BIORECOVER
Raw Materials. Sustainable. Safe

H2020 WORK PROGRAMME

D7.10 – SOCIO-ECONOMIC REPERCUSSIONS & PUBLIC PERCEPTION STUDY 1

LEAD BENEFICIARY: ENSO

Authors: Laura Rancaño (ENSO), Adrián Prol (ENSO) and Mathilde Legay (LGI)

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Contents

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LIST OF ABBREVIATIONS

BR Bauxite Residue

CRM Critical Raw Materials

DG Directorate General

EC European Commission

H&S Health and Safety

HREEs Heavy Rare Earth Elements

IPR Intelectual Property Rights

JRC Joint Research Centre

KPI Key Performance Indicators

LREEs Light Rare Earth Elements

MgW Magnesium low grade waste

PGM Platinum Group Metals

REEs Rare Earth Elements

RMIS Raw Materials Information System

S-LCA Social Life Cycle Assessment

WP Work Package

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EXECUTIVE SUMMARY

BIORECOVER project aims to apply new sustainable and safe extractive technologies to obtain a wide range of Critical Raw Materials (CRMs) from unexploited secondary and primary sources. The specific sources evaluated are the Bauxite Residue (BR), Mg low-grade waste (MgW), Platinum Group Metals (PGM) low-grade sources and PGM content by-products. The extracted materials will be manufactured at industrial scale and further used to produce components such as catalysts, brake pads, powder Mg, and oxygen sensors.

Task 7.4 aims to evaluate the socio-economic impact and public receptivity of the new biotechnological processes developed in BIORECOVER by two different approaches. In one hand, social impact of the project will be carried out using Social Life Cycle Assessment, which will allow to quantify different socio-economic indicators. Additionally, public receptivity will be addressed by a consumer survey and a public perception study.

This deliverable sets the methodology basis for both analyses. Methodology to be used in S-LCA is described in this deliverable, together with the assessment of the social impact for the 3 reference scenarios previously analysed in task 7.2 and 7.5. Moreover, and based on these results, 6 Social indicators have been selected, to evaluate the socio-economic impact of BIORECOVER during the project.

For the Public perception study, the description of the methodology to be used and the questionnaires developed are gathered in this deliverable. Results regarding both actions will be updated in the next deliverable (D7.11), based in the progress of the project.

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1 SOCIO-ECONOMIC REPERCUSSIONS

The socio-economic impact of the new biomining processes developed in BIORECOVER will be addressed and quantified using Social Life Cycle Assessment (S-LCA) methodology.

S-LCA assess is a social impact assessment technique that aims to assess the social and socio-economic aspects of products and their potential impact (positive and/or negative) along their life cycle, including extraction and processing of raw materials; manufacturing; distribution; use; re-use; maintenance; recycling; and final disposal, under the same framework as the environmental Life Cycle Assessment[1]. S-LCA may represent a very valuable approach for accounting for social impacts along supply chains and to support decision makers ion different contexts[2].

For the development of the S-LCA, the Social Hotspots database has been used. SHDB database (NEW EARTH®). SHDB contains social quantitative and qualitative information weighted according to social risks for over 220 countries and 57 sectors. Through the SHDB it is possible to quantify the social footprint using social risk points for each stage of the 3 reference mining processes studied in the project, setting different indicators that can be monitored during the project based on this methodology of analysis.

1.1 Framework for social assessment

The Social Life Cycle Analysis (Social LCA) is defined as the methodology to be followed to evaluate the social impacts of products, processes and services throughout their life cycle through a systematic evaluation framework that combines quantitative and qualitative data. Thus, the Social LCA provides information on social and socioeconomic aspects that can be used in decision making, taking into account the perspective of improving the social performance of an organization.

Social LCA is based on a combination of methods, models and data:

- The methods that are applied in the Social LCA can be found in reference documents and are used to develop the calculations and obtain the results.
- Models are used to provide a representation of the life cycles/systems of the product, process or service to be evaluated.
- The data is the information about the useful life of the product, cycle or system and the potential impacts that allow the evaluation to be carried out.

For the development of this analysis, software tools are used to apply the methods, access generic data in databases and be able to generate reports that contain the information processed with graphic designs. The methodology to be followed is based on the Life Cycle Analysis (LCA) and the Cost Cycle Analysis (CCA) and is made up of the four stages:

[1] Benoît et al., *Guidelines for Social Life Cycle Assessment of Products*.
[2] Joint Research Centre (European Commission) et al., *Social Life Cycle Assessment*.

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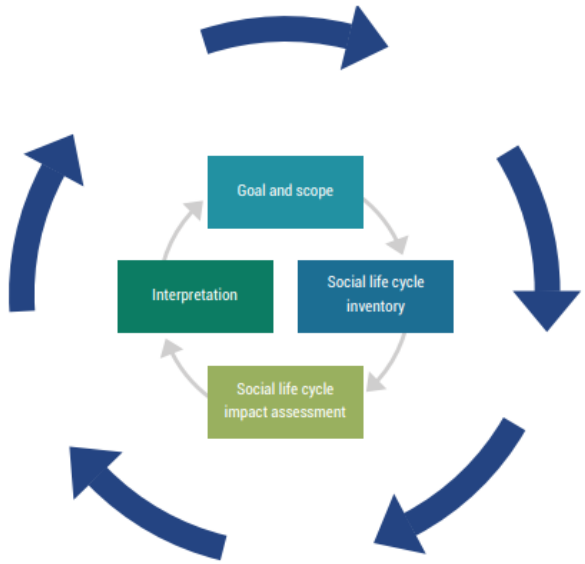

Figure 1 Iterative phases of the Social LCA

1) Definition of the objective and scope: Generally, this is the first phase of the development of the Social LCA. It establishes the application and purpose of the study. The scope of the Social LCA will define the product or process to be analysed, establishing the functional unit of study, the limits of the system, the impact methodology followed, the hypotheses that have been raised in its preparation, and the initial quality requirements of the data.

2) Inventory Analysis: The inventory analysis consists of collecting the data and calculation procedures necessary to be able to quantify all the inputs and outputs of the studied system. This stage is generally the one that requires the most effort, due to the practical limitations of data collection, and it is necessary to consider this aspect when defining the scope of the Social LCA.

3) Impact Assessment of the social life cycle: The main objective of this phase is to quantify the importance of the social impact produced by the product, process or service studied. This process involves associating the results obtained in the inventory analysis with a series of specific categories of social impact and some indicators for each of these categories that facilitates their understanding and comparison. The choice, modelling and evaluation of the impact categories introduces subjectivity to the impact assessment phase; therefore, transparency is critical to ensure that the assumptions made are clearly described.

This phase consists of mandatory elements such as the selection of impact categories, indicators for each category, classification and characterization models, as opposed to others that are optional and can be used depending on the objective and scope of the Social LCA (normalization, grouping, weighting and data quality analysis).

4) Interpretation: The purpose of the interpretation phase is, based on the results obtained in the impact assessment, to provide results in accordance with the objectives and scope defined in the initial phase of the social life cycle analysis. The interpretation of the Social LCA aims to provide an

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understandable reading of the results obtained, facilitating the drawing of conclusions and the use of the information in decision making. In the cases of comparison of similar products, it allows to determine which one presents a better social behaviour.

1.2 Goal and Scope definition

As part of the Task 7.4 Social-Economic Repercussions, this study follows the approach of the environmental LCA. It will be composed of 6 scenarios, of which 3 of them using the conventional extraction process and the others using the recovery of CRM through the BIORECOVER process, as can be seen in the following table:

Table 1 Scenarios considered for Social LCA

BIORECOVER SCENARIOS			
	SCENARIO	***CRM***	***DESCRIPTION***
Reference Scenarios	SC 1	REE: La, Nd, Sc, Y, Pr…	Pyro & Hydrometallurgical process from open-pit mining.
	SC 2	Mg	Pidgeon process from dolomite
	SC 3	PGM: Rh, Ru, Pd, Os, Ir, Pt	Extraction of PGM from chromite and sulphide ores
BIORECOVER	BR BIOPROCESS	PGM: Pd, Pt.	Recovery REE from the bauxite residue mainly using bio-technology.
	MgW BIOPROCESS	Mg	Recovery Mg from magnesium industrial waste using biotechnology
	PLGO and PCBP BIOPROCESS	REE: La, Ce, Nd, Sm, Eu, Gd, Dy, Sc, Y.	Recovery PGM from flotation tailings and from slags, dusts and press cake

1.2.1 Functional Unit

The **functional unit (UF)** in a Social LCA is a reference unit with respect to which the social analysis is carried out. In this case, the functional unit selected will be **the obtention of 1 kg of a specific CRM for each scenario** of each process, following the same structure and data established in the environmental impact analysis.

1.2.2 Social Life Cycle Inventory Analysis (Social-LCIA)

The Social LCIA comprises the collection of all the data and the performance of the necessary calculations to quantify all the inputs and outputs of the study system, according to the selected functional unit. We can consider that the inventory of a Social LCA is made up of two types of data, according to its origin:

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- Primary Data: Those data that have been directly obtained in the BIORECOVER project, or have been obtained directly by stakeholders based on their know-how, facilities and daily activity. These data are, for example:
    - Characteristics, quantities and origin of the raw materials and sources used in the CRM recovery.
    - Operating characteristics and electrical consumption of the different mining processes.
    - Operating characteristics and electrical consumption of the BIORECOVER processes.

- Secondary Data: These are data outside the project, less specific but coming from reliable sources, such as environmental databases, bibliographic references, etc. The following data belong to this type:
    - Industrial production of raw materials and chemical reagents, commodity prices.
    - Transportation of raw materials by ship and road

1.2.3 Social LCA Methodology

To carry out the Social LCA, the SimaPro 9.0 software, developed by PRé Consultants, has been used. The necessary data to complement the Life Cycle Inventory and the calculation of the social footprint were obtained from The Social Hotspots Database (SHDB)[3] , which has a large amount of verified social data referring to different countries distributed in categories such as human rights, workers' rights and working conditions, health and safety, governments and social framework.

There are two life cycle impact assessment methods offered for working with the SHDB database. The first weights and evaluates the impact categories equally considering the associated damages (*Social Hotspot 2019 subcategories & categories Method with Damages*). The second one weights and evaluates the impact subcategories equally (*Social Hotspot 2019 subcategories Method with Weights*). As in these analyses there is a variable number of indicators per impact subcategory and a variable number of impact subcategories per impact category, it is necessary to select the level required for the study.

[3] Benoit, Bennema and Norris, « The Social Hotspots Database » Supporting documentation, update 2019 (V4).

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Figure 2 SHDB categories and subcategories

In the social evaluation of the BIORECOVER project, the *Social Hotspot 2019 subcategories & categories Method with Damages* method will be used, since it evaluates both the categories and the subcategories. Thus, the impact categories are weighted equally to evaluate the results of each of them (social footprint) and the contribution of the processes, products or services (social hotspots), and the subcategories are also weighted equally with the objective to assess the results at the subcategory level, which provides information in a more general framework.

Table 2 Impact categories considered. Social Hotspot 2019

Impact categories	
Labour Rights and Decent Work 	Subcategories such as wage assessments, poverty, child labour, excessive working time, freedom of association, collective bargaining and the right to strike, and immigrant employment are taken into account in this category. All these subcategories are conditioned by the geographical location in which the study is being carried out. In order to quantify them, indicators are taken into account such as the risk that the average wage in the sector is less than the living wage, poverty (BM), percentage of the population living below the corresponding poverty line, risk of total child labour in the country, percentage of total child labour in the sector (Quantitative), overall forced labour in the country, excessive working time, freedom of association rights, collective bargaining rights, right to strike (Qualitative), total immigrants in the country of destination, workers' remittances and Compensation Received by Emigrant (USD), etc.

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Health and Safety 	Subcategories such as occupational toxics and potential hazards, injuries, and fatalities are considered in this category. All these subcategories are conditioned by the geographical location in which the study is being carried out. In order to quantify them, indicators such as noise exposure at work for men (85-90 dBA), noise exposure at work for women (>90 dBA), work-related deaths, leukaemia, years disability-adjusted life expectancies due to work-related lung cancer, occupational cancer global risk – loss of life, chronic obstructive pulmonary disease as a result of workplace exposure to airborne particles, both sexes etc.
Human Rights 	This category takes into account subcategories such as indigenous rights, gender equity, areas of high political, social or economic conflict, and human health, non-communicable and health issues. All these subcategories are conditioned by the geographical location in which the study is being carried out. In order to quantify them, indicators such as the global risk of indigenous rights being infringed, the risk of a country not adopting the conventions, the Social and Gender Institutions Index (SIGI), and the Gender Inequality Index (UNDP Human Development Indicator) are taken into account, female representation in the workforce by sector, life expectancy at birth (years), Age-standardized mortality rates for injuries (per 100,000 population), Estimated obesity (BMI = 30 kg/ m²), mortality rate attributed to household and ambient air pollution and exposure to unsafe water and sanitation services, etc.
Governance 	Subcategories such as the legal system and corruption are taken into account in this category. All these subcategories are conditioned by the geographical location in which the study is being carried out. In order to quantify them, indicators such as the World Bank's global governance, Rule of Law indicator (1-100), Global Integrity Index - Judicial Responsibility, Judicial (25%), Rule of Law (25%), Law Enforcement (50%), (50%) (Weighted average of 3, 1-100), general fragility of the legal system, World Economic Forum, Transparency International's Corruption Perceptions Index, general corruption, etc.
Community 	This category takes into account subcategories such as access to improved drinking water source, availability of a developed health system, non-schooling of children, access to hospital beds and the ratio of small farmers compared to commercial farms applied to the agricultural sector. In order to quantify them, indicators such as urban access to an improved source of drinking water, percentage of children not attending primary school, access to hospital beds, number of hospital beds per 1000 inhabitants, percentage of farms are taken into account. family farms in each country, percentage of commercial farms in each country, small farms % < x hectares, etc.

In order to calculate different types of socioeconomic impacts throughout the value chain of a product or process, the SHDB bases its calculation on two factors; productivity, expressed in hours of

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equivalent work to achieve a productivity of 1USD within the study value chain, and a risk factor that determines the relationship between the socioeconomic impact for a specific subcategory (poverty, child labour, etc.), depending on the degree of existing risk for a particular region, thus weighting the volume of working hours. In this way, the unit to express the results of the social analysis is medium risk hours equivalent (Mrheq).

1.3 Conventional scenarios

This section describes the main industrial processes for production of REE, Mg and PGM to be compare with the BIORECOVER process. Based on the consumption data used in the environmental impact analysis of D7.2, the data taken into account in these studies were taken from historical databases provided by websites managed by teams of experts in economics, analysts, etc, such as: CEIC Data, Trading Economics, ECHEMI Group, Investing, among others. Also, extrapolations of intermediate material costs were made, as well as transportation costs in the case of the mining process, due to the lack of specific information on these processes.

1.3.1 Scenario 1: Conventional process for the REE extraction

The REE most common extraction method is open-pit mining of bastnasite and monazite (mainly in the Bayan Obo region in Inner Mongolia)[4] and transported by railway to the production plant in Baotou, also in the inner region of Mongolia[5]. For that reason, this will be the location selected in the conventional scenario. Besides, the data used for the of the REE conventional scenario are extracted from bibliographic data.

In this process, the location of the materials used were taken for materials generated in China and the prices were established, as far as possible, according to their price for the year 2011, taking into account the exchange rates in the cases that were necessary in order to obtain their price in dollars for the year 2011 to have the same point of reference.

[4] Vahidi, Navarro, and Zhao, "An Initial Life Cycle Assessment of Rare Earth Oxides Production from Ion-Adsorption Clays."
[5] NS Energy, "Bayan Obo Rare Earth Mine".

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Table 3 Inventory data for the conventional REE extraction process.

INVENTORY				
STAGE	ITEM	VALUE	UNITS	SBDH
Mining	INPUTS			
	Primary Energy	0.0001	$USD 2011	Oil/CHN
	Explosive	2.52	$USD 2011	Chemical products/ CHN
	Transport	0.0003	$USD 2011	Transport/ CHN
Beneficiation	INPUTS			
	Ore	135	$USD 2011	From Mining
	Electricity	0.0384	$USD 2011	Electricity/CHN
	Steam	1.2600	$USD 2011	Water/CHN
	Water	35	$USD 2011	Water/CHN
	Organic flotation chemicals	0.0320	$USD 2011	Chemical products/ CHN
	Other inorganic flotation chemicals	0.0177	$USD 2011	Chemical products/ CHN
Roasting and hydrometallurgy	INPUTS			
	REE concentrate	150	$USD 2011	From Beneficiation
	Electricity	0.0045	$USD 2011	Electricity/CHN
	Primary Energy	0.0846	$USD 2011	Oil/CHN
	Sulphuric acid	186	$USD 2011	Chemical products/ CHN
	Hydrochloric acid	99	$USD 2011	Chemical products/ CHN
	Water	15	$USD 2011	Water/CHN
	Ammonia	0.1650	$USD 2011	Chemical products/ CHN
	Iron Chloride	0.1742	$USD 2011	Chemical products/ CHN
Solvent Extraction and calcination	INPUTS			
	RE Chloride	1756	$USD 2011	From Roasting and Hydrometallurgy
	Primary Energy	0.0853	$USD 2011	Oil/CHN
	Hydrochloric acid	509	$USD 2011	Chemical products/ CHN
	Sodium hydroxide	0.2406	$USD 2011	Chemical products/ CHN
	Other inorganic chemicals	0.0082	$USD 2011	Chemical products/ CHN
	Kerosene	17	$USD 2011	Petroleum products/CHN
	Ammonium bicarbonate	0.2345	$USD 2011	Chemical products/ CHN
	Sodium carbonate	0.3311	$USD 2011	Chemical products/ CHN
	Oxalic acid	0.3738	$USD 2011	Chemical products/ CHN
	Water	41	$USD 2011	Water/CHN

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1.3.2 Results for conventional REE extraction process

The social impact is evaluated with the conventional process for REE obtention. For a pleasant interpretation of the obtained result, a graph representation of each impact category is show (Figure 3). For the conventional REE extraction process, the graph shows how each stage affects each principal category of the analysis and his contribution to the total.

As can be seen, the stages with the greatest impact in all categories are given by Beneficiation Stage, where the REE raw ore is concentrated, and the Roasting and hydrometallurgy Stage of the REE concentrate, the latter having the slightly greater impact.

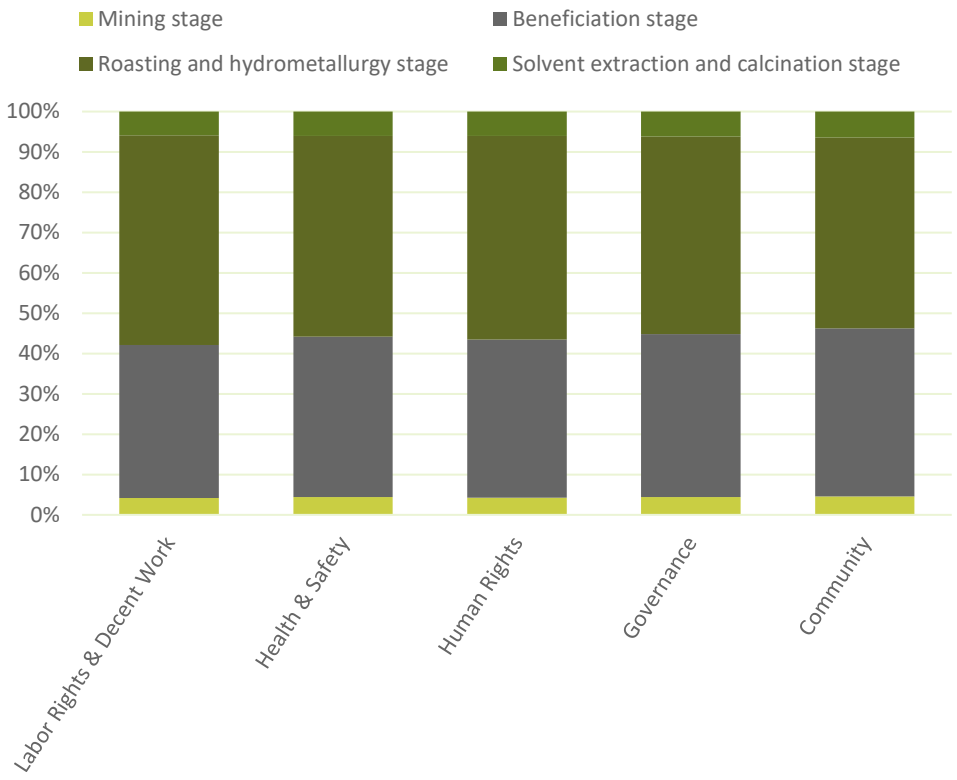

Figure 3 Main categories of social impact due to conventional REE extraction process

For these two stages, taking into account the 25 sub-categories analysed, their impact was graphed separately to observe the source with the greatest contribution in their processes.

In the case of the Beneficiation stage, the main contributor to all impacts is water use. China is a nation with medium to high water stress[6]. Due to the amounts used in this process, it can be seen how it is the largest and almost total contributor to all the subcategories analysed.

[6] Ritchie and Roser, "Water Use and Stress."

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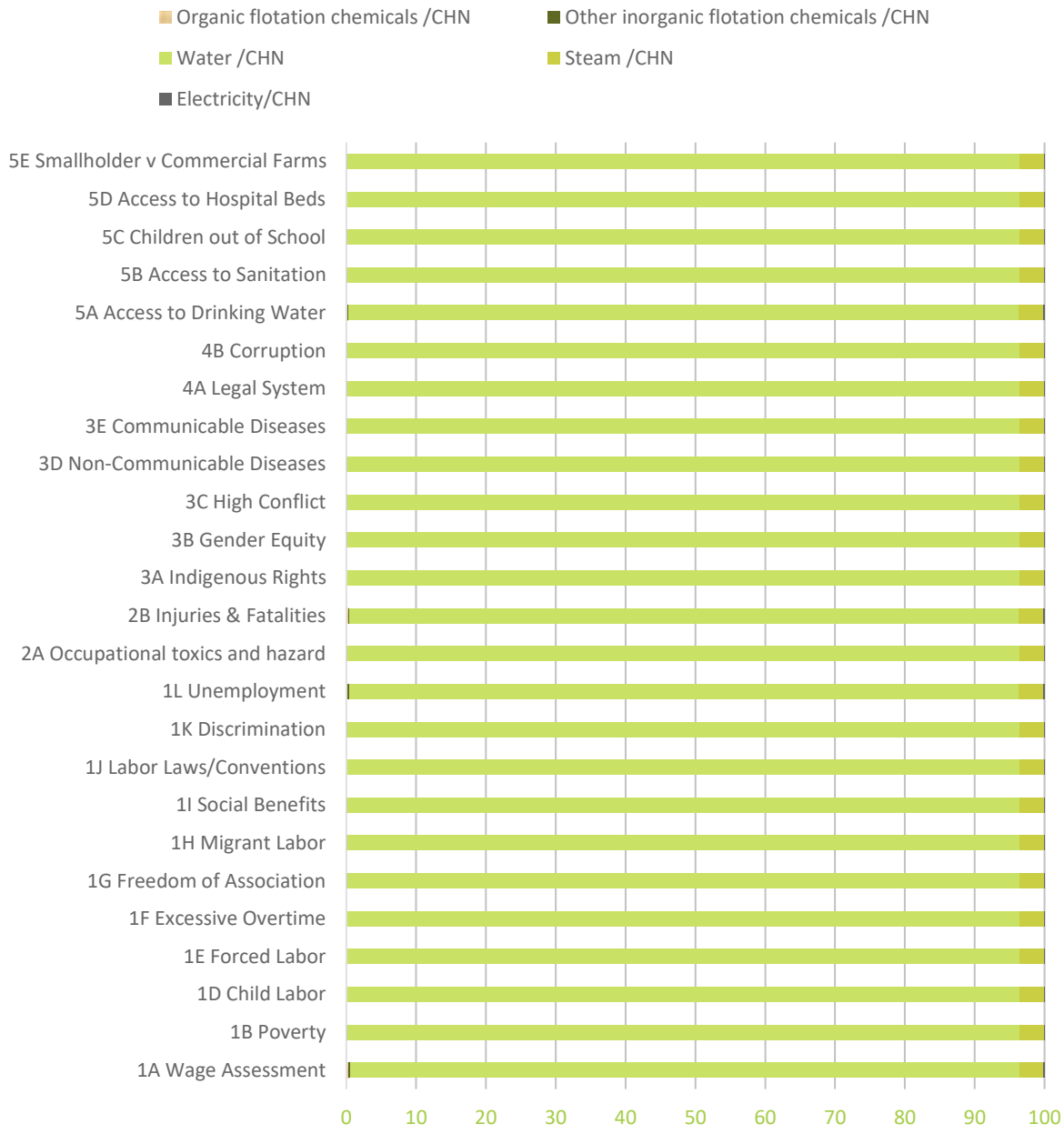

Figure 4 Subcategories of social impact due to Beneficiation Stage

For the Roasting and Hydrometallurgy stage, it was observed that the largest contributors, in all subcategories, almost equally, were due to the use of chemical products (Sulfuric acid and Hydrochloric acid respectively). Lesser extent but not least, the use of water, due to its impact on the category of Labour Rights + Decent Work, in aspects related to Excessive overtime and Labour laws and conventions mainly.

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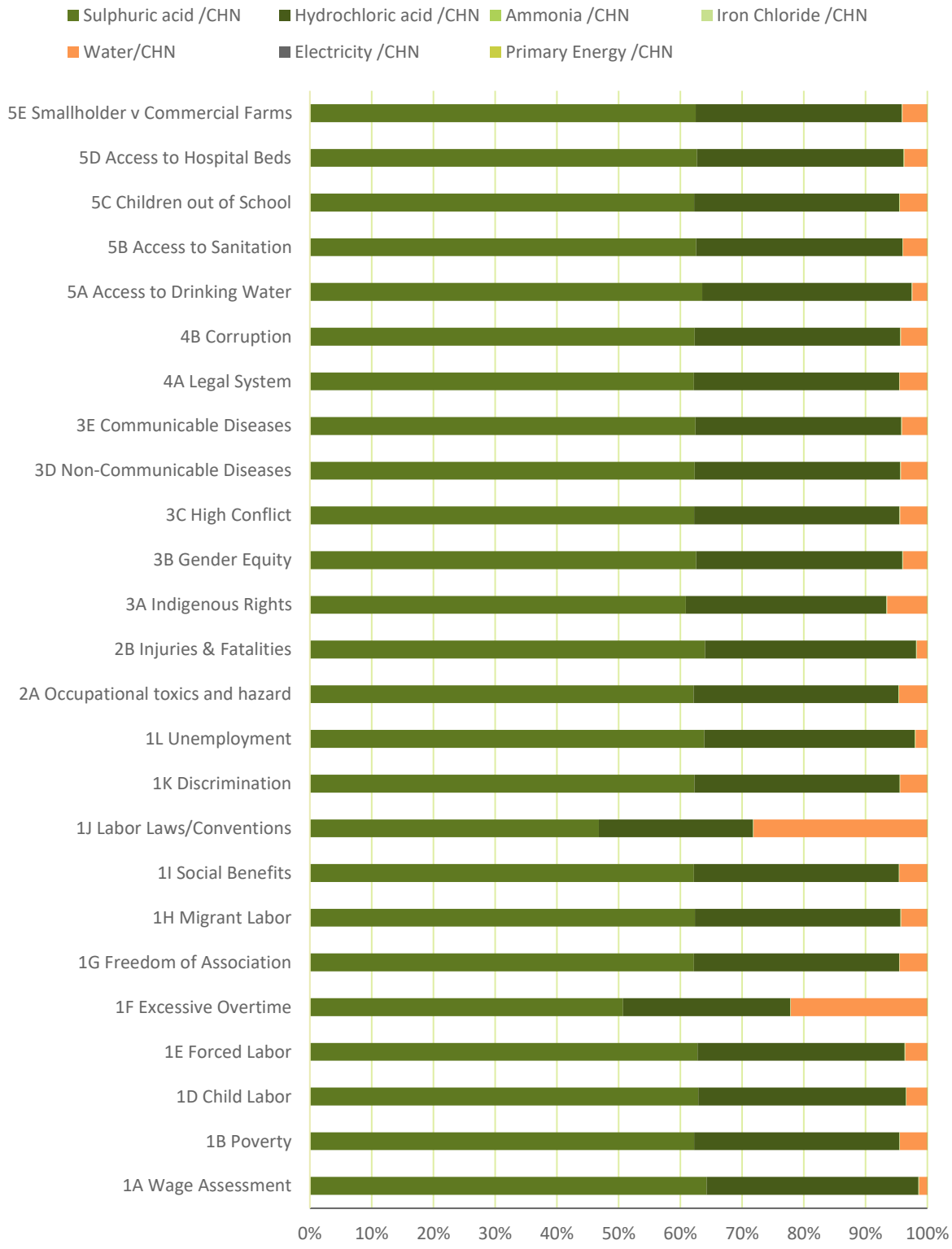

Figure 5 Subcategories of social impact due to Roasting and Hydrometallurgy stage

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For the Roasting and Hydrometallurgy stage, it was observed that the largest contributors, in all subcategories, almost equally, were due to the use of chemical products (Sulfuric acid and Hydrochloric acid respectively). Lesser extent but not least, the use of water, due to its impact on the category of Labour Rights + Decent Work, in aspects related to Excessive overtime and Labour laws and conventions mainly.

1.3.3 Scenario 2: Conventional process for Mg obtention

Shanxi Province (China) has been the largest primary magnesium producer in the world since year 2000, supplying the 75% of the global market. Also, the main raw material for the metal production is dolomite which contains around 20% of Mg and the main production process is the Pidgeon process. Since that are the most common conditions and location for the Mg production, those conditions will be assumed for the impact assessment of the Mg conventional scenario [7,8].

The production process is based on the following stages: The dolomite ore is calcined in rotary or vertical furnaces at about 1,200°C, which is called calcination step. The dolomite mixed with ferrosilicon containing above 75% of silicon as reduction agent and fluorite containing around 95% of CaF2 as catalyst after calculating and measuring ingredients is ground. Then, these three kinds of materials were placed inside the reduction pots after being compressed into balls by a pelleter and heated to 1,200°C, subsequently drawing the air from the reduction pots at a vacuum, and the magnesium vapor appears after the reduction reaction. This vapor sublimates crystal magnesium in the condenser in the front part of reduction pots. The last step of the Pidgeon process is the refining, where the Mg crowns are melted and treated with purifying agents [9].

Table 4 Inventory data for the conventional process for Mg obtention.

INVENTORY				
STAGE	**ITEM**	**VALUE**	**UNITS**	**SBDH**
PGM extraction process	INPUTS			
	Dolomite	1.50	$USD 2011	Minerals/ CHN
	Ferrosilicon	1.68	$USD 2011	Mineral products/ CHN
	Fluorite	0.10	$USD 2011	Mineral/ CHN
	Electricity	0.03	$USD 2011	Electricity/ CHN
	Coal	1.94	$USD 2011	Coal/ CHN

[7] Ruan and Unluer, "Comparative Life Cycle Assessment of Reactive MgO and Portland Cement Production."
[8] Gao et al., "Life Cycle Assessment of Primary Magnesium Production Using the Pidgeon Process in China."
[9] Navarro and Zhao, "Life-Cycle Assessment of the Production of Rare-Earth Elements for Energy Applications."

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As for the REE process, the analysis was carried out using materials/energy generated in China, with their prices established, as far as possible, for the year 2011 according to the available commodity databases. As well as the currency conversion, if required.

1.3.4 Results for conventional process for Mg obtention.

Impact of Mg obtention over the 5 main categories evaluated are showed in Figure 6. As can be observed, the different raw matters and inputs from the process have a similar impact over the 5 main categories analysed

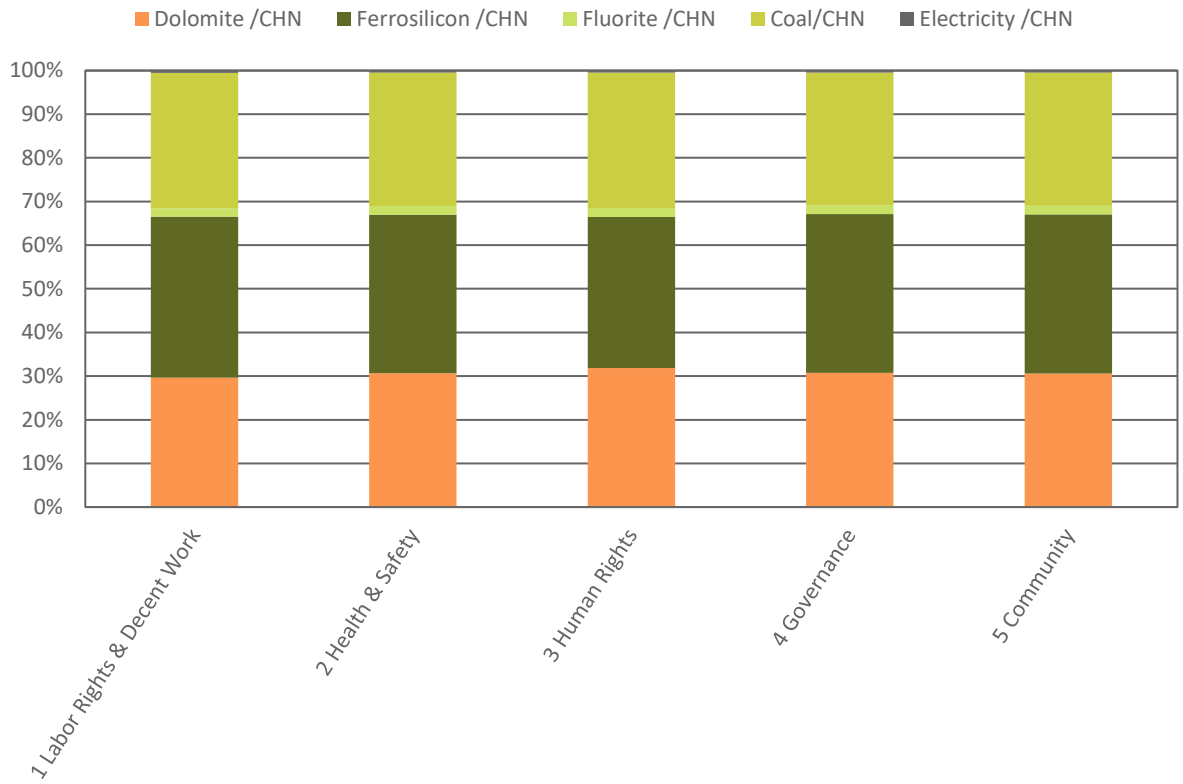

Figure 6 Main categories of social impact due to Mg obtention

In the conventional magnesium extraction process evaluated, it was determined that, due to their consumption, dolomite, ferrosilicon and coal were the ones with the greatest impact, almost equally, in all the subcategories evaluated. Being slightly higher in all subcategories for ferrosilicon, with the exception of those for "Excessive Worktime" and "Indigenous Rights", being higher in these cases due to the use of coal and dolomite, respectively (Figure 7).

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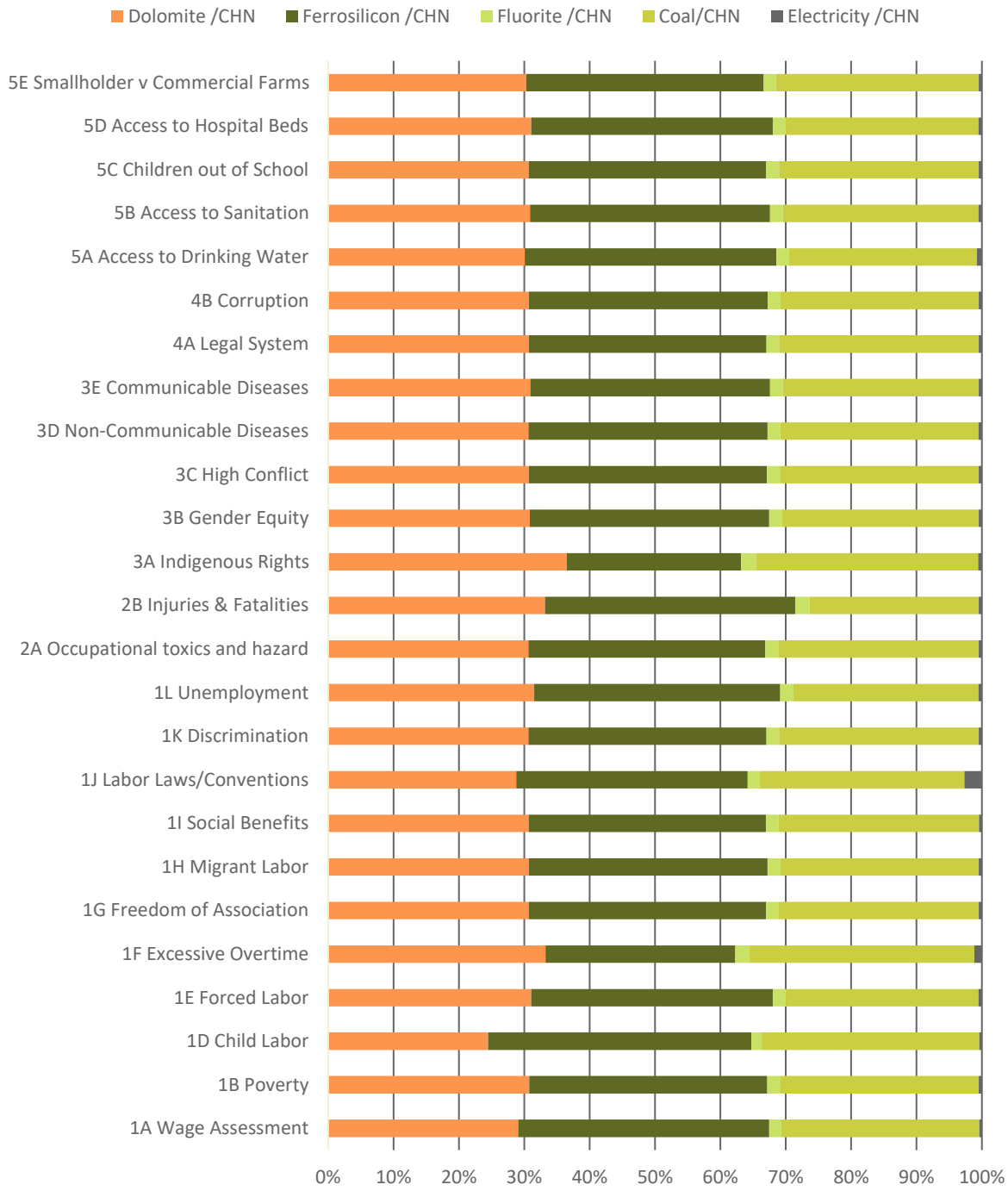

Figure 7 Subcategories of social impact due to Mg obtention

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1.3.5 Scenario 3: Conventional process for PGM obtention

Extraction of PGMs from the South African ores in the Anglo Platinum Limited miner is provided since they dominate world supply. The main sources of minerals are chromite and sulphide ores. Therefore, the South Africa location will be selected for the PGM conventional obtention process simulation, as well as the materials/energy used in this process. For this, a database with a registry of commodities was used, as far as possible, according to the information available, for the year 2011. In turn, the monetary conversion rate was carried out, if necessary.

Table 5 Inventory data for the conventional process for PGM obtention

INVENTORY				
STAGE	**ITEM**	**VALUE**	**UNITS**	**SBDH**
PGM extraction process	INPUTS			
	Ore milled	4	$USD 2011	Minerals/ ZAF
	Coal	0.10	$USD 2011	Coal/ ZAF
	Liquid petroleum gas	56	$USD 2011	Gas manufacture, distribution/ ZAF
	Fuel	276	$USD 2011	Petroleum, coal products/ ZAF
	Lubricating and hydraulic oils	393	$USD 2011	Petroleum, coal products/ ZAF
	Electricity	0.22	$USD 2011	Electricity/ ZAF
	Water	1121	$USD 2011	Water/ ZAF

1.3.6 Result for conventional PGM obtention process

Figure 8 shows the main social impact categories for the consumption of raw materials made, entirely, in South Africa. The socio-economic impact for all the main categories is generated, almost entirely, by the consumption of process water.

This high impact is explained by the combination of a water intensive mining process and the water scarcity risk of the region where the mining activity takes place (South Africa). PGM extraction is extremely-hight water consumption process. According to Mwanza et al.[10], PGM mining requires up to 674.000 m^3 of water per ton of PGM, of which about 272.000 m^3 are consumed, and the remaining fraction is recycled. This amount is significantly higher than other water-intensive mining processes such gold processing (379.000 m^3/ton). Additionally, South Africa is considered under high water stress, as over 63% of freshwater resources are withdraw from freshwater resources at the moment.

[10] Mwanza and Telukdarie, "Modelling the Water Network of a PGM Mining and Beneficiation Value Chain."

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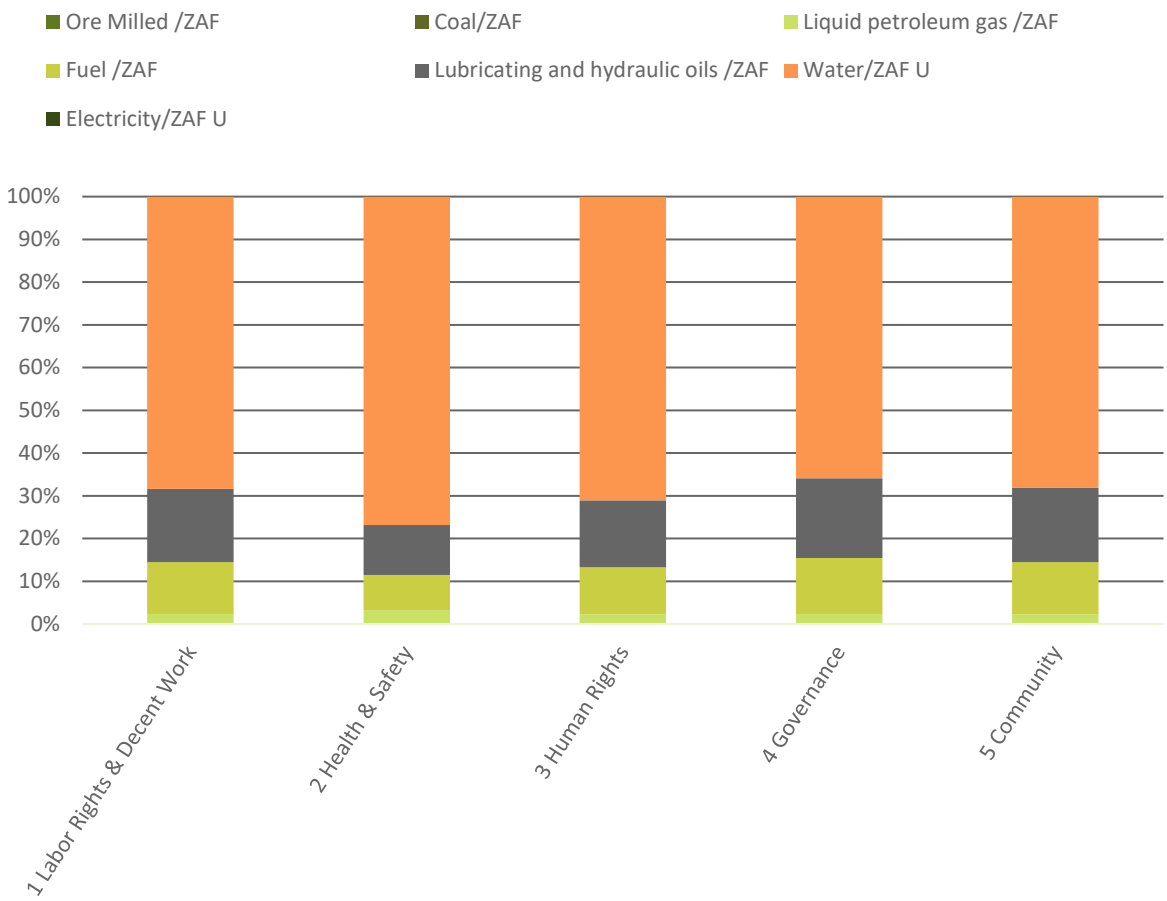

Figure 8 Main categories of social impact due to PGM obtention process

Besides the impact of the water consumed in the process, high impact of the use of petroleum derivatives can be observed in subcategories as Gender Equity and Wage Assessment.

Despite the fact that most, and a large proportion, of the impact subcategories are generated by the use of water, a greater impact was observed in the subcategories for "Gender Equity" and "Wage Assessment" generated by the use of petroleum derivatives. This could be explained by the low percentage of women in the gas and oil industry in South Africa, ranging 20% of the work force and below 17% in middle or senior leadership positions[11].

[11] "Local Energy Sector Still Has Too Few Women Participants, Says Petroleum Agency."

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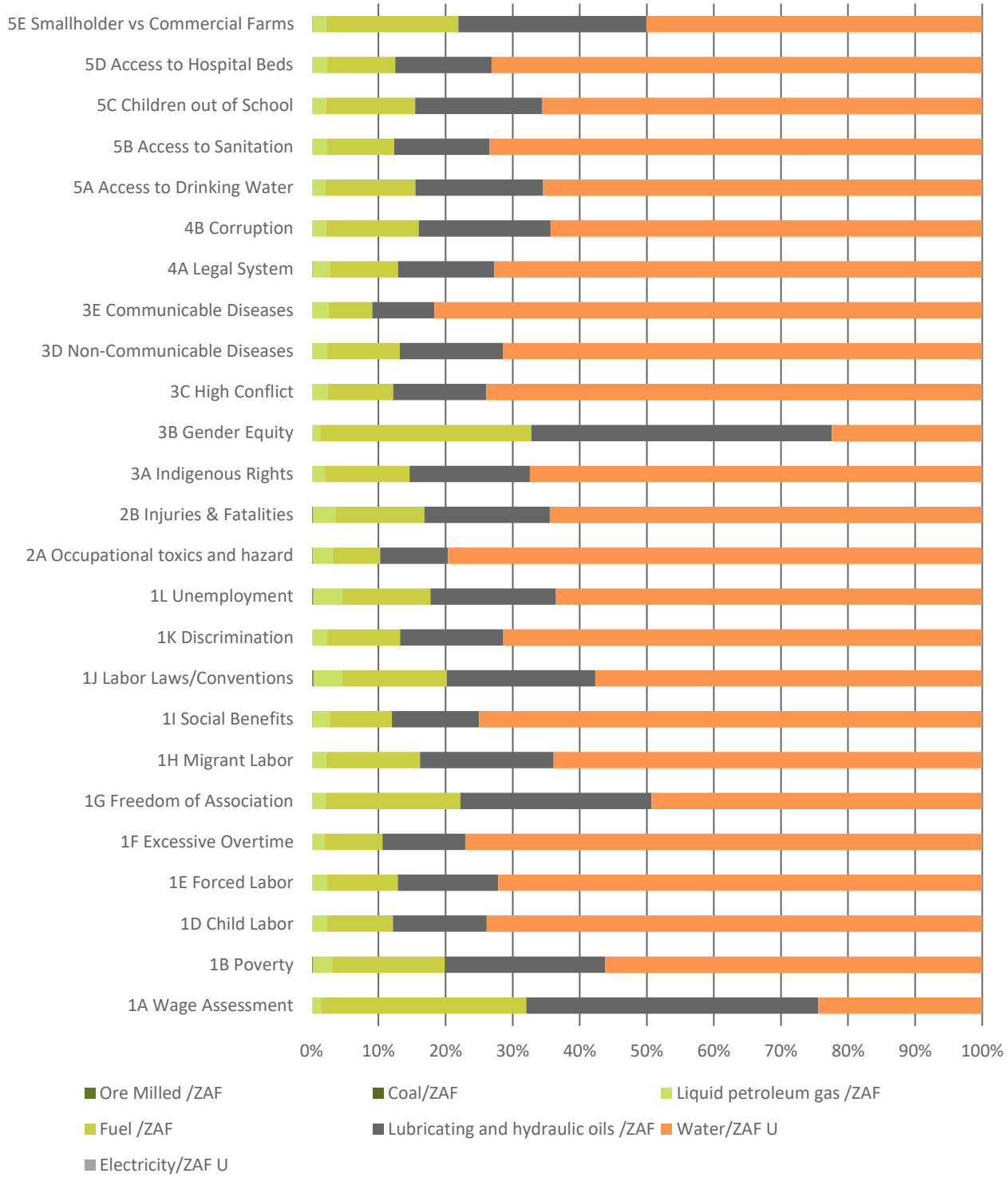

Figure 9 Subcategories of social impact due to PGM obtention process

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1.4 Definition of Socio-economic KPIs

Based on the preliminary assessment of the reference scenarios analysed, a set of indicators based in the S-LCA methodology have been defined. As showed for the different scenarios analysed, a wide number of social indicators (up to 25) can be quantified based on the SHDB and the S-LCA

In order to have a comprehensive vision of the socio-economic impact of BIORECOVER process, the 5 main Impact Categories from Social Hotspots Database have been selected, as it provides a complete picture of the impacts from a larger number of subcategories, thus evaluating globally the influence of Biorecover processes over working condition, health, human rights, governance and community. Additionally Gender Dimension will be also quantified as an independent category by sung the "*Gender Equity*" subcategory, which is addressed twice as part of the Human Rights category. A detailed description of the indicators and sub-categories considered under each KPI can be found in Annex I

Table 6 Key Performance Indicators for Conventional Scenarios

Indicator	Conventional process for the REE extraction (Pt)	Conventional process for Mg obtention (Pt)	Conventional process for PGM obtention (Pt)
Labor Rights & Decent Work	16,97	56,44	228,91
Health & Safety	17,37	62,68	41,74
Human Rights	9,10	32,54	211,53
Governance	21,52	77,58	251,48
Community	10,67	38,17	301,87
Gender Equity	0,97	3,52	16,72

These results were obtained due to the processes involved in each Conventional Scenario. Being these categories influenced by the type of material used in the process, the amount of it and the location in which it is generated. These results obtained will be compared with those of BIORECOVER in order to know the difference in social impacts between scenarios.

1.5 Preliminary conclusions & next steps

Conventional scenarios were planned and reported for the processes of obtaining REE, Mg and PGM.

In the **REE extraction** process, the **Beneficiation stage and Roasting and hydrometallurgy stage generated the greatest social impact** in general. The social impact for all the subcategories analysed in the Beneficiation stage was generated in more than 90% by the consumption of water. For the Roasting and hydrometallurgy stage, the main contributor in the subcategories analysed was due to the use of chemical products (sulfuric acid and hydrochloric acid). In addition to this, the consumption

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of water in the process had its greatest impact on Excessive overwork and Labour laws and conventions subcategories.

For the **conventional process for Mg** obtaining, the c**onsumption of dolomite, ferrosilicon and coal** were the ones that generated the greatest impact in all categories, in a very similar way.

The social impact for conventional **PGM obtaining process was mainly due to water consumption**. For the Gender equity and Wage Assessment subcategories, the greatest impact was due to oil derivatives.

As next steps, hotspots identified in the conventional scenarios will be reviewed in order to ensure adequate modelling scenarios to be compared with the BIORECOVER scenarios.

BIORECOVER scenarios are currently being modelled based on the information recovered from questionnaires and the new available deliverables. In the next weeks, Social LCA analysis of labscale tests is currently being carried out, combining data provided from Consortium and data from peer-reviewed journals and Social Hotspot Database. Results regarding this work will be reported under the "Socio-economic repercussions & public perception study 2" deliverable.

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2 PUBLIC PERCEPTION STUDY

2.1 Subcontractor election

The implementation of this task, required the subcontracting of a company with expertise, experience and software/equipment to develop the questionnaire. Different options were analysed, the characteristics of the planned study, which required interviews in France, Greece and Spain were a bottleneck for some companies that lacked the capacity to implement a field study in Spain and Greece.

After analysing different offers, following the internal procedures of ENSO Innovation for suppliers selection as well as the best value for money criteria, GAD3[12] was selected as services supplier to develop the public perception study described in Task 7.4 Socio-economic repercussions and public perception study.

GAD3 is a social research and communication consulting firm with one specific business line dedicated to research. Throughout its 20 years of experience, GAD3 has developed its own research and analysis tools and has become one of the main references in this field at both a national and an international level. GAD3 was selected to conduct the study in Spain and Greece. The study in France is being carried out by LGI as partner of the consortium of BIORECOVER.

2.2 Design of the questionnaire

Once the external supplier was selected, an iterative process was started among ENSO, LGI and GAD3 with the support of the project coordinator CETIM. The first version of the questionnaire was designed in English for a better understanding among the parts involved in the development. This questionnaire was translated to Spanish, French and Greek.

The following lines correspond to the last version of the questionnaire:

We are conducting a study in Greece and Spain to know the perception of sustainable extraction of raw materials. The survey is completely anonymous and lasts approximately 5 minutes. Thank you very much in advance.

Introduction

Q1 **Indicate your sex**

Man	1
Woman	2
Non-binary	3
I don't want to share this information	4

[12] https://www.gad3.com/en/

Q2 **Indicate your age**

Dropdown 18-70 years

Q3 **In relation to the knowledge about environmental issues**

I am interested and I inform myself about it daily	1
I am interested and I inform myself about it sporadically	2
I'm interested, but I don't inform myself about it	3
I'm not interested	4
I do not know	5

Q4 **And regardless of the above, indicate to what extent you would say that you have knowledge about mining and extraction:**

I am an expert	1
Pretty much	2
Little	3
Nothing	4
I do not know	5

If the answer is "I am an expert" a dropdown is presented with these options

I am not working in these fields
<3 years
3-5 years
6-10 years
011-20 years
+ 20 years

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BLOCK I: Perception of the mining and extractive sector today

Q5 **In relation to the mining and extractive sector at present, please indicate to what extent you agree with the following statements…**

	Totally agree	I agree	Disagreeing	Strongly disagree	Doesn't know
Mining and the extractive sector are high polluting industries	1	2	3	4	5
You would live 10 km from a mine or quarry	1	2	3	4	5
Working conditions in the mining sector are extremely harsh	1	2	3	4	5
Technological advances have reduced the environmental impacts caused by extraction	1	2	3	4	5

Q6 **And thinking about the causes of the relocation of mining and extractive activities outside Europe, indicate what you think is the main cause of this situation -**Multiresponse-**:**

Lack of competitiveness	1
Local environmental impact	2
Improving social conditions in Europe	3
None of the above	4
Doesn't know	5

Q7 **And, of the following consequences derived from mining, indicate which one worries you the most.** ***MULTI-RESPONSE (Select maximum 2)***

Materials waste	1
Water withdrawal	2
Biodiversity loss	3
Low sustainability	4
None of the above	5

BLOCK II: Perception of critical raw materials

Q8 **In relation to critical raw materials, hereinafter MPCs, indicate how much do you agree with the following statements…**

*The term **critical raw materials** refers to non-energy minerals of high industrial value, fundamental in the development of new technologies and with high supply risk (e.g.: lithium, tungsten, magnesium, cobalt …).*

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	Totally agree	I agree	Disagreeing	Strongly disagree	Doesn't know
CRMs are essential in our daily lives	1	2	3	4	5
New technologies depend on CRMs imported from outside Europe	1	2	3	4	5
Technological advances favor the emergence of new sources of materials	1	2	3	4	5
A geopolitical crisis could affect the supply of CRMs	1	2	3	4	5
My quality of life depends on the availability and price of CRMs	1	2	3	4	5
I am committed to reducing the use of CRMs by purchasing second-hand electronics and recycling them	1	2	3	4	5

BLOCK III: Perception of technological solutions

Q9 **And, as for technological solutions, please indicate** to **what extent you agree with the following statements...**

	A lot	Pretty much	Little	Nothing	Doesn't know
Technological advances favor less polluting mining and extraction	1	2	3	4	5
Governments should prioritise research in this sector	1	2	3	4	5
Technological advances will improve workers' conditions	1	2	3	4	5
The situation of the sector is very different outside Europe due to technology	1	2	3	4	5

BLOQUE IV: Perception of the political situation

Q10 **And, as for the type of policies, indicate which should be applied from Europe in the** mining and extraction sector. ***multi-RESPONSE***

Reducing reliance on the supply of CRMs	1
Tightening environmental impact legislation	2
Softening environmental impact legislation	3
Supporting research into sustainable forms of extraction	4
Reactivating offshore industries	5
Doesn't know	6

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Q11 **Indicate what measures should be applied by the government of your country *MULTI-RESPONSE***

Follow the policies set by the EU	1
Self-regulate the sector in the country	2
Support research into sustainable forms of extraction	3
Reactivate offshore industries	4
Doesn't know	5

Q12 **Do you think mines and quarries should be relocated in Europe? If yes, why?**

To raise consumer awareness	
to have better labour conditions all along the value chain	
to have a lower environmental impact all along the value chain	
I don't know	

Sociodemographic profile

Q13 **Finally, please indicate your current employment situation:**

Private sector worker	1
Public sector worker	2
Self-employed/Entrepreneur	3
Retired or pensioner	4
Unemployed	5
Student	6
Unpaid domestic worker	7

Q14 **Indicate your level of education:**

Primary or lower	1
Secondary	2
University	3

Q15 **Indicate your Region of residence:**

Dropdown regions

Q16 **Approximately, what is the volume of total net monthly income from your household among all household members?**

Less than 500€	1
Between 500€ and 1.000€	2
Between 1.001€ and 1.500€	3

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Between 1.501€ and 2.000€	4
Between 2.001€ and 2.500€	5
Between 2.501€ and 3.000€	6
Between 3. 501€ and 4.000€	7
Between 4.000€ and 5.000€	8
More than 5.000€	9
Don't know/Don't answer	10

During the implementation of this study this questionnaire will be available through these links:

Spain - Spanish-: https://es.research.net/r/MinESP22

Greece -Greek-: https://es.research.net/r/MinGRE22

France – French-: https://forms.office.com/Pages/ResponsePage.aspx?id=3BDlYXovMEG-MWqvm8D72jAdM-DmBH5LgS_jES64fzFUNTVVUjFCTjBISVJINkEwVTQoRohNSjY1TC4u

2.3 Methodology

The study was designed following the characteristics detailed in

Table 7 Technical features of the study

	Spain	Greece	France
Organisation	ENSO – GAD3	ENSO – GAD3	LGI
Universe	Population between 18 and 70 years old residing in Spain	Population between 18 and 70 years old residing in Greece	Population between 18 and 95 years old residing in France
Geographical scope	National	National	National
Quotas	By sex, age and geographical according to the distribution of the population in each territory (INE).	By sex, age and geographical according to the distribution of the population in each territory (National Statistical Service)	By sex, age and geographical according to the distribution of the population in each territory (National Statistical Service)
Information collection procedure	Computer-assisted online interview (CAWI).	Computer-assisted online interview (CAWI).	Form (excel)
Sample size	1,200 total interviews, of which 1,050 have already been carried out.	1,200 total interviews, of which 985 have already been carried out	100 minimum by the end of June, of which 30 have been carried out
Sampling error	±2.9% for a confidence level of 95.5% (two sigma) and in the most unfavourable hypothesis of P=Q=0.5 in the assumption of simple random poll.	±2.9% for a confidence level of 95.5% (two sigma) and in the most unfavourable hypothesis of P=Q=0.5 in the assumption of simple random sampling.	
Duration of the interview	Approximately 4-5 minutes (12 closed questions).	Approximately 4-5 minutes (12 closed questions).	Approximately 8 minutes (average time to answer)
Fieldwork dates	May 31 to June 7/8, 2022 (1 week). Prior to the start of the field work, a pilot test of 100 interviews to confirm the correct functioning of the applied questionnaire.	June 1 to 8/9, 2022 (1 week). Prior to the start of the field work, a test was carried out pilot of 100 interviews to confirm the correct functioning of the applied questionnaire.	A pilot test has been conducted by posting on LinkedIn. Dissemination will continue until November.

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2.4 Next steps

At this point, data are being collected through the questionnaires. Once this stage is finished, the responses will be analysed to obtain conclusions about current public opinion comparing the situation in the three analysed countries.

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4 ANNEX 1. SOCIAL CATEGORIES AND INDICATORS

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The following section details the social indicators considered under each subcategories from SHDB

4.1 Labour Rights and Decent Work

Subcategories	Indicator
1.A Wage Assessments	1.A.a Sector Average Wage
	1.A.b Risk that Sector Avg Wage is below Living Wage
	1.A.c Risk that Sector Avg Wage is below Sweeatfree Wage
	1.A.d Risk that Avg Wage is Below Country Minimum Wage
1.B Poverty (WB)	1.B.a Percent of population living under the relevant poverty line
1.D Child Labour	1.D.a Risk of Male Child Labour in Country
	1.D.b Risk of Female Child Labour in Country
	1.D.c Risk of Total Child Labour in Country
	1.D.d Risk of child labour by sector (qualitative)
	1.D.e Percent Total Child Labour in Sector (quantitative)
1.E Forced Labour	1.E.a U.S. Dept of Labour Trafficking in Persons Report Tiers
	1.E.b Forced Labour in Country – Qualitative Global Slavery Index
	1.E.c Overall Forced Labour in Country
	1.E.d Forced labour by sector
1.F Excessive Working Time	1.F.a Percent of Population working >X hrs per week, >60 hrs per week
1.G Freedom of Association, Collective Bargaining, Right to Strike	1.G.a Freedom of Association Rights, Collective Bargaining Rights, Right to Strike - Qualitative
	1.G.b Collective bargaining coverage
	1.G.c Overall risk of Freedom of Association
1.H Migrant Labour	1.H.a Net Migration Rate (NMR) per 1,000 Population
	1.H.b Total Immigrants to Destination Country 2017
	1.H.c Immigrants as a Percentage of the Population, 2017
	1.H.d Workers' Remittances and Compensation Received per Emigrant (USD) - calculated using Total R&C/#Emigrants
	1.H.e Workers' Remittances and Compensation Paid per Immigrant (USD) - calculated using Total R&C/#Immigrants
	1.H.f Risk that a country has not ratified international conventions or set up

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	policies for immigrants
	1.H.g Evidence of Risk to Migrant Workers - Qualitative
1.I Social Benefits	1.I.a Paid annual leave
	1.I.b Paid sick leave coverage begins on first day of incapacity
	1.I.c Sick leave duration
	1.I.d Sick leave pay
	1.I.e Child education leave
	1.I.f Child health leave
	1.I.g Adult need leave
	1.I.h Maternity leave duration
	1.I.i Maternity leave pay
	1.I.j Paternity leave duration
	1.I.k Paternity leave pay
	1.I.l Parental leave duration
	1.I.m Wage replacement of paid parental leave
	1.I.n Overall risk of inadequate social benefits
1.J Labour Laws/Conventions	1.J.a Year Minimum Wage was last Updated
	1.J.b Total Number of Labour Laws in Country
	1.J.c Number of ILO Conventions Ratified, Abstained, Denounced
	1.J.d Number of Labour Laws by Sector
	1.J.e Ratification of Conventions by Sector
1.K Discrimination and equal opportunity	1.K.a Prevalence of discrimination in the workplace (qualitative)
1.L Unemployment	1.L.a Average of Unemployment Percentage at the country level
	1.L.b Unemployment percentage at sector level

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4.2 Health and Safety

Subcategories	Indicator
2.A Occupational Toxics & Hazards	2.A.a Occupational Noise Exposure to Males (85-90 dBA)
	2.A.b Occupational Noise Exposure to Male (>90 dBA)
	2.A.c Occupational Noise Exposure to Females (85-90 dBA)
	2.A.d Occupational Noise Exposure to Females (>90 dBA)
	2.A.e Overall Occupational Noise Exposure Risk
	2.A.f Deaths due to occupational-related Lung Cancer
	2.A.g Deaths due to occupational-related Leukemia
	2.A.h Deaths due to occupational-related Mesothelioma
	2.A.i Disability-adjusted life years due to occupational-related Lung Cancer
	2.A.j Disability-adjusted life years due to occupational-related Leukemia
	2.A.k Disability-adjusted life years due to occupational-related Mesothelioma
	2.A.l Overall Occupational Cancer Risk – los of life (DALYs)
	2.A.m Overall Occupational Cancer Risk - Deaths
	2.A.n Asthma DALYs as a result of Workplace Exposure to airborne particulates, both genders
	2.A.o Chronic Obstructive Pulmonary Disease DALYs as a result of Workplace Exposure to airborne particulates, both genders
	2.A.p Asbestosis DALYs as a result of Workplace Exposure to airborne particulates, both genders
	2.A.q Silicosis DALYs as a result of Workplace Exposure to airborne particulates, both genders
	2.A.r Heart disease Due to Particulate Matters (DALYs)
	2.A.s Miners' pneumoconiosis DALYs as a result of Workplace Exposure to airborne particulates
	2.A.t Health Care Sector Percent of workforce infected with HIV from sharps injuries
	2.A.uHealth Care Sector Percent of workforce infected with HCV from sharps injuries
	2.A.v Health Care Sector Percent of workforce infected with HBV from sharps injuries
	2.B.a Non Fatal Work Related injuries by sector
	2.B.b Fatal injuries by sector

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2.B Injuries and Fatalities	2.B.c Non-fatal injuries by country
	2.B.d Fatality Rate of injuries by country

4.3 Human Rights

Subcategories	Indicator
3.A Indigenous Rights	3.A.a Overall risk of indigenous rights being infringed
	3.A.b Percent of Population that is Indigenous
	3.A.c Risk of a country not adopting Intl Conventions to Protect Indigenous
	3.A.d Number of laws to protect indigenous according to ILO
	3.A.e Indigenous Sector Issues Identified
3.B Gender Equity	3.B.a Social Institutions and Gender Index (SIGI)
	3.B.b The Global Gender Gap Index, Global Gender Gap Report, World Economic Forum
	3.B.c Gender Inequality Index (GII), UNDP Human Development Indicators Report
	3.B.d The Cingranelli-Richards Human Rights Dataset (CIRI), Women's Rights
	3.B.e Overall Gender Inequity in Country
	3.B.f Female Representation in the workforce by Sector
3.C High Conflict Zones	3.C.a High Conflict Heidelberg Institute – overall
	3.C.b Center for Systemic Peace – State Fragility Index (0-25)
	3.C.c High Conflict UNDP
	3.C.d Minority Rights Group International - People under Threat, Total Score based on several indicators
	3.C.e Overall High Conflict
3.D Human Health Issues – Non-communicable Diseases and other health risk	3.D.a Life expectancy at birth (years)
	3.D.b Under-five mortality rate (probability of death before age 5 per 1000 live births)
	3.D.c Age-standardized mortality rates for non-communicable diseases (per 100,000 population)
	3.D.d Age-standardized mortality rates for injuries (per 100,000 population)

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	3.D.e Proportion of undernourished in population, Dash (-) = <5% of population undernourished
	3.D.f Digestive diseases, Estimated Age Standardized Death Rate (per 100,000)
	3.D.g Diabetes (mellitus) Estimated Age Standardized Death Rate (per 100,000)
	3.D.h Cardiovascular diseases, Estimated Age Standardized Death Rate (per 100,000)
	3.D.i Cerebrovascular disease, Estimated Age Standardized Death Rate (per 100,000)
	3.D.j Neuropsychiatric conditions, Estimated Age Standardized Death Rate (per 100,000)
	3.D.k Malignant neoplasms, Estimated Age Standardized Death Rate (per 100,000)
	3.D.l Respiratory diseases, Estimated Age Standardized Death Rate (per 100,000)
	3.D.m Estimated Obesity (BMI = 30 kg/m²) Prevalence, Aged 15+, Males
	3.D.n Estimated Obesity (BMI = 30 kg/m²) Prevalence, Aged 15+, Females
	3.D.o Mortality rate attributed to household and ambient air pollution and exposure to unsafe WASH services (per 100 000 population)
	3.D.p Population affected by natural disasters, average per year per million people
	3.D.q Overall Non-communicable Diseases and other health risks

4.4 Governance

Subcategories	Indicator
4.A Legal System	4.A.a World Bank Worldwide Governance Rule of Law Indicator (1-100)
	4.A.b Bertelsmann Transformation Index - Rule of law – Independent Judiciary (1-10)
	4.A.c CIRI Human Rights Data Project - Independent Judiciary, (0,1,2)
	4.A.d Global Integrity Index - Judicial Accountability (25%), Rule of Law (25%), Law Enforement (50%) (Weighted Ave of all 3, 1-100)
	4.A.e World Justice Project Rule of Law Index (Ave of 15 indicators, 0-1)
	4.A.f Overal Fragility in Legal System
4.B	4.B.a Worldwide Governance Indicators Corruption Index World Bank

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Corruption	4.B.b World Economic Forum Competitiveness Report
	4.B.c Transparency International Corruption Perception Index (2017)
	4.B.d Transparency International 3 year trend (2014-2017)
	4.B.e Overall Corruption

4.5 Community

Subcategories	Indicator
5.A Access to Improved Drinking Water	5.A.a % Urban Access to an Improved Source of Drinking Water
	5.A.b % Rural Access to an Improved Source of Drinking Water
	5.A.c % Total Access to an Improved Source of Drinking Water
5.B Access to Improved Sanitation	5.B.a % Urban Access to an Improved source of Sanitation
	5.B.b % Rural Access to an Improved source of Sanitation
	5.B.c % Total Access to an Improved source of Sanitation
5.C Children out of School	5.C.a Percent of Children Out of Primary School, male
	5.C.b Percent of Children Out of Primary School, female
	5.C.c Percent of Children Out of Primary School, total
5.D Access to Hospital Beds	5.D.a Number of Hospital Beds per 1000 population
5.E Smallholder v. Commercial Farms (only Agriculture sectors)	5.E.a Percentage of family-owned farms in country
	5.E.b Percentage of commercially-owned farms in country
	5.E.c Smallholdings Land % < x hectares
	5.E.d Largeholdings Land % < x hectares

4.6 Socioeconomic Contributions

Subcategories	Indicator
6.A Contributions to Value Added	6.A.a Total value added
	6.A.b Total wage payments
	6.A.c Payments to technically skilled professionals
	6.A.d Payments to clerks
	6.A.e Payments to service and shop floor workers

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	6.A.f Payments to officers and managerial professionals
	6.A.g Payments to agricultural and other low- skilled workers
	6.A.h Payments to capital
	6.A.i Payments for land
	6.A.j Payments for natural resources
6.B Other Socioeconomic Impacts	6.B.a Total economic output
	6.B.b Hours of paid employment (worker hours)
	6.B.c Total tax payments
	6.B.d Export tax payments
	6.B.e Transport tax payments
	6.B.f Import tax payments
	6.B.g Sales tax payments
	6.B.h Factor tax payments

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