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Social impact assessment in the mining sector: Review and comparison of indicators frameworks

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ABSTRACT

Mining provides inputs for other industrial sectors that are vital for sustaining population wellbeing and the functioning of global economies. At the same time, it can generate social and environmental impacts, which could compromise public acceptance of the sector. Given this twofold role in human society, the improvement of the sustainability performance is a very important objective both for industry and for the European policy, willing to boost a sustainable supply of raw materials.

In various contexts, social impacts of mining are assessed with different sets of indicators and targets. In this study we perform a review of the associated literature, identify a list of typical social impacts occurring in the sector, and explore their geographical distribution. The list of identified impacts is compared against the indicators used for assessing and promoting sustainability in different contexts and at different scales: (i) the United Nations Sustainable Development Goals (SDG), (ii) the Global Reporting Initiative (GRI), (iii) the EU policy making through the analysis of the Better Regulation policy and three impact assessment reports, and (iv) the databases used in Social Life Cycle Assessment (SLCA).

Land use-related impacts and environmental impacts affecting human health and human rights appear to be the most concerning social aspects in the mining sector. Benefits from income and employment are, instead, the main positive impacts identified in the screened literature.

The paper compares the different indicator sets used in the above-mentioned frameworks with the list of impacts emerged from the literature review. Working conditions and human rights are well-covered aspects in the indicator lists. Main differences concern demographic changes and migration due to the presence of a mine and land use-related impacts, which are described in literature and partially covered in other schemes. A challenge for sustainability assessment is the evaluation of the mining sector's contribution to society, beyond the mere economic value added, and in general the assessment of positive impacts.

1. Introduction

Strategically important for the competiveness of the industrial sector and essential for populations' wellbeing and economic development, mineral resources are at the basis of modern societies. Many of the Sustainable Development Goals (SDGs) set by the United Nations for 2030 (UN General Assembly, 2015) could not be reached without the contribution of minerals and metals, which are fuelling the manufacturing sector and creating jobs and value added along the supply chains of material goods. At the same time, the production of mineral raw materials can generate negative environmental and social impacts, constraining the achievement of other sustainable development goals (e.g., climate action, good health, clean water).

The fact that resources use can lead to both benefits and impacts for human societies is also reflected in the scholarly debate on the "resource curse" hypothesis. The "resource curse" is based on the observation that countries rich in natural resources tend to grow more slowly than resource-poor countries (Mikesell, 1997; Anderson, 1998; Sachs and Warner, 2001; Cai and Newth, 2013). The resource curse hypothesis has been widely analysed and empirically tested both in developing and developed countries, with diverging conclusions arising from the literature. Some authors agree on the role of institutions and governance in determining the different outcomes (e.g., van der Ploeg, 2011; Mehlum et al., 2006). Moreover, the importance of analysing regional (within-country) effects of resource booms, in order to avoid unobserved country heterogeneity, is outlined in Fleming et al. (2015) and van der Ploeg (2011).

Resource scarcity concerns driven by increasing world population

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and security of supply considerations are additional aspects that have amplified the policy relevance of raw materials in the last decades (Dewulf et al., 2016; Graedel and Reck, 2016).

The European Union adopted a Raw Materials (RM) policy and strategy in 2008. It aims at: (i) ensuring a fair and sustainable supply of non-energy, non-agricultural raw materials from global markets; (ii) boosting a sustainable domestic supply; (iii) improving resource efficiency and supply of secondary raw materials through recycling (EC - European Commission, 2008). In order to support the EU policy on RM, the European Commission has developed the Raw Materials Information System (RMIS), which is a European reference web-based knowledge platform for non-energy, non-agricultural materials from primary and secondary sources. The RMIS includes information on trade, social and environmental considerations (EC - European Commission, 2017).

As described in the Raw Materials Scoreboard (EC - European Commission, 2016), which presents an overview of considerations related to raw materials in EU, public acceptance of the extractive sector is very low in Europe and the general public has little trust that the extractive industry can behave responsibly. The lack of so-called "Social Licence to Operate" (SLO) can be a potential bottleneck in the process of enhancing domestic production in EU. Among other factors, mitigation of environmental and social impacts of the sector contribute to create and maintain social acceptability (Moffat and Zhang, 2014). Moreover, human rights risk, conflicts, and political instability can affect the raw materials security of supply (Blengini et al., 2017).

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 Kimberley process,[1] initiated in 2000, has established a voluntary international certification scheme for diamonds. The Dodd-Frank Wall Street Reform and Consumer Protection Act[2] has tackled the challenge of conflict-free sourcing of Tin, Tungsten, Tantalum, and Gold in US. The European Union Regulation on conflict minerals was published in May 2017 and will become effective from 2021 (EU, 2017).

The provision and use of raw materials is a central topic also for scholars in the research field of sustainability assessment. While the discipline is foremost advanced in the assessment of negative impacts, the consideration of the positive impacts is a more recent field of investigation (Di Cesare et al., 2018). The Social Life Cycle Assessment (SLCA) methodology assesses the social and sociological aspects of products, their actual and potential positive and negative impacts along the life cycle. It makes use of both site-specific and generic data on countries and sectors provided by dedicated databases.

Improving the social sustainability of the sector is a relevant objective also for industries in the raw materials production, especially in view of gaining trust and acceptability (Euromines, 2016; ICMM, 2005). This is reflected in the growing role of Corporate Social Responsibility (CSR) and information disclosure practices, like the Global Reporting Initiative (GRI) (Global Reporting Initiative, 2013a). Companies in the resource sector are involved in many initiatives,[3] e.g., the Conflict-Free Sourcing Initiative, or the Organization Environmental Footprint, which includes, among others, also considerations of human health impacts (EC - European Commission, 2013). The "Responsible Mining Index" (RMF, 2017) is currently under development for the purpose of measuring mining company performances in terms of social, environmental and governance practices, including their efforts to contribute to the SDGs (RMF, 2017).

So far, despite its relevance, the evaluation of social sustainability performance has been conducted adopting a variety of approaches and indicators (Azapagic, 2004). Data collection performed at company level for sustainability reporting is rarely used in other contexts, while it could represent a rich source of information for research, policy makers, and supply chain analysis (e.g., Northey et al., 2013). However, the harmonization of indicators for the social assessment of the mining sector could ease the information exchange among different stakeholders.

The aim of this paper is to review and analyse indicators used in different contexts for assessing the social impacts of the mining sector. It aims at exploring the most relevant social aspects in the sector, their geographical distribution, to what extent top-down approaches used in policy contexts (at global and country level) are able to capture and measure social considerations at the local level of a community (bottom-up perspective).

For this we, firstly, examined the scientific and grey literature to obtain a reference list of social impacts characterizing the mining sector. Secondly, we compare this list with the following schemes for the social sustainability assessment:

- Sustainable Development Goals (SDG), which is the main global reference for sustainable development policies.
- Global Reporting Initiative (GRI), one of most widely used framework for company sustainability reporting.
- EU Better Regulation policy (EC - European Commission, 2015), taking into account impact assessment guidelines and practices as applied in three impact assessment reports related to the extractive sector. While other countries and regions face similar resource security challenges as the EU, we consider that the assessment of social impacts is particularly crucial in the European context, where the RM policy strategy aims at improving both security of supply, sustainability of the sector, and consequently its public acceptance.
- Social Life Cycle Assessment (SLCA) databases, a methodology for the evaluation of social impacts along supply chains.

The second section of the paper describes the methodology used in the literature review. The third section shows the results of the review, the impacts categories clustering and the geographical distribution analysis. The fourth section compares the review results with the indicators used in the above-mentioned frameworks. The final section illustrates concluding considerations on the completeness of the examined documents and presents challenges for social sustainability assessments in different contexts.

2. Methodology: literature review of social impacts in mining

The first part of this section focuses on the literature review, describing the features of the selected sample of studies. Furthermore, it illustrates the different frameworks used for the comparison with the review results.

2.1. Literature review

The literature review performed in this study aimed at having a representative sample of studies from the literature, describing the most frequent social impacts occurring in the mining sectors. Therefore, the search was conducted through both commonly used web research engines and academic interdisciplinary databases including Scopus and Google Scholar. The key words used in the search were "social impacts mining" in the timeframe 2000–2017. We complemented this with thematic searches, in which other keywords were added to the original anchor title: econom*, employment, environment*, health, safety, human rights, land use, demograph*, and migration. From the results, we selected the most cited studies. The aim was not to comprehensively cover the literature in the field, but to obtain a list of most common social impacts characterizing the sector.

We selected 50 studies following these criteria:

[1] https://www.kimberleyprocess.com/en.

[2] Section 1502 and 1504, https://www.sec.gov/about/laws/wallstreetreform-cpa.pdf.

[3] E.g.: Initiative for Responsible Mining Assurance (IRMA); Aluminium Stewardship Initiative (ASI).

Table 1
List of studies selected from the literature and main features.

N°	Reference	Category[a]	Affiliation[b]	Typology	Geographical area of the study	Commodity	Scale of the analysis
1	Azapagic (2004)	P	A	Methodological	n.a.	n.a.	Global
2	Kitula (2006)	P	A	Case study	Tanzania	Gold	Local
3	Solomon et al. (2008)	P	A	Review	Australia	n.a.	National
4	Petkova-Timmer et al. (2009)	P	A	Case study	Australia	n.a.	Local
5	Kotey and Rolfe (2014)	P	A	Statistical	Australia	n.a.	Regional
6	Fleming and Measham (2015)	P	A	Statistical	Australia	n.a.	Regional
7	Owen and Kemp (2015)	P	A	Case study	n.a.	n.a.	Global
8	IIED and WBCSD (2002)	R	ORI	Methodological	n.a.	n.a.	Global
9	Environmental Law Alliance Worldwide (2010)	R	NGO	Methodological	n.a.	n.a.	Global
10	Switzer (2001)	R	NGO	Methodological	n.a.	n.a.	Global
11	Franks (2012)	R	A	Methodological	n.a.	n.a.	Global
12	Hajkowicz et al. (2011a)	P	ORI	Statistical	Australia	n.a.	Regional
13	Esteves (2008)	P	A	Case study	Australia and South Africa	n.a.	Global
14	Tonts et al. (2012)	P	A	Statistical	Australia	n.a.	Regional
15	Freudenburg and Wilson (2002)	P	A	Statistical	United States	n.a.	Regional
16	Langton and Mazel (2015)	P	A	Review	Australia	n.a.	National
17	Lockie et al. (2009)	P	A	Case study	Australia	Coal	Local
18	Shandro et al. (2011)	P	A	Case study	Canada	Coal	Local
19	McIntyre et al. (2016)	P	A	Case study	Mongolia	Gold	National
20	Patrick and Bharadwaj (2016)	P	A	Case study	Peru	n.a.	Local
21	Abuya (2016)	P	A	Case study	Kenya	Titanium	Local
22	Hilson (2002)	P	A	Case study	Papua New Guinea	Copper, gold	Global
23	Mensah and Okyere (2014)	P	A	Case study	Ghana	Gold mining	Local
24	Holden (2005)	P	A	Case study	Philippines	Non-ferrous metals	National
25	Lahiri-Dutt and Ahmad (2006)	P	ORI	Case study	India	Coal	Local
26	Živković (2012)	P	A	Review	Serbia	Lignite	Local
27	Kavouridis (2008)	P	A	Review	Greece	Lignite	National
28	Adler et al. (2007)	P	ORI	Historical	South Africa	Gold	National
29	Weldegiorgis and Ali (2016)	P	A	Statistical	Rwanda	Tin	Local
30	Damigos and Kaliampakos (2006)	P	A	Case study	Greece	Gold	Local
31	Macdonald (2004a)	R	NGO	Case study	Papua New Guinea	Gold	Local
32	Martin et al. (2005)	R	NGO	Case study	Philippines	Gold and copper	Local
33	Macdonald and Southall (2005)	R	NGO	Case study	Philippines	Copper	Local
34	Martin and Newell (2008)	R	NGO	Case study	Philippines	Polymetallic	Local
35	Macdonald (2004b)	R	NGO	Case study	Fiji	Gold	Local
36	Veiga et al. (2001)	P	A	Case study	various	Copper, etc	Global
37	Wilson (2004)	P	A	Case study	USA	Copper, Lead	Regional
38	Aroca (2001)	P	A	Statistical	Chile	Copper	Local
39	Ejdemo and Söderholm (2011)	P	A	Statistical	Sweden	Iron ore	Local
40	Ivanova and Rolfe (2011)	P	A	Statistical	Australia	Coal	Regional
41	Kumah (2006)	P	A	Review	Ghana	Gold	Global
42	Stilwell et al. (2000)	P	A	Statistical analysis	South Africa	Gold, coal	National
43	Corno and de Walque (2012)	O	ORI	Statistical analysis	South Africa	n.a.	National
44	Ticci and Escobal (2015)	Report	A	Statistical	Peru	n.a.	Regional
45	Oyarzún and Oyarzún (2011)	P	A	Case study	Chile	Copper	National
46	Schueler et al. (2011)	P	A	Case study	Ghana	Gold	Local
47	Jul-Larsen et al. (2006)	report	ORI	Case study	Mali	Gold	Regional
48	Aragon and Rud (2013)	P	A	Case study	Peru	Gold	Local
49	Petrova and Marinova (2013)	O	A	Case study	Australia	n.a.	Local
50	MPFPR (2016)	R	ORI	Case study	various	n.a.	Global

[a] P: journal paper; R: report; O: other.
[b] A: academic; NGO: Non-governmental organizations; ORI: other research institutes.

- Focus on social consequences of minerals mining activities, excluding oil and gas extraction (but including coal).
- Exclusion of studies concerning broader topics, which do not commonly report direct impact-related indicators. Examples include Corporate Social Responsibility (CSR) and governance, conflict minerals, Social Licence to Operate (SLO), and Artisanal and Small-scale Mining (ASM).
- Broad geographical coverage (we included all continents with at least two studies).
- Diversity of the studies in terms of:
  - o output category (journal papers, reports)
  - o study typologies (methodological, case study, statistical or descriptive analysis, etc.)
  - o commodity
  - o author affiliation (academy, NGOs and other research institutes)
  - o level of the analysis (global scale, national scale, regional/intra-country scale, local scale).

Table 1 shows the resulting set of examined studies, while Fig. S1 in the Supplementary information displays the characteristics of the sample. Most of the studies are journal articles (72%) published by universities (60%). The most studied geographic areas are Australia (22%) and Africa (22%). While in 46% of the studies the commodity is not specified, gold has the highest frequency (26%). Most of the publications relate to case studies and in 42% of the studies the scale of the analysis is local.

2.2. Comparison of indicators for social sustainability in business and policy context

Several schemes and initiatives aiming at assessing and/or promoting sustainability at global or EU level, in policy and business contexts exist. The following sections describe those selected for our analysis.

2.2.1. The UN Sustainable Development Goals (SDG)

The UN Sustainable Development Goals (SDG) have set out a vision for a future global society based on sustainability principles (UN General Assembly, 2015). The 17 goals and 169 targets that are composing the SDG agenda cover the ecological, economic, and social dimensions of sustainability thereby providing principles and a reference for national and local policy. The SDG initiative encourages both governments and the private sector to engage in the implementation of the goals: companies should commit for an improvement of the production processes' sustainability and policy makers at all levels are asked to align their strategies to the sustainable development principles of the Agenda.

The contribution of the mining sector in the SDG achievement is discussed in a report by the Columbia Center on Sustainable Investment, the Word Economic Forum, and the United Nations (CCSI et al., 2016). The report shows how mining companies could integrate into core business actions and objectives that contribute to the achievement of SDG. The International Council on Mining & Metals analysed the relevance of each goal for the sector, providing guidance on how to minimize negative impacts and maximize positive contributions to sustainable development.[4]

In this paper, the contribution of the mining sector to the SDGs is analysed starting from the reference list of impacts detected from the literature review and by verifying if they are represented in the goals and targets proposed by the United Nations.

2.2.2. The Global Reporting Initiative

At company level, the analysis of the sustainability performance is embedded in the Corporate Social Responsibility (CSR) practice, standardized by ISO 26000 (ISO 26000 2010). CRS refers to companies' activities and their contribution to achieving economic, social, and environmental sustainability. In particular, CSR is a "helpful conceptual framework for exploring the corporate attitude of companies towards stakeholders" (Jenkins and Yakovleva, 2006) conducted mainly through the disclosure of environmental and social information. Several schemes and international initiatives have been set for promoting social sustainability principles and supporting companies in their implementation. One of them is the Global Reporting Initiative (GRI),[5] a multi-stakeholder process and independent institution that supports businesses, governments, and other organizations to understand and communicate the impact of business on critical sustainability issues.

GRI has developed sector-specific disclosures, containing additional guidance for some sectors on the reporting practices. Among others, the mining and metals sector, which includes exploration, mining and primary metal processing (including smelting, recycling, and basic fabrication) and covers the complete project life cycle, from development through operational lifetime to closure and post-closure. The guidance is developed by working groups consisting of international experts representing business, financial markets, labour, civil society organizations, and mediating institutions.

We compare the indicators proposed in the GRI G4 guidance (Global Reporting Initiative, 2013b) with the list of impacts detected in literature, in order to understand if all the relevant social impacts are checked in the reporting practice.

2.2.3. European Union regulation and policy impact assessment

The assessment of social impacts is part of the EU legislative procedure, through the impact assessment phase that examines potential consequences of policy initiatives. In the Better Regulation Agenda (EC - European Commission, 2015) the European Commission engaged in the improvement of the quality and transparency of the legislation process, including a better impact assessment and quality control. The "Better Regulation Toolbox[6]" provides operational guidance for the implementation of the better regulation principles, including tools for the impact assessment and a list of impacts to be screened.

We analyse three policy impact assessment (IA) reports in order to check which social impacts were considered. They concern the minerals trade and the extractive sector and refer to the years 2011 and 2014:

- Impact assessment of a proposal for a regulation setting due diligence requirements for the responsible import of selected ores, concentrates, and metals originating from conflict areas (from now on called "Conflict Minerals" IA) (EC - European Commission, 2014b). This proposal aims at addressing the problem of the financing of armed groups and security forces via the revenues of the extraction and trade of minerals in conflict-affected high-risk areas. Six options for the implementation of the regulation are compared (from a soft-law voluntary approach to a mandatory one)
- Impact assessment of the communication from the Commission to the Parliament on the "Exploration and production of hydrocarbons (such as shale gas) using high volume hydraulic fracturing in the EU" (EC - European Commission, 2014a) (from now on called "Shale Gas" IA)
- Impact assessment of the proposal for a regulation on the safety of offshore oil and gas prospection, exploration and production activities (EC - European Commission, 2011) (from now on called "Offshore" IA).

2.2.4. Social Life Cycle Assessment

The sustainability discipline offers different methodologies for the impact assessment that can be used also in policy evaluation (Sala et al., 2013b, 2013a). In the context of the sustainability research field, Life Cycle Thinking is a well-known concept to help identifying impacts along the supply chains in order to compare management alternatives and avoid unintentional shifting of burdens. "Traditional" Life Cycle Assessment (LCA), is a standardized methodology taking into account mainly impacts due to environmental interventions, namely resource extraction 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 along the life cycle (including 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 stakeholder categories (usually workers, local community, society, consumers and value chain actors). While LCA inventories consist of physical quantities related to the product system, SLCA requires quantitative and qualitative information on organization-related aspects. The variable used to measure the process activity, or the share of a given activity associated with each unit process is usually "worker-hours". The impact assessment phase uses performance reference points and threshold, and accounts for both positive and negative impacts.

Nine years after the publication of the methodological guidelines (UNEP/UNEP/SETAC Life Cycle Initiative, 2009) the SLCA methodology is still considered in its infancy, even though the number of

[4] https://www.icmm.com/en-gb/metals-and-minerals/making-a-positive-contribution/no-poverty.

[5] https://www.globalreporting.org/Pages/default.aspx.

[6] http://ec.europa.eu/smart-regulation/guidelines/toc_tool_en.htm.

Table 2
Reference list of social impacts detected in the literature review.

Impact category	Positive/ Negative	N°	Abbreviation	Local (L)/ National (N)	Impact description	Sources (as in Table 1)
Economy, income and security	**Positive impacts**	1	Income	L	Contribution local income	2, 8, 11, 12, 13, 14, 29, 30, 32, 36, 38, 39, 40, 47, 48
				N	Increase in export and GDP	
				L, N	Poverty alleviation	
		2	Business	L	Business and employment opportunities in other sectors due to revitalized economy and markets	2,4, 22, 30, 32, 36, 38, 39, 40
	Negative impacts	3	Bribery	L, N	Bribery (to obtain licences and permits or to sway judicial decision) and corruption (due to bad management of mineral wealth)	1, 8, 11, 32
		4	Thefts and accidents	L	Thefts and accidents in the mining community	2
		5	Inequality	L, N	Income inequality	4, 6, 40, 42, 47
				L	Low level of economic stimulus from mining due to the prevalence of non-resident workers	
		6	Social tensions	L	Conflicts and social tensions due to the inequitable distribution of benefits and costs with communities or to limited access to resources	8, 10, 21, 28, 29, 31, 34, 41, 45, 46, 50
				L	Conflicts between companies and illegal miners; politically motivated killings of anti-mining activists	
		7	Poverty	L	Adverse economic outcome, increased poverty due to the loss of means of livelihood	5, 29, 34, 41
				N	Government's failure in reinvesting revenues from mining	
Employment and education	**Positive impacts**	8	Employment	L	Increased employment (direct and indirect in local community)	1, 4, 11, 12, 17, 22, 29, 32, 36, 39, 40, 47, 48
				N	Increased employment in national economy	
		9	Skills and education	L	Employee skill development and further education	1, 12, 36, 38, 44, 47
	Negative impacts	10	Child/forced labour	L	Child labour, forced and compulsory labour	1, 2, 50
		11	Poor working conditions	L	Poor working conditions, low wages,	1, 2, 8, 9, 11, 35, 50
				L	Heath impacts for workers, fatalities and work related accidents	
				L	Sub-standard housing provided to workers	
		12	Lack of freedom	L	Lack of freedom to organize in Trade Unions and non-conformity with the requirements of the International Labour Organization conventions	1, 50
		13	Temporary jobs	L	Creation of mostly temporary jobs in relation to permanent	1
				L	Low stability of jobs and the workforce	
		14	Unemployment	L, N	Increased unemployment	15, 37, 47
				L, N	Volatile employment due to dependency on minerals prices	
Land use and territorial aspects	**Positive impacts**	15	Infrastructures	L	Improved infrastructures (telecommunications, road network, power and water supplies)	2, 11, 12, 22, 29, 32, 36, 38, 47
				L	Improved access to health and education	
	Negative impacts	16	Expropriation/displacement	L	Expropriation, population displacement and resettlement (and consequent unemployment, landlessness, homelessness, loss of common resources, impoverishment of living standards)	1, 2, 7, 8, 9, 11, 21, 22, 23, 25, 26, 27, 29, 32, 35, 41, 46, 47, 50
				L	Forceful acquisition of land	
		17	Access to land	L	Limited access to land and consequent impact on livelihood, food insecurity, and loss of protected areas	2, 8, 9, 11, 22, 23, 41, 46, 50
Demography	**Positive impacts**	18	Population growth	L	Positive impacts due to demographic change and population growth	5, 44, 49
	Negative impacts	19	Gender imbalance and migration	L	Population growth, migration influx and gender imbalance in mining communities (and consequential alcoholism, drug and prostitution, HIV spread, domestic violence, sexual violence, change in social norms, culture and customs, migration, high school turnover)	2, 4, 9, 11, 13, 22, 29, 38, 43
		20	Inflation	L	Inflation, rising cost and access of accommodation for workers other than mining	4, 11, 13, 17, 22, 29, 31, 47, 48, 49
Environment, health and safety	**Negative impacts**	21	Water use competition	L	Reduced water supplies or water contamination, competition with other uses (e.g. agriculture) and increased water scarcity	19, 20, 28, 45
		22	Health impacts	L	Negative health and safety impacts in mining community (e.g. damages caused to dwellings by explosive, mine related injuries during booming mine activities)	1, 18, 22, 29, 31, 33, 34, 38
				L	Social impacts related to boom-bust cycles (e.g. increases in pregnancies, sexually transmitted infections, during bust times, mental health issues such as depression and anxiety; overarching community health issues prominent during both boom and bust periods include burdens to health and social services, family stress, violence towards women, etc.).	
		23	Environmental impacts affecting health	L	Environmental impacts affecting social conditions and health	2,8, 9, 11, 17, 18, 22, 29, 31, 33, 34, 35, 36, 38, 41, 46, 50

(*continued on next page*)

Table 2 (*continued*)

Impact category	Positive/ Negative	N°	Abbreviation	Local (L)/ National (N)	Impact description	Sources (as in Table 1)
Human rights	**Negative impacts**	24	Human rights	L	Human rights abuses	1, 8, 11, 24, 41, 50
		25	Cultural/aesthetic resources	L, N	Impact on cultural and aesthetic resources	9, 11, 22, 31
		26	Stakeholder inclusion	L	Lack of stakeholder inclusion and non- involvement of indigenous communities	11, 7, 1, 22, 31, 32, 33, 50
				L	Lack of informed consensus and social acceptability	
		27	Discrimination	L	Unequal opportunities and discrimination (gender based, marginalization vulnerable groups, i.e. disabled, aged, ethnic minorities, indigenous, young)	11, 7, 1, 22, 25
		28	Indigenous rights	L	Lack of respect of the rights of indigenous people	1, 22, 24, 50

published studies has substantially increased in the last five years (Petti et al., 2016). Data collection is a crucial step in performing any LCA, including SLCA. In order to support assessments, at least at a national or sectorial level, and to highlight hotspots in the supply chains, generic databases have been developed:

- The Social Hotspot Database (SHDB) that provides social risk data on a sector and country level, and is integrated with a global input-output model derived from the GTAP database. It allows modelling of social impacts and risks and covers 22 social topics for numerous countries and sectors (Benoit-Norris et al., 2012).
- The Product Social Impact Life Cycle Assessment (PSILCA) database that uses a multi-regional input/output database (Eora, Lenzen et al., 2013) to develop indicators on social impacts. These indicators, organized in clusters, describe 25 social and socio-economic topics inspired by UNEP/SETAC guidance. Five stakeholder categories are addressed (Ciroth and Eisfeld, 2016).

These databases have been analysed in order to investigate if they encompass the impacts detected in literature with appropriate indicators and if properly capture critical issues for the mining sector. However, such databases provide mostly macro-level insights, hence cannot provide detailed analysis insights/support for specific supply chain studies at, e.g., company or material level.

3. Results and discussion

Section 3.1 presents the results of the literature review in terms of impacts and key issues regarding the social sustainability of the mining sectors. Section 3.2 discusses the results of the comparison between the reference list of impacts and the different schemes for social sustainability assessment.

3.1. Results of literature review

The first part of the result presents a clustering of the impact in thematic areas, and the second analyses their geographical distribution.

3.1.1. Social impact typologies identified in the reviewed studies

Social impacts of the mining industry emerged from the literature review and are grouped into six categories (Table 2). The list of categories refers to main areas of social impacts, for which we report the representative ones.

- Economy, income and security (impacts from I1 to I7): economic impacts can be both positive and negative, and are reported both at local and national scale. Mining often gives stimulus to local economy and increase population income and business opportunity, also in other sectors. However, income inequality, i.e. 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 miners, as well as anti-mining activists. Increased poverty can also occur, if local population lose traditional means of livelihood, and when governments fail in reinvesting revenues from mining.
- Employment and education (impacts from I8 to I14): 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, both at local and national level. 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 and dangerous working conditions, low wages, health impacts, accidents and fatalities, substandard housing provided to workers, lack of freedom in organizing trade

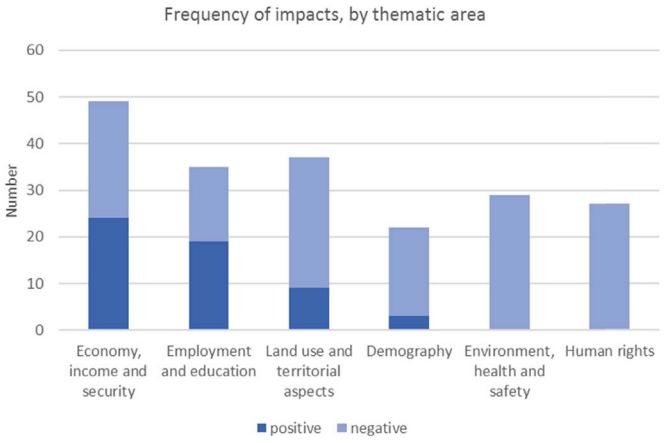

Fig. 1. Frequency of positive or negative impacts in the selected studies, by macro area of impact.

unions activities). In one case, increased unemployment is documented, explained by the increasing mechanization of mining operations.

- Land use and territorial aspects (impacts from I15 to I17): land competition can arise when mining projects are developed, endangering wellbeing of local population and leading to their impoverishment. Almost 30% of the scrutinized studies report land expropriation, displacement and resettlement of local communities. 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 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 allow local populations to access health and education services. All these impacts are typically reported at local level.
- Demography (impacts from I18 to 120): 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 psychological or behavioural nature (e.g., alcoholism, drug addiction, prostitution, etc.). Inflation and the rising of accommodation costs can also negatively affect the local population wellbeing. In one study, population growth is perceived as a positive consequence of the mining activity.
- Environment, health and safety (impacts from I21 to I23): health and safety problems can also touch local communities (e.g., through damages caused to dwellings by explosive and injuries during booming mine activities). Environmental impacts can affect human health in local communities directly (e.g., having toxic or carcinogenic effects) or indirectly through, e.g., reduced water supply or contamination (and consequential prevention of fishery and loss of means of livelihood). Water use competition, increased water scarcity and depletion are recurrent issues affecting local communities.
- Human rights (impacts from I24 to I28): 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.

The impacts clustering, while useful for the comparison with indicators frameworks, overlooks interlinkages and trade-offs among impacts, which are instead investigated in some of the scrutinized studies. For instance, some studies describe trade-offs among impacts at different scales. Benefits of mining often display at national level in economic terms through an increase of GDP, income and mining rents, but also because the sector allows meeting the material and, in the case of coal, energy demand (Živković, 2012). Instead, negative impacts are perceived more often at local level in relation to, e.g., reduced access to means of livelihood, increased water scarcity, resettlements, uneven income distribution affecting especially indigenous communities, etc. (Jul-Larsen et al., 2006; Hajkowicz et al., 2011b; Esteves, 2008; Lahiri-Dutt and Ahmad, 2006). This unequal distribution of burdens requires redistribution of resource rents, ensuring a compensation for affected local communities (Esteves, 2008) and establishing long-term benefits for the communities (Veiga et al., 2001). Unfair compensational practices and unmet promises are pointed as one of the causes of mine-community disputes and conflicts by some authors (Abuya, 2016; Hilson, 2002; Mensah and Okyere, 2014; Switzer, 2001).

According to the screened literature, there are some key factors influencing the social performance of mining. In case of high economic dependency on the mining industry, the whole regional economy is more vulnerable to commodity price fluctuations and negative effects of boom-bust cycles can occur (Tonts et al., 2012; Petkova-Timmer et al., 2009; Wilson, 2004; Shandro et al., 2011). This aspect is especially critical in geographically remote resource towns which have less opportunity for economic diversification (Tonts et al., 2012; Langton and Mazel, 2015). However, mining can also improve socio-economic conditions in remote areas (Kotey and Rolfe, 2014). A further key factor influencing the social performance is the presence of non-resident workforce that can drive the economic stimulus outside the mining community, and create a demographic imbalance (with a prevalence of male population) and consequential problems of psychological or behavioural nature (Petkova-Timmer et al., 2009; Wilson, 2004; Hajkowicz et al., 2011a; Aroca, 2001; Ivanova and Rolfe, 2011). Finally, some authors stress that the high diversity in the socio-economic performance of the mining activity depends on a mix of factors which include also the company structure, the typology of mine operation, the commodity extracted and the general social and demographic conditions of the interested area (Wilson, 2004; van der Ploeg, 2011).

3.1.2. *Occurrence of social impacts and geographical distribution*

Among thematic areas (Fig. 1), “economy and income” has the highest frequency of impacts, while “environment, health and safety” displays the highest frequency of negative impacts, followed by “human rights” and “land use” areas. Only in the “employment” area positive impacts exceed the negative ones.

Considering the single impacts and their geographical distribution (Fig. 2), “expropriation and displacements” and “environmental impacts affecting health” have the highest frequency in the reviewed studies. The positive impact on income has also a high frequency (reported in 15 out of 50 studies). From Fig. 2 also emerges that some impacts (like income, business and environmental problems affecting health) occur in both developed and developing countries, while others (expropriation and land use related impacts) are more frequent in developing countries.

Concerning the geographical distribution of social impacts, studies from Australia report positive impacts in 50% of the cases, and 15 impacts out of 24 relate to “economy and income”, “demography” and “employment”. Africa has the highest number of total impacts (excluding the studies with unspecified geographical region), and 76% of them are negative; most of these are in the “land use” and “economy and income” area. Most of the studies from Oceania report impacts on the “environment, health and safety” and “human rights” area. Asia is characterized by impacts in the “economy”, “environment”, “land use” and “human rights” areas. For South America (represented by Peru and Chile) impacts are distributed in the “economy”, “employment”, “demography” and “environment” areas. North America displays two impacts in the “environment” area and two on “employment”. Europe (Serbia, Greece and Sweden) have five positive impacts in the “economy and income” and “employment” area and two negative in the “land use” area.

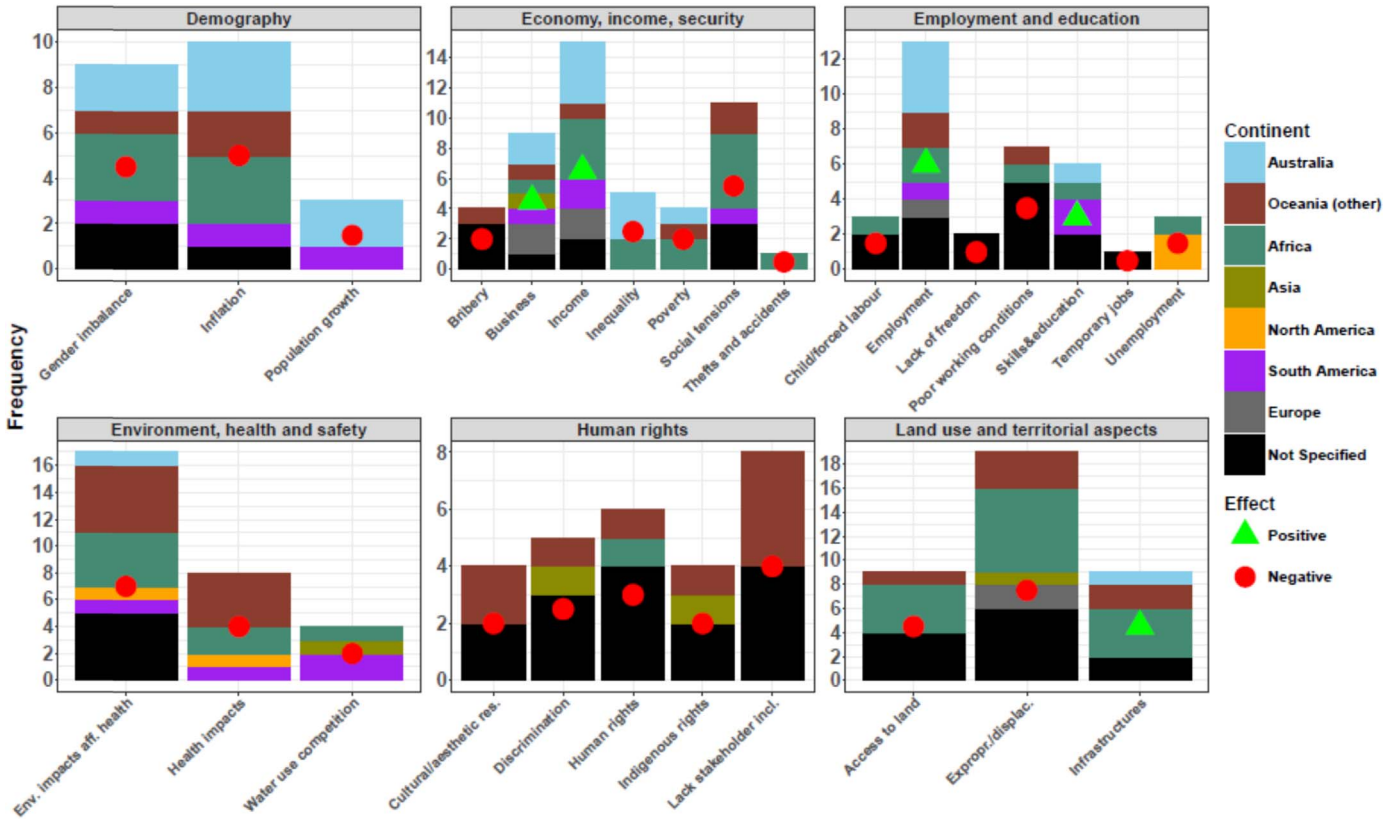

Fig. 2. Illustrative results showing impacts occurrence and their geographical distribution, in the selected studies. Dots and triangles represent negative and positive impacts, respectively.

3.2. Comparisons of the reference list of impacts with indicators frameworks

The set of impacts resulting from the literature review (Table 3) is compared with the indicators proposed in different contexts, applied at different scales:

1. At global level, the Sustainable Development Goals developed a global framework including 232 indicators that are applied at national level but involve all stakeholder groups e.g. industry, civil society, administration etc., thus embracing from macro to micro-scale.
2. At sector level, in the context of industry reporting practices, the Global Reporting Initiative disclosures guidance provides a set of indicators for the minerals and metals industry, aimed at assessing company performance with respects to workers and local communities.
3. At EU level, policy impact assessment is performed at macro and sector scale: the Better Regulation guidance provides the full list of social impacts to be screened, while three examples of policy impact assessment reports are illustrative cases of the policy impact assessment practice.
4. Social Life Cycle Assessment databases provide country-sector specific data which complement primary data from companies and other stakeholders in the supply chain analysis

A complete version of the table, including description of the indicators, is available in the Supplementary information (Table 3S), while Table 3 below presents the main findings.

3.2.1. UN Sustainable Development Goals

The UN Agenda for sustainable development is a comprehensive document covering environmental, social and economic objectives for future societies (UN General Assembly, 2015). Therefore, the SDG scheme includes most of the social impacts detected in literature. Some of them relate to general objectives (e.g., ending poverty, promote just and peaceful societies) while others are reflected in more specific targets (e.g., reduce corruption and bribery). Table 3 shows the correspondence between the considerations reported in the screened literature and the SDGs.

In the economy area, Goals 1 (poverty reduction), 8 (economic growth) and 16 (peaceful societies) cover almost all the considerations detected in the literature review.

Regarding the area of employment and education, specific targets represents the impacts on employment, skill development, child and forced labour, poor working conditions and freedom to organize in trade unions organizations. The impact related to the creation of temporary and unstable jobs does not find any correspondent target, even though this aspect is included in the Global Jobs Pact of the International Labour Organization that is the objective of the goal 8.12.

Specific targets fully address land use and territorial aspects, aiming at protecting and fostering the access to basic infrastructure, drinking water, but also land and natural resources as a mean of ensuring agricultural productivity. Such goals also mention the control over land and protection of property.

Demography-related impacts (e.g., the gender imbalance arising in mining communities, population growth) are not included in the development goals, also because demography-related impacts are often occurring at regional/local scale, while the SDGs have a global perspective. Goals on poverty and economic growth partially include issues like inflation and rising costs for accommodation which, however, do not have any specific target. However, the Agenda addresses migration and mobility of people in goal 10 (Reduce inequality within and among countries) and recognise its positive role for a sustainable and inclusive growth. As acknowledged is a recent report from the International Labour Organization, the presence of foreign migrant workers in the mining industry raises a wide range of social, economic, political and legal issues (Coderre-Proulx et al., 2016).

The SDGs extensively cover the “environment, health and safety”

Table 3
Correspondence of social impacts of mining detected in literature with objectives and indicators proposed in the different frameworks: UN SDG; GRI; EU policy (Better Regulation Toolbox (a) and three impact assessment reports: "conflict minerals"(b),"shale gas" (c); "off shore extraction" (d)); Social LCA databases (SHDB and PSILCA). (Summary table, see SI for the complete table) (*: partially covered aspects; U.D.: under development: NSS: non sector-specific).

	Impacts identified in literature review	Sources (as in Table 1)	International context		EU context				SLCA databases	
			UN SDG	GRI	a	b	c	d	SHDB	PSILCA
	ECONOMY, INCOME AND SECURITY									
1	Contribution to national and local income; increase in export and GDP; poverty alleviation	2, 8, 11, 12, 13, 14, 29, 30, 32, 36, 38, 39, 40, 47, 48	1, 8.1	G4-EC1	X	X	X			U.D.
2	Business and employment opportunities in other sectors due to revitalized economy and markets	2,4, 22, 30, 32, 36, 38, 39, 40	8.3	G4-EC8	X		X	X		
3	Bribery and corruption	1, 8, 11, 32	16.5	G4-SO3; G4-SO4; G4-SO5	X				X (NSS)	X
4	Thefts and accidents in the mining community	2	16	–	X					
5	Income inequality, low level of economic stimulus from mining due to the prevalence of non-resident workers	4, 6, 40, 42, 47	10	G4-EC6*	x					X
6	Conflicts and social tensions due to the inequitable distribution of benefits and costs with communities or to limited access to resources; conflicts between companies and illegal miners; politically motivated killings of anti-mining activists	8, 10, 21, 28, 29, 31, 34, 41, 45, 46, 50	16.1	G4-SO11*	X				X	U.D.
7	Adverse economic outcome, increased poverty due to the loss of means of livelihood, government's failure in reinvesting revenues from mining	5, 29, 34, 41	1.	G4-EC1*	X				X	X
	EMPLOYMENT AND EDUCATION									
8	Increased employment (direct and indirect to community and national economy)	1, 4, 11, 12, 17, 22, 29, 32, 36, 39, 40, 47, 48	8.3.	G4-LA1;G4-LA2; G4-LA3	X	X	X			U.D.
9	Employee skill development and further education	1, 12, 36, 38, 44, 47	4.4.	G4-LA9; G4-LA10	X					
10	Child labour, forced and compulsory labour	1, 2, 50	8.7	G4-HR5 G4-HR6	X				X	X
11	Poor working conditions, low wages, sub-standard housing provided to workers, heath impacts for workers, fatalities and work related accidents	1, 2, 8, 9, 11, 35, 50	8.5	G4-LA5, G4LA6, G4LA7, G4-LA8	X		X		X	X
12	Lack of freedom to organize in Trade Unions and non-conformity with the requirements of the International Labour Organization conventions	1, 50	8.12	MM4 G4-HR4	X				X (NSS)	X
13	Creation of mostly temporary jobs in relation to permanent, low stability of jobs	1	8	–			X			
14	Increased unemployment, volatile employment due to dependency on minerals prices	15, 37, 47	8.3	–	X				X	X (NSS)
	LAND USE AND TERRITORIAL ASPECTS									
15	Improved infrastructures (telecommunications, road network, power and water supplies), improved access to health and education	2, 11, 12, 22, 29, 32, 36, 38, 47	9.1 6.1	G4-EC7					X (NSS)	X (NSS)
16	Expropriation, population displacement and resettlement (and consequent unemployment, landlessness, homelessness, loss of common resources, impoverishment of living standards), forceful acquisition of land	1, 2, 7, 8, 9, 11, 21, 22, 23, 25, 26, 27, 29, 32, 35, 41, 46, 47, 50	1.4	G4-SO2; MM6; MM7; MM9	X		X			U.D.
17	Limited access to land and consequent impact on livelihood, food insecurity, and loss of protected areas	2, 8, 9, 11, 22, 23, 41, 46, 50	2.3							
	DEMOGRAPHY									
18	Positive impacts due to demographic change and population growth	5, 44, 49								
19	Population growth, migration influx and gender imbalance in mining communities (and consequential alcoholism, drug and prostitution, HIV spread, domestic violence, sexual violence, change in social norms, culture and customs, migration, high school turnover)	2, 4, 9, 11, 13, 22, 29, 38, 43								
20	Inflation, rising cost and access of accommodation for workers other than mining	4, 11, 13, 17, 22, 29, 31, 47, 48, 49	1, 4, 8	G4-EC8*						
	ENVIRONMENT, HEALTH AND SAFETY									
21	Reduced water supplies or water contamination, competition with other uses (e.g. agriculture) and increased water scarcity	19, 20, 28, 45	6	G4-EN8, G4-EN9, G4-EN10	X		X	X	X	X
22	Negative health and safety impacts in mining community; social impacts related to boom-bust cycles	1, 18, 22, 29, 31, 33, 34, 38	3.3, 3.4, 3.5, 3.9	G4-DMA (Local communities)*[a]	X		X	X	X (NSS)	U.D.
23	Environmental impacts affecting social conditions and health	2,8, 9, 11, 17, 18, 22, 29, 31, 33, 34, 35, 36, 38, 41, 46, 50	3.9		X				X (NSS)	X (NSS)
	HUMAN RIGHTS									
24	Human rights abuses	1, 8, 11, 24, 41, 50	16	G4-HR1;G4-HR2;G4-HR9;G4-R10;G4-R11	X					
25	Impact on cultural and aesthetic resources	9, 11, 22, 31	11.4		X					

(*continued on next page*)

Table 3 (*continued*)

	Impacts identified in literature review	Sources (as in Table 1)	International context		EU context				SLCA databases	
			UN SDG	GRI	a	b	c	d	SHDB	PSILCA
26	Lack of stakeholder inclusion and non- involvement of indigenous communities, lack of informed consensus and social acceptability	11, 7, 1, 22, 31, 32, 33, 50	16.7	G4-SO1	X				X (NSS)	X (NSS)
27	Unequal opportunities and discrimination (gender based, marginalization vulnerable groups, i.e. disabled, aged, ethnic minorities, indigenous, young)	11, 7, 1, 22, 25	5.1	G4-HR3; G4-LA12; G4-LA13					X	X
28	Lack of respect of the rights of indigenous people	1, 22, 24, 50	10.2	G4-HR8 MM5					X	X

[a] This aspect does not contain indicators; to address this aspect, the company may use alternative indicators or develop their own indicator.

area, with specific targets regarding negative health impacts (including communicable and non-communicable diseases, but also mental health and well-being, prevention of drugs and alcohol abuses). A specific target concerns the reduction of the deaths due to illness from hazardous chemicals, pollution and contamination, an impact detected in several studies from the literature. A specific goal is dedicated to access to safe water, sanitation and sound management of freshwater ecosystems, which appear to be a relevant aspect linked to mining activity.

Finally, some SD targets focus on human rights, including impacts on cultural and aesthetic resources, inclusion of indigenous communities, equal opportunities and respect of indigenous people rights. The goal on the promotion of peaceful and inclusive societies includes also human right abuses impact.

3.2.2. *Global Reporting Initiative*

The list of indicators in the GRI G4 guidance (Table 1S in Supplementary information) covers a wide range of aspects, including human rights, labour practices and decent work, society, product responsibility. However, it does not encompass some of the impacts emerged from the literature review, for instance the gender imbalance and migration in the mining community and the loss of cultural and aesthetic resources.

Concerning economic aspects and employment, both positive and negative impacts emerged from the literature: increased employment (I8)/increased unemployment (I14); positive economic outcome and income increase (I1)/negative economic outcome and increased poverty (I7); business opportunities in other sectors (I2)/income inequality (I5). In GRI disclosures, these aspects are included in a company perspective, assessing the employee hires and turnover, the direct economic value generated and distributed and the indirect economic impact (including economic development in areas of high poverty and economic impact of improving or deteriorating social or environmental conditions).

GRI disclosures have a good coverage of land use and territorial aspects, with indicators on disputes related to land (MM6) and resettlements (MM9). Besides, some specific issues like mine closure and small scale mining have sector-specific indicators together with emergency preparedness, material stewardship and compliance.

Although reported in many studies from the literature (17 over 50), environmental impacts affecting health are only partially embodied in the environmental indicators (like those on emissions, water, energy). Also negative impacts on health and safety in mining communities (which includes damages due to explosive and, e.g., mental health issues due to boom-bust cycles) are not included in the G4 guidance with specific indicators.

Other impacts detected by a single study in literature are also missing in the GRI disclosure, like thefts and accidents in the mining community and the prevalence of temporary jobs. However, the presence of grievance mechanisms for labour practices, human rights and impacts on society is part of the disclosures.

Other aspects are indirectly or partially captured in GRI indicators. This is the case for the impact "poor working conditions" (I11) (including low wages but also sub-standard housing provided to workers) that could result in a higher number of strikes (indicator MM4 in GRI). The GRI indicator on indirect economic impacts (G4-EC8) partially includes the impact on inflation and rising costs for accommodation (I20).

Some aspects did not emerge from the literature review, but are part of the GRI framework. For instance, indicators on product responsibility (including certification and labelling system of products and materials stewardship) and the supplier assessment for labour practices, human rights, and impacts on societies. Such indicators refer to good practices in terms of supply chain responsibility and increased transparency that are key issues for the sustainability of every sector. Moreover, they could be a basis for performing supply chain due diligence obligations.

3.2.3. Better regulation policy and impact assessment reports

The identification and assessment of the most significant impacts is the core of the policy impact assessment. The Better Regulation guidelines provide a list of social impacts to be screened during the impact assessment, which includes a wide set of aspects.[7] Horizontal impacts (concerning the economic, social and environmental spheres) consist of economic and social cohesion, impacts in developing countries, sustainable development, and fundamental rights.

Table 3 shows that the Better Regulation toolbox includes almost all the impacts detected in the literature review. Exceptions are the creation of mostly temporary jobs in relation to permanent, low stability of jobs and the workforce, and the improved infrastructure.

The "conflict minerals" impact assessment report considers two main social effects of the proposed policy options: the employment in EU and the livelihood in conflict zones. It evaluates these aspects with respect to different policy options. In the policy option based on voluntary certification of "EU responsible importer", job creation is expected in the areas of audit, consulting and training. Reversely, the study foresees that a mandatory approach for certification could negatively affect the employment situation, because companies may avoid sourcing from conflict-affected areas having similar consequences of a de facto embargo. The compulsory scheme could have negative impacts on local livelihood, due to the fall in mineral exports that would reduce revenues for local/central governments and the lower chance of economic and social development in the affected regions and worsening working conditions in the mines.

The "shale gas" impact assessment analyses the different policy options and their effects on employment. It acknowledges that the extractive activity is typically capital intensive and the job creation would be less than proportional to the growth of the sector and mainly temporary. Employment effects in related sectors could be positive (e.g. for mining equipment and transport sectors) and negative (e.g. for tourism and water-using sectors). The study takes into account also health impacts in relation to workers and local community and consequences for the demand perspective (i.e. positive impacts would interest households using natural gas for heating, which might benefit from a gas price decrease, if changes passed through to final consumers). Finally, the report acknowledges land related impacts from shale gas activities, including eventual effects on land prices.

The third scrutinized impact assessment report concerns the offshore oil and gas extractions and its objective is the prevention of major incidents in EU offshore oil and gas exploitation. The reduction of injuries and fatalities is the main foreseen benefit, while secondary impacts regard related economic sectors like tourism and fishery that would have negative consequences from incidents in offshore extraction plants. Additionally, introducing policy measures for improving safety conditions will create new business opportunities for consultancies and expertise service companies helping with the preparation of major hazard reports. Lowering the risk of incidents, economic and environmental conditions of local communities are also likely to improve.

3.2.4. Social Life Cycle Assessment databases

As shown in Table 3, the macro area "economy, income and security" is poorly represented in the SLCA databases, in particular with respect to positive impacts. In PSILCA an indicator on "Contribution of the sector to economic development" is under development, while there aren't specific indicators on the business opportunities in other sectors that could arise from the revitalization of the economy due to mining activities. In general, the assessment of positive impacts in SLCA is a challenge for the development of the methodology and the scientific community is debating how to systematically identify all potential positive impacts in supply chains (Ekener et al., 2016; Di Cesare et al., 2018).

SLCA databases have a better coverage of negative impacts in the economy area, especially corruption and bribery that have a sector-specific indicator in PSILCA database. A negative outcome of the mining activity described in the literature refers to the low level of economic stimulus due to the prevalence of non-resident workers. The indicator "International migrant workers in the sector" in PSILCA partially reflects this situation, even though the focus is on the risk of discrimination and conflict due to a high share of migrant workers.

Some studies reported conflicts and social tensions linked to the extractive activities. The inequitable distribution of benefits and costs with communities or the limited access to resources for the local population are the main causes. Conflicts between companies and illegal miners are also described, as well as politically motivated killings of anti-mining activists. In the SHDB databases the indicator "overall risk for high conflicts" (in SHDB) covers this aspect, while in PSILCA more specific but still under development indicators are planned, i.e., "Risk of conflict with regard to the sector" and "Description of potential material resource conflict". Three studies reported adverse economic outcome and increased poverty (e.g. due to loss of traditional means of livelihood and/or to government's failure in reinvesting revenues from mining). In SLCA databases sector-specific indicators on the wages level barely capture this aspect. Thefts and accidents in the mining community are not present in the SLCA databases.

Negative impacts in the "employment and education" area are well represented in both SLCA databases, especially child and forced labour, as well as those concerning the lack of freedom to organize in trade unions and non-conformity with the requirements of the International Labour Organization conventions (sector-specific data in PSILCA). Poor working conditions have an indicator on wages level (in both databases) and "hours of work per employee" in PSILCA, while specific issues linked to working conditions like "substandard housing provided to workers" are missing. The creation of temporary jobs – frequent in the extractive sector - is not included in SLCA databases. Increased unemployment (documented in one study from the literature) is accounted in SLCA databases through a "risk of unemployment" indicator that use sector-specific data only partially. Positive impacts in terms of employment creation and skill development do not have specific indicators but in PSILCA an indicator accounting for the work force hired locally is under development.

PSILCA and SHDB do not comprise specific indicators on some land use-related and territorial aspects like improvements in local infrastructures, telecommunications, road networks, power and water supply and the consequent better access to health and education services. Indicators on infrastructure access are available in SLCA databases but they do not take into account the contribution of the sector, but assess the country status. Concerning negative impacts related to land use, in PSILCA the indicators "risk of conflicts with regard to the sector" and "description of potential material resource conflicts" are under development.

Demographic changes and population growth do not have specific indicators in SLCA databases. In PSILCA, migration has a set of indicators, taking into account the international migrant workers in the sector and the net migration rate at country level. No indicators are actually available to represent the inflation and rising cost for accommodation in the mining community.

SLCA databases cover with sector-specific indicators impacts on dangerous working conditions, fatalities and accidents at work and risk of fatal and non-fatal injuries. Moreover, SHDB includes also an indicator on the risk of loss of life in the coal-mining sector due to airborne particulates and indicators on risk of toxic noise levels, occupational carcinogens and airborne particulates. In PSILCA, data on the presence of security measures are available for sectors, while "DALY[8]

[7] Employment, working conditions, income distribution and social inclusion, health and safety, social protection, education, security, governance and good administration, preserving the cultural heritage / multi-linguism, crime, terrorism and security, social protection, health and educational systems, cultural heritage.

due to indoor and outdoor air and water pollution" are available but not sector-specific.

Concerning negative impacts on mining community health and safety, the indicators "risk of mortality for communicable and non-communicable diseases" and "risk of death due to air and water pollution" are in SHDB, but are not sector-specific. In PSILCA, a set of indicators on "access to resources" is available: the extraction of material resources (ores, fossil fuels, biomass, water, construction materials) at country level is assumed to constrain the access for local communities.

Both SHDB and PSILCA have indicators in the human rights domain, e.g. concerning indigenous rights and unequal opportunities. Lack of stakeholder inclusion has indicators but without sector specification; while human rights abuses and impact on cultural and aesthetic resources are missing.

In conclusion, the SLCA databases covers many different aspects related to social sustainability. However, in some cases the databases have limitations in representing specifically how an economic sector affects social conditions. Indeed, many indicators refers to the situation of the country rather than reflecting sectors performance.

4. Conclusions

Given its multi-disciplinary nature, sustainability assessment is approached by different disciplines, (ranging from social and environmental science, geography, business and management, economics and econometrics, engineering, etc.) and a variety of approaches and methodologies are used for performing the assessment. At business and policy level, sustainability is often assessed through quantitative indicators, which can measure, compare, communicate, and monitor progresses towards a defined goal.

In order to compare the indicator frameworks used for the assessment of social aspects in the mining sector at policy and business level we extracted a set of typical social impacts of mining from the literature. Using a reductionist approach, we scrutinized fifty studies, and obtained a list of twenty-eight impacts, representing the typical social consequences of the mining activity. Even though not comprehensive, the list is assumed to represent the broader literature on the topic.

From the review of the studies emerged that impacts of mining relates mainly to three areas: land use and territorial aspects, environmental impacts affecting health, and human rights. Moreover, demography-related impacts emerged, especially in terms of migration and gender imbalance in the mining communities. While environmental impacts affecting health are of interest in all the geographic regions assessed, land use and territorial aspects concern mostly African countries. Australia has the highest frequency of positive impacts, mostly in terms of income and employment (i.e., under economic considerations).

From the literature review trade-offs among positive and negative impacts occurring at different scales also emerged. In particular, positive income and employment effects were reported at national level, while negative land use-related, environmental and health impacts occur at local level.

Concerning the comparison of indicators frameworks, impacts occurring mostly at local scale (e.g. land use and demography) are less represented in the macro-scale frameworks, which use data at country and sector level (e.g. SLCA databases and SDGs). The GRI framework, acting at company level, could provide a better insight into impacts of mining companies at local level but this information should be organized and harmonized, to be used in macro-scale and policy assessments. While knowledge gaps on demographic aspects affect also the GRI frameworks, the supply chain control information requirements is a strength of this framework and could support supply chain due diligence obligations.

The EU policy impact assessment on shale gas, including the effect on energy prices, provides an example of how to include the perspective of the demand in the social impact assessment, often overlooked in other frameworks, also due to the limited capacity of assessing positive impacts. Assessing the benefits of economic sectors, also in terms of capability of meeting the resources demand, is instead very relevant for supporting the raw materials policy.

Concerning the SLCA databases, given their broad coverage of social aspects and countries, they can be a powerful tool for screening global supply chain in terms of social hotspots. However, they have some limitations in representing how an economic sector affects social conditions. Indeed, many indicators refers to the overall situation of the country rather than being able to assess specifically the sectors performance.

In conclusion, the analysis showed that indicators used in different contexts for sustainability assessment have different perspective and scope, therefore, they capture different aspects. The main identified research gaps consist in the quantification of: land use conflicts, impacts related to land competition (especially for the SLCA databases), and the demographic dimension (in all the frameworks). Moreover, evaluating positive impacts and the contribution of the sector to the socio-economic development, taking into account both local and macro scale, is challenging.

The reference list of social impacts of mining gathered in this study could be a starting point for the harmonization of indicators for the social sustainability assessment. In the future, the Raw Materials Information System, being the European reference web-based knowledge platform for raw materials, could provide this harmonized information in a structured and comprehensive way.

Due to the broad coverage of GRI indicators set, data collected in mining sites for corporate disclosure practices could also feed supply chain analysis and sustainability assessment studies with field data that would increase the meaningfulness of such analysis. Policy impact assessment could also draw from indicators used in other contexts, in order to have a more comprehensive assessment of social impacts, as suggested by the new Better Regulation agenda.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found in the online version at http://dx.doi.org/10.1016/j.resourpol.2018.02.002.

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