of GDP	UNESCO 2017
		Adult illiteracy rate (15+ years), male	% of male population	
		Adult illiteracy rate (15+ years), female	% of female population	
		Adult illiteracy rate (15+ years), total	% of total population	
		Youth illiteracy rate, male	% of male population, 15-24	
		Youth illiteracy rate, female	% of female population, 15-24	
		Youth illiteracy rate, total	% of total population, 15-24	

Table 8 Risk assessment scheme applied for each indicator used in PSILCA (nr: no risk; vlr: very low risk; lr: low risk; mr: medium risk; hr: high risk; vhr: very high risk)

Indicator	Unit of measurement	Risk assessment
Rate of non-fatal accidents at workplace	Cases per 100,000 employees and year	0≤y<750 → vlr; 750≤y<1500 → lr; 1500≤y<2250 → mr; 2250≤y<3000 → hr; 3000≤y → vhr
Rate of fatal accidents at workplace	Cases per 100,000 employees and year	0≤y<7.5 → vlr; 7.5≤y<15 → lr; 15≤y<25 → mr; 25≤y<40 → hr; 40≤y → vhr
DALYs due to indoor and outdoor air and water pollution	DALYs per 1,000 inhabitants in the country	0=y → nr; 0<y<5 → vlr; 5<y<15 → lr; 15<y<30 → mr; 30<y<50 → hr; 50≤y → vhr
Presence of sufficient safety measures	OSHA cases per 100,000 employees in the sector	0<y<100 → vlr 100≤y<300 → lr 300≤y<600 → mr 600≤y<1000 → hr 1000≤y → vhr
Workers affected by natural disasters	Affected persons as % of whole population between 2012 and 2014	0≤y<1 → vlr; 1≤y<3 → lr; 3≤y<5 → mr; 5≤y<10 → hr; 10≤y → vhr
Trade union density	% of employees organised in trade unions	20≥y →vhr; 20<y≤40 → hr; 40<y≤60 → mr; 60<y≤80→ lr; 80>y → vlr
Right of Association	score of ordinal 0-3 scale	0=No; 1=Yes, with major restrictions; 2=Yes, with minor restrictions; 3=Yes
Right of Collective bargaining	score of ordinal 0-3 scale	
Right to strike	score of ordinal 0-3 scale	
Child labour, total	% of all children 7-14	0=y → nr; 0<y<2.5 → vlr; 2.5<y<5 → lr; 5<y<10 → mr; 10<y<20 → hr; 20≤y → vhr
Living wage, per month	USD	y<100 → vlr; 100≤y<200 → lr; 200≤y500 → mr; 500≤y1000 → hr; 1000≤y → vhr
Minimum wage, per month	USD	1000≤y → vlr; 500≤y<1000 → lr; 300≤y<500 → mr; 200≤y<300 → hr; y<200 → vhr; If Living wage (LW) is available: x=LW/MW; x<0.5 → vlr; y>300 AND 0.5≤x<0.9 → lr; (y≤300 AND 0.5≤x≤0.9) OR (y>300 AND 0.9≤x<0.3) → mr; (y≤300 AND 0.9≤x≤1.3) OR (y>300 AND 1.3≤x<1.8) → hr; (y≤300 AND 1.3≤x≤1.8) OR (x≥1.8) → vhr;
Sector average wage, per month	USD	0<y<1 → vhr; 1≤y<1.5 → hr; 1.5≤y<2 → mr 2≤y<2.5 → lr; 2.5≤y → vlr
Hours of work per employee, per week	h	40≤y<48 → lr; 30≤y<40 OR 48≤y<55 → mr; 20≤y<30 OR 55≤y<60 → hr; 60≤y vhr
Presence of indigenous population	Y/N	No=nr; Yes=mr
Human rights issues faced by indigenous people	Score	y=5 → vlr; y=4 → lr; y=3 → mr; y=2 → hr; y+1 OR 0 → vhr
International migrant workers in the sector	% (employed international migrant population related to total employed population)	Difference x to migrant stock, % y=0 → nr 0<y≤2.5 AND x≤|5|→ vlr 2.5<y≤5 AND x≤|5|→ lr 5<y≤10 AND (x≤|5|OR |5|<y≤|10|) → mr 10<y≤20 AND (x≤|5|OR |10|<y≤|15|) → hr y≥20 AND x≤|15|→ vhr
International migrant stock	% (of total population)	0=y → nr; 0<y<2.5 → vlr; 2.5≤y<5 → lr; 5≤y<10 → mr; 10≤y<20 → hr; 20≤y → vhr
Net migration rate	‰ (= per 1,000 persons)	0=y → nr 0<y<|2.5|→ vlr |2.5|≤y<|5|→ lr |5|≤y<|10|→ mr |10|≤y<|15|→ hr |15|≤y → vhr
Public sector corruption	Score (Corruption Perceptions Index score of the country)	100≥y≥85 → vlr; 84≥y≥75 → lr; 74≥y≥65 → mr 64≥y≥55 →hr; 55≥y → vhr
Active involvement of enterprises in corruption and bribery	% of sector-related cases out of all registered foreign bribery cases	0<y≤3 → vlr; 3<y≤7 → lr; 7<y≤11 → mr; 11<y≤14 → hr; 14<y → vhr
Contribution of the sector to economic development	% of GDP	0≤y<1 → no opportunity; 1≤y≤10 → low opportunity; 10<y≤25 → medium opportunity 25<y → high opportunity
Public expenditure on education	% of GDP	0≤y<2.5 → vhr; 2.5≤y<5 → hr; 5≤y<7.5 → mr 7.5≤y<10 → lr; 10≤y → vlr

Indicator	Unit of measurement	Risk assessment
Adult illiteracy rate (15+ years), male	% of male population	0≤y<1 → vlr; 1≤y<4 → lr; 4≤y<8 → mr; 8≤y<15 → hr; 15≤y → vhr
Adult illiteracy rate (15+ years), female	% of female population	
Adult illiteracy rate (15+ years), total	% of total population	
Youth illiteracy rate, male	% of male population, 15-24	
Youth illiteracy rate, female	% of female population, 15-24	
Youth illiteracy rate, total	% of total population, 15-24	

6.3.3. Aggregation of EU countries

The objective of the analysis is to assess social risk of the European raw materials sectors, on average. As data in PSILCA are provided by country, the 28 EU countries have been aggregated in a weighted average. The production values for each economic sector, scaled to 1, are used as weighting factors. Each fraction represents the country contribution to the total EU supply.

The data source for the production value is Eurostat "Annual enterprise statistics for special aggregates of activities (NACE Rev. 2)". 2014 or latest available year was used for the calculation of weighting values. Table 9 presents the weighting values applied in the analysis for the different sectors.

No specific values were available for "Forestry and Logging", "Manufacture of wood and of products of wood and cork" and "Manufacture of non-metallic mineral products". Hence, values from the "Manufacture of paper and paper products" sector were used for the aggregation of "Forestry and Logging" and "Manufacture of wood and of products of wood and cork"; "Manufacture of non-metallic mineral products" used the same values as "Manufacture of fabricated metal products, except machinery and equipment".

Table 9 Weighting factors used for the EU-28 average

	Forestry	Mining and quarrying	Manufacture of paper and paper products	Manufacture of basic metals	Manufacture of non-metallic mineral products	Manufacture of wood and of products of wood and cork
Belgium	2.7E-02	4.7E-03	2.7E-02	5.3E-02	2.5E-02	2.7E-02
Bulgaria	3.0E-03	5.9E-03	3.0E-03	1.1E-02	3.4E-03	3.0E-03
Czech Republic	1.5E-02	1.7E-02	1.5E-02	2.2E-02	2.6E-02	1.5E-02
Denmark	7.6E-03	3.9E-02	7.6E-03	3.8E-03	1.4E-02	7.6E-03
Germany	2.2E-01	6.3E-02	2.2E-01	2.9E-01	2.7E-01	2.2E-01
Estonia	1.2E-03	1.6E-03	1.2E-03	2.2E-04	2.3E-03	1.2E-03
Ireland	2.8E-03	5.5E-03	2.8E-03	2.1E-03	4.4E-03	2.8E-03
Greece	6.9E-03	4.5E-03	6.9E-03	1.3E-02	6.3E-03	6.9E-03
Spain	6.9E-02	2.4E-02	6.9E-02	8.3E-02	6.2E-02	6.9E-02
France	1.0E-01	3.6E-02	1.0E-01	8.3E-02	1.2E-01	1.0E-01
Croatia	2.1E-03	1.9E-02	2.1E-03	1.1E-03	3.0E-03	2.1E-03
Italy	1.3E-01	2.6E-01	1.3E-01	1.6E-01	1.7E-01	1.3E-01
Cyprus	2.9E-04	4.4E-04	2.9E-04	1.5E-04	4.3E-04	2.9E-04
Latvia	7.1E-04	7.3E-04	7.1E-04	3.5E-04	1.3E-03	7.1E-04
Lithuania	2.3E-03	7.9E-04	2.3E-03	2.0E-04	1.4E-03	2.3E-03
Luxembourg	3.5E-04	-	-	1.5E-03	1.5E-03	-
Hungary	8.3E-03	1.7E-03	8.3E-03	7.6E-03	8.3E-03	8.3E-03
Malta	-	-	-	2.7E-06	2.0E-04	-
Netherlands	4.0E-02	9.7E-02	4.0E-02	2.2E-02	4.0E-02	4.0E-02
Austria	3.5E-02	1.1E-02	3.5E-02	4.5E-02	3.0E-02	3.5E-02
Poland	4.8E-02	6.6E-02	4.8E-02	3.2E-02	4.3E-02	4.8E-02
Portugal	2.2E-02	6.0E-03	2.2E-02	7.2E-03	1.2E-02	2.2E-02
Romania	5.1E-03	2.8E-02	5.1E-03	1.3E-02	8.4E-03	5.1E-03
Slovenia	4.4E-03	1.5E-03	4.4E-03	4.7E-03	6.5E-03	4.4E-03
Slovakia	7.2E-03	2.5E-03	7.2E-03	1.2E-02	1.1E-02	7.2E-03
Finland	8.1E-02	8.4E-03	8.1E-02	2.7E-02	1.4E-02	8.1E-02
Sweden	8.3E-02	2.4E-02	8.3E-02	3.8E-02	3.0E-02	8.3E-02
United Kingdom	7.5E-02	2.7E-01	7.5E-02	6.5E-02	9.2E-02	7.5E-02

7. Results

The sectors and countries selected for the investigation were compared based on their social risk, for a set of impact subcategories (as in table 7). The analysis has a life cycle approach, thus social risk results include the contribution of the upstream phases in the different supply chains (e.g. energy, equipment, parts, construction materials). The first section of this chapter compares the various economic sectors in all countries under investigation. The second part focuses on the EU sectors, while the third part presents a contribution analysis, taking into account upstream phases of the supply chains.

7.1. International comparison

Figures 7-13 show the overall social risks for nine impact categories, in the raw materials sectors and their supply chains, for the EU-28 and 6 extra-EU countries. Each figure represents one of the selected raw materials sectors, while figure 13 displays the sum of the social risk in all countries and sectors. The various impact categories are displayed on the x-axis and the respective social risks for the separate countries can be compared on the basis of the coloured bars. Social risk is measured in medium risk hours, which is the number of worker hours along the supply chain that are characterized by a certain social risk. Therefore, higher values correspond to higher risks (i.e. more negative performance). Given the sensitiveness of the topic, country names are not displayed in the figures.

The following general considerations can be drawn:

- Risk hotspots appear in the impact subcategories "fair salary", "corruption", "freedom of association" and "health and safety" in most of the sectors (fig. 13).
- Impact on "working time" is negligible, compared to other subcategories using the approach adopted here (fig. 13).
- Risk hotspots in specific countries concern: country "E" for "child labour"; country "C" for "freedom of association and collective bargaining", country "F" for "respect of indigenous rights" (fig. 7-12).
- The EU region shows a very low risk, compared to other countries, in almost all the sectors under investigation. Only for the mining and quarrying sector, for some impact categories (e.g. corruption and health and safety) risk is higher than other countries (especially A and F) (fig. 7-12).

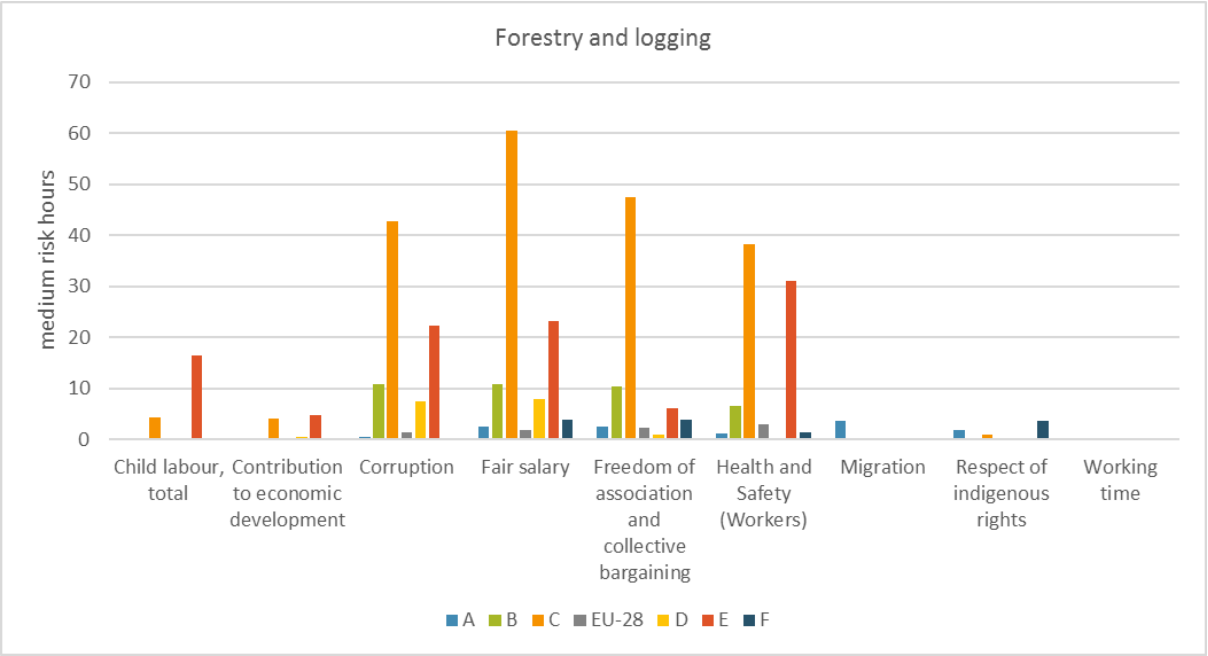

Figure 7 Life cycle-based results on social risk associated to the forestry and logging sector, in all selected countries and in EU-28

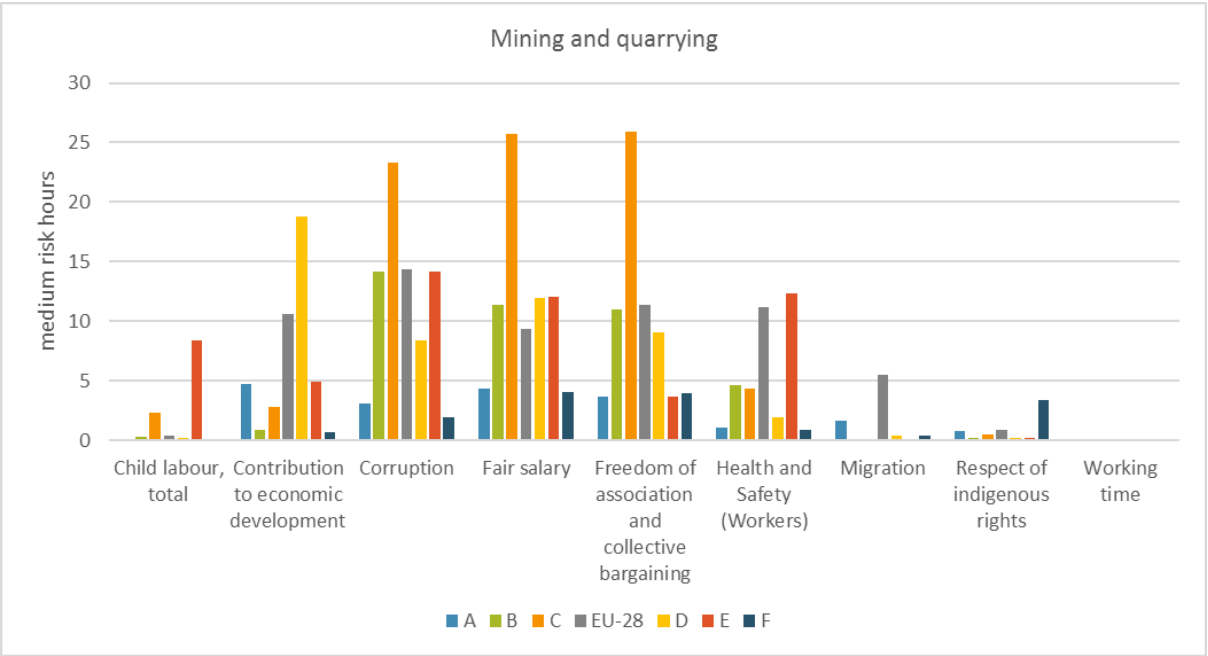

Figure 8 Life cycle-based results on social risk associated to the mining and quarrying sector, in all selected countries and in EU-28

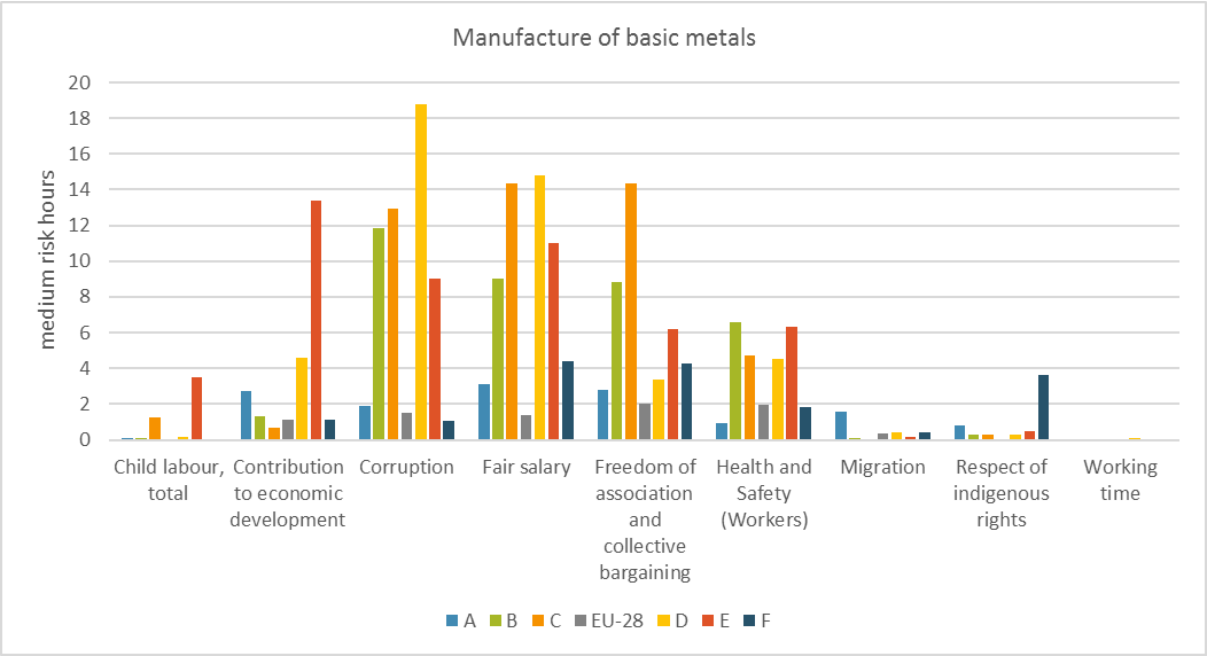

Figure 9 Life cycle-based results on social risk associated to the metals manufacturing sector, in all selected countries and in EU-28

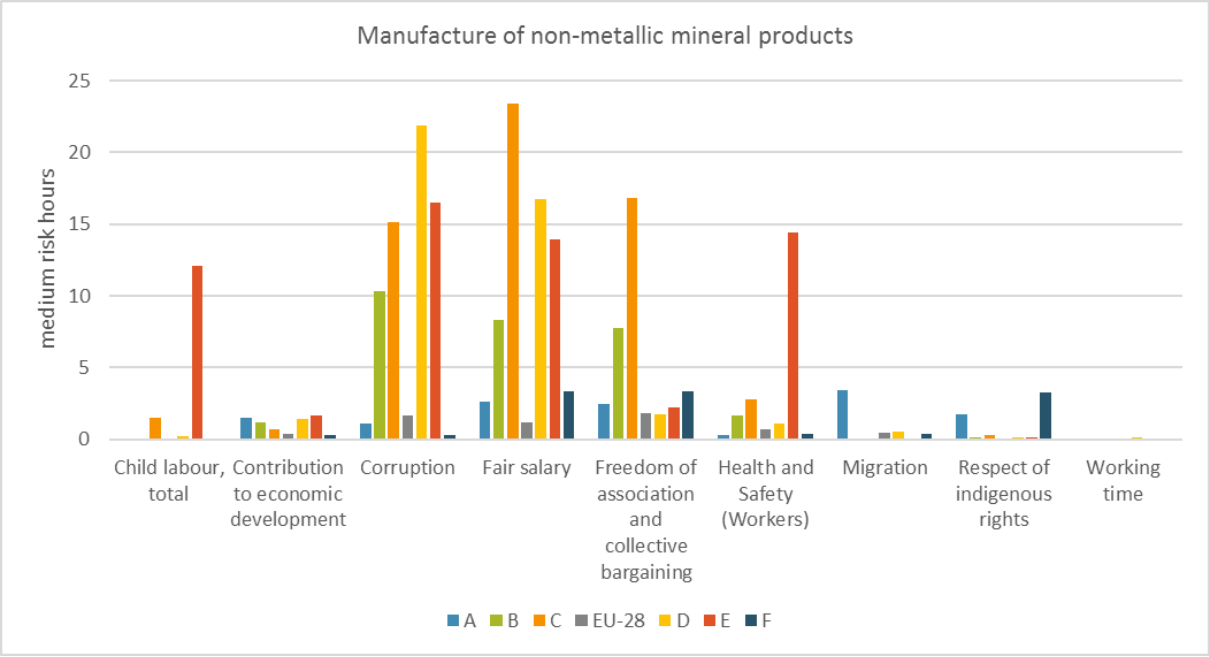

Figure 10 Life cycle-based results on social risk associated to the minerals products manufacturing sector, in all selected countries and in EU-28

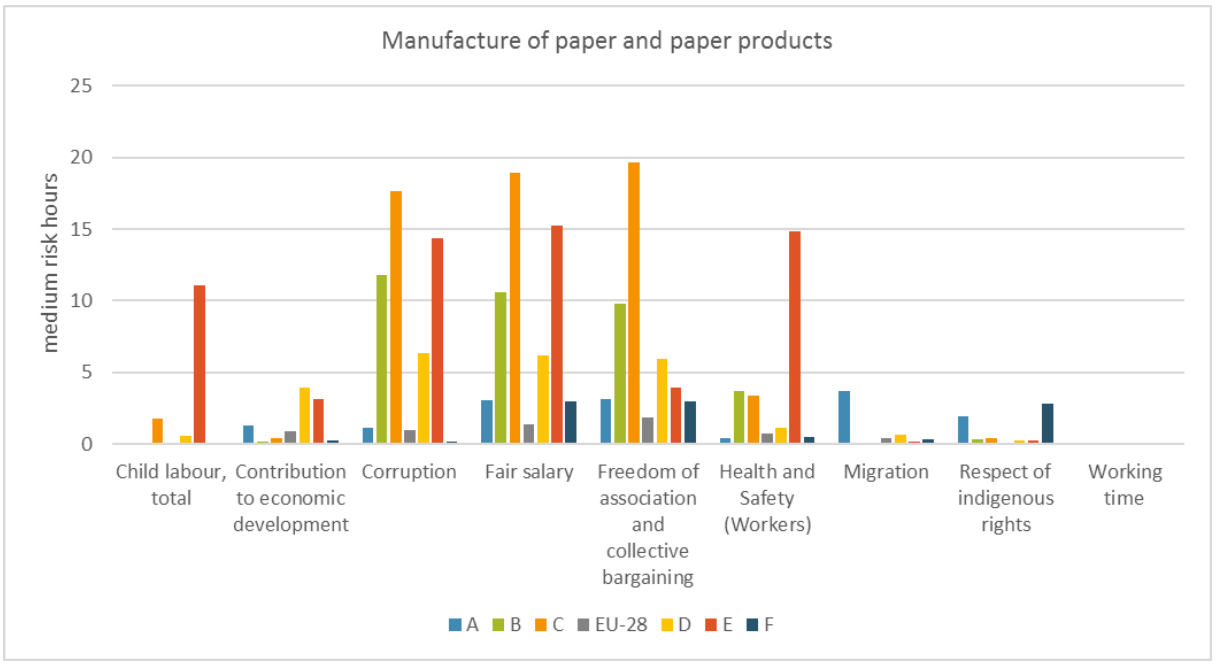

Figure 11 Life cycle-based results on social risk associated to the paper and paper products manufacturing sector, in all selected countries and in EU-28

Figure 12 Life cycle-based results on social risk associated to the wood and wood products manufacturing sector, in all selected countries and in EU-28

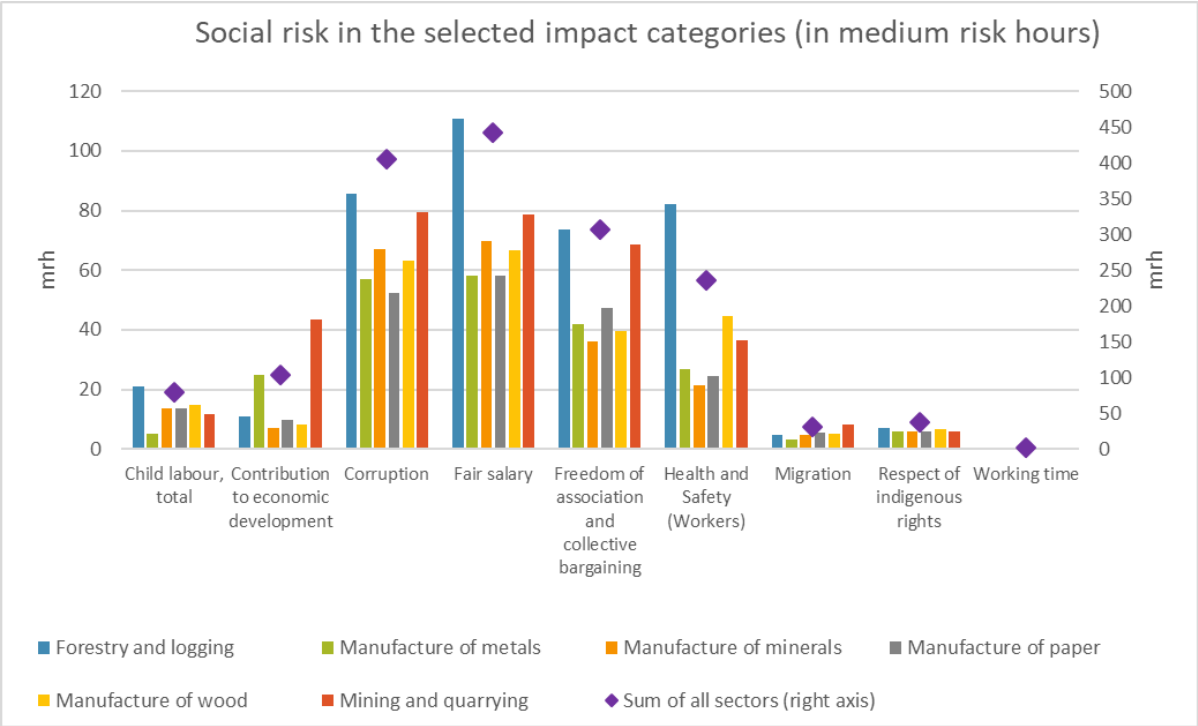

Figure 13 Social risk in the sectors under investigation (as sum of countries under investigation) and in total (sum of sectors and countries, right axis): the figure allows detecting the most relevant impact categories in terms of social risk.

Country governance (as an average of the World Governance Indicators) is a component of the criticality assessment in the EU methodology (Blengini et al. 2015), and in many other methodologies for the identification of critical raw materials. It is assumed, indeed, that a low governance in countries supplying materials increases the supply risk.

Comparing the results of the analysis with the general socio-economic and governance conditions in the selected countries, table 10 shows the Human Development Index and the World Governance Indicators for the selected countries and for the EU. Results on social risk seem to be, to some extent, linked to these conditions. For instance, country A and F have the highest level of governance and development status and showed also the lowest risk in all the analysed sectors. Concerning the other countries, social risk seems to be less connected to governance: for instance, country D has the lowest governance scores but only in few cases has a very high social risk; countries C and E have the highest risk in most of the categories and sectors, with governance from average to low levels.

Looking at specific social categories, the scatting plots in fig. 14 shows that, in most cases, countries A, F and EU have the highest governance and low levels of social risk, with the exception of the indigenous rights social category. This can be partially explained by the fact that not all countries have indigenous populations in their territories. The group of countries B, C, D and E have lower of governance and higher risk in the categories corruption and fair salary. Country E shows the highest social risk in child labour and health and safety categories, country C in freedom of association, fair salary and corruption categories.

Table 10 Human Development Index and Word Governance Indicators in countries under investigation Colour code legend: from dark green (highest performance) to red (lowest performance)

Country/ Region	Human Development Index** (2015)	Worldwide Governance Indicators (2016)***					
		Voice and Accountability	Political Stability and absence of violence/ terrorism	Government Effectiveness	Regulatory Quality	Rule of Law	Control of Corruption
A	0.939	1.3	0.96	1.58	1.9	1.75	1.77
B	0.754	0.47	-0.45	-0.18	-0.21	-0.08	-0.44
C	0.738	-1.62	-0.52	0.36	-0.26	-0.22	-0.25
D	0.804	-1.21	-0.89	-0.22	-0.42	-0.8	-0.86
E	0.666	0.64	-0.13	0.27	0.21	0.07	0.05
F	0.92	1.1	0.35	1.48	1.5	1.67	1.33
EU-28 average*	0.88	1.07	0.64	1.11	1.17	1.12	1.03

* HDI and WGI calculated as an average among the 28 European countries

**Human Development Index combines three dimensions (A long and healthy life; Education index; A decent standard of living) and ranges from 0 (lowest) to 1 (highest) development level

***Estimate of governance ranges from approximately -2.5 (weak) to 2.5 (strong) governance performance

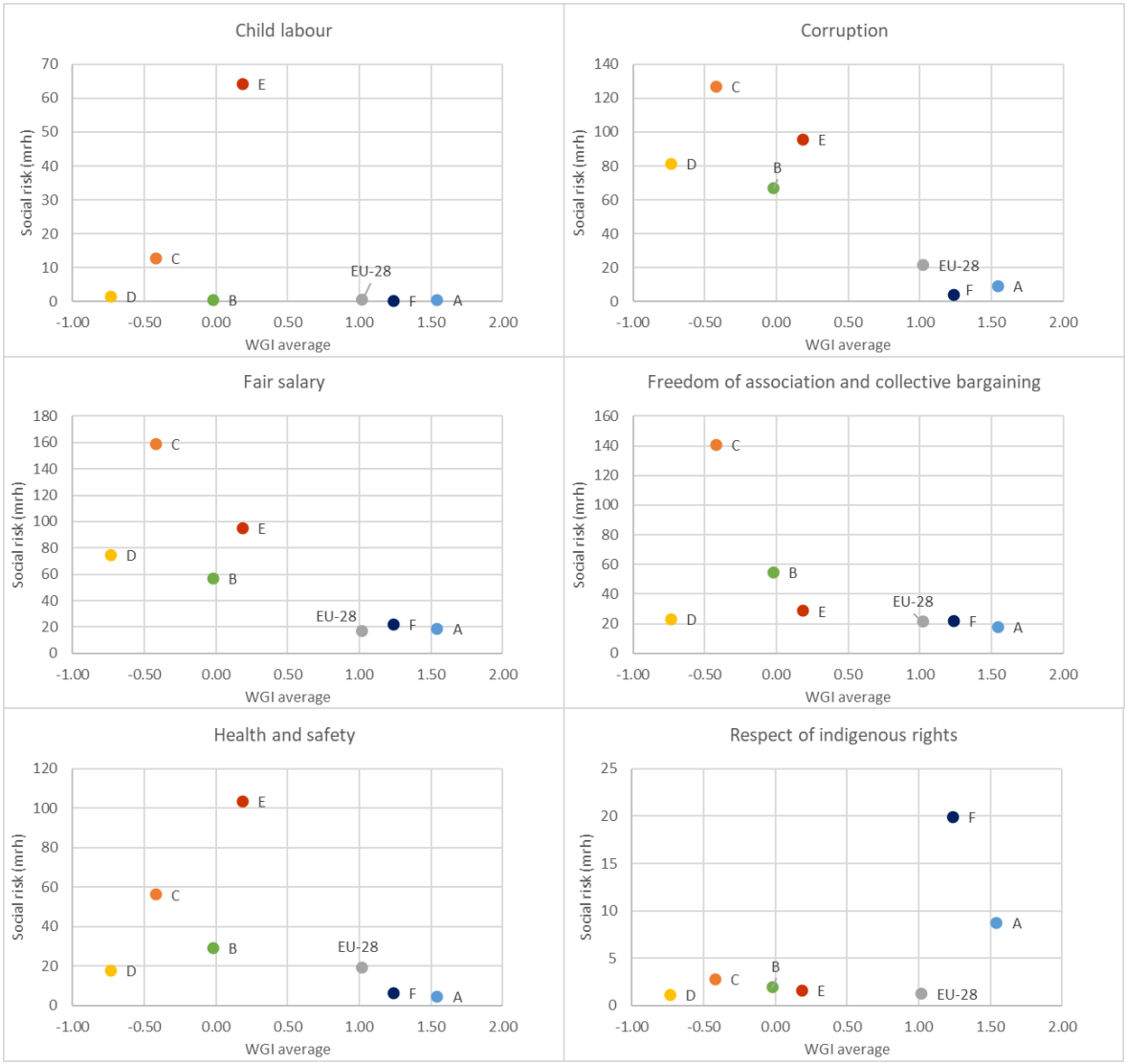

Figure 14 Scatter plots showing the sum of the social risk results by country (for a set of social categories) vs. the average of the Worldwide Governance Indicators (2016). For EU-28, WGI is calculated as an average among the 28 European countries.

7.2. Focus on European industries: sectors comparison

Figure 15 compares the EU sectors based on the social risk, for nine impact subcategories. For all the impact categories, the impact linked to the mining and quarrying sector seem to be considerably higher than in the other sectors. The average percentage difference between the medium risk hours linked to mining and those linked to other sectors is +89%.

The highest risk value is for the impact on "Corruption", which has a value of 14.39 medium risk hours for 1$ output (see also table 19 in Appendix with full results). Impacts on child labour, respect of indigenous rights and working time are negligible compared to the other categories.

As most of the social data used for the assessment relates to a general "mining and quarrying sector", it was not possible to deduct the impact of oil and gas sector from the results.

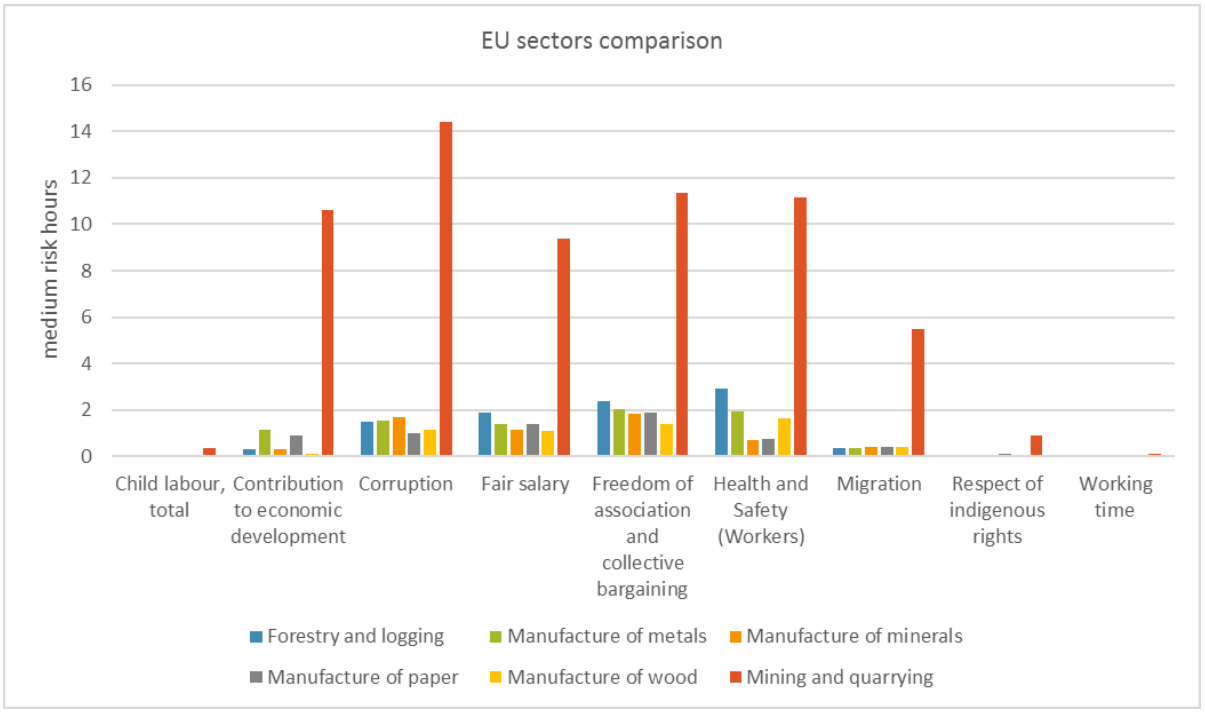

Figure 15 Life cycle-based results on social risk associated to six raw materials sectors in EU-28

7.3. The life cycle perspective: contribution analysis

As explained in the methodology, the SLCA analysis accounts for the contribution of all the upstream phases of the supply chain. In this case, the results for each combination of country/region-sector (e.g., mining in EU), encompass the risk hours of supplying country-sectors (e.g. construction sector in India). As shown in the contribution tree in fig. 16, the supply chain involves many country-sectors, which are interconnected in various layer of a complex structure. The results of this analysis allow to know the contribution of all supplying country-sectors to the overall risk, as shown zooming in the contribution tree (fig. 17). The following sections describe how the risk is distributed in the supply chains, according to the results of our analysis, and the contribution of direct vs. indirect impacts.

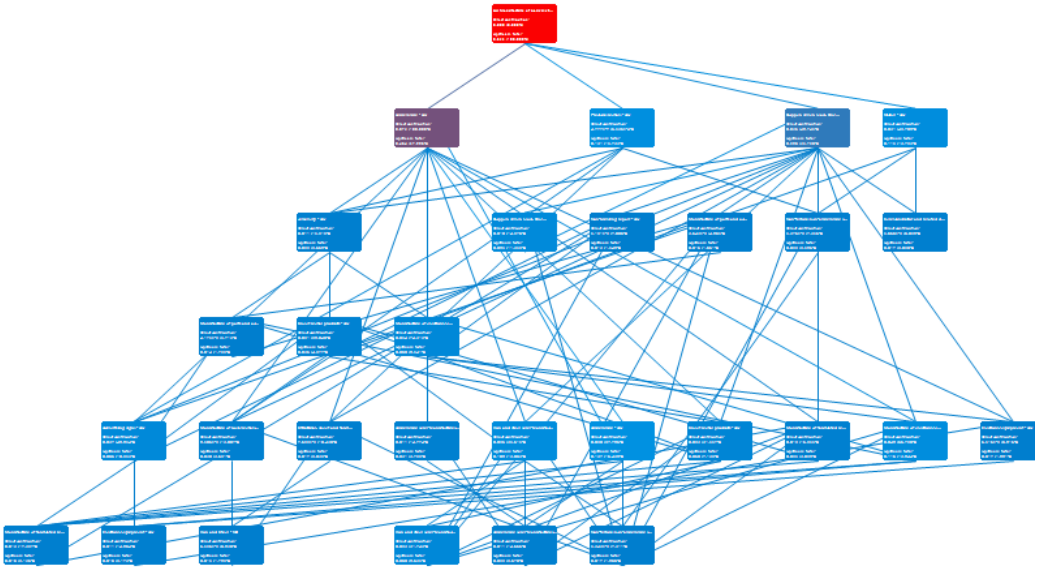

Figure 16 Contribution tree for the CSS "Manufacture of basic metals, Australia", overall structure

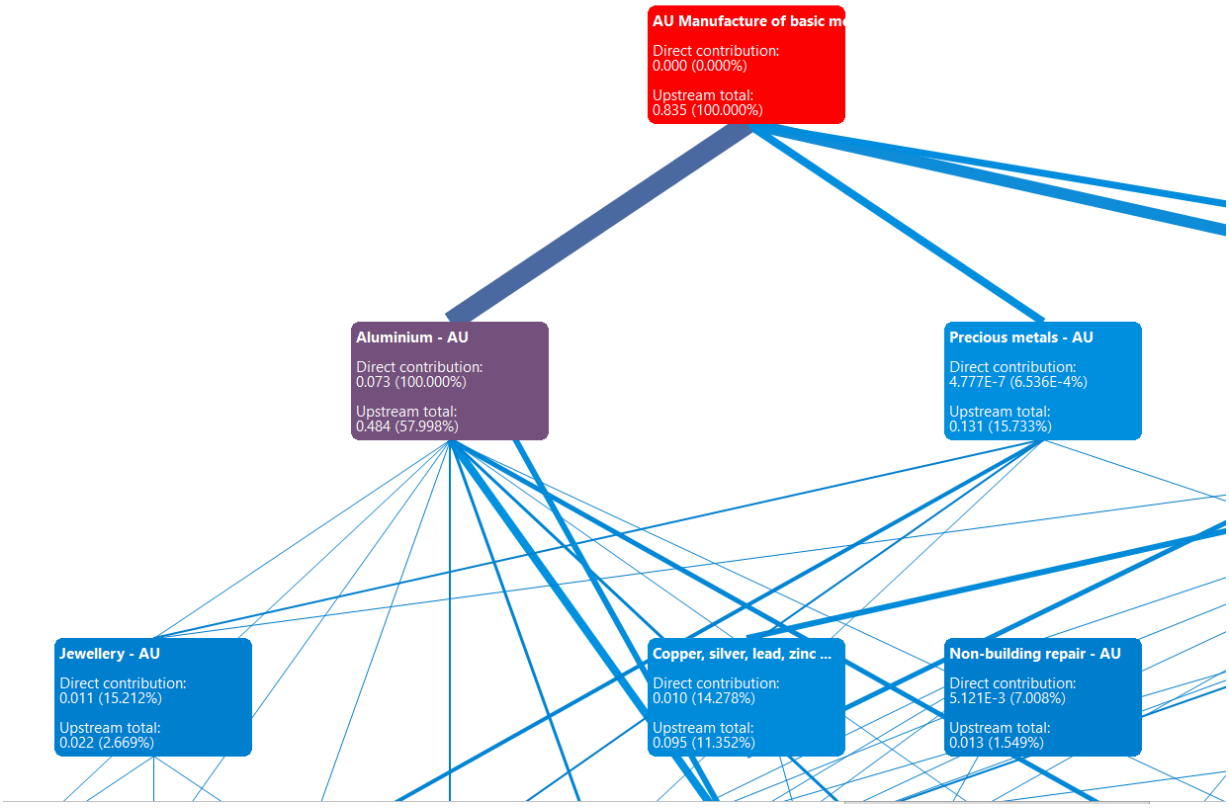

Figure 17 Zoom into the contribution tree of the CSS "Manufacture of basic metals, Australia". The figure shows the contribution of the different CSS to the overall risk in the social category "respect of indigenous rights".

7.3.1. Direct and indirect impacts

The figures below (18-20) show the share of direct impacts (coming from the sector under investigation) vs. those of the upstream sectors (indirect), in three sectors: forestry and logging, mining and quarrying, paper manufacturing, in EU.

Figure 19 shows that the direct contribution of the "mining and quarrying" sector to the total risk is very low, compared to the indirect one. This means that most of the overall risk derives from upstream sectors supplying the mining and quarrying sector. As the mining and quarrying sector appears to be the most critical (among the sectors under investigation) in EU (see fig. 16 above) the fact that most of the social risk comes from the upstream phases of the supply chain suggests that the sources of risks are to be detected especially in the sectors providing inputs to mining, which are likely to occur outside the EU, given the globalized nature of modern supply chains. Indeed, fig. 21 shows that the tops three locations that are contributing to the risk in the category "child labour" in the supply chain of this sector are South Africa, China and Angola. Within each country, the top three sectors contributing to this social risk are also shown.

For forestry and paper manufacture sectors, direct impact is generally higher, especially for the impact category "Health and safety", with higher than 50% and 40% of the total for the forestry and paper manufacturing sectors, respectively.

In conclusion, mining and quarrying sectors shows the highest social risk within the EU sectors under investigation. This sector seems to have the most "globalised" supply chain, as the prevalent part of the risk comes from the upstream phases of the supply chain.

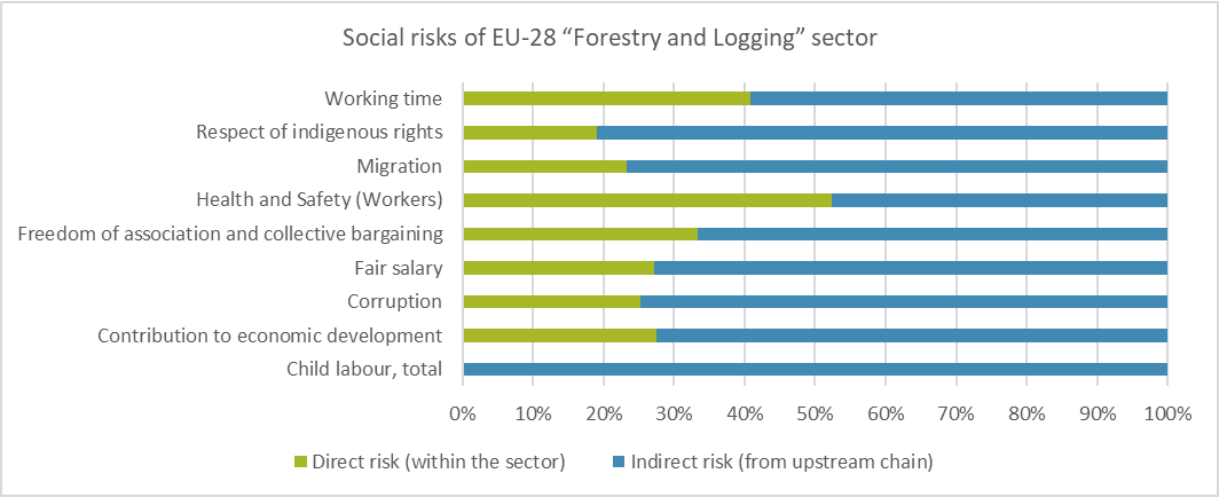

Figure 18 Contribution to the social risk of "forestry and logging" sector in EU-28, including direct risk and indirect risk

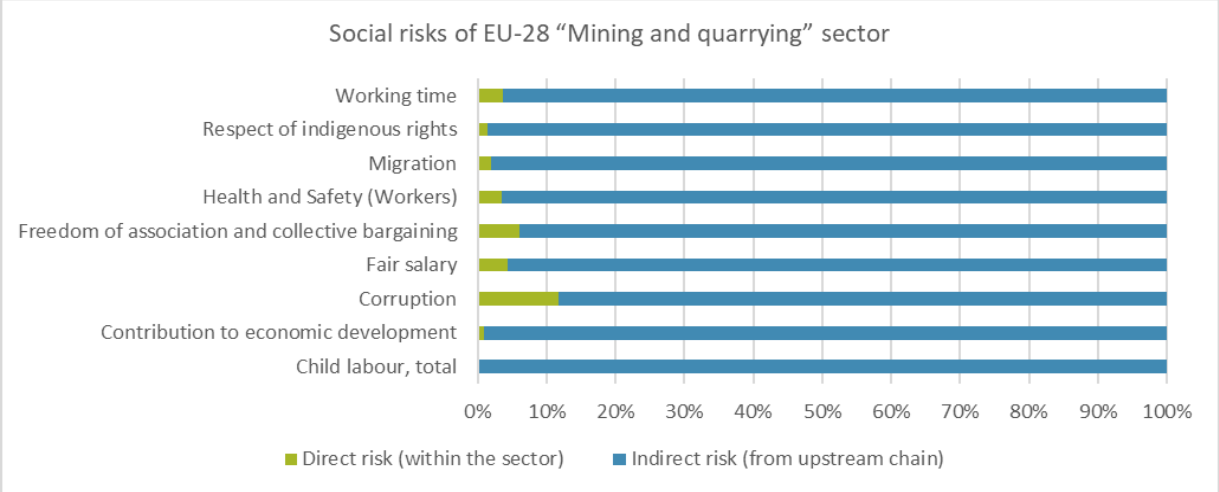

Figure 19 Contribution to the social risk of "mining and quarrying" sector in EU-28, including direct risk and indirect risk

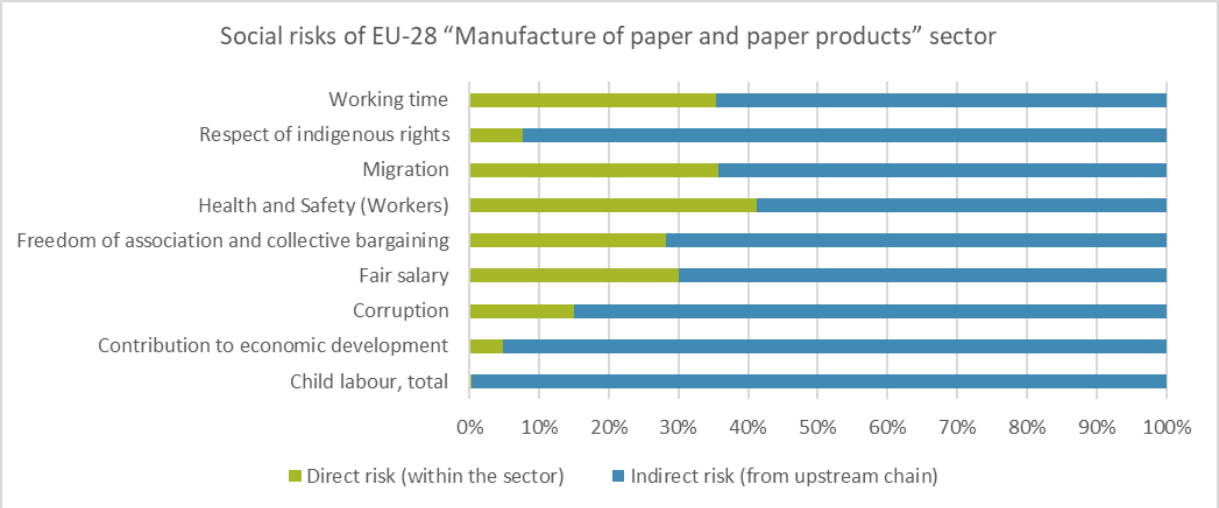

Figure 20 Contribution to the social risk of "manufacture of paper and paper product" sector in EU-28 including direct risk and indirect risk

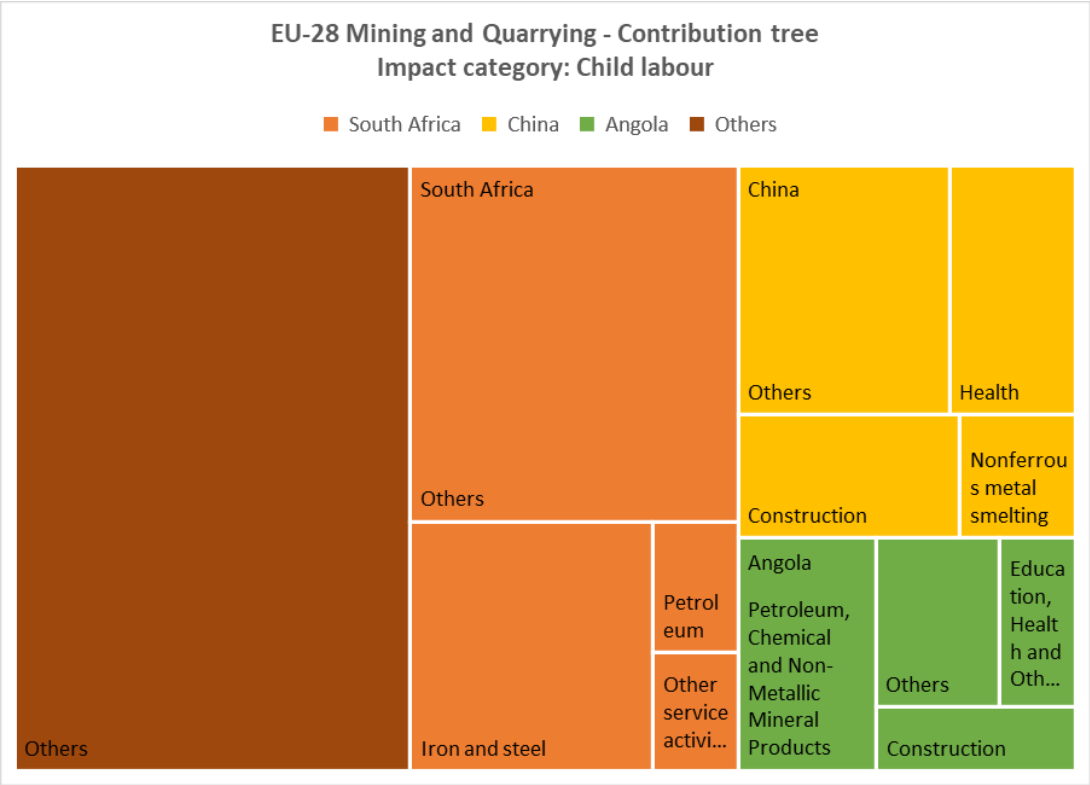

Figure 21 Contribution tree for the impact category "Child labour" in the supply chain of the EU-28 Mining and quarrying

7.3.2. Fair salary in the EU mining and quarrying sector: contribution analysis

This section focuses on the supply chain analysis of EU mining and quarrying sector, for the "fair salary" impact category.

The choice of this impact category is due its high data quality (see section 8); while for the sector, mining and quarrying shows the highest impact in EU among the selected ones (as in fig. 15).

The contribution tree in fig. 22 shows which sectors are mostly contributing to the impact on "fair salary", for the EU mining and quarrying sector. It shows first and second level processes contributing to the impact on fair salary, i.e. Country-Specific Sectors (CSS) directly contributing to the impact of the sector (first level) and the nested ones (second level).

The first level CSS are identified by the coloured squares in the figure and are named as in the IO nomenclature:

- Metal ores – SI (Slovenia), blue
- Lead, zinc and tin ores and concentrates – GR (United Kingdom), green
- Nickel ores and concentrates – GR (United Kingdom), orange
- Metal ores – IT (Italy), grey
- Other mining and quarrying products – IT (Italy), yellow
- Aluminium ores and concentrates – GB (United Kingdom), red.
- Others – dark blue

Within each square, the nested (second level) CSS contributing to each first level process is shown. For instance, most of the impact of the Metal ores sector derives from the "manufacture of chemicals and chemical products – SI".

Table 11 complements the figure with data on contribution to the impacts of first and second level processes.

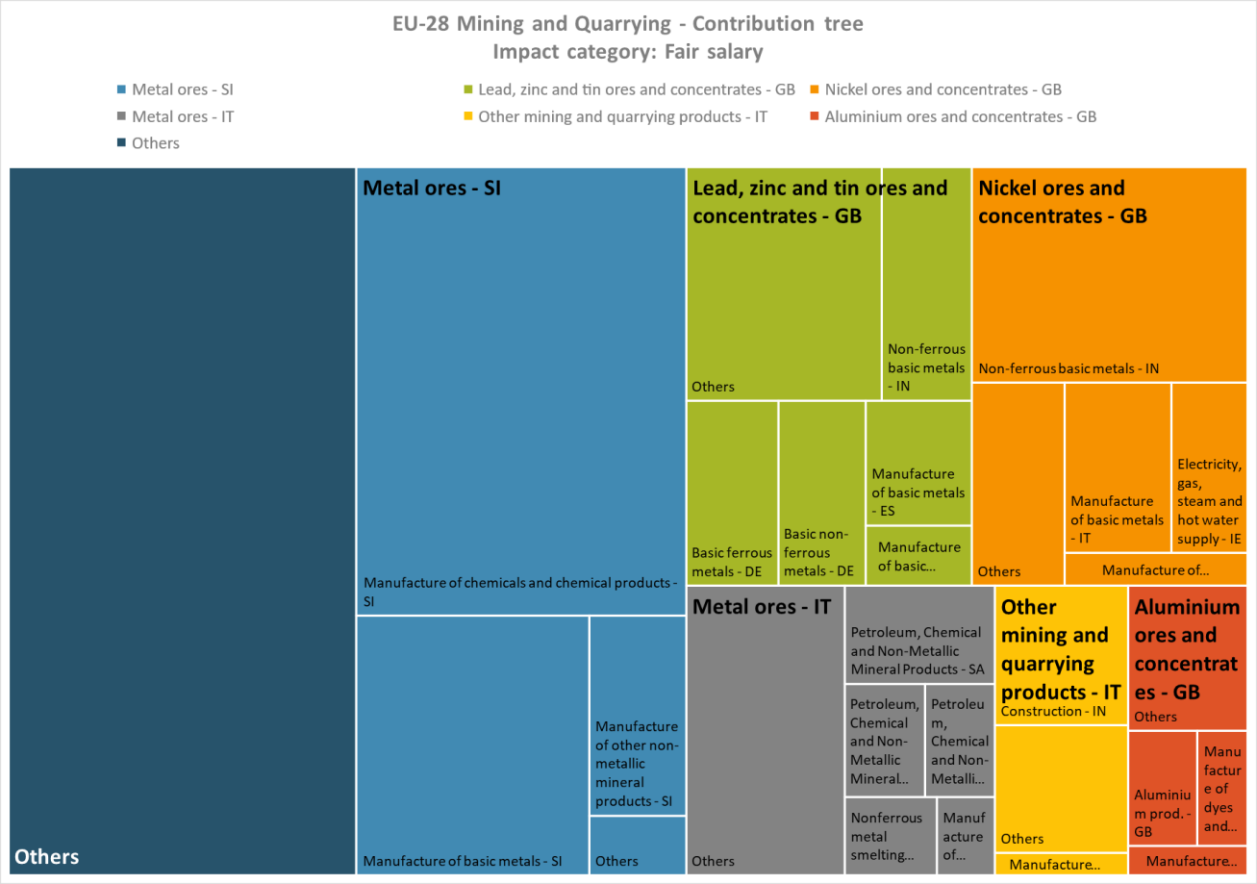

Figure 22 Contribution tree for the impact category "Fair salary" in the sector Mining and quarrying in EU-28 (SI: Slovenia, IT: Italy, GB: Great Britain; IN: India, ES: Spain; DE: Germany; IE: Ireland; SA: South Africa)

Table 11 Contribution analysis for the impact category "Fair salary" in the sector Mining and quarrying in EU-28

Contribution to the total impact	Contribution to the nested impact	Process	Amount (medium risk hours)
100%		**EU Mining and quarrying**	**9.37**
27%	**100%**	**Metal ores - SI**	**2.54**
17%	*63%*	*Manufacture of chemicals and chemical products - SI*	*1.61*
7%	*26%*	*Manufacture of basic metals - SI*	*0.66*
2%	*8%*	*Manufacture of other non-metallic mineral products - SI*	*0.21*
1%	*2%*	*Others*	0.06
14%	**100%**	**Lead, zinc and tin ores and concentrates - GB**	**1.30**
2%	*18%*	*Non-ferrous basic metals - IN*	*0.23*
2%	*14%*	*Basic ferrous metals - DE*	*0.19*
2%	*14%*	*Basic non-ferrous metals - DE*	*0.18*
2%	*11%*	*Manufacture of basic metals - ES*	*0.14*
6%	*44%*	*Others*	*0.57*
13%	**100%**	**Nickel ores and concentrates - GB**	**1.19**
7%	*54%*	*Non-ferrous basic metals - IN*	*0.65*
2%	*17%*	*Manufacture of basic metals - IT*	*0.20*
2%	*12%*	*Electricity, gas, steam and hot water supply - IE*	*0.14*
2%	*17%*	*Others*	*0.20*
9%	**100%**	**Metal ores - IT**	**0.85**
2%	*19%*	*Petroleum, Chemical and Non-Metallic Mineral Products - SA*	*0.16*
1%	*12%*	*Petroleum, Chemical and Non-Metallic Mineral Products - EG*	*0.10*
1%	*10%*	*Petroleum, Chemical and Non-Metallic Mineral Products - GY*	*0.09*
5%	*59%*	*Others*	*0.50*
4%	**100%**	**Other mining and quarrying products - IT**	**0.42**
2%	*48%*	*Construction - IN*	*0.20*
0.3%	*8%*	*Manufacture of cement - IN*	*0.03*
2%	*44%*	*Others*	*0.19*
4%	**100%**	**Aluminium ores and concentrates - GB**	**0.38**
1%	*23%*	*Aluminium production - GB*	*0.09*
1%	*17%*	*Manufacture of dyes and pigments - GB*	*0.06*
0.4%	*10%*	*Manufacture of industrial gases - GB*	*0.04*
2%	*50%*	*Others*	*0.19*
29%		**Others**	**2.69**

7.3.3. Location analysis

In addition to the analysis presented in previous sections, results can be analysed taking into account geographical locations where impacts occur, along the supply chain.

This is done clustering all the processes contributing to the impact by the country in which they occur. In the case of "fair salary" for the EU mining and quarrying sector, 36.9% of the impacts are occurring in India (table 12), 8.3% in China and 6.9% in United Kingdom.

Results on most contributing locations can be displayed in a map, as in fig. 23. It combines the information on countries with the highest share of impacts (social hotspots), both direct and indirect, with pie charts showing the upstream sectors contribution within these countries. It can be noticed that even if the activity under investigation is in EU (the

aggregation of 28 EU mining and quarrying sectors), hotspots are concentrated in two Asian countries (and in UK). This can be explained looking at figure 17 above, which show that indirect impact (from upstream sectors in the supply chain) are prevalent, especially in the mining and quarrying sector.

In this case, "Construction" is the sector with the highest contribution in India and the second one in China, together with "Health". In UK the most relevant sectors contributing to the impact are "manufacture of industrial gases" and "manufacture of dyes and pigments". Other maps showing location hotspots for other impact subcategories in the EU mining and quarrying sector are in the Appendix (figures from 28 to 35).

Table 12 Contribution to the impact category "Fair salary" for the mining and quarrying sector (direct and indirect contributions), in EU, by location

Country	Amount (medium risk hours)	Share of impact (%)
India	3.46	36.9
China	0.77	8.3
United Kingdom	0.64	6.9
Russian Federation	0.50	5.4
Germany	0.46	4.9
Ireland	0.39	4.2
United States	0.36	3.8
Denmark	0.25	2.7
Poland	0.23	2.4
Others	2.30	24.5

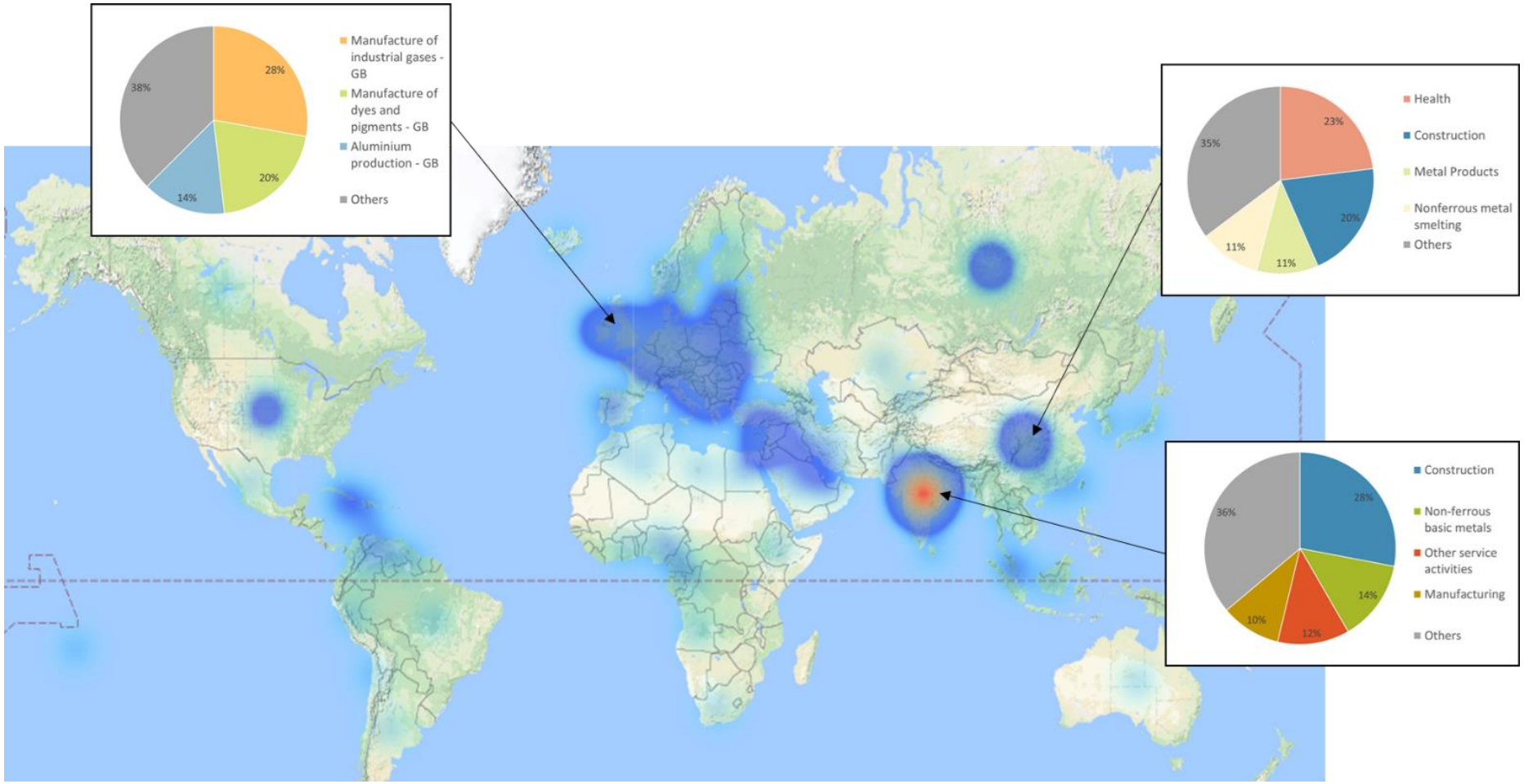

Figure 23 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "fair salary". The map shows the countries with the highest contribution to the overall risk, and the pie charts show the upstream sectors, in that countries that are mostly contributing to the overall risk

8. Uncertainty and limitations of the study

The aim of this section is to describe the main sources of uncertainty connected with our analysis.

Concerning the methodology used in this study, a key source of uncertainty relates to the aggregation of countries in the EU-28 group. As explained in the methodology section, we aggregated EU countries with a weighted average, using the production values for each economic sector as weighting factors. As no specific values were available for "Forestry and Logging", "Manufacture of wood and of products of wood and cork" and "Manufacture of non-metallic mineral products", values for the aggregation of the first two sectors are the same as in the "Manufacture of paper and paper products"; for the latter, we used those from "Manufacture of fabricated metal products".

Furthermore, in the calculation of results we applied a cut-off criteria of 1E-04, necessary to run the calculation in a reasonable timeframe. Due to the high amount of data to analyse, the software would require a very high calculation capacity for performing the analysis of all the processes, without any cut-off.

Concerning the mining and quarrying sector, we selected activities related to the production of non-energy raw materials, in line with the objective of our study. However, data on social aspects (for instance, on occupational safety or on wages) usually refer to the broad sector, including also the extraction of energy materials. It is not possible to estimate how results would change when excluding the oil and gas sector from the values for social conditions.

Concerning the SLCA methodology and the PSILCA database used for the analysis, uncertainty derives from the underlying multi-regional input/output model, as described in (Lenzen et al., 2010). In this respect, the main elements affecting the certainty of the results include: the use of old data associated with the models; the uncertainty in data gathering (e.g. sampling, response rate, missing/incomplete data); estimations and extrapolations techniques used to fill data gaps; assumptions made to allocate aggregated data to the most appropriate sector; mapping and aggregation of sectors when combining datasets with different sectors classifications.

In SLCA databases, each country-specific sector has a set of data on social indicators that are used in the life cycle analysis to assess social risk. These data are often retrieved from international statistical agencies. Although the database provides country and sector specific data wherever possible, often only country-level data is currently available.

Moreover, data from international statistics come from different sources (e.g. surveys, administrative records, etc.), each of them having its limitations in terms of data quality and uncertainty. For instance, statistics derived from surveys (whether household surveys or establishment surveys) are subject to a number of limitations linked to the sample design and more generally, due to the fact that a sample is used to refer to the whole population. The results observed for the selected sample can be extrapolated to the whole population (and representative of the whole population), depending on the characteristics of the sample design and the sample size; however there is always some degree of uncertainty associated with estimates from surveys. Data quality depends also on the accuracy of respondents and how well respondents understood each question. For instance, statistics on working time, wages, child labour derive form household and establishment surveys. Statistics deriving from administrative records (e.g. for occupational safety) often have poor coverage, can be not up to date, data quality may be questionable and units and concepts might not refer to statistical standards (ILO, 2017).

Concerning the limitations of the study, the main considerations are the following:

- Low granularity of the input data on social aspects and, in turn of the results. Indeed, only part of the result on social risk are sector-specific, while for most of the cases the social risk depends on the conditions of the country where the sectors operates. In this respect, the social risk results are slightly more specific than

indexes like the Worldwide Governance Index or the Human Development Index (which can be used also as input data to assess social risk).

- Difficulty to communicate the results' unit of measurement, i.e. the medium risk hours, especially in the case of social categories that are not linked to working conditions. This is particularly constraining if results should support policy making or communicated to a broader public.
- The characterization of positive impacts is not well developed yet in the SLCA methodology and this analysis focuses on negative aspects. Indeed, only one indicator on contribution of the sector to the GDP was used, but the positive impact was compensated by other indicators on negative impacts in the same category (Contribution to economic development). Therefore, we could not match social risk against the opportunities and contribution that sectors provides to, e.g. workers (as job opportunities) society, consumers, etc. In the context of the EU raw materials, providing an assessment of both risk and opportunities would be particularly relevant, especially in the light of the policy objective of increasing public acceptance for mining and exploiting domestic resources in a sustainable way.

8.1. Data quality analysis

In PSILCA, together with the results, the software provides an assessment of the data quality, based on the following criteria:

- Reliability of the source(s) (R)
- Completeness conformance (C)
- Temporal conformance (T)
- Geographical conformance (G)
- Further technical conformance (F)

For each criteria, results have a score from 1 (best quality) to 5 (worst quality). The pedigree matrix describing how the scores are assigned for each criteria is in the appendix (table 20).

For the results of our analysis, table 13 illustrates the average data quality. Due to graphical constraints, we do not show the full table but an average of the six sectors under investigation. However, the software provides data quality assessment for every data point (i.e. deriving from the combination of six sectors, seven countries and nine impact categories, see table 20 in appendix).

Concerning the data quality of our results, the following considerations arise from the data quality assessment:

- Child labour: very low score (5) in the further technological conformance, as data are not sector-specific; average temporal conformance is also very low, as data are older than five years for most of the countries under investigation. Average completeness compliance is low (4), as estimations on child labour are not available for all the countries.
- Corruption: reliability of one of the data sources is low (in particular, Transparency International estimates on public sector corruption).
- Freedom of association and collective bargaining: very low score (5) in the further technological conformance as data are not sector-specific. On average, temporal conformance is low (4) as for some countries data are older than five years.

Corruption and Freedom of association are among the top three categories in terms of total social risk (fig. 13), together with the category Fair salary, which has the best data quality among those selected.

Table 13 Average data quality for the results on the selected impact categories

	Reliability of sources	**Completeness conformance**	**Temporal conformance**	**Geographical conformance**	**Further technical conformance**
Child labour	2	4	5	3	5
Contribution to economic development	2	2	3	1	3
Corruption	4	3	1	1	3
Fair salary	2	2	1	1	1
Freedom of association (…)	2	2	4	1	5
Health and Safety	1	2	2	3	2
Migration	2	2	3	1	3
Respect of indigenous rights	2	3	1	1	n.a.
Working time	2	2	3	1	2

8.2. Comparison of results from different databases

As described in the methodology, the two available SLCA databases uses different input/output models: EORA in PSILCA and GTAP in SHDB. This implies that the databases have also different sets of country-specific sectors and a different set of indicators, impact categories, etc. SHDB, launched in 2009, includes 227 countries and 57 sectors (the same sectors set for all countries), while PSILCA, developed in 2016, comprises data for around 15000 sectors and 189 countries (having different sectors sets).

Impact categories are also different in the databases, with PSILCA providing results for 49 disaggregated impact categories and SHDB for 14 impact categories. The latter are aggregated into five broad social categories: Labor Rights, Health&Safety, Human Rights, Governance and Community, as shown in fig. 24 (Benoit-Norris et al., 2013).

In order to get a better insight into the differences of the two databases, we analysed the sector of metals production in Australia, using SHDB (2013 version) and PSILCA (2.0 beta version).

We calculated the following processes: "Ferrous metals/AU" (in SHDB) and "Iron and steel semi-manufacture/AU" (PSILCA). In order to reduce all the sources of differences, we used a common impact assessment method (applying the same characterization factors for the quantification of risk levels), the same weighting system (assigning the same weight for all the impact categories) and a set of similar impact categories (table 14).

Fig. 25 shows the results of this exercise.

Among the social categories under investigation, those having the highest risk when using PSILCA are: fair salary, freedom of association, contribution to economic development and corruption. Social hotspots emerging from SHDB are instead migrant labor and (as in PSILCA) collective bargaining. It should be noticed, however, that the characterization of the impact category "migrant labor" in SHDB differs substantially from that of category "migration" in PSILCA (compare table 14 with table 7), with SHDB taking into account not only the presence of migrants (in country and sectors) but also remittances and adoption of ILO conventions on migration in hosting countries.

In addition to the differences among databases listed above, the "worker hours", are different: 1.34E-2 in SHDB and 0.41E-2 in PSILCA. Worker hours are the time of work needed to produce 1$ output, in the system under investigation. This information, provided by the underpinning input/output models, is used in SLCA methodology as "activity variable", to describe the relevance of the social impacts caused by a process in a life cycle.

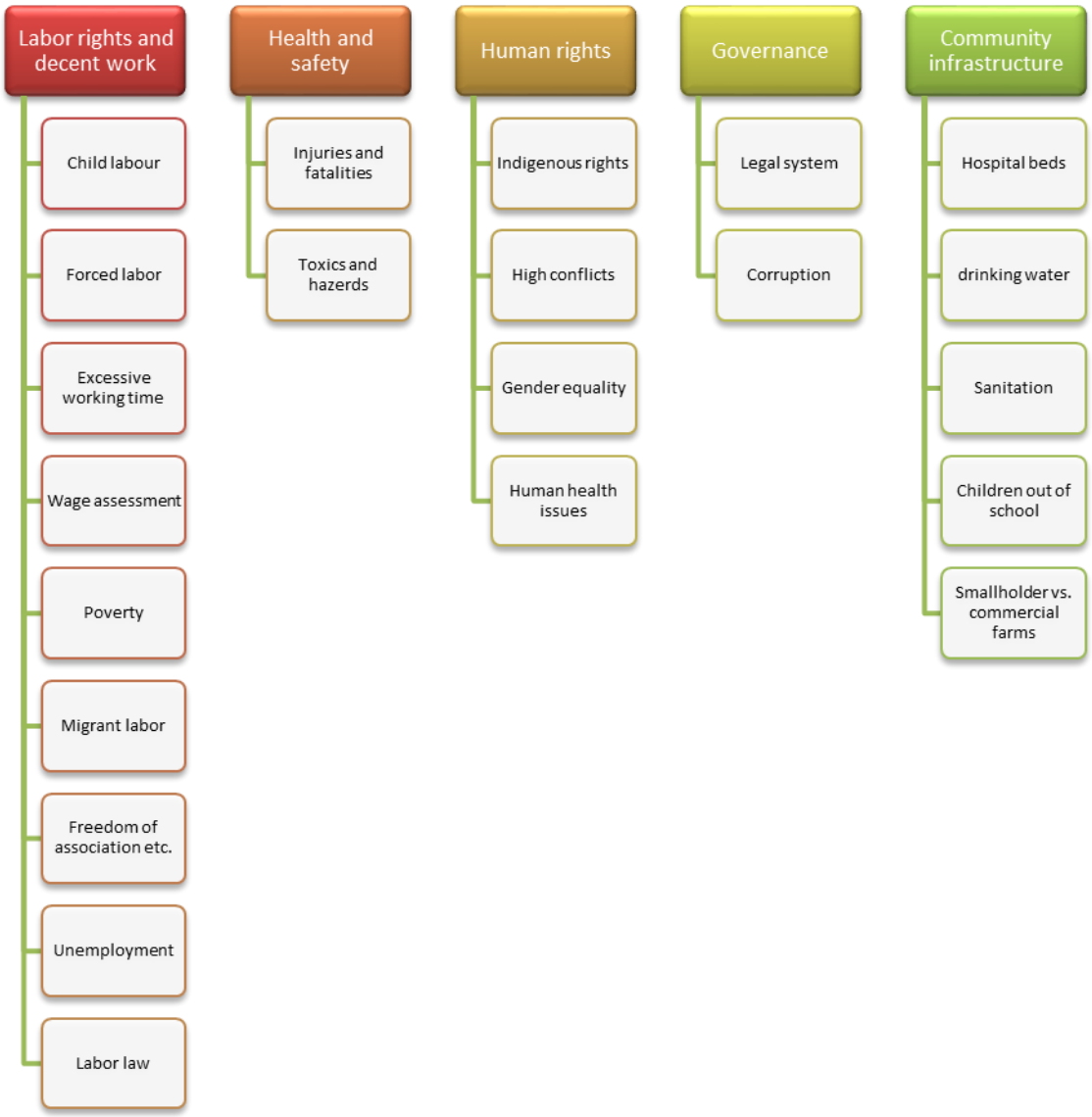

Figure 24 Social themes and social categories in the Social Hotspot Database (adapted from Benoit Norris 2013).

Table 14 List of themes, indicators, characterized issue and data sources in SHDB (for the impact categories under investigation in fig. 25). For details, see Benoit-Norris et al. 2013.

Stakeholder	Theme	Indicators	Characterized issue	Sector Specific	Main data sources
Labour Rights and Decent Work	Wage assessment	Average unskilled wages by sector	Compared to minimum wage and non-poverty guideline (not characterized)	X	International Labor Organization (ILO) Laborsta Database, 2009 United Nations Industrial Development Organization (UNIDO). (2009) (etc.)
		Minimum wage	Risk of sector average wage being lower than country's minimum wage	X	Federation of European Employers, 2012 Human Resources and Skils Development Canada, 2012 United States Department of Labor, 2012 U.S. Department of State, 2011 (etc.)
		Non-poverty guidelines	Risk of sector average wage being lower than country's non-poverty guideline	X	Sweatfree Communities – A Campaign of the Labor Rights Forum, 2007-2008
	Child labour	Child labour % in country – male, female, total	Risk of Child Labour in country		International Trade Union Confederation, 2011 UCW Project, 2012 UNICEF, 2012
		Child labour % by country – male, female, total	Risk of Child Labour in sector (used country-level risk where no data was found)	X	
	Freedom Of Association, Collective Bargaining, and Right to Strike	Qualitative assessment	Risk that a country lacks or does not enforce freedom of association rights		International Trade Union Confederation Annual Reports, 2009 International Trade Union Confederation - WTO General Reviews, 2006---11 (etc.)
		Qualitative assessment	Risk that a country lacks or does not enforce collective bargaining rights		
		Qualitative assessment	Risk that a country lacks or does not enforce the right to strike		
	Working time	Percent working >48 hours/week in a country	Risk of population working >48 hours/week in country		ILO Key Indicators of the Labor Market, 1999-2009 ILO Laborsta, 2003---2004 Eurofund, 2008 (etc.)
		Qualitative assessment	Risk of population working >48 hours/week by sector	X	
	Migrant labor	Net migration rate (NMR) per 1000 population	Risk that NMR is very high or very low		Population Reference Bureau, 2009 Population Data Sheet (etc.)
		Total emigrants from origin country, according to 2000 census	Characterization of total emigrants		Development Research Centre on Migration, Globalisation and Poverty, 2007
		Total immigrants to destination country, according to 2000 census	Characterization of total immigrants		United Nations Department of Economic and Social Affairs, 2010
		Immigrants as percentage of the population, 2010	Characterization of the percentage of immigrants		ILO Laborsta, 2010 Eurostat 2008
		Women as percentage of all immigrants	Risk that women are not accepted into country as immigrants		

Stakeholder	Theme	Indicators	Characterized issue	Sector Specific	Main data sources
		Workers' remittances and compensation received per emigrant	Risk that a country's remittances from its emigrants is low		World Bank, 2000
		Workers' remittances and compensation paid per immigrant	Risk that a country does not pay immigrants enough for remittances		
		Policy regarding integration of non-citizens	Risk that a country has not adopted policies and conventions for the protection of immigrants		ILO ILOLEX (2010)
		Ratification of ILO convention No. 97 on Migration for Employment, 1949			
		Ratification of ILO convention No. 143 on Migrant Workers, 1975			
		Ratification of the Int. Convention on the Protection of Rights of Migrant Workers and their Families, 1990			
Health and safety	Occupational injuries & deaths	Accident rate of insured/covered workers (per 100000) by sector	Risk of occupational injuries	X	Hamalainen et al. 2009; ILO Laborsta 1998-2009
		Fatality rate of insured/covered workers (per 100000) by sector	Risk of occupational fatality	X	
		Fatal work related diseases (estimate)	Risk of occupational disease causing death		
Human Rights	Indigenous Rights	Presence of indigenous population	Not characterized		Minority Rights Group International, 2009 World Bank, 2005 ILO, 2009 (etc.)
		Indigenous population, %	Characterization of % of indigenous popul.		
		ILO Convention adopted for indigenous	Risk of countries not adopting Indigenous ILO convention and UN Declaration		
		UN Declaration for Indigenous			
		Number of laws enacted to protect indigenous	Risk of country not passing laws to protect indigenous		
		Qualitative assessment	Risk for indigenous rights infringements by sector	X	
Governance	Corruption	Worldwide Governance Indicators (Control of Corruption)	Risk of corruption		World Bank 2011
		World Economic Forum – Global competitiveness Survey			World Economic Forum, 2010-2011
		Transparency International's Corruption Perception Index			Transparency International, 2010

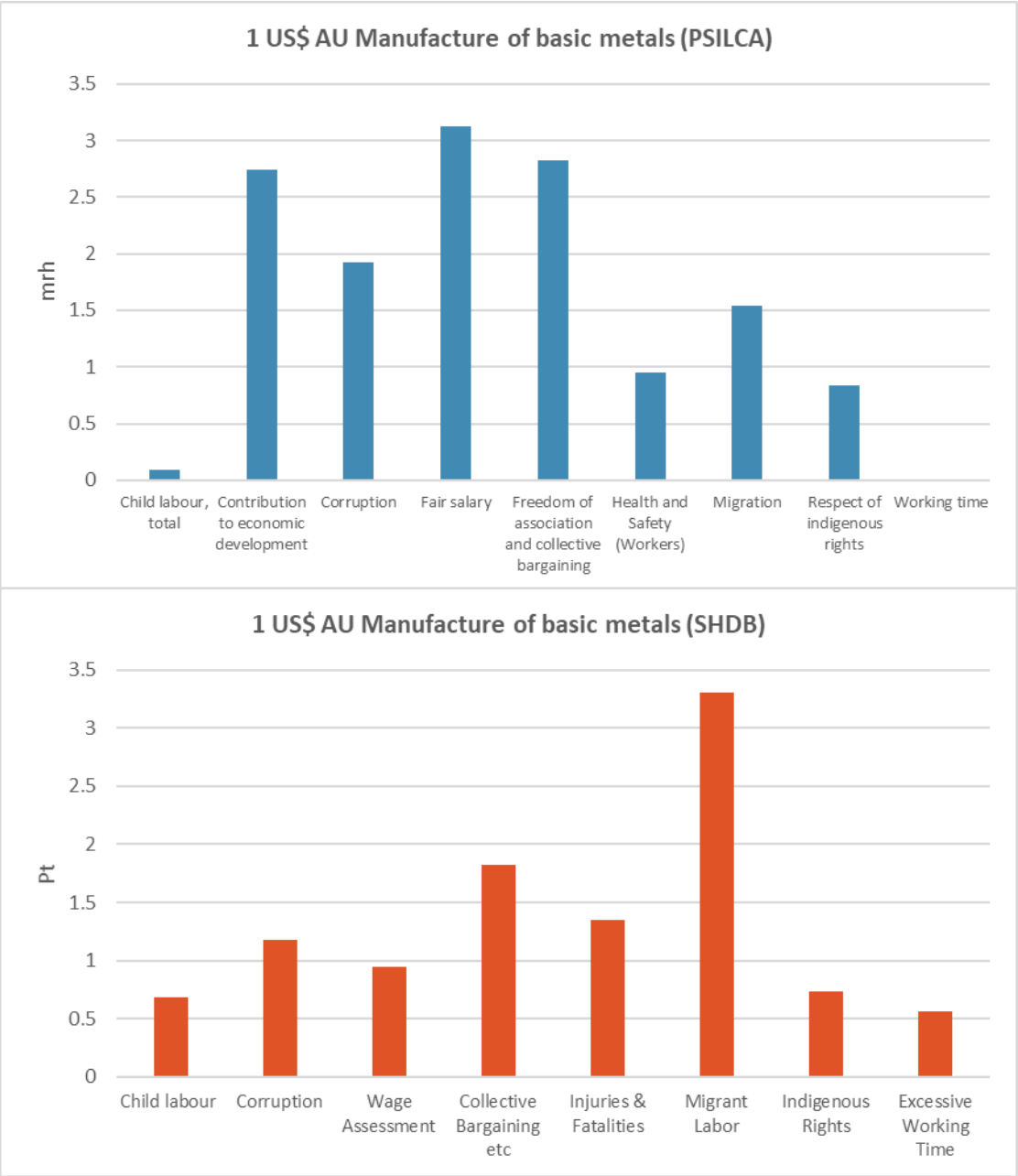

Figure 25 Social risk in the metal manufacturing sector in Australia, calculated with the databases PSILCA (2.0 beta version) and SHDB (version 2013).

Finally, we compare the results on social risk for the metal manufacturing sector in the countries investigated in section 4 and 5, and elaborated the processes with the two databases. Again, we used the same impact assessment and weighting methods, in order to reduce variability. Figures 26 and 27 show relative results, countries with the highest impact in the set have 100% of the total risk.

In relative terms, results are similar for the impact categories child labour and corruption (with countries E and D having the highest impact, respectively); results are partially similar in the categories wage assessment/fair salary, freedom of association, health and safety; results are different for migration, indigenous rights, excessive working time.

Despite some differences, the following country hotspots emerges from the two databases:

Country C: fair salary, freedom of association

Country D: corruption

Country E: child labour

Country B: health and safety.

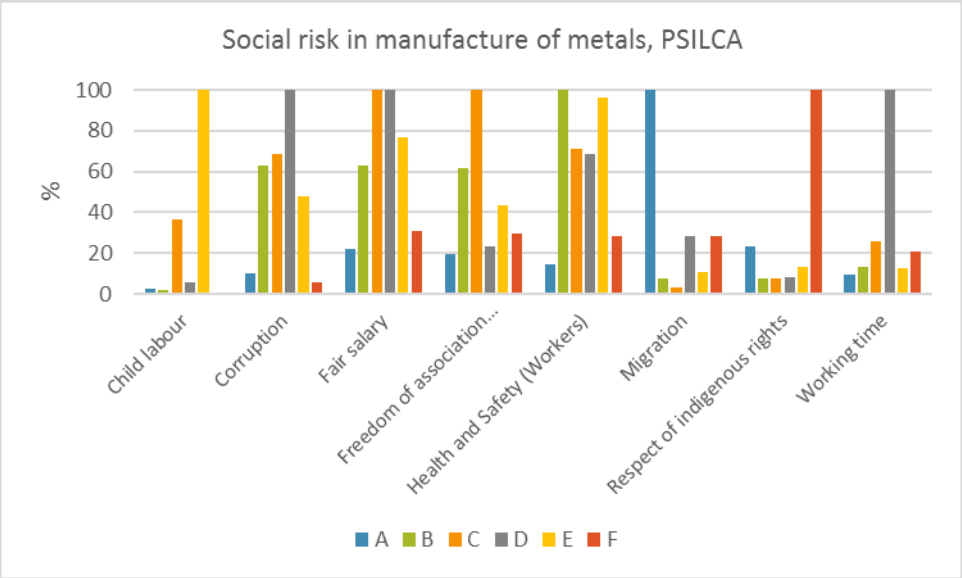

Figure 26 Life cycle-based social risk results in the metals manufacturing sector in six countries and in selected impact categories, relative results from PSILCA database

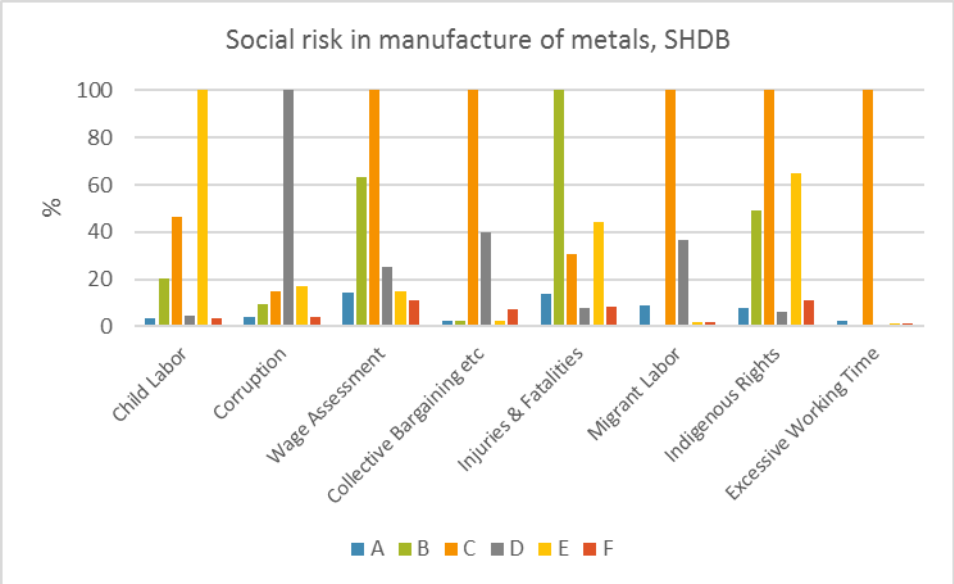

Figure 27 Life cycle-based social risk results in the metals manufacturing sector in six countries and in selected impact categories, relative results from SHDB database

9. Conclusions

Many of the UN Sustainable Development Goals focus on improving social conditions worldwide and mitigating impacts from production and consumption systems. In the global supply chains, these impacts are spread worldwide and barely catchable without a structured life cycle approach.

In the case of raw materials production and trade, social impacts can be particularly severe, as is the case of minerals produced in conflict areas. In these contexts, minerals trade can be used to finance armed groups, fuel forced labour and other human rights abuses, and support corruption and money laundering.

The European policy on raw materials promotes a sustainable supply of materials both from external and domestic sources. So far, despite its relevance, the evaluation of social sustainability performance has been conducted by adopting a variety of approaches and indicators (Mancini and Sala, 2018). The indicators used in the RM Scoreboard to measure social sustainability focus on limited aspects (e.g. occupational safety) or assess it indirectly (through sustainability reporting) and are not life-cycle based.

Social Life Cycle Assessment databases are repositories of social indicator data relevant to a wide range of impact categories and thematic areas. While originally intended to complement micro-scale, product-level assessments, this data availability also creates the possibility of considering the macro-scale social dimensions of production and consumption, including international commodity trade flows and sector analysis.

This report presents the results of a macro-scale quantitative assessment of social risk, using the Product Social Impact Life Cycle Assessment (PSILCA) database and modelling tool and providing insights into the comparison with another tool, the Social Hotspot Database (SHDB).

The sectors under investigation are those of current focus in the EU raw materials policy; the provision of secondary raw materials from e.g. recycling is out of the scope of this study. The objective of the study was primarily to test the applicability of SLCA data and models with a top-down approach to quantitatively assess social performance in raw materials supply chains, and to reflect on their application for policy making support.

Results shows the social performance (in terms of overall risk, measured in medium risk hours for 1$ output) of various country-sector combinations, in a set of social categories affecting different stakeholders. They also account for the contribution of the upstream phases in the supply chain. Within the country-sectors under investigation, the social categories "fair salary", "corruption" and "health and safety" seems to be the most relevant ones, while the risk in the category "working time" is negligible, compared to the other social categories. For the EU-28, the mining and quarrying sector (including energy materials) seems to have the highest risk, but also the highest share of indirect impacts, thus coming from the upstream phases of the supply chain.

Concerning the contribution analysis within the supply chain, we showed with some examples the significant analytical capacity of the life-cycle analysis and pointed out the country-sectors and locations that are mostly contributing to the risk. The high share of indirect impact confirms the importance of a life cycle-based approach to understanding and managing social risk, in global supply chains.

The comparison of results from different databases highlighted that, using different input/output models results may differ, even though the same hotspots emerge in the comparison of countries. Variations depend to a large extent on the characterization models used for the assessment, which are transparently documented. Differences can also come from a different age of the MRIO data; data for the SHDB is more than 10 years older than for PSILCA.

For some social categories, social risk results reflect country governance levels (expressed by an average of the Worldwide Governance Indicators, WGI). Further analysis could

investigate if these dimensions are correlated, taking into account the various social categories and the six WGI components.

The uncertainty of this analysis originates from different sources, e.g. input/output models, data sources on social aspects, assumptions made to allocate aggregated data to the most appropriate sector, etc. While social data are transparently documented and subject to a data quality evaluation, data from the input-output models are less traceable within the SLCA databases. The combination of data from different models is likely to cause propagation of the uncertainty that was not possible to quantify in this study.

The low granularity of the data feeding the model (which are country based, and sometimes also sector based) is one of the main limitations of the study. Indeed, variability within the same sector in a country and regional differences within a country are not caught by this macro-scale assessment.

The main question underpinning this study is if SLCA databases and macro-scale modelling can support policy making through a sector-based sustainability assessment, providing insight into the social hotspots of raw materials sectors. In particular, we wondered if these life-cycle based metrics can be suitable to monitor the challenges in the raw materials sector as done, for instance, in the RM Scoreboard. Given the results of the study and the discussed limitations, we envisage that these tools might be appropriate for a first-screening assessment of supply chains and for prioritizing areas for more detailed investigation.

One of the strengths of this approach is to show social performance in various social categories and in different stakeholders, over the entire life cycle worldwide, thus has the capability of detecting trade-offs and burden shifting. However, given the granularity of the study, the results reflect only to a limited extent the sectors performance. Moreover, some relevant issues concerning the social sustainability of raw materials sectors are not caught in this analysis (for instance, in the case of mining, territorial aspect, land competition, positive economic impacts, provision of infrastructures etc.). On the other hand, existing indicators used in the Raw Materials Scoreboard are also country-sector based and do not provide additional insight into the subnational level.

It should be also acknowledged that assessing the social dimension of sustainability is a complex task and a discipline still under discussion/development. Social conditions, even though measurable, to some extent, with indicators, are complex and include certain subjectivity. They are not subject to biophysical laws, and are extensively dependent on cultural values and other context-related elements. A bottom-up modelling approach, as predominantly used in SLCA (as described by the UNEP/SETAC guidelines) can address the above mentioned challenges. Indeed, field investigations and primary data would provide more detailed insight into these issues. However, the generalization and comparability of organization or product-based assessment and the upscaling of results from a single case study to the whole sector can have some constraints.

As the governance indicators used in the criticality assessment, social risk results could be used for macro-scale assessment of material trade flows, in order to estimate, for instance, social implications of high import reliance, or evaluate consequences of changes in trade partners for the EU.

In conclusion, the analysis in this report demonstrates the potential and the limitations of social data combined with MRIO models for assessing social risk in supply chains. The results suggest that the current use of these models in e.g. policy analysis should be applied with caution due to the uncertainty derived by the combination of input/output models with social data. Further areas investigation include, for instance, the use of bottom-up approach to explore specific supply chains, could take into account the end-of-life phase and the potential of circular economy to mitigate also social impacts. Methodological advancements on the assessment of positive impacts in SLCA would also allow to complement this analysis and to match risk against opportunities created by the raw materials sectors.

Appendix

Table 15 Overview of social indicators included in the Global Reporting Initiative scheme (: Sector specific aspects; Global Reporting Initiative, 2013a, 2013b)*

ASPECT	GRI INDICATORS (and codes)	Sector Specific Indicator
SUB-CATEGORY: LABOUR PRACTICES AND DECENT WORK		
Employment	**G4-LA1** Total number and rates of new employee hires and employee turnover by age group, gender, and region	
	G4-LA2 Benefits provided to full-time employees that are not provided to temporary or part-time employees, by significant locations of operation	
	G4-LA3 Return to work and retention rates after parental leave, by gender	
Labour/ Management Relations	**G4-LA4** Minimum notice periods regarding operational changes, including whether these are specified in collective agreements	
	MM4 Number of strikes and lock-outs exceeding one week's duration, by country	**x**
Occupational Health and Safety	**G4-LA5** Percentage of total workforce represented in formal joint management–worker health and safety committees that help monitor and advise on occupational health and safety programs	
	G4-LA6 Type of injury and rates of injury, occupational diseases, lost days, and absenteeism, and total number of work-related fatalities, by region and by gender	
	G4-LA7 Workers with high incidence or high risk of diseases related to their occupation	
	G4-LA8 Health and safety topics covered in formal agreements with trade unions	
Training and Education	**G4-LA9** Average hours of training per year per employee by gender, and by employee category	
	G4-LA10 Programs for skills management and lifelong learning that support the continued employability of employees and assist them in managing career endings	
	G4-LA11 Percentage of employees receiving regular performance and career development reviews, by gender and by employee category	
Diversity and Equal Opportunity	**G4-LA12** Composition of governance bodies and breakdown of employees per employee category according to gender, age group, minority group membership, and other indicators of diversity	
Equal Remuneration for Women and Men	**G4-LA13** Ratio of basic salary and remuneration of women to men by employee category, by significant locations of operation	
Supplier Assessment for Labour Practices	**G4-LA14** Percentage of new suppliers that were screened using labor practices criteria	
	G4-LA15 Significant actual and potential negative impacts for labour practices in the supply chain and actions taken	
Labour Practices Grievance Mechanisms	**G4-LA16** Number of grievances about labour practices filed, addressed, and resolved through formal grievance mechanisms	
SUB-CATEGORY: HUMAN RIGHTS		
Investment	**G4-HR1** Total number and percentage of significant investment agreements and contracts that include human rights clauses or that underwent human rights screening	
	G4-HR2 Total hours of employee training on human rights policies or procedures concerning aspects of human rights that are relevant to operations, including the percentage of employees trained	
Non-discrimination	**G4-HR3** Total number of incidents of discrimination and corrective actions taken	

Freedom of Association and Collective Bargaining	**G4-HR4** Operations and suppliers identified in which the right to exercise freedom of association and collective bargaining may be violated or at significant risk, and measures taken to support these rights	
Child Labour	**G4-HR5** Operations and suppliers identified as having significant risk for incidents of child labour, and measures taken to contribute to the effective abolition of child labour	
Forced or Compulsory Labour	**G4-HR6** Operations and suppliers identified as having significant risk for incidents of forced or compulsory labour, and measures to contribute to the elimination of all forms of forced or compulsory labour	
Security Practices	**G4-HR7** Percentage of security personnel trained in the organization's human rights policies or procedures that are relevant to operations	
Indigenous Rights	**G4-HR8** Total number of incidents of violations involving rights of indigenous peoples and actions taken	
	MM5 Total number of operations taking place in or adjacent to indigenous peoples' territories, and number and percentage of operations or sites where there are formal agreements with indigenous peoples' communities	**x**
Assessment	**G4-HR9** Total number and percentage of operations that have been subject to human rights reviews or impact assessments	
Supplier Human Rights Assessment	**G4-HR10** Percentage of new suppliers that were screened using human rights criteria	
	G4-HR11 Significant actual and potential negative human rights impacts in the supply chain and actions taken	
Human Rights Grievance Mechanisms	**G4-HR12** Number of grievances about human rights impacts filed, addressed, and resolved through formal grievance mechanisms	
SUB-CATEGORY: SOCIETY		
Local Communities	**G4-SO1** Percentage of operations with implemented local community engagement, impact assessments, and development programs	
	G4-SO2 Operations with significant actual or potential negative impacts on local communities	
	MM6 Number and description of significant disputes relating to land use, customary rights of local communities and indigenous peoples	**x**
	MM7 The extent to which grievance mechanisms were used to resolve disputes relating to land use, customary rights of local communities and indigenous peoples, and the outcomes	**x**
Anti-corruption	**G4-SO3** Total number and percentage of operations assessed for risks related to corruption and the significant risks identified	
	G4-SO4 Communication and training on anti-corruption policies and procedures	
	G4-SO5 Total number and percentage of operations assessed for risks related to corruption and the significant risks identified	
Public Policy	**G4-SO6** Total value of political contributions by country and recipient/beneficiary	
Anti-competitive behaviour	**G4-SO7** Total number of legal actions for anti-competitive behaviour, anti-trust, and monopoly practices and their outcomes	
Compliance	**G4-SO8** Monetary value of significant fines and total number of non-monetary sanctions for non-compliance with laws and regulations	Sector addition to G4 indicator
Supplier Assessment for Impacts on Society	**G4-SO9** Percentage of new suppliers that were screened using criteria for impacts on society	
	G4-SO10 Significant actual and potential negative impacts on society in the supply chain and actions taken	
Grievance Mechanisms for Impacts on Society	**G4-SO11** Number of grievances about impacts on society filed, addressed, and resolved through formal grievance mechanisms	
Emergency Preparedness*	This sector specific Aspect does not contain Indicators	
Artisanal and Small-scale Mining*	**MM8** Number (and percentage) of company operating sites where artisanal and small-scale mining (asm) takes place on, or adjacent to, the site; the associated risks and the actions taken to manage and mitigate these risks	**x**

Resettlement*	**MM9** Sites where resettlements took place, the number of households resettled in each, and how their livelihoods were affected in the process	**x**
Closure Planning*	**MM10** Number and percentage of operations with closure plans	
Materials Stewardship*	This sector specific Aspect does not contain Indicators.	
SUB-CATEGORY: PRODUCT RESPONSIBILITY		
Customer Health and Safety	**G4PR1** Percentage of significant product and service categories for which health and safety impacts are assessed for improvement	
	G4PR2 Total number of incidents of non-compliance with regulations and voluntary codes concerning the health and safety impacts of products and services during their life cycle, by type of outcomes	
	G4PR3 Type of product and service information required by the organization's procedures for product and service information and labelling, and percentage of significant product and service categories subject to such information requirements	
	G4PR4 Total number of incidents of non-compliance with regulations and voluntary codes concerning product and service information and labelling, by type of outcomes	
	G4PR5 Results of surveys measuring customer satisfaction	
	G4PR6 Sale of banned or disputed products	
	G4PR7 Total number of incidents of non-compliance with regulations and voluntary codes concerning marketing communications, including advertising, promotion, and sponsorship, by type of outcomes	
	G4PR8 Total number of substantiated complaints regarding breaches of customer privacy and losses of customer data	
	G4PR9 Monetary value of significant fines for non-compliance with laws and regulations concerning the provision and use of products and services	
Materials Stewardship*	This sector specific Aspect does not contain Indicators	

Table 16 Assessment of impact subcategories available in PSILCA database

Impact category	Criteria					
	1. Relevance for the RM sectors	**2. Policy relevance**	**3. Link between topic and the indicator**	**4. Link between indicator and risk assessment**	**5. Reliability of the data sources**	**6. Appropriate resolution**
Child labour	2	1	2	0.5	2	1
Forced labour	1	1	2	0.5	1	2
Fair salary	2	2	2	1	1	2
Working time	1	1	2	1.5	2	2
Discrimination	1	1	1	0.5	2	2
Health and Safety	2	2	2	0.5	2	2
Social benefits, legal issues	1	1	1.5	0.5	2	1
Workers´ rights	2	2	2	1	2	2
Fair competition	0	0	1.5	0.5	1	1
Corruption	1	1	2	1	2	2
Contribution to economic development	2	2	0.7	0.5	2	1
Health and Safety (society)	0	0	1.5	0.5	2	1
Prevention and mitigation of conflicts	2	2	2	1		
Access to material resources	0	0	1	0.5	1	1
Respect of indigenous rights	2	2	1.5	1	2	1
Safe and healthy living conditions	2	2	1.5	0.65	1	0
Local employment	2	1	1.5	1.5	1	1
Migration	1	2	1.5	1	2	2
Health and Safety (consumers)	0	0	1	1	0	0
Transparency	0	0	1	1	0	0
End of life responsibility	0	0	1	1	0	0

Table 17 Risk assessment schemes applied for each indicator used in the assessment. (nr: no risk; vlr: very low risk; lr: low risk; mr: medium risk; hr: high risk; vhr: very high risk)

Stakeholder	Category	Indicator	Unit of measurement	Risk assessment
Workers	Health and Safety	Rate of non-fatal accidents at workplace	Cases per 100,000 employees and year	0≤y<750 → vlr 750≤y<1500 → lr 1500≤y<2250 → mr 2250≤y<3000 → hr 3000≤y → vhr
		Rate of fatal accidents at workplace	Cases per 100,000 employees and year	0≤y<7.5 → vlr 7.5≤y<15 → lr 15≤y<25 → mr 25≤y<40 → hr 40≤y → vhr
		DALYs due to indoor and outdoor air and water pollution	DALYs per 1,000 inhabitants in the country	0=y → nr 0<y<5 → vlr 5<y<15 → lr 15<y<30 → mr 30<y<50 → hr 50≤y → vhr
		Presence of sufficient safety measures	OSHA cases per 100,000 employees in the sector	0<y<100 → vlr 100≤y<300 → lr 300≤y<600 → mr 600≤y<1000 → hr 1000≤y → vhr
		Workers affected by natural disasters	Affected persons as % of whole population between 2012 and 2014	0≤y<1 → vlr 1≤y<3 → lr 3≤y<5 → mr 5≤y<10 → hr 10≤y → vhr
	Freedom of association and collective bargaining	Trade union density	% of employees organised in trade unions	20≥y →vhr 20<y≤40 → hr 40<y≤60 → mr 60<y≤80→ lr 80>y → vlr
		Right of Association	score of ordinal 0-3 scale	0=No; 1=Yes, with major restrictions; 2=Yes, with minor restrictions; 3=Yes
		Right of Collective bargaining	score of ordinal 0-3 scale	
		Right to strike	score of ordinal 0-3 scale	
	Child labour	Child labour, total	% of all children 7-14	0=y → nr 0<y<2.5 → vlr 2.5<y<5 → lr 5<y<10 → mr 10<y<20 → hr 20≤y → vhr
	Fair salary	Living wage, per month	USD	y<100 → vlr 100≤y<200 → lr 200≤y500 → mr 500≤y1000 → hr 1000≤y → vhr
		Minimum wage, per month	USD	1000≤y → vlr 500≤y<1000 → lr 300≤y<500 → mr 200≤y<300 → hr y<200 → vhr; if Living wage (LW) is available: x=LW/MW; x<0.5 → vlr; y>300 AND 0.5≤x<0.9 → lr; (y≤300 AND 0.5≤x≤0.9) OR (y>300 AND 0.9≤x<0.3) → mr; (y≤300 AND 0.9≤x≤1.3) OR (y>300 AND 1.3≤x<1.8) → hr; (y≤300 AND 1.3≤x≤1.8) OR (x≥1.8) → vhr;
		Sector average wage, per month	USD	0<y<1 → vhr 1≤y<1.5 → hr 1.5≤y<2 → mr 2≤y<2.5 → lr 2.5≤y → vlr

Stakeholder	Category	Indicator	Unit of measurement	Risk assessment
	Working time	Hours of work per employee, per week	h	40≤y<48 → lr; 30≤y<40 OR 48≤y<55 → mr; 20≤y<30 OR 55≤y<60 → hr; 60≤y vhr
Local communities	Respect of indigenous rights	Presence of indigenous population	Y/N	No=nr; Yes=mr
		Human rights issues faced by indigenous people	Score	y=5 → vlr; y=4 → lr; y=3 → mr; y=2 → hr; y+1 OR 0 → vhr
	Migration	International migrant workers in the sector	% (employed international migrant population related to total employed population)	Difference x to migrant stock, % y=0 → nr 0<y≤2.5 AND x≤|5|→ vlr 2.5<y≤5 AND x≤|5|→ lr 5<y≤10 AND (x≤|5|OR |5|<y≤|10|) → mr 10<y≤20 AND (x≤|5|OR |10|<y≤|15|) → hr y≥20 AND x≤|15|→ vhr
		International migrant stock	% (of total population)	0=y → nr 0<y<2.5 → vlr 2.5≤y<5 → lr 5≤y<10 → mr 10≤y<20 → hr 20≤y → vhr
		Net migration rate	‰ (= per 1,000 persons)	0=y → nr 0<y<|2.5|→ vlr |2.5|≤y<|5|→ lr |5|≤y<|10|→ mr |10|≤y<|15|→ hr |15|≤y → vhr
Value Chain Actors	Corruption	Public sector corruption	Score (Corruption Perceptions Index score of the country)	100≥y≥85 → vlr 84≥y≥75 → lr 74≥y≥65 → mr 64≥y≥55 →hr 55≥y → vhr
		Active involvement of enterprises in corruption and bribery	% of sector-related cases out of all registered foreign bribery cases	0<y≤3 → vlr 3<y≤7 → lr 7<y≤11 → mr 11<y≤14 → hr 14<y → vhr
Society	Contribution to economic development	Contribution of the sector to economic development	% of GDP	0≤y<1 → no opportunity 1≤y≤10 → low opportunity 10<y≤25 → medium opportunity 25<y → high opportunity
		Public expenditure on education	% of GDP	0≤y<2.5 → vhr 2.5≤y<5 → hr 5≤y<7.5 → mr 7.5≤y<10 → lr; 10≤y → vlr
		Adult illiteracy rate (15+ years), male	% of male population	0≤y<1 → vlr 1≤y<4 → lr 4≤y<8 → mr 8≤y<15 → hr 15≤y → vhr
		Adult illiteracy rate (15+ years), female	% of female population	
		Adult illiteracy rate (15+ years), total	% of total population	
		Youth illiteracy rate, male	% of male population, 15-24	
		Youth illiteracy rate, female	% of female population, 15-24	
		Youth illiteracy rate, total	% of total population, 15-24	

Table 18 Characterization factors applied for each level of risk in the selected indicators

Indicators – risk levels	Factor	Unit
Rate of non-fatal accidents at workplace; high risk	10	NFA med risk hours/h
Rate of non-fatal accidents at workplace; low risk	0.1	NFA med risk hours/h
Rate of non-fatal accidents at workplace; medium risk	1	NFA med risk hours/h
Rate of non-fatal accidents at workplace; no data	0.1	NFA med risk hours/h
Rate of non-fatal accidents at workplace; very high risk	100	NFA med risk hours/h
Rate of non-fatal accidents at workplace; very low risk	0.01	NFA med risk hours/h
Rate of fatal accidents at workplace; high risk	10	FA med risk hours/h
Rate of fatal accidents at workplace; low risk	0.1	FA med risk hours/h
Rate of fatal accidents at workplace; medium risk	1	FA med risk hours/h
Rate of fatal accidents at workplace; no data	0.1	FA med risk hours/h
Rate of fatal accidents at workplace; very high risk	100	FA med risk hours/h
Rate of fatal accidents at workplace; very low risk	0.01	FA med risk hours/h
DALYs due to indoor and outdoor air and water pollution; high risk	10	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; low risk	0.1	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; medium risk	1	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; no data	0.1	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; no risk	0	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; very high risk	100	DALY med risk hours/h
DALYs due to indoor and outdoor air and water pollution; very low risk	0.01	DALY med risk hours/h
Presence of sufficient safety measures; high risk	10	SM med risk hours/h
Presence of sufficient safety measures; low risk	0.1	SM med risk hours/h
Presence of sufficient safety measures; medium risk	1	SM med risk hours/h
Presence of sufficient safety measures; no data	0.1	SM med risk hours/h
Presence of sufficient safety measures; very high risk	100	SM med risk hours/h
Presence of sufficient safety measures; very low risk	0.01	SM med risk hours/h
Workers affected by natural disasters; high risk	10	ND med risk hours/h
Workers affected by natural disasters; low risk	0.1	ND med risk hours/h
Workers affected by natural disasters; medium risk	1	ND med risk hours/h
Workers affected by natural disasters; no data	0.1	ND med risk hours/h
Workers affected by natural disasters; very high risk	100	ND med risk hours/h
Workers affected by natural disasters; very low risk	0.01	ND med risk hours/h
Trade union density; high risk	10	TU med risk hours/h
Trade union density; low risk	0.1	TU med risk hours/h
Trade union density; medium risk	1	TU med risk hours/h
Trade union density; very high risk	100	TU med risk hours/h
Trade union density; very low risk	0.01	TU med risk hours/h
Right of Association; high risk	10	ACB med risk hours/h
Right of Association; low risk	0.1	ACB med risk hours/h
Right of Association; no data	0.1	ACB med risk hours/h
Right of Association; no risk	0	ACB med risk hours/h
Right of Association; very high risk	100	ACB med risk hours/h
Right of Collective bargaining; high risk	10	ACB med risk hours/h
Right of Collective bargaining; low risk	0.1	ACB med risk hours/h
Right of Collective bargaining; no data	0.1	ACB med risk hours/h
Right of Collective bargaining; no risk	0	ACB med risk hours/h
Right of Collective bargaining; very high risk	100	ACB med risk hours/h
Right to Strike; high risk	10	ACB med risk hours/h
Right to Strike; low risk	0.1	ACB med risk hours/h
Right to Strike; no data	0.1	ACB med risk hours/h
Right to Strike; no risk	0	ACB med risk hours/h
Right to Strike; very high risk	100	ACB med risk hours/h
Children in employment, total; high risk	10	CL med risk hours/h
Children in employment, total; low risk	0.1	CL med risk hours/h
Children in employment, total; medium risk	1	CL med risk hours/h
Children in employment, total; no data	0.1	CL med risk hours/h
Children in employment, total; no risk	0	CL med risk hours/h
Children in employment, total; very high risk	100	CL med risk hours/h
Children in employment, total; very low risk	0.01	CL med risk hours/h
Living wage, per month; high risk	1	FS med risk hours/h
Living wage, per month; low risk	0.01	FS med risk hours/h
Living wage, per month; medium risk	0.1	FS med risk hours/h
Living wage, per month; no data	0.1	FS med risk hours/h
Living wage, per month; very high risk	10	FS med risk hours/h
Living wage, per month; very low risk	0.001	FS med risk hours/h
Minimum wage, per month; high risk	1	FS med risk hours/h

Indicators – risk levels	Factor	Unit
Minimum wage, per month; low risk	0.01	FS med risk hours/h
Minimum wage, per month; medium risk	0.1	FS med risk hours/h
Minimum wage, per month; no data	0.01	FS med risk hours/h
Minimum wage, per month; very high risk	10	FS med risk hours/h
Minimum wage, per month; very low risk	0.001	FS med risk hours/h
Sector average wage, per month; high risk	10	FS med risk hours/h
Sector average wage, per month; low risk	0.1	FS med risk hours/h
Sector average wage, per month; medium risk	1	FS med risk hours/h
Sector average wage, per month; no data	0.1	FS med risk hours/h
Sector average wage, per month; very high risk	100	FS med risk hours/h
Sector average wage, per month; very low risk	0.01	FS med risk hours/h
Weekly hours of work per employee; high risk	10	WH med risk hours/h
Weekly hours of work per employee; low risk	0.1	WH med risk hours/h
Weekly hours of work per employee; medium risk	1	WH med risk hours/h
Weekly hours of work per employee; no data	0.1	WH med risk hours/h
Weekly hours of work per employee; very high risk	100	WH med risk hours/h
Presence of indigenous population; medium risk	0.1	IR med risk hours/h
Presence of indigenous population; no risk	0	IR med risk hours/h
Human rights issues faced by indigenous people; high risk	10	IR med risk hours/h
Human rights issues faced by indigenous people; low risk	0.1	IR med risk hours/h
Human rights issues faced by indigenous people; medium risk	1	IR med risk hours/h
Human rights issues faced by indigenous people; no data	0.1	IR med risk hours/h
Human rights issues faced by indigenous people; not applicable	0	IR med risk hours/h
Human rights issues faced by indigenous people; very high risk	100	IR med risk hours/h
Human rights issues faced by indigenous people; very low risk	0.01	IR med risk hours/h
International migrant workers in the sector; high risk	10	IMW med risk hours/h
International migrant workers in the sector; low risk	0.1	IMW med risk hours/h
International migrant workers in the sector; medium risk	1	IMW med risk hours/h
International migrant workers in the sector; no data	0.1	IMW med risk hours/h
International migrant workers in the sector; no risk	0	IMW med risk hours/h
International migrant workers in the sector; very high risk	100	IMW med risk hours/h
International migrant workers in the sector; very low risk	0.01	IMW med risk hours/h
International Migrant Stock; high risk	10	IMS med risk hours/h
International Migrant Stock; low risk	0.1	IMS med risk hours/h
International Migrant Stock; medium risk	1	IMS med risk hours/h
International Migrant Stock; no data	0.1	IMS med risk hours/h
International Migrant Stock; no risk	0	IMS med risk hours/h
International Migrant Stock; very high risk	100	IMS med risk hours/h
International Migrant Stock; very low risk	0.01	IMS med risk hours/h
Net migration rate; high risk	10	NM med risk hours/h
Net migration rate; low risk	0.1	NM med risk hours/h
Net migration rate; medium risk	1	NM med risk hours/h
Net migration rate; no data	0.1	NM med risk hours/h
Net migration rate; no risk	0	NM med risk hours/h
Net migration rate; very high risk	100	NM med risk hours/h
Net migration rate; very low risk	0.01	NM med risk hours/h
Public sector corruption; high risk	10	C med risk hours/h
Public sector corruption; low risk	0.1	C med risk hours/h
Public sector corruption; medium risk	1	C med risk hours/h
Public sector corruption; no data	0.1	C med risk hours/h
Public sector corruption; very high risk	100	C med risk hours/h
Public sector corruption; very low risk	0.01	C med risk hours/h
Active involvement of enterprises in corruption and bribery; high risk	10	AI med risk hours/h
Active involvement of enterprises in corruption and bribery; low risk	0.1	AI med risk hours/h
Active involvement of enterprises in corruption and bribery; medium risk	1	AI med risk hours/h
Active involvement of enterprises in corruption and bribery; no data	0.1	AI med risk hours/h
Active involvement of enterprises in corruption and bribery; very high risk	100	AI med risk hours/h
Active involvement of enterprises in corruption and bribery; very low risk	0.01	AI med risk hours/h
Contribution of the sector to economic development; high opportunity	10	CE med risk hours/h
Contribution of the sector to economic development; low opportunity	0.1	CE med risk hours/h
Contribution of the sector to economic development; medium opportunity	1	CE med risk hours/h
Contribution of the sector to economic development; no data	0.1	CE med risk hours/h
Contribution of the sector to economic development; no opportunity	0	CE med risk hours/h
Public expenditure on education; high risk	10	E med risk hours/h
Public expenditure on education; low risk	0.1	E med risk hours/h
Public expenditure on education; medium risk	1	E med risk hours/h
Public expenditure on education; no data	0.1	E med risk hours/h

Indicators – risk levels	Factor	Unit
Public expenditure on education; very high risk	100	E med risk hours/h
Public expenditure on education; very low risk	0.01	E med risk hours/h
Illiteracy rate, female; high risk	10	ED med risk hours/h
Illiteracy rate, female; low risk	0.1	ED med risk hours/h
Illiteracy rate, female; medium risk	1	ED med risk hours/h
Illiteracy rate, female; no data	0.1	ED med risk hours/h
Illiteracy rate, female; very high risk	100	ED med risk hours/h
Illiteracy rate, female; very low risk	0.01	ED med risk hours/h
Illiteracy rate, male; high risk	10	ED med risk hours/h
Illiteracy rate, male; low risk	0.1	ED med risk hours/h
Illiteracy rate, male; medium risk	1	ED med risk hours/h
Illiteracy rate, male; no data	0.1	ED med risk hours/h
Illiteracy rate, male; very high risk	100	ED med risk hours/h
Illiteracy rate, male; very low risk	0.01	ED med risk hours/h
Illiteracy rate, total; high risk	10	ED med risk hours/h
Illiteracy rate, total; low risk	0.1	ED med risk hours/h
Illiteracy rate, total; medium risk	1	ED med risk hours/h
Illiteracy rate, total; no data	0.1	ED med risk hours/h
Illiteracy rate, total; very high risk	100	ED med risk hours/h
Illiteracy rate, total; very low risk	0.01	ED med risk hours/h
Youth illiteracy rate, female; high risk	10	YI med risk hours/h
Youth illiteracy rate, female; low risk	0.1	YI med risk hours/h
Youth illiteracy rate, female; medium risk	1	YI med risk hours/h
Youth illiteracy rate, female; no data	0.1	YI med risk hours/h
Youth illiteracy rate, female; very high risk	100	YI med risk hours/h
Youth illiteracy rate, female; very low risk	0.01	YI med risk hours/h
Youth illiteracy rate, male; high risk	10	YI med risk hours/h
Youth illiteracy rate, male; low risk	0.1	YI med risk hours/h
Youth illiteracy rate, male; medium risk	1	YI med risk hours/h
Youth illiteracy rate, male; no data	0.1	YI med risk hours/h
Youth illiteracy rate, male; very high risk	100	YI med risk hours/h
Youth illiteracy rate, male; very low risk	0.01	YI med risk hours/h
Youth illiteracy rate, total; high risk	10	YI med risk hours/h
Youth illiteracy rate, total; low risk	0.1	YI med risk hours/h
Youth illiteracy rate, total; medium risk	1	YI med risk hours/h
Youth illiteracy rate, total; no data	0.1	YI med risk hours/h
Youth illiteracy rate, total; very high risk	100	YI med risk hours/h
Youth illiteracy rate, total; very low risk	0.01	YI med risk hours/h

Table 19 Full results of the impact assessment

Country /Region	Impact category	Forestry and logging	Manufacture of metals	Manufacture of minerals	Manufacture of paper	Manufacture of wood	Mining and quarrying
A	Child labour	0.043	0.096	0.011	0.057	0.080	0.137
A	Contribution to economic development	0.156	2.745	1.514	1.271	0.188	4.748
A	Corruption	0.615	1.927	1.072	1.142	1.063	3.131
A	Fair salary	2.508	3.120	2.642	3.025	2.967	4.337
A	Freedom of association and collective bargaining	2.575	2.826	2.457	3.097	3.117	3.646
A	Health and Safety	1.267	0.947	0.295	0.384	0.561	1.056
A	Migration	3.716	1.545	3.465	3.732	3.247	1.657
A	Respect of indigenous rights	1.842	0.835	1.708	1.889	1.660	0.828
A	Working time	0.020	0.011	0.017	0.023	0.021	0.010
B	Child labour	0.016	0.068	0.039	0.059	0.054	0.290
B	Contribution to economic development	0.326	1.312	1.194	0.130	0.286	0.876
B	Corruption	10.858	11.832	10.319	11.772	7.940	14.133
B	Fair salary	10.787	9.012	8.329	10.593	6.652	11.338
B	Freedom of association and collective bargaining	10.381	8.807	7.795	9.821	6.537	11.023
B	Health and Safety	6.717	6.591	1.699	3.681	5.721	4.642
B	Migration	0.026	0.113	0.032	0.094	0.168	0.050
B	Respect of indigenous rights	0.184	0.272	0.123	0.292	0.890	0.180
B	Working time	0.018	0.016	0.017	0.033	0.019	0.018
C	Child labour	4.264	1.279	1.505	1.763	1.510	2.297
C	Contribution to economic development	4.191	0.702	0.678	0.440	0.608	2.847
C	Corruption	42.700	12.910	15.118	17.674	15.149	23.307
C	Fair salary	60.495	14.339	23.442	18.930	16.077	25.740
C	Freedom of association and collective bargaining	47.432	14.337	16.788	19.663	16.863	25.863
C	Health and Safety	38.231	4.699	2.758	3.394	2.732	4.384
C	Migration	0.066	0.051	0.055	0.080	0.040	0.081
C	Respect of indigenous rights	0.901	0.277	0.328	0.409	0.356	0.497
C	Working time	0.218	0.031	0.047	0.032	0.046	0.041
EU-28	Child labour	0.064	0.017	0.010	0.049	0.007	0.362
EU-28	Contribution to economic development	0.324	1.148	0.339	0.898	0.119	10.592
EU-28	Corruption	1.489	1.531	1.689	0.995	1.131	14.389
EU-28	Fair salary	1.889	1.392	1.169	1.380	1.112	9.371
EU-28	Freedom of association and collective bargaining	2.395	2.023	1.838	1.869	1.408	11.371
EU-28	Health and Safety	2.912	1.931	0.730	0.758	1.647	11.173
EU-28	Migration	0.366	0.345	0.438	0.430	0.430	5.465
EU-28	Respect of indigenous rights	0.065	0.060	0.068	0.109	0.059	0.896
EU-28	Working time	0.021	0.016	0.019	0.017	0.018	0.134
D	Child labour	0.094	0.189	0.183	0.588	0.192	0.160
D	Contribution to economic development	0.645	4.583	1.420	3.900	1.485	18.752
D	Corruption	7.418	18.771	21.882	6.353	18.683	8.354
D	Fair salary	8.012	14.795	16.725	6.152	16.748	11.961
D	Freedom of association and collective bargaining	0.966	3.361	1.739	5.943	2.164	9.047

Country /Region	Impact category	Forestry and logging	Manufacture of metals	Manufacture of minerals	Manufacture of paper	Manufacture of wood	Mining and quarrying
D	Health and Safety	0.265	4.517	1.133	1.131	8.761	1.921
D	Migration	0.104	0.438	0.532	0.671	0.584	0.438
D	Respect of indigenous rights	0.081	0.287	0.165	0.251	0.188	0.187
D	Working time	0.073	0.118	0.119	0.027	0.148	0.025
E	Child labour	16.511	3.482	12.090	11.039	12.794	8.378
E	Contribution to economic development	4.847	13.413	1.646	3.123	5.222	4.951
E	Corruption	22.367	9.016	16.529	14.388	19.185	14.128
E	Fair salary	23.122	11.014	13.916	15.236	19.952	12.006
E	Freedom of association and collective bargaining	6.229	6.200	2.226	3.967	6.278	3.653
E	Health and Safety	31.102	6.336	14.450	14.852	24.134	12.363
E	Migration	0.284	0.169	0.047	0.141	0.303	0.068
E	Respect of indigenous rights	0.320	0.469	0.160	0.226	0.291	0.162
E	Working time	0.027	0.015	0.018	0.022	0.023	0.015
F	Child labour	0.013	0.020	0.006	0.004	0.001	0.039
F	Contribution to economic development	0.286	1.148	0.279	0.218	0.196	0.725
F	Corruption	0.245	1.035	0.264	0.189	0.138	1.940
F	Fair salary	3.823	4.383	3.384	2.954	3.254	4.086
F	Freedom of association and collective bargaining	3.821	4.241	3.376	2.999	3.277	3.981
F	Health and Safety	1.466	1.858	0.395	0.456	1.214	0.858
F	Migration	0.381	0.438	0.365	0.318	0.340	0.429
F	Respect of indigenous rights	3.666	3.605	3.241	2.838	3.230	3.354
F	Working time	0.031	0.025	0.019	0.022	0.021	0.027

Table 20 Data quality results by country/region and impact category, as average between sectors

Country	Impact category	Average data quality among sectors				
		R	C	T	G	F
Australia	Child labour	2	4	5	4	5
Australia	Contribution to economic development	2	2	2	1	3
Australia	Corruption	4	3	1	1	3
Australia	Fair salary	1	2	1	1	1
Australia	Freedom of association and collective bargaining	2	2	4	1	5
Australia	Health and Safety	1	2	1	3	2
Australia	Migration	1	2	2	1	2
Australia	Respect of indigenous rights	2	3	1	1	n.a.
Australia	Working time	2	2	2	1	2
Brazil	Child labour	2	4	4	2	5
Brazil	Contribution to economic development	2	2	2	1	3
Brazil	Corruption	4	3	1	1	2
Brazil	Fair salary	2	3	1	1	1
Brazil	Freedom of association and collective bargaining	2	2	4	1	5
Brazil	Health and Safety	1	2	2	3	2
Brazil	Migration	2	3	3	2	4
Brazil	Respect of indigenous rights	2	2	1	1	n.a.
Brazil	Working time	2	2	3	1	2
China	Child labour	2	4	5	4	5
China	Contribution to economic development	4	4	3	3	3
China	Corruption	4	3	1	1	4
China	Fair salary	2	3	1	1	1
China	Freedom of association and collective bargaining	2	3	3	1	4
China	Health and Safety	2	2	2	3	3
China	Migration	3	3	3	3	4
China	Respect of indigenous rights	2	2	1	1	n.a.
China	Working time	2	2	5	1	2
EU	Child labour	2	4	5	3	5
EU	Contribution to economic development	2	2	3	1	3
EU	Corruption	4	3	1	1	2
EU	Fair salary	1	2	1	1	1
EU	Freedom of association and collective bargaining	2	2	4	1	5
EU	Health and Safety	1	2	2	3	2
EU	Migration	2	2	4	1	2
EU	Respect of indigenous rights	2	3	1	1	n.a.
EU	Working time	2	2	1	1	2
Russia	Child labour	2	4	4	4	5
Russia	Contribution to economic development	2	2	3	1	3
Russia	Corruption	4	3	1	1	2
Russia	Fair salary	2	3	1	1	1
Russia	Freedom of association and collective bargaining	2	2	4	1	5
Russia	Health and Safety	1	2	1	4	2
Russia	Migration	1	2	2	1	4
Russia	Respect of indigenous rights	2	3	1	1	n.a.
Russia	Working time	2	2	4	1	2
South Africa	Child labour	2	4	5	1	5
South Africa	Contribution to economic development	2	2	2	1	3
South Africa	Corruption	4	3	1	1	3
South Africa	Fair salary	2	3	1	1	1
South Africa	Freedom of association and collective bargaining	2	2	5	1	5
South Africa	Health and Safety	2	3	4	2	3
South Africa	Migration	2	2	3	1	3
South Africa	Respect of indigenous rights	1	2	1	1	n.a.
South Africa	Working time	2	3	4	1	3
United States	Child labour	2	4	5	4	5
United States	Contribution to economic development	1	2	3	1	3
United States	Corruption	3	3	1	1	3
United States	Fair salary	1	1	1	1	1
United States	Freedom of association and collective bargaining	2	2	4	1	5
United States	Health and Safety	1	2	1	4	2
United States	Migration	1	2	2	1	4
United States	Respect of indigenous rights	2	3	1	1	n.a.
United States	Working time	2	3	3	1	3

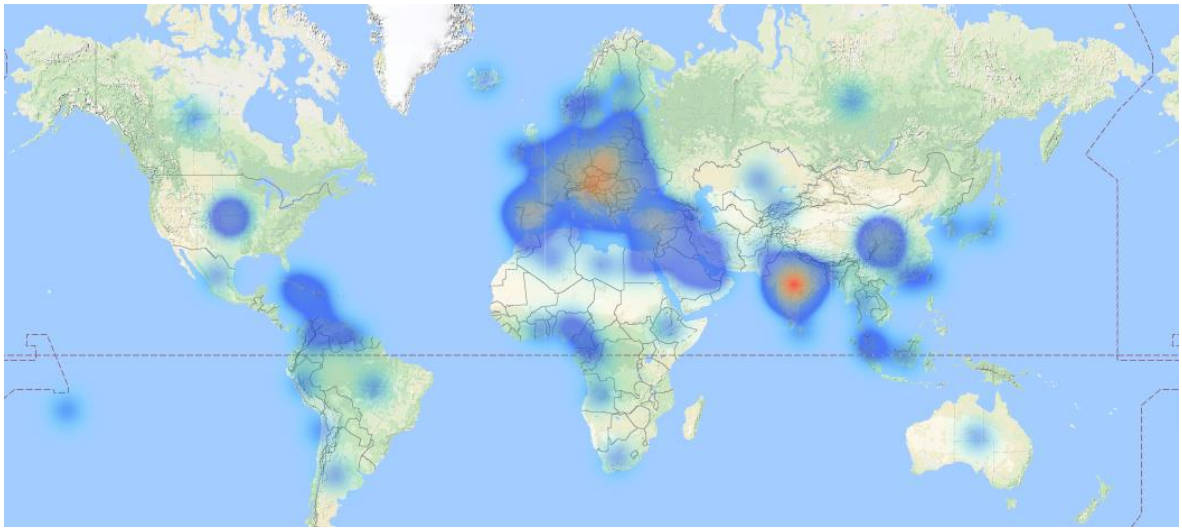

Figure 28 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Freedom of association and collective bargaining"

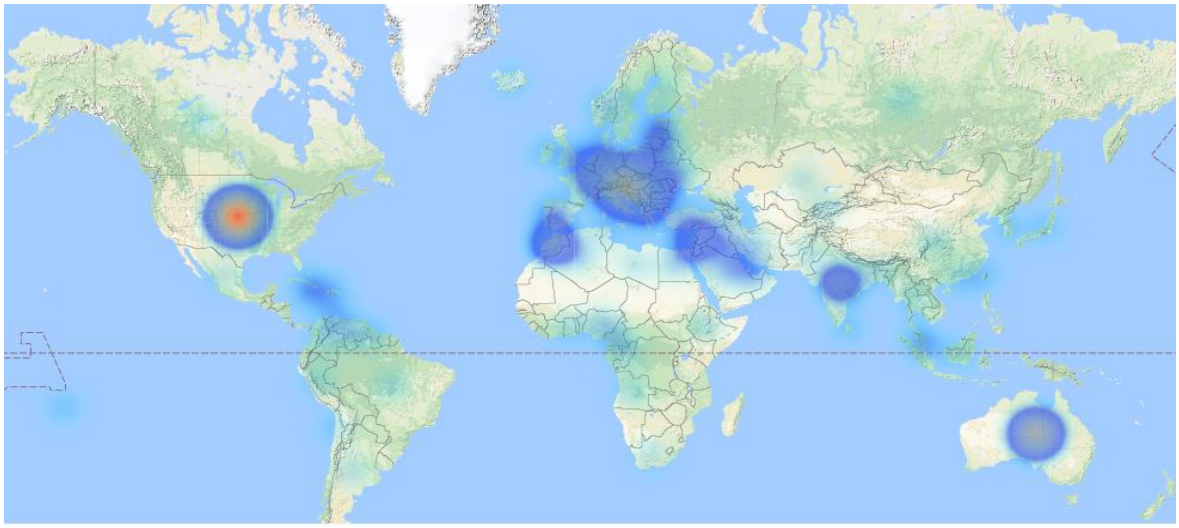

Figure 29 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Respect of indigenous rights"

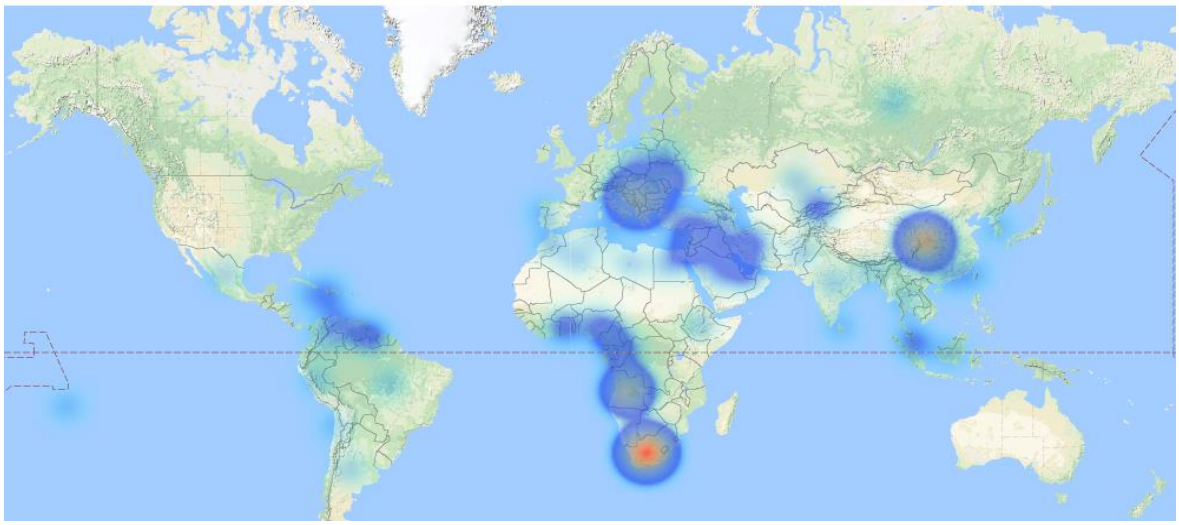

Figure 30 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Child labour"

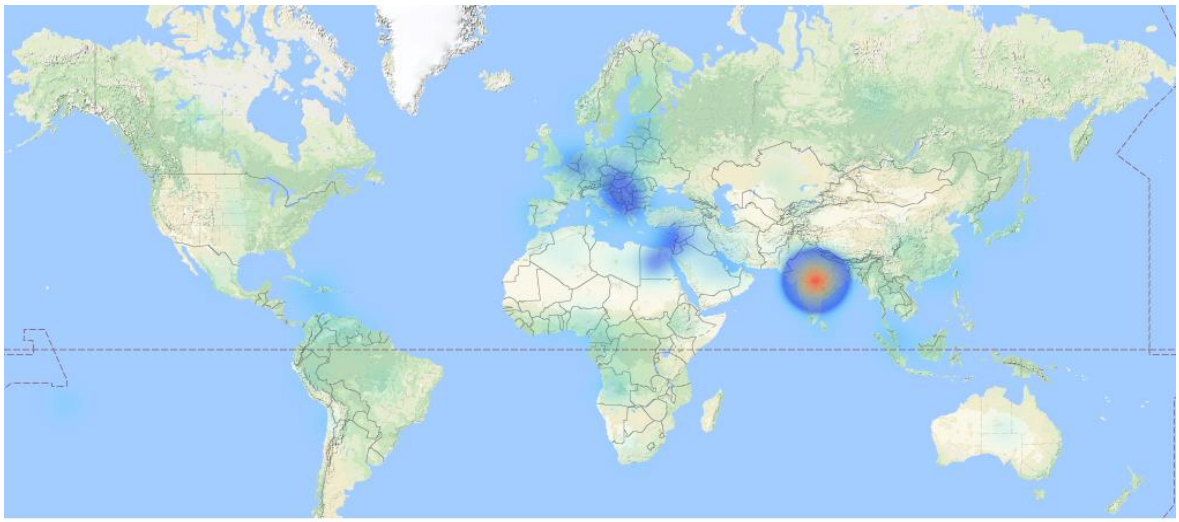

Figure 31 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Contribution to economic development"

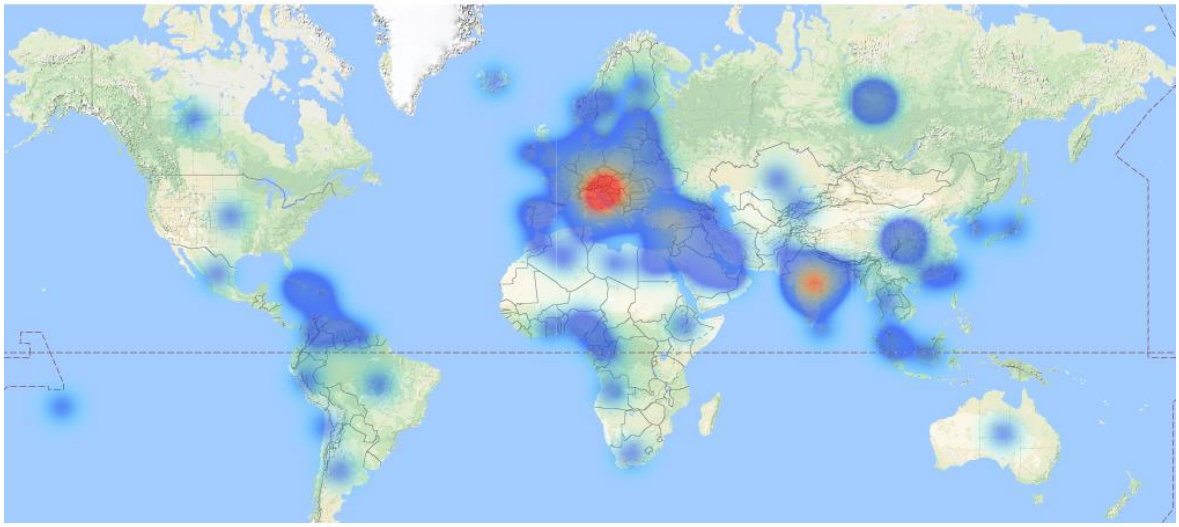

Figure 32 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Corruption"

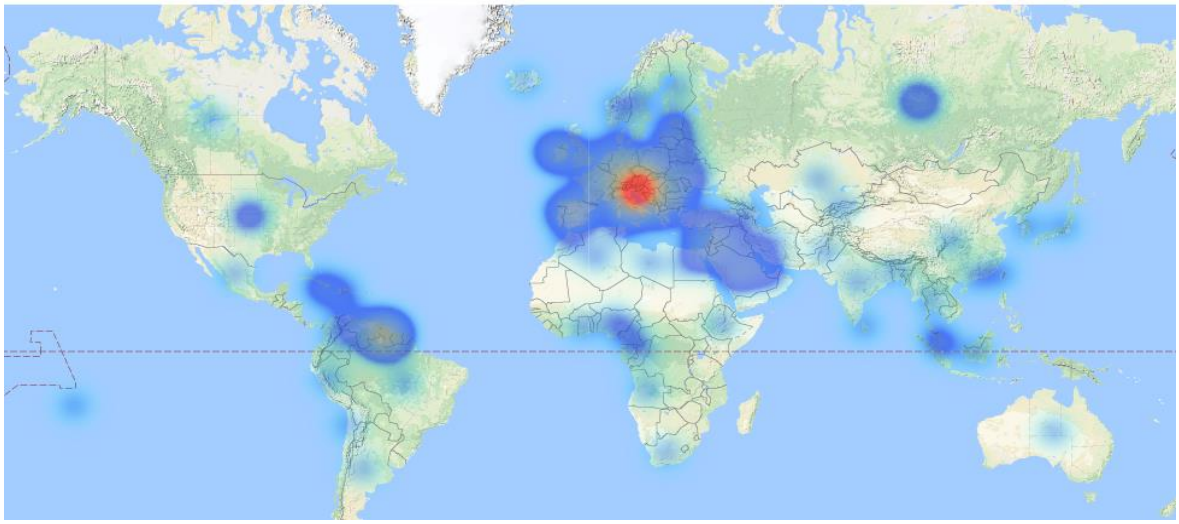

Figure 33 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Working time"

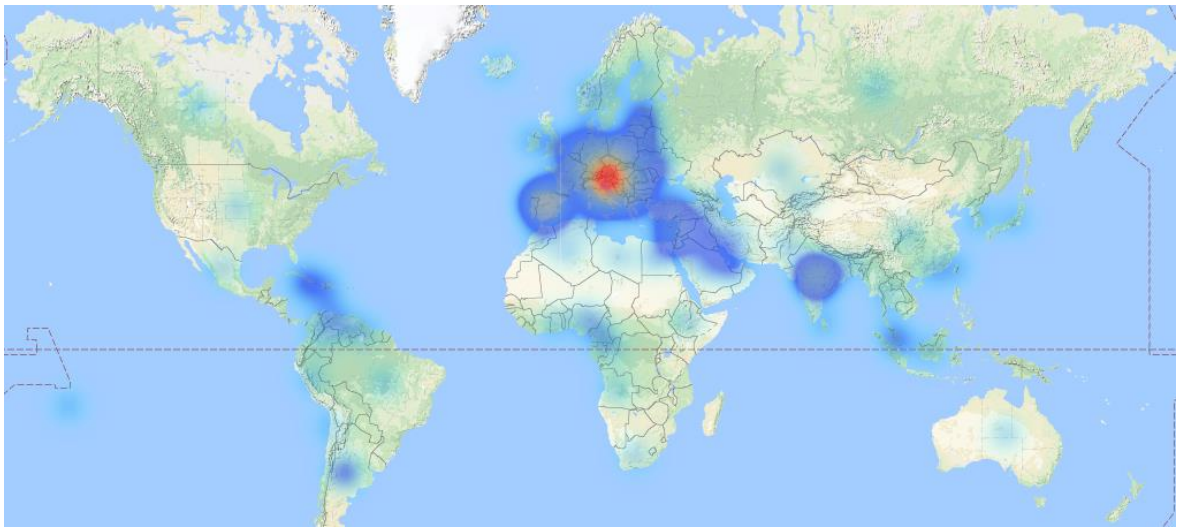

Figure 34 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Health and Safety "

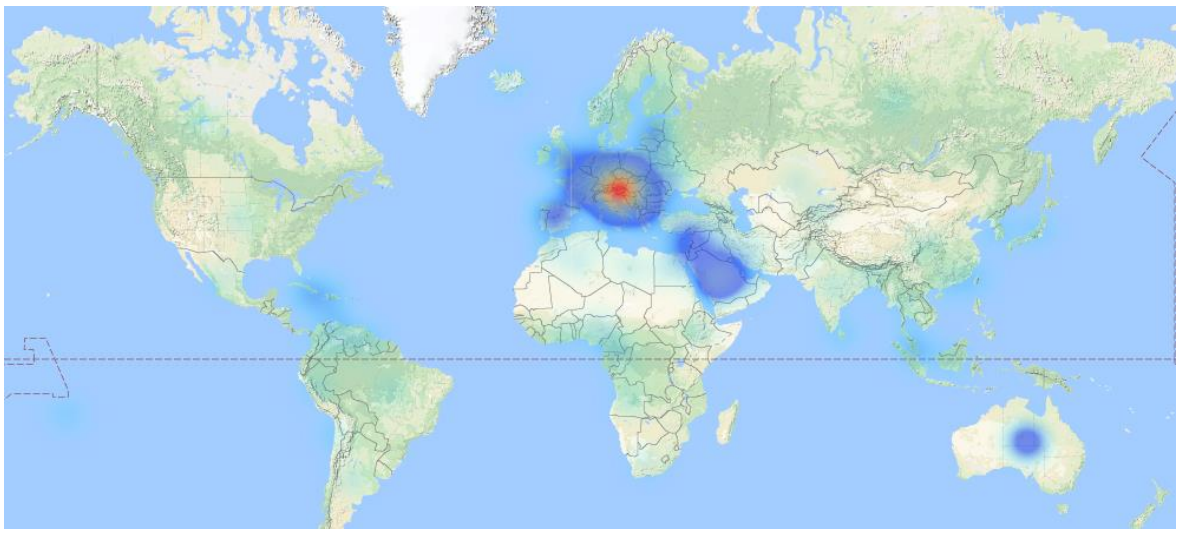

Figure 35 Social hotspots (including direct and indirect impacts) in the supply chain of mining and quarrying in EU, for the impact category "Migration"

Table 21 Pedigree matrix for data quality assessment of social data, used in PSILCA (1: highest data quality; 5: lowest data quality)

	Scores				
Criteria	**1**	**2**	**3**	**4**	**5**
Reliability of the source(s)	Statistical study, or verified data from primary data collection from several sources	Verified data from primary data collection from one single source or non-verified data from primary sources , or data from recognized secondary sources	Non-verified data partly based on assumptions or data from non-recognized sources	Qualified estimate (e.g. by expert)	Non-qualified estimate or unknown origin
Completeness conformance	Complete data for country-specific sector / country	Representative selection of country-specific sector / country	Non-representative selection, low bias	Non-representative selection, unknown bias	Single data point / completeness unknown
Temporal conformance	Less than 1 year of difference to the time period of the dataset	Less than 2 years of difference to the time period of the dataset	Less than 3 years of difference to the time period of the dataset	Less than 5 years of difference to the time period of the dataset	Age of data unknown or data with more than 5 years of difference to the time period of the dataset
Geographical conformance	Data from same geography (country)	Country with similar conditions or average of countries with slightly different conditions	Average of countries with different conditions, geography under study included, with large share; or country with slightly different conditions	Average of countries with different conditions, geography under study included, with small share; or not included	Data from unknown or distinctly different regions
Further technical conformance	Data from same technology (sector)	Data from similar sector, e.g. within the same sector hierarchy; or average of sectors with similar technology	Data from slightly different sector, or average of different sectors, sector under study included, with large share	Average of different sectors, sector under study included, with small share; or not included	Data with unknown technology / sector or from distinctly different sector

References

Baines, J., Morgan, B., 2004. Sustainability appraisal: a social perspective. Sustain. Apprais. A Rev. Int. Exp. Pract. Dalal-clayt. B Sadler B,(Eds), First Draft Work Progress, Int. Inst. Environ. Dev. London.

Beck, U., 1992. Risk society: Towards a new modernity. Sage.

Bendell, J., Kearins, K., 2005. The political bottom line: the emerging dimension to corporate responsibility for sustainable development. Bus. Strateg. Environ. 14, 372–383.

Benoit-Norris, C., Norris, G., Xiao, Y., Murray, J., 2018. Human Rights Due Diligence with the Social Hotspots Database, in: Murray, J., Malik, A., Geschke, A. (Eds.), The Social Effects of Global Trade. Quantifying Impacts Using Multi-Regional Input-Output Analysis. Pan Stanford Publishing Pte. Ldt.

Benoit-Norris, C., Norris, A.G., Aulisio, D., 2014. Efficient Assessment of Social Hotspots in the Supply Chains of 100 Product Categories Using the Social Hotspots Database. Sustainability. doi:10.3390/su6106973

Benoit-Norris, C., Norris, G.A., Aulisio Cavan, D., 2013. Social Hotspots Database. Supporting documentation.

Benoît-Norris, C., Traverso, M., Valdivia, S., Vickery-Niederman, G., Franze, J., Azuero, L., Ciroth, A., Mazijn, B., Aulisio, D., 2013. The methodological sheets for sub-categories in social life cycle assessment (S-LCA). Life cycle Initiat. UNEP-SETAC. Retrieved May 2, 2014.

Benoit-Norris, C., Cavan, D.A., Norris, G., 2012. Identifying Social Impacts in Product Supply Chains:Overview and Application of the Social Hotspot Database. Sustainability 4, 1946–1965. doi:10.3390/su4091946

Boström, M., 2012. A missing pillar? Challenges in theorizing and practicing social sustainability: introduction to the special issue. Sustain. Sci. Pract. Policy 8, 3–14. doi:10.1080/15487733.2012.11908080

Buxton, A., 2013. Responding to the challenge of artisanal and small-scale mining. How can knowledge networks help? London.

Chambers, R., Conway, G., 1992. Sustainable rural livelihoods: practical concepts for the 21st century. Institute of Development Studies (UK).

Chiu, R.L.H., 2004. Socio-cultural sustainability of housing: a conceptual exploration. Housing, Theory Soc. 21, 65–76.

Chiu, R.L.H., 2003. Social sustainability, sustainable development and housing development, in: Housing and Social Change: East-West Perspectives. Routledge.

Ciroth, A., Eisfeldt, F., 2016. PSILCA – A Product Social Impact Life Cycle Assessment database. Database version 1.0. Documentation 1–99.

Čuček, L., Klemeš, J.J., Kravanja, Z., 2012. A Review of Footprint analysis tools for monitoring impacts on sustainability. J. Clean. Prod. 34, 9–20. doi:https://doi.org/10.1016/j.jclepro.2012.02.036

Cuthill, M., 2010. Strengthening the 'social'in sustainable development: Developing a conceptual framework for social sustainability in a rapid urban growth region in Australia. Sustain. Dev. 18, 362–373.

Dendena, B., Corsi, S., 2015. The Environmental and Social Impact Assessment: a further step towards an integrated assessment process. J. Clean. Prod. 108, 965–977.

Di Cesare, S., Silveri, F., Sala, S., Petti, L., 2016. Positive impacts in social life cycle assessment: state of the art and the way forward. Int. J. Life Cycle Assess. 1–16. doi:10.1007/s11367-016-1169-7

EC, OECD, I., 2008. System of National Accounts, United Nations, New York. doi:10.1057/ukna.2008.3

EC - European Commission, 2018. Raw Materials Scoreboard European innovation partnership on raw materials. Luxembourg. doi: 10.2873/13314

EC - European Commission, 2017a. Communication from the Commission to the European Parliament, the European Council, the Council, the European Economic and Social Committee, the Committee of the Regions and the European Investment Bank. Investing in a smart, innovative and sustainable Industry A renewed EU Industrial Policy Strategy. COM/2017/0479 final.

EC - European Commission, 2017b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions on the 2017 list of Critical Raw Materials for the EU. COM/2014/0398 final.

EC - European Commission, 2017c. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Commettee of the Regions. Establishing a European Pillar of Social Rights. COM/2017/0250 final.

EC - European Commission, 2016a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Commettee of the Regions. Next steps for a sustainable European future European action for sustainability. COM/2016/739 final.

EC - European Commission, 2016b. Raw materials scoreboard European innovation partnership on raw materials. Luxembourg. doi:10.2873/85546

EC - European Commission, 2015a. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions. A Global Partnership for Poverty Eradication and Sustainable Development after 2015. COM/2015/44 final.

EC - European Commission, 2015b. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Commettee of the Regions. Closing the loop - An EU action plan for the Circular Economy. COM/2015/0614 final.

EC - European Commission, 2013. COMMISSION RECOMMENDATION of 9 April 2013 on the use of common methods to measure and communicate the life cycle environmental performance of products and organisations.

EC - European Commission, 2010a. Communication from the Commission. Europe 2020 A strategy for a smart, sustainable and inclusive growth. COM/2010/2020 final.

EC - European Commission, 2010b. An Integrated Industrial Policy for the Globalisation Era Putting Competitiveness and Sustainability at Centre Stage. COM/2010/614 final

EC - European Commission, 2008. Communication from the Commission to the European Parliament and the Council. The raw materials initiative: meeting our critical needs for growth and jobs in Europe. COM/2008/0699 final.

Eizenberg, E., Jabareen, Y., 2017. Social sustainability: A new conceptual framework. Sustainability 9, 68.

Elkington, J., 1998. Cannibals with Forks: the Triple Bottom Line of 21st Century Business, Conscientious Commerce. doi:0865713928

Esteves, A.M., Franks, D., Vanclay, F., 2012. Social impact assessment: the state of the art. Impact Assess. Proj. Apprais. 30, 34–42.

European Union, 2017. Regulation (EU) 2017/821 of the European Parliament and of the Council of 17 May 2017 laying down supply chain due diligence obligations for Union

importers of tin, tantalum and tungsten, their ores, and gold originating from conflict-affected and high-risk areas.

Global Reporting Initiative, 2013a. G4 Sustainability Reporting Guidelines. Reporting principles and standard disclosures.

Global Reporting Initiative, 2013b. G4 Sector disclosures. Mining and metals. Amsterdam.

Global Witness, 1998. A Rough Trade. A seminal Global Witness report on the role of diamonds in funding the Angolan civil war.

Godschalk, D.R., 2004. Land Use Planning Challenges. J. Am. Plan. Assoc. 70, 5–13. doi:10.1080/01944360408976334

Hans-Böckler-Stiftung, E., 2001. Pathways towards a sustainable future. Düsseldorf, Hans Böckler Stift.

Hellweg, S., Demou, E., Scheringer, M., McKone, T.E., Hungerbühler, K., 2005. Confronting Workplace Exposure to Chemicals with LCA: Examples of Trichloroethylene and Perchloroethylene in Metal Degreasing and Dry Cleaning. Environ. Sci. Technol. 39, 7741–7748. doi:10.1021/es047944z

Hentschel, T., Hruschka, F., Priester, M., 2002. Global Report on Artisanal & Small-Scale Mining.

Interorganizational Committee on Guidelines and Principles (ICGP), 1995. Guidelines and principles for social impact assessment. Environ. Impact Assess. Rev. 15, 11–43.

International Labour Organization (ILO), 2017. Quick guide on sources and uses of labour statistics. Geneva, Switzerland.

International Labour Organisation (ILO), 2015. ILOSTAT database 2015

International Labour Organization (ILO), 2005. Code of practice on safety and health in the iron and steel industry. Geneva, Switzerland.

Inayatullah, S., 2005. Spirituality as the fourth bottom line? Futures 37, 573–579.

Interorganizational Committee on Guidelines and Principles (ICGP), 1995. Guidelines and principles for social impact assessment. Environ. Impact Assess. Rev. 15, 11–43.

ISO 14044, 2006. Environmental management - Life cycle assessment - Principles and framework. Organization for Standardization.

Jenkins, H., Yakovleva, N., 2006. Corporate social responsibility in the mining industry: Exploring trends in social and environmental disclosure. J. Clean. Prod. 14, 271–284. doi:10.1016/j.jclepro.2004.10.004

Kaufmann, D., Kraay, A., Mastruzzi, M., 2010. The Worldwide Governance Indicators: Methodology and Analytical Issues.

Lenzen, M., Moran, D., Kanemoto, K., Geschke, A., 2013. Building Eora: a global multi-region input–output database at high country and sector resolution. Econ. Syst. Res. 25, 20–49.

Lenzen, M., Wood, R., Wiedmann, T., 2010. Uncertainty analysis for Multi-Region Input-Output Models. A case study of the UK's Carbon Footprint. Econ. Syst. Res. 22, 43–63. doi:10.1080/09535311003661226

Litmanen, T., Jartti, T., Rantala, E., 2016. Refining the preconditions of a social licence to operate (SLO): reflections on citizens' attitudes towards mining in two Finnish regions. Extr. Ind. Soc. 3, 782–792.

Littig, B., Griessler, E., 2005. Social sustainability: a catchword between political pragmatism and social theory. Int. J. Sustain. Dev. 8, 65. doi:10.1504/IJSD.2005.007375

Macombe, C., Leskinen, P., Feschet, P., Antikainen, R., 2013. Social life cycle assessment

of biodiesel production at three levels: a literature review and development needs. J. Clean. Prod. 52, 205–216.

Mancini, L., Benini, L., Sala, S., 2016. Characterization of raw materials based on supply risk indicators for Europe. Int. J. Life Cycle Assess. doi:10.1007/s11367-016-1137-2

Mancini, L., Sala, S., 2018. Social impact assessment in the mining sector: Review and comparison of indicators frameworks. Resour. Policy. doi:10.1016/j.resourpol.2018.02.002

Mancini L., Vidal Legaz B., Vizzarri M., Wittmer D., Grassi G. Pennington D. Mapping the role of Raw Materials in Sustainable Development Goals. A preliminary analysis of links, monitoring indicators and related policy initiatives. EUR 29595 EN, Publications Office of the European Union, Luxembourg, 2018 ISBN 978-92-79-98482-2, doi:10.2760/933605, JRC112892.

Mani, V., Gunasekaran, A., Papadopoulos, T., Hazen, B., Dubey, R., 2016. Supply chain social sustainability for developing nations: Evidence from India. Resour. Conserv. Recycl. 111, 42–52. doi:10.1016/J.RESCONREC.2016.04.003

Martínez-Blanco, J., Lehmann, A., Muñoz, P., Antón, A., Traverso, M., Rieradevall, J., Finkbeiner, M., 2014. Application challenges for the social Life Cycle Assessment of fertilizers within life cycle sustainability assessment. J. Clean. Prod. 69, 34–48. doi:10.1016/j.jclepro.2014.01.044

Mathe, S., 2014. Integrating participatory approaches into social life cycle assessment: the SLCA participatory approach. Int. J. Life Cycle Assess. 19, 1506–1514.

Milne, M.J., Gray, R., 2013. W (h) ither ecology? The triple bottom line, the global reporting initiative, and corporate sustainability reporting. J. Bus. ethics 118, 13–29.

Missimer, M., Robèrt, K.H., Broman, G., 2017. A strategic approach to social sustainability - Part 1: exploring the social system. J. Clean. Prod. 140, 32–41. doi:10.1016/j.jclepro.2016.03.170

Moffat, K., Lacey, J., Zhang, A., Leipold, S., 2016. The social licence to operate: a critical review. Forestry 89, 477–488.

Monash University, 2008. Human Rights Translated: A Business Reference Guide. United Nations Publications.

Norris, G.A., 2006. Social Impacts in Product Life Cycles - Towards Life Cycle Attribute Assessment. Int. J. Life Cycle Assess. 11, 97–104. doi:10.1065/lca2006.04.017

OECD, 2016. Due Diligence Guidance for Responsible Supply Chains of Minerals from Conflict-Affected and High-Risk Areas. Third Edition. Paris.

Omann, I., Spangenberg, J.H., 2002. Assessing social sustainability, in: Biennial Conference of the International Society for Ecological Economics. p. 304.

Parsons, R., Lacey, J., Moffat, K., 2014. Maintaining legitimacy of a contested practice: How the minerals industry understands its 'social licence to operate.' Resour. Policy 41, 83–90. doi:10.1016/j.resourpol.2014.04.002

Pelletier, N., Ustaoglu, E., Benoit, C., Norris, G., 2016. Sustainability in Trade and Development Policy. Int. J. Life Cycle Assess.

Pelletier, N., Ustaoglu, E., Benoit, C., Norris, G., 2013. Social sustainability in trade and development policy. A life cycle approach to understanding and managing social risk attributable to production and consumption in the EU-27. Luxemburg. doi:10.2788/659

Peterson, N., 2016. Introduction to the special issue on social sustainability: integration, context, and governance. Sustain. Sci. Pract. Policy 12, 3–7.

Poulsen, P.B., Jensen, A.A., 2004. Working Environment in Life-Cycle Assessment.

Pensacola SETAC Press.

Prno, J., 2013. An analysis of factors leading to the establishment of a social licence to operate in the mining industry. Resour. Policy 38, 577–590. doi:http://dx.doi.org/10.1016/j.resourpol.2013.09.010

Raa, T. ten, 2009. Input-Output Economics: Theory and Applications: Featuring Asian Economies. World Sci. 1–5.

Reichl, C., Schatz, M., Zsak, G., 2017. World mining data. Vienna (Austria).

Sachs, I., 1999. Social sustainability and whole development: exploring the dimensions of sustainable development. Sustain. Soc. Sci. a cross-disciplinary approach to Integr. Environ. considerations into Theor. reorientation 25–36.

Sala, S., Vasta, A., Mancini, L., Dewulf, J., Rosenbaum, E., 2015. Social Life Cycle Assessment - State of the Art and Challenges for Supporting Product Policies, JRC Technical Reports. doi:10.3390/su6074200

Schüler, D., Brunn, C., Gsell, M., Manhart, A., 2016. Outlining Socio-Economic Challenges in the Non-Fuel Mining Sector. European Policy Brief Strategic Dialogue on Sustainable Raw Materials for Europe (STRADE) No. 05 / 2016.

Seghezzo, L., 2009. The five dimensions of sustainability. Env. Polit. 18, 539–556.

Shinn, C., Magis, K., 2008. Emergent principles of social sustainability, in: Understanding the Social Dimension of Sustainability. Routledge, pp. 31–60.

Sinner, J., Baines, J., Crengle, H., Salmon, G., Fenemor, A., Tipa, G., 2004. Sustainable Development: A summary of key concepts. Ecol. Res. Rep 2, 1–23.

Thin, N., Lockhart, C., Yaron, G., 2002. Conceptualising socially sustainable development. Dep. Int. Dev. (DFID), UK World Bank.

UK Department for International Development, (DFID), 1999. Sustainable livelihoods guidance sheets. London DFID.

UN, 1987. Report on the World Commission on Environment and Development, General Assembly Resolution 41/187.

UN General Assembly, 2015. Transforming our world: the 2030 Agenda for Sustainable Development. New York United Nations.

UNEP/SETAC Life Cycle Initiative, 2009. Guidelines for Social Life Cycle Assessment of Products.

United Nations Development Programme (UNDP), World Economic Forum (WRF), Columbia Center on Sustainable Investments (CCSI), Sustainable Development Solutions Network, 2016. Mapping Mining to the Sustainable Development Goals: An Atlas. Cologny/Geneva Switzerland.

Vallance, S., Perkins, H.C., Dixon, J.E., 2011. What is social sustainability? A clarification of concepts. Geoforum 42, 342–348. doi:10.1016/j.geoforum.2011.01.002

Vanclay, F., 2004. Impact assessment and the triple bottom line: competing pathways to sustainability. Sustain. Soc. Sci. Round Table Proc. 2003, 27–39.

Von Grote, J., Hürlimann, C., Scheringer, M., Hungerbühler, K., 2003. Reduction of occupational exposure to perchloroethylene and trichloroethylene in metal degreasing over the last 30 years: influences of technology innovation and legislation. J. Expo. Sci. Environ. Epidemiol. 13, 325–340.

Weidema, B.P., Wesnæs, M.S., 1996. Data quality management for life cycle inventories—an example of using data quality indicators. J. Clean. Prod. 4, 167–174. doi:https://doi.org/10.1016/S0959-6526(96)00043-1

WHO (World Health Organization), 2016. Dioxins and their effects on human health, Fact

sheet N° 225.

List of figures

List of tables

Europe Direct is a service to help you find answers to your questions about the European Union.

Freephone number (*)**:**

00 800 6 7 8 9 10 11

(*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

More information on the European Union is available on the internet (http://europa.eu).

HOW TO OBTAIN EU PUBLICATIONS

Free publications:

- one copy:
  via EU Bookshop (http://bookshop.europa.eu);
- more than one copy or posters/maps:
  from the European Union's representations (http://ec.europa.eu/represent_en.htm);
  from the delegations in non-EU countries (http://eeas.europa.eu/delegations/index_en.htm);
  by contacting the Europe Direct service (http://europa.eu/europedirect/index_en.htm) or
  calling 00 800 6 7 8 9 10 11 (freephone number from anywhere in the EU) (*).

  (*) The information given is free, as are most calls (though some operators, phone boxes or hotels may charge you).

Priced publications:

- via EU Bookshop (http://bookshop.europa.eu).

KJ-NA-29632-EN-N

JRC Mission

As the science and knowledge service of the European Commission, the Joint Research Centre's mission is to support EU policies with independent evidence throughout the whole policy cycle.

EU Science Hub
ec.europa.eu/jrc

@EU_ScienceHub

EU Science Hub - Joint Research Centre

Joint Research Centre

EU Science Hub

Publications Office

doi:10.2760/470881

ISBN 978-92-79-99074-8