GLOBAL BIODIVERSITY SCORE

MANUFACTURE OF BASIC AND FABRICATED METALS

BIODIVERSITY FOOTPRINT

Sectoral appendix

August 2023

Version 1 – DRAFT

CDC BIODIVERSITÉ | Caisse des Dépôts GROUPE

Table of contents

A. PURPOSE OF THE DOCUMENT

The current **sectoral appendix** supports the **Manufacture of basic and fabricated metals benchmark factsheet** and provides additional content that could not be included in the factsheet due to space constraints. Such additional content relates to the perimeter of the factsheet, more detailed results and charts and specific methodology and references.

In addition to the sectoral appendix, this factsheet is supplemented by two documents, common to all the factsheets:

- A **general appendix**, which provides methodological elements to understand how the sectoral benchmark factsheets are built and how computations and charts are obtained. It includes all the methodology and references which are common to all the factsheets, as well as guidance on how to read and use the factsheets.

- A **reading guide**, which explains the structure of the factsheets. It provides the main contents, definitions and necessary elements to know how to read the factsheets for readers with limited knowledge about the Global Biodiversity Score.

Figure 1 below encapsulates the four benchmark documents available for each sector.

Figure 1: The four benchmark documents.

B. WHAT DOES THE SECTOR INCLUDE?

1. Perimeter of the factsheet in terms of impact calculation

The factsheet "Manufacture of metals"[1] covers the processes needed to produce metals after the extraction and mineral processing. The latter are covered by the factsheet "Raw materials extraction".

To have a better understanding of the perimeter, the different stages of the transformation from metal ores to fabricated metals products are here explained. First, ores are extracted (mining) and processed to separate metals from ores (mineral processing). This stage produces the metal concentrate. Both operations occur at mine level. Industries of mining and mineral processing are covered by the **Raw materials extraction factsheet**. Secondly, metal concentrate leaves the mine level for metallurgical processing and production of fabricated metal products. The EXIOBASE industry "Fabricated metal products" includes the manufacture of "pure" metal products into more complex units and is included in this factsheet.

Industries from those sectors (metallurgical processing and production of fabricated metal products) are covered by the current factsheet: "**Manufacture of metals**".

Figure 2 summarizes the operation to produce metals and the division between the two factsheets:

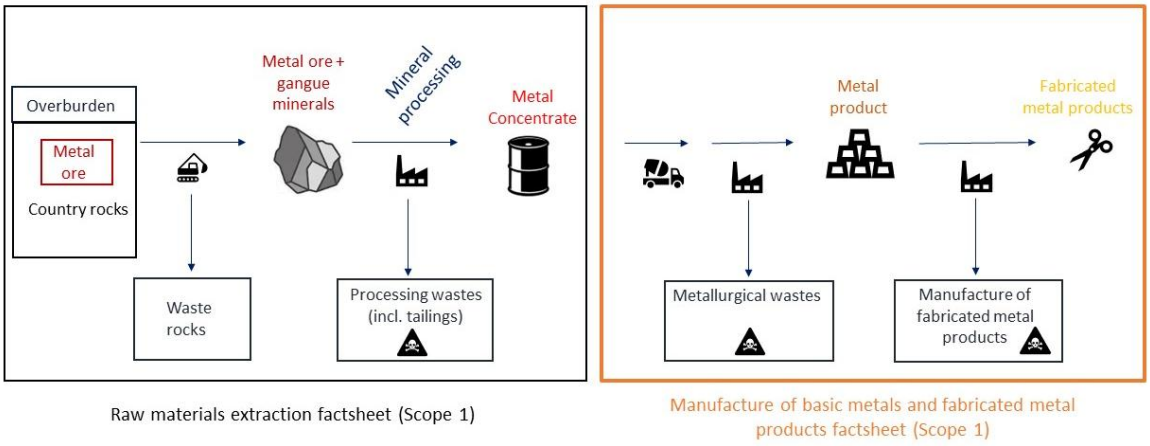

Figure 2: Explanation of the operation to produce metals and the associated factsheet, Anna Montagner - CDC Biodiversité

The sector includes three EXIOBASE industry groups: "Electricity, gas, steam and air conditioning supply", "Manufacture of basic metals" and "Manufacture of fabricated metal products, except machinery and equipment". These groups are themselves divided into industries listed below with their EXIOBASE code:

- **Manufacture of basic metals**
  i27.a Manufacture of basic iron and steel and of ferro-alloys and first products thereof
  i27.41 Precious metals production
  i27.42 Aluminium production
  i27.43 Lead, zinc and tin production
  i27.44 Copper production
  i27.45 Other non-ferrous metal production
  i27.5 Casting of metals

[1] For practical reasons, the sector "Manufacture of basic metals and fabricated metal products" is designated as "Manufacture of metals" in the factsheet and in the annex.

- **Manufacture of fabricated metal products, except machinery and equipment**
  i28 Manufacture of fabricated metal products, except machinery and equipment

- **Electricity, gas, steam and air conditioning supply**
  i23.3 Processing of nuclear fuel

The manufacture of machinery and equipment sector (i29) is not covered in this benchmark factsheet but will be addressed in the future "Manufacturing industry" benchmark factsheet.

These EXIOBASE industry groups are consistent with the following subdivisions of the NACE rev 2 classification: for the section C "Manufacturing", the division 24 "Manufacture of basic metals" and the division 25 "Manufacture of fabricated metal products, except machinery and equipment" NACE rev 2 (EUROSTAT 2008).

Figure 3 below shows the correspondence between the EXIOBASE industries covered by the benchmark factsheet and the NACE subdivisions.

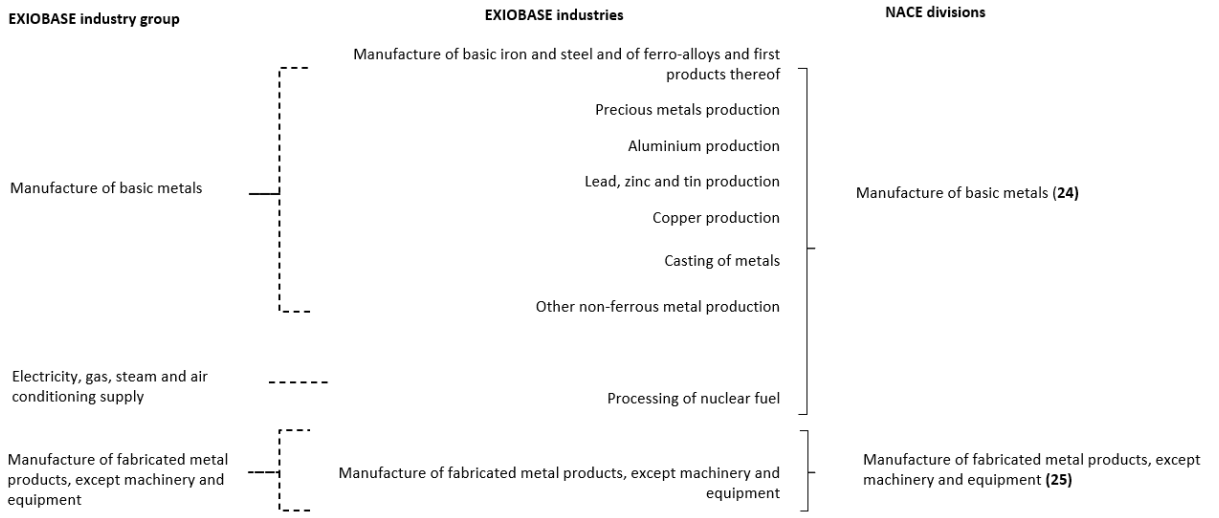

Figure 3: Correspondence between EXIOBASE and NACE rev 2 for the "Manufacture of metals" benchmark factsheet

The results in the factsheet are expressed in MSA.m²/kEUR of turnover. Table 1 shows the distribution of the turnovers of the industries included in the Manufacture of metals factsheet. Please note that version 1.4.6 of the GBS uses 2011 turnover data.

Table 1: Turnover of the EXIOBASE industries included in the "Manufacture of metals" benchmark factsheet (data obtained from GBS 1.4.6 and therefore from EXIOBASE 3.8.1)

EXIOBASE industry	Turnover (MEUR)	Share of the EXIOBASE industry in the benchmark perimeter
Manufacture of fabricated metal products, except machinery and equipment (28)	1 836 797	40 %
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	1 622 540	35 %
Aluminium production	304 878	6.6 %
Copper production	268 551	5.8 %
Casting of metals	202 612	4.4 %
Other non-ferrous metal production	140 589	3.06 %
Precious metals production	138 602	3.02 %
Lead, zinc and tin production	67 578	1.4 %
Processing of nuclear fuel	13 610	0.30 %
Total	**4 595 757**	**100 %**

CDC Biodiversité has decided to treat these different EXIOBASE industries under the heading "Manufacture of metals". The sector covers industries occurring at different stage of the value chain of the production of a final product. As an example, manufacture of scissors and hair clippers industries are covered by the "Manufacture of fabricated metal products" industry group. This stage occurs after the production of steel industries (covered by the "Manufacture of basic metals" industry group). As Upstream scope 3 of "Manufacture of fabricated metal products" industry includes Scope 1 of " Manufacture of basic iron and steel" industry, it has been decided to have some results broken down in 3 groups. The first one, "Basic metals", is composed of all the EXIOBASE industries except "Manufacture of fabricated metal products, except machinery and equipment" and "Processing of nuclear fuel". The group "Fabricated metal products" includes the industry of "Manufacture of fabricated metal products, except machinery and equipment". And the group "Nuclear fuel" includes the industry "Processing of nuclear fuel" and will be treated separately. Processing of nuclear fuel is covered by the Manufacture of basic metals division in the NACE rev 2 classification (EUROSTAT 2008), it is thus included in this benchmark factsheet. However, the process is indeed very different from the production of other metals and explains that it will treated separately. An overall benchmark for all activities will be provided and results will also be presented by industry most of the time to give the most accurate analysis for each industry of the sector.

It should also be noted that the «Manufacture of metals» sector positions itself at the center of the value chain of final products. Figure 4 below summarizes the perimeter of the benchmark factsheet.

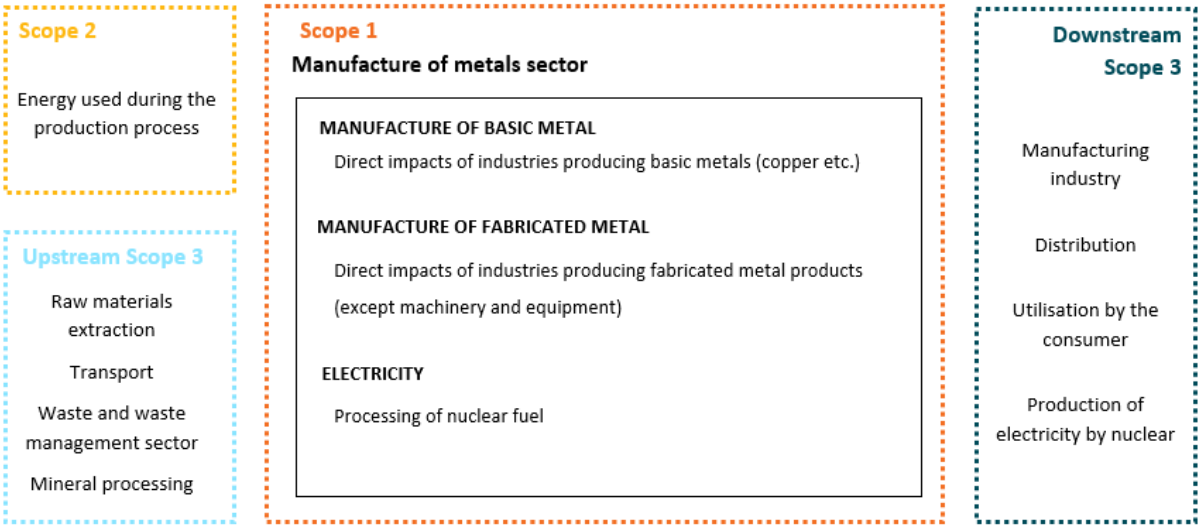

Figure 4: Perimeter of the "Manufacture of metals" benchmark factsheet and associated Scopes

2. Perimeter of the factsheet in terms of dependencies

To understand the dependencies of the Manufacture of metals sector expressed in scores by ENCORE, a correspondence of the sectors of EXIOBASE and ENCORE is necessary. In ENCORE, the "Manufacture of metals" sector corresponds to the "Materials" sector with its subindustries "Iron", "Metal & Glass Containers" and "Aluminium". It should be noted that "Processing of nuclear fuel" is not covered by ENCORE, thus the dependencies of this industry group are not evaluated for their Scope 1.

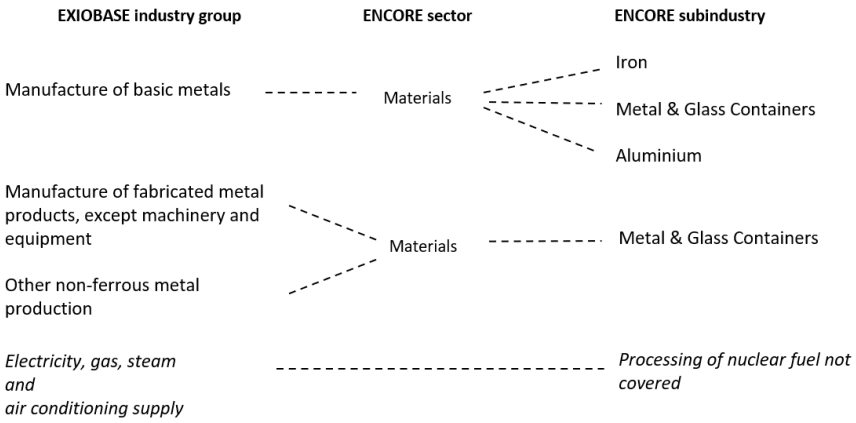

Figure 5: Correspondence between EXIOBASE and ENCORE for the "Manufacture of metals" benchmark factsheet

3. NACE rev 2 (EUROSTAT 2008)

This section contains extracts from the NACE rev 2 classification (EUROSTAT 2008) and details the industries covered by the benchmark factsheet "Manufacture of metals" .

Section C - Manufacture

Manufacture of basic metals **(24)**

This division includes the activities of smelting and/or refining ferrous and non-ferrous metals from ore, pig or scrap, using electrometallurgic and other process metallurgic techniques. This division also includes the manufacture of metal alloys and super-alloys by introducing other chemical elements to pure metals. The output of smelting and refining, usually in ingot form, is used in rolling, drawing and extruding operations to make products such as plate, sheet, strip, bars, rods, wire or tubes, pipes and hollow profiles, and in molten form to make castings and other basic metal products.

Manufacture of basic iron and steel and of ferro-alloys (24.1)

This group includes activities such as direct reduction of iron ore, production of pig iron in molten or solid form, conversion of pig iron into steel, manufacture of ferroalloys and manufacture of steel products.

Manufacture of basic iron and steel and of ferro-alloys (24.1)

This class includes:

- operation of blast furnaces, steel converters, rolling and finishing mills
- production of pig iron and spiegeleisen in pigs, blocks or other primary forms
- production of ferro-alloys
- production of ferrous products by direct reduction of iron and other spongy ferrous products
- production of iron of exceptional purity by electrolysis or other chemical processes
- remelting of scrap ingots of iron or steel
- production of granular iron and iron powder
- production of steel in ingots or other primary forms
- production of semi-finished products of steel
- manufacture of hot-rolled and cold-rolled flat-rolled products of steel
- manufacture of hot-rolled bars and rods of steel
- manufacture of hot-rolled open sections of steel manufacture of sheet piling of steel and welded open sections of steel
- manufacture of railway track materials (unassembled rails) of steel

This class excludes:

- cold drawing of bars, see 24.31

Manufacture of tubes, pipes, hollow profiles and related fittings, of steel (24.2)

Manufacture of tubes, pipes, hollow profiles and related fittings, of steel (24.20)

This class includes:

- manufacture of seamless tubes and pipes of circular or non-circular cross section and of blanks of circular
cross section, for further processing, by hot rolling, hot extrusion or by other hot processes of an intermediate product which can be a bar or a billet obtained by hot rolling or continuous casting
- manufacture of precision and non-precision seamless tubes and pipes from hot rolled or hot extruded blanks by further processing, by cold-drawing or cold-rolling of tubes and pipes of circular cross section and by cold
drawing only for tubes and pipes of non circular cross section and hollow profiles
- manufacture of welded tubes and pipes of an external diameter exceeding 406,4 mm, cold formed from hot rolled flat products and longitudinally or spirally welded

- manufacture of welded tubes and pipes of an external diameter of 406,4 mm or less of circular cross section
by continuous cold or hot forming of hot or cold rolled flat products and longitudinally or spirally welded and
of non-circular cross section by hot or cold forming into shape from hot or cold rolled strip longitudinally
welded
- manufacture of welded precision tubes and pipes of an external diameter of 406,4 mm or less by hot or cold forming of hot or cold rolled strip and longitudinally welded delivered as welded or further processed, by cold
drawing or cold rolling or cold formed into shape for tube and pipe of non-circular cross section
- manufacture of flat flanges and flanges with forged collars by processing of hot rolled flat products of steel
- manufacture of butt-welding fittings, such as elbows and reductions, by forging of hot rolled seamless tubes of steel
- threaded and other tube or pipe fittings of steel

This class excludes:

- manufacture of seamless tubes and pipes of steel by centrifugally casting, see 24.52

Manufacture of other products of first processing of steel (24.3)

This group includes manufacturing other products by cold processing of steel.

Cold drawing of bars (24.31)

This class includes:

- manufacture of steel bars and solid sections of steel by cold drawing, grinding or turning

This class excludes:

- drawing of wire, see 24.34

Cold rolling of narrow strip (24.32)

This class includes:

- manufacture of coated or uncoated flat rolled steel products in coils or in straight lengths of a width less than 600 mm by cold re-rolling of hot-rolled flat products or of steel rod

Cold forming or folding (24.33)

This class includes:

- manufacture of open sections by progressive cold forming on a roll mill or folding on a press of flatrolled products of steel
- manufacture of cold-formed or cold-folded, ribbed sheets and sandwich panels.

Cold drawing of wire (24.34)

This class includes:

- manufacture of drawn steel wire, by cold drawing of steel wire rod

This class excludes:

- drawing of bars and solid sections of steel, see 24.31
- manufacture of derived wire products, see 25.93

Manufacture of basic precious and other non-ferrous metals (24.4)

Precious metals production (24.41)

This class includes:

- production of basic precious metals:
    - production and refining of unwrought or wrought precious metals: gold, silver, platinum etc. from ore and scrap
- production of precious metal alloys
- production of precious metal semi-products
- production of silver rolled onto base metals
- production of gold rolled onto base metals or silver
- production of platinum and platinum group metals rolled onto gold, silver or base metals

This class also includes:
- manufacture of wire of these metals by drawing
- manufacture of precious metal foil laminates

This class excludes:
- casting of non-ferrous metals, see 24.53, 24.54
- manufacture of precious metal jewellery, see 32.12

Aluminium production (24.42)

This class includes:
- production of aluminium from alumina
- production of aluminium from electrolytic refining of aluminium waste and scrap
- production of aluminium alloys
- semi-manufacturing of aluminium

This class also includes:
- manufacture of wire of these metals by drawing
- production of aluminium oxide (alumina)
- production of aluminium wrapping foil
- manufacture of aluminium foil laminates made from aluminium foil as primary component

This class excludes:
- casting of non-ferrous metals

Lead, zinc and tin production (24.43)

This class includes:
- production of lead, zinc and tin from ores
- production of lead, zinc and tin from electrolytic refining of lead, zinc and tin waste and scrap
- production of lead, zinc and tin alloys
- semi-manufacturing of lead, zinc and tin

This class also includes:
- manufacture of wire of these metals by drawing
- production of tin foil

This class excludes:
- casting of non-ferrous metals

Copper production (24.44)

This class includes:
- production of copper from ores
- production of copper from electrolytic refining of copper waste and scrap
- production of copper alloys
- manufacture of fuse wire or strip
- semi-manufacturing of copper

This class also includes:
- manufacture of wire of these metals by drawing

This class excludes:

- casting of non-ferrous metals

Other non-ferrous metal production (24.45)

This class includes:

- production of chrome, manganese, nickel etc. from ores or oxides
- production of chrome, manganese, nickel etc. from electrolytic and aluminothermic refining of chrome, manganese, nickel etc., waste and scrap
- production of alloys of chrome, manganese, nickel etc.
- semi-manufacturing of chrome, manganese, nickel etc.
- production of mattes of nickel

This class also includes:

- manufacture of wire of these metals by drawing

This class excludes:

- casting of non-ferrous metals

Processing of nuclear fuel (24.46)

This class includes:

- production of uranium metal from pitchblende or other ores
- smelting and refining of uranium

Casting of metals (24.5)

This group includes the manufacture of semi-finished products and various castings by a casting process.

This group excludes:

- manufacture of finished cast products such as:
  - boilers and radiators, see 25.21
  - cast household items, see 25.99

Casting of iron (24.51)

This class includes activities of iron foundries.

This class includes:

- casting of semi-finished iron products
- casting of grey iron castings
- casting of spheroidal graphite iron castings
- casting of malleable cast-iron products
- manufacture of tubes, pipes and hollow profiles and of tube or pipe fittings of cast-iron

Casting of steel (24.52)

This class includes activities of steel foundries.

This class includes:

- casting of semi-finished steel products
- casting of steel castings
- manufacture of seamless tubes and pipes of steel by centrifugal casting
- manufacture of tube or pipe fittings of cast-steel

Casting of light metals (24.53)

This class includes:

- casting of semi-finished products of aluminium, magnesium, titanium, zinc etc.
- casting of light metal castings

Casting of other non-ferrous metals (24.54)

This class includes:

- casting of heavy metal castings
- casting of precious metal castings
- die-casting of non-ferrous metal castings

Manufacture of fabricated metal products, except machinery and Equipment **(25)**

This division includes the manufacture of "pure" metal products (such as parts, containers and structures), usually with a static, immovable function, as opposed to the following divisions 26-30, which cover the manufacture of combinations or assemblies of such metal products (sometimes with other materials) into more complex units that, unless they are purely electrical, electronic or optical, work with moving parts.

The manufacture of weapons and ammunition is also included in this division.

This division excludes:

- specialised repair and maintenance activities, see 33.1
- specialised installation of manufactured goods produced in this division in buildings, such as central heating boilers, see 43.22

Manufacture of structural metal products (25.1)

This group includes the manufacture of structural metal products (such as metal frameworks or parts for construction).

Manufacture of metal structures and parts of structures (25.11)

This class includes:

- manufacture of metal frameworks or skeletonnes for construction and parts thereof (towers, masts, trusses, bridges etc.)
- manufacture of industrial frameworks in metal (frameworks for blast furnaces, lifting and handling equipment etc.)
- manufacture of prefabricated buildings mainly of metal:
n site huts, modular exhibition elements etc.

This class excludes:

- manufacture of parts for marine or power boilers, see 25.30
- manufacture of assembled railway track fixtures, see 25.99
- manufacture of sections of ships, see 30.11

Manufacture of doors and windows of metal (25.12)

This class includes:

- manufacture of metal doors, windows and their frames, shutters and gates
- metal room partitions for floor attachment

Manufacture of tanks, reservoirs and containers of metal (25.2)

This group includes the manufacture of tanks, central heating radiators and boilers.

Manufacture of central heating radiators and boilers (25.21)

This class excludes:

- manufacture of electrical ovens and water heaters, see 27.51

Manufacture of other tanks, reservoirs and containers of metal (25.29)

This class includes:

- manufacture of reservoirs, tanks and similar containers of metal, of types normally installed as fixtures for storage or manufacturing use manufacture of metal containers for compressed or liquefied gas

This class excludes:

- manufacture of metal casks, drums, cans, pails, boxes etc. of a kind normally used for carrying and packing of goods, of a capacity not exceeding 300 litres, see 25.91, 25.92
- manufacture of transport containers, see 29.20
- manufacture of tanks (armoured military vehicles), see 30.40

Manufacture of steam generators, except central heating hot water boilers (25.3)

This group includes the manufacture of steam generators.

Manufacture of steam generators, except central heating hot water boilers (25.30)

This class includes:

- manufacture of steam or other vapour generators
- manufacture of auxiliary plant for use with steam generators: condensers, economisers, superheaters, steam collectors and accumulators
- manufacture of nuclear reactors, except isotope separators
- manufacture of parts for marine or power boilers

This class also includes:

- pipe system construction comprising further processing of tubes generally to make pressure pipes or pipe systems together with the associated design and construction work

This class excludes:

- manufacture of central heating hot-water boilers and radiators, see 25.21
- manufacture of boiler-turbine sets, see 28.11
- manufacture of isotope separators, see 28.99

C. ADDITIONAL RESULTS

1. Overall sector's impacts

The following calculations were performed using GBS 1.4.6 in August 2023. Note that, given the complexity of the subject, the methodology and results are constantly improving: the current limitations and uncertainties are detailed in Limits and uncertainties, Section C.4.

The pressure Ecotoxicity is not included in the results because of intrinsic difficulties in its modelling that result in higher uncertainties. However, because there are impacts from air pollution, wastewater and solid waste during the processing of metals, further analyses will be added in Section C.8.

Table 2 and Table 3 provide the absolute impacts of the «Manufacture of metals» sector in MSA.km² for respectively the Scope 1 and vertically integrated[2] .

The aquatic dynamic results have a high uncertainty and are therefore less reliable. They are included in these tables only for informational purposes as they are used for the computation of the aggregated scores in MSAppb*/bEUR. They will not be reported in the rest of the results.

Table 2: Absolute Scope 1 biodiversity impact of the "Manufacture of metals" sector, computation with GBS 1.4.6 by Anna Montagner

Realm	Accounting category	Scope 1 impact in MSA.km²		
		Basic metals	Fabricated metal products	Processing of nuclear fuel
Terrestrial	Static	1500	860	11
	Dynamic	7 300	1 100	11
Aquatic	Static	33	24	0.35
	Dynamic	73	11	0.11

Table 3: Absolute vertically integrated biodiversity impact of the "Manufacture of metals" sector, computation with GBS 1.4.6 by Anna Montagner

Realm	Accounting category	Vertically integrated in MSA.km²		
		Basic metals	Fabricated metal products	Processing of nuclear fuel
Terrestrial	Static	707 000	270 000	10 000
	Dynamic	23 000	7 000	106
Aquatic	Static	45 000	19 000	860
	Dynamic	440	140	5.2

Table 4 and Table 5 present the results in detail for each industry of the sector, respectively for the Scope 1 and vertically integrated, in MSA.km².

[2] The vertically integrated results refer to the sum of Scope 1, 2 and upstream Scope 3 impacts.

Table 4: Absolute Scope 1 biodiversity impact of the "Manufacture of metals" sector in MSA.km², computation with GBS 1.4.6 by Anna Montagner

Industry	MSA.km²		
	Accounting category	Terrestrial	Aquatic
Processing of nuclear fuel	Static	11	0.35
	Dynamic	11	0.11
Aluminium production	Static	60	1.5
	Dynamic	240	2.4
Casting of metals	Static	29	0.52
	Dynamic	704	7.0
Copper production	Static	420	5.7
	Dynamic	206	2.1
Lead, zinc and tin production	Static	120	2.8
	Dynamic	50	0.54
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Static	118	12
	Dynamic	5700	57
Other non-ferrous metal production	Static	67	2.0
	Dynamic	280	2.8
Precious metals production	Static	680	8.5
	Dynamic	110	1.1
Manufacture of fabricated metal products	Static	860	24
	Dynamic	1080	11

Table 5: Absolute vertically integrated biodiversity impact of the "Manufacture of metals" sector in MSA.km2, computation with GBS 1.4.6 by Anna Montagner

Industry	MSA.km²		
	Accounting category	Terrestrial	Aquatic
Processing of nuclear fuel	Static	10 060	860
	Dynamic	105	5.1
Aluminium production	Static	82 000	6 100
	Dynamic	2 200	51
Casting of metals	Static	46 000	3 100
	Dynamic	1 600	31
Copper production	Static	87 000	5 300
	Dynamic	1 700	47
Lead, zinc and tin production	Static	54 000	1 600
	Dynamic	605	13
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Static	320 000	22 000
	Dynamic	15 000	246
Other non-ferrous metal production	Static	59 000	3 200
	Dynamic	1 100	24
Precious metals production	Static	58 000	3 500
	Dynamic	930	30.2
Manufacture of fabricated metal products	Static	270 000	19 100
	Dynamic	7 000	140

Table 6 below displays the Scope 1 biodiversity impact intensity figures of the "Manufacture of metals" sector, and Table 7 displays the vertically integrated figures. Results are expressed in MSA.m²/kEUR and are broken down by categories based on the EXIOBASE industry groups (Manufacture of basic metals, Manufacture of fabricated metal products & Processing of nuclear fuel). They are computed by weighting the impacts in MSA.m² by the turnover of each EXIOBASE industry for the three categories previously mentioned. The results are also converted into MSAppb per bEUR to be aggregated in MSAppb* per bEUR (See 2.3 of the common technical annex for methodology).

Table 6: Scope 1 impact intensities for the "Manufacture of metals" sector, computation with GBS 1.4.6

Industry Categories	Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Manufacture of basic metals	Terrestrial	Static	0.54	4.1	23
		Dynamic	2.7	20	
	Aquatic	Static	$1.2.10^{-2}$	1.2	
		Dynamic	*$2.7.10^{-2}$*	*2.6*	
Manufacture of fabricated metal products	Terrestrial	Static	0.47	3.5	5
		Dynamic	0.59	4.4	
	Aquatic	Static	$1.3.10^{-2}$	1.3	
		Dynamic	*$5.9.10^{-3}$*	*0.57*	
Processing of nuclear fuel	Terrestrial	Static	0.79	6.0	7
		Dynamic	0.79	5.9	
	Aquatic	Static	$2.5.10^{-2}$	2.5	
		Dynamic	*$7.8.10^{-3}$*	*0.76*	

Table 7: Vertically integrated impact intensities for the "Manufacture of metals" sector, computation with GBS 1.4.6

Industry categories	Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Manufacture of basic metals	Terrestrial	Static	260	1900	150
		Dynamic	8.4	64	
	Aquatic	Static	17	1500	
		Dynamic	*0.16*	*16*	
Manufacture of fabricated metal products	Terrestrial	Static	150	1060	76
		Dynamic	3.8	28	
	Aquatic	Static	10.3	1004	
		Dynamic	*$7.5.10^{-2}$*	*7.2*	
Processing of nuclear fuel	Terrestrial	Static	740	5500	326
		Dynamic	7.8	58	
	Aquatic	Static	63	6100	
		Dynamic	*0.38*	*36*	

2. Breakdown by EXIOBASE industry groups

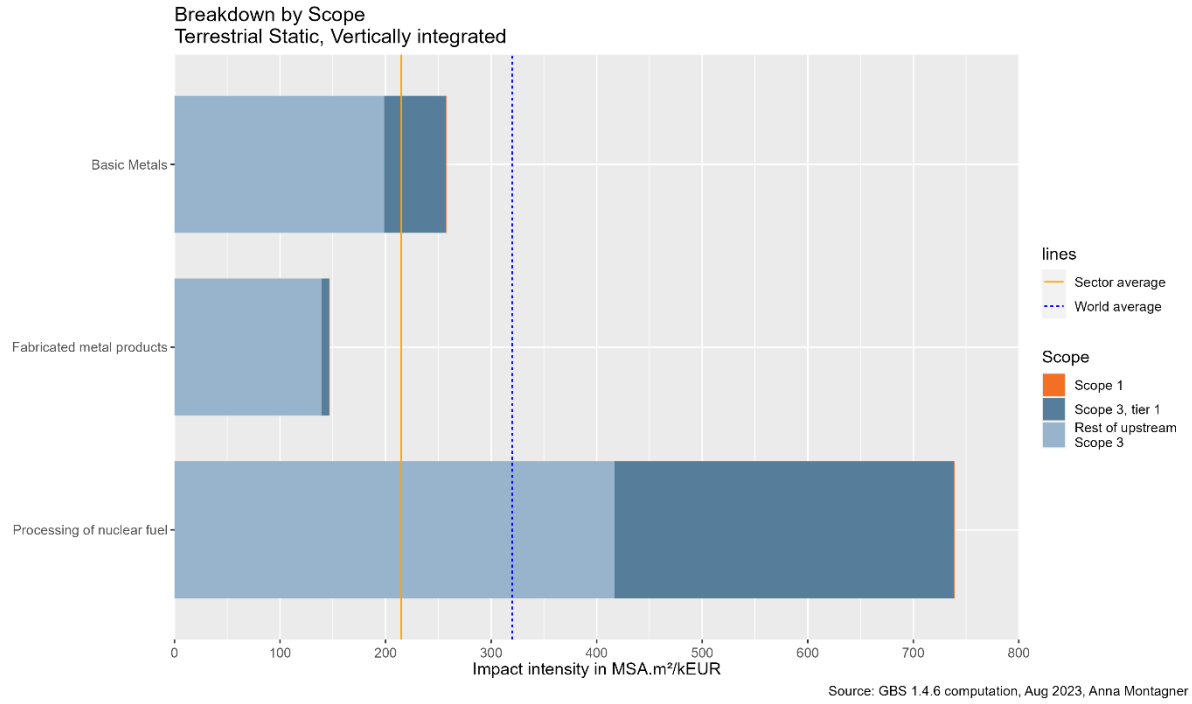

Figure 6: Breakdown by EXIOBASE industry group and Scope, Terrestrial static, vertically integrated, results by kEUR of each processing category turnover

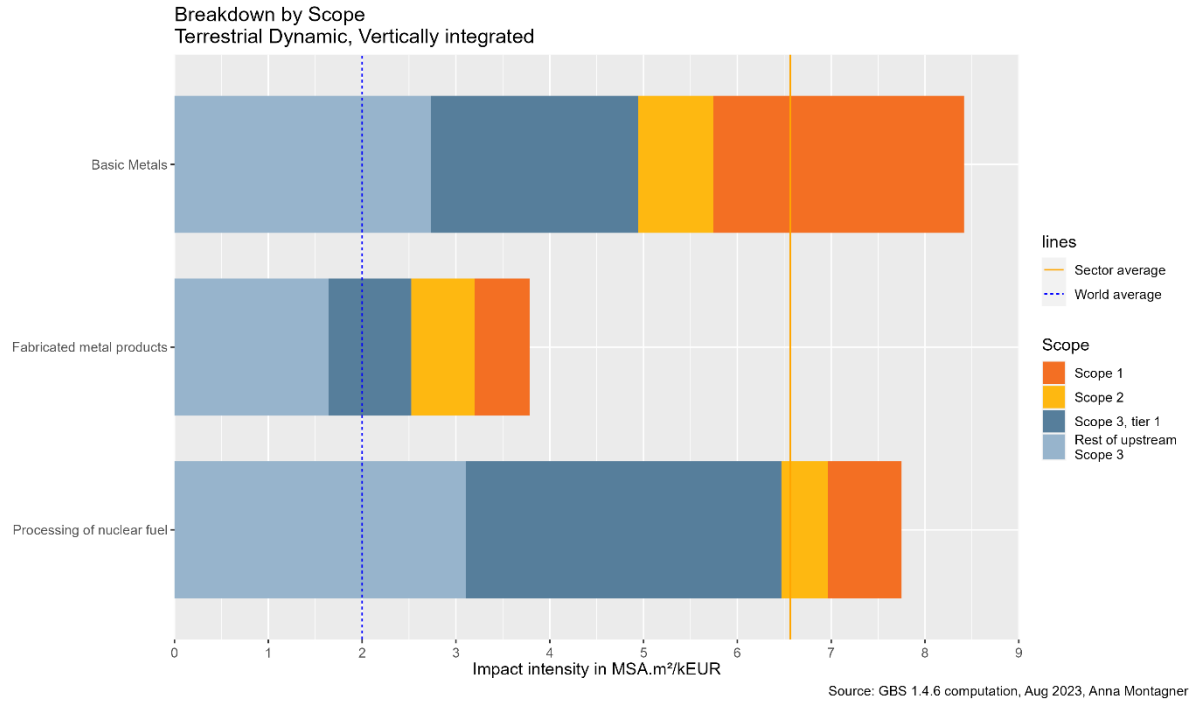

Figure 7: Breakdown by EXIOBASE industry group and Scope, Terrestrial dynamic, vertically integrated, results by kEUR of each processing category turnover

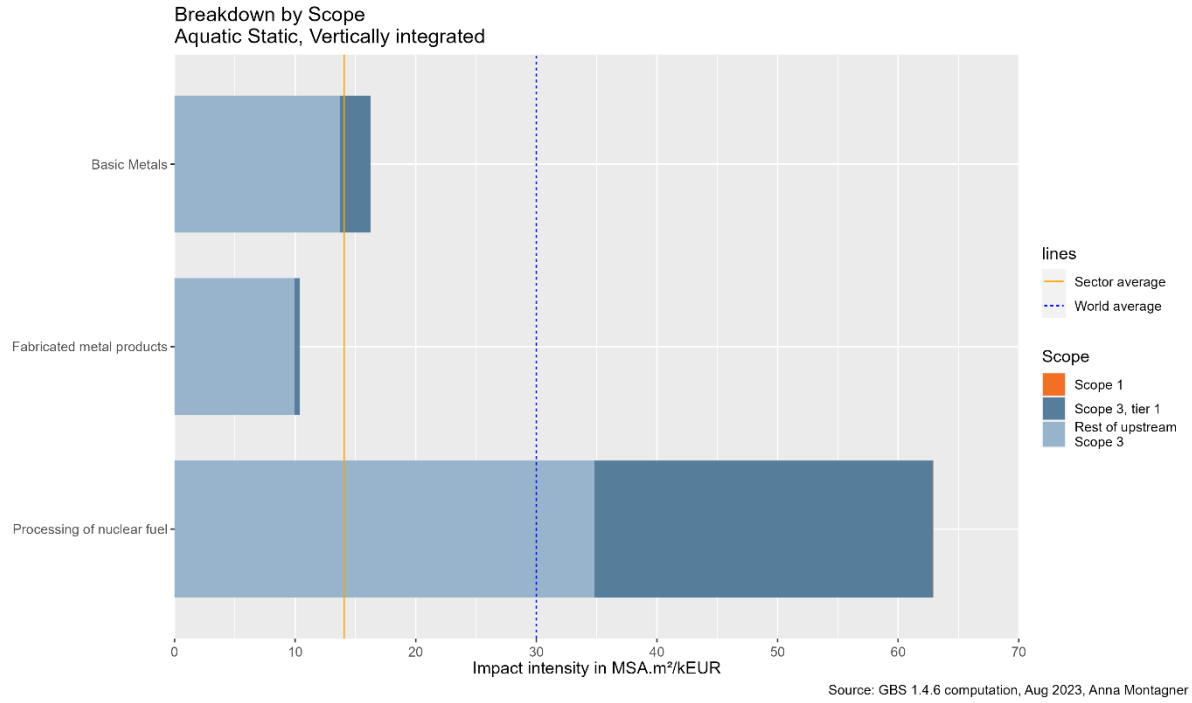

Figure 8: Breakdown by EXIOBASE industry group and Scope, Aquatic static, vertically integrated, results by kEUR of each processing category turnover

For the three industry groups, most of static and dynamic impacts occurs within the Upstream Scope 3.

Regarding terrestrial dynamic results, the three industry groups impacts are mostly in their Upstream Scope 3. However, their Scope 1 and Scope 2 are also impacting, mainly due to the pressure Climate change as we will see in detail in the next part.

Impacts of the industry "Processing of nuclear fuel" will be commented in Section C.3, with the results presented by industry.

It must be mentioned that the GBS does not yet compute the terrestrial static impacts related to the Climate change pressure. An estimate of this impact is proposed in Section C.6. On a global scale, fossil fuels are the most consumed primary energy source. The burning of fossil fuels is widely known to be a major cause of Climate change through the emission of GHG (Greenhouse gas). Some industries from the sector are known to use energy-intensive processes (manufacturing of aluminium, iron and steel).

3. Breakdown by EXIOBASE industries

In this section, the results are presented in MSA.m²/kEUR of the EXIOBASE industry, *i.e.,* for each industry the impact in MSA.m² is divided by the turnover of the corresponding industry. This allows the different industries to position themselves within the benchmark sector.

Breakdown by Scope

Scope 1

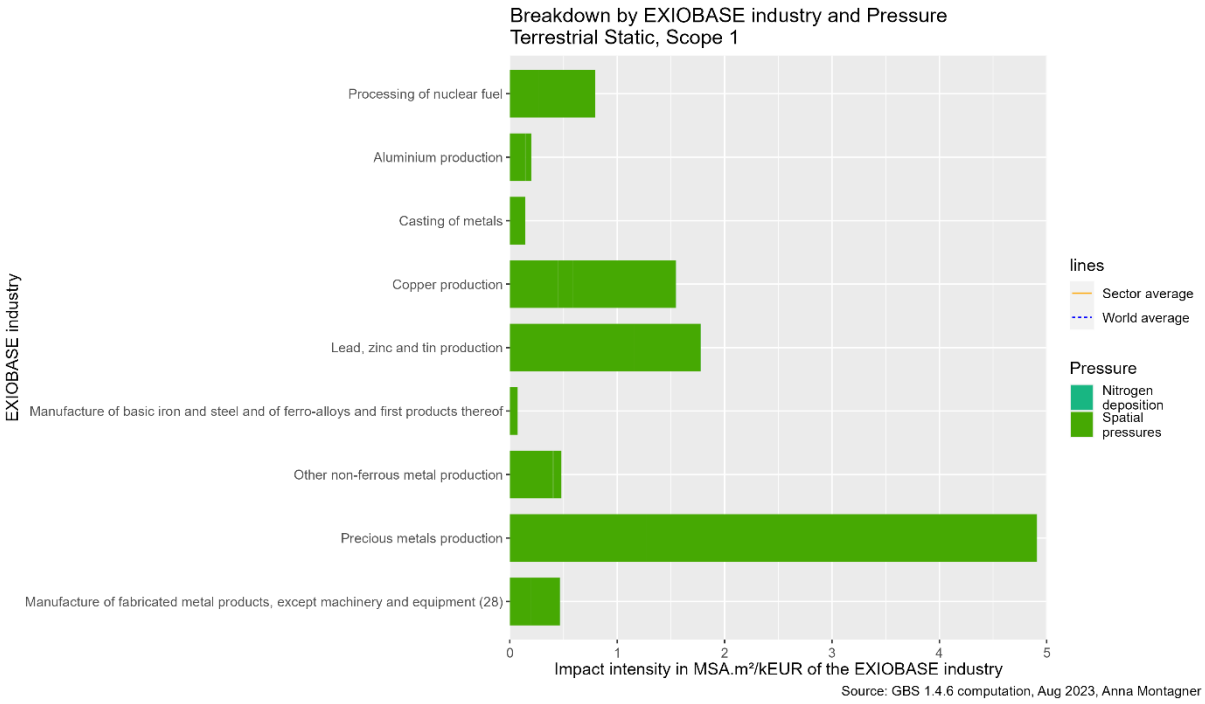

Figure 9: Breakdown by EXIOBASE industry and Pressure, Terrestrial static, Scope 1, results by kEUR of each industry turnover, presented in the benchmark factsheet

Concerning terrestrial static impacts, industries of the sector have intensities between 0.072 MSA.m^2/kEUR for the industry “Manufacture of fabricated metal products, except machinery and equipment ” and 4.9 MSA.m^2/kEUR for the industry “Precious metal production”. The Spatial pressure for the industry “Precious metals production” is mainly due to the commodity “Grazing” (see Figure 10), which is surprising. Among potential sources of error, one concerns possible inaccuracies in the way in which purchases are allocated in EXIOBASE for the metal sector. Further research is underway. In all cases, these impacts are not that material compared to other sectors. However, the industry “Precious metals production” is the industry with the highest impact drivers for one tonne of metal produced in the sector (for terrestrial static and dynamic impact but also aquatic static impacts).

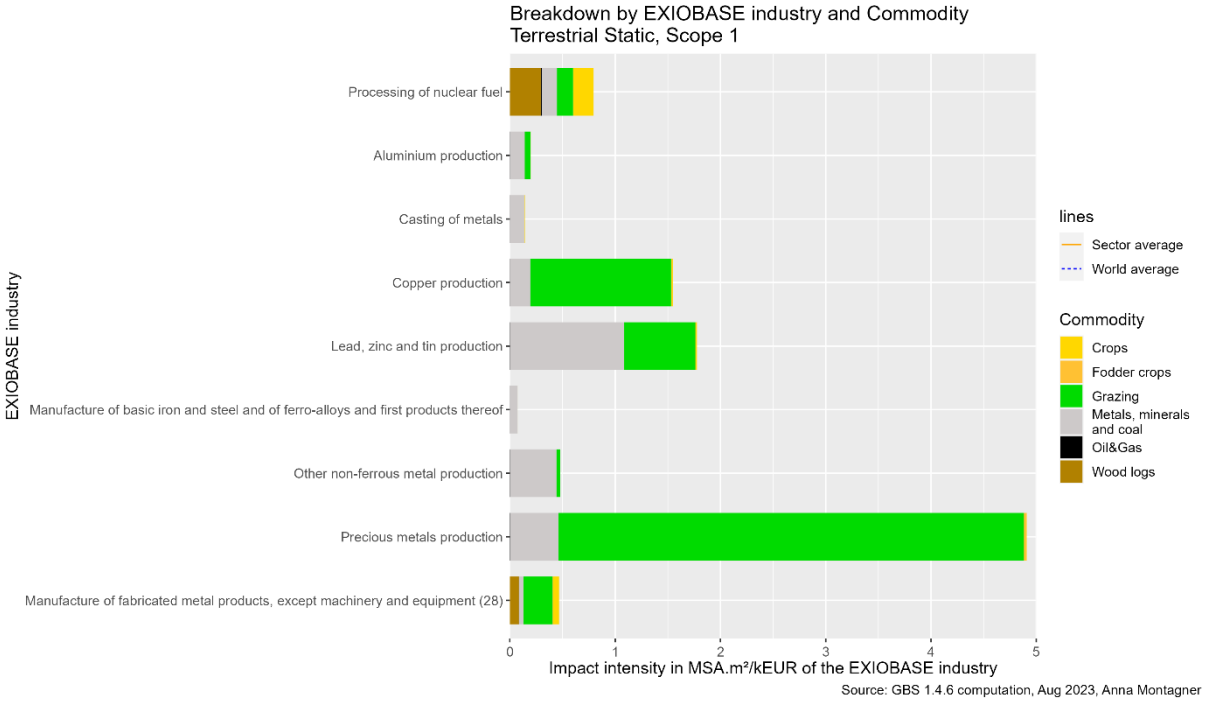

Figure 10: Breakdown by EXIOBASE industry and Commodity, Terrestrial static, Scope 1, results by kEUR of each industry turnover

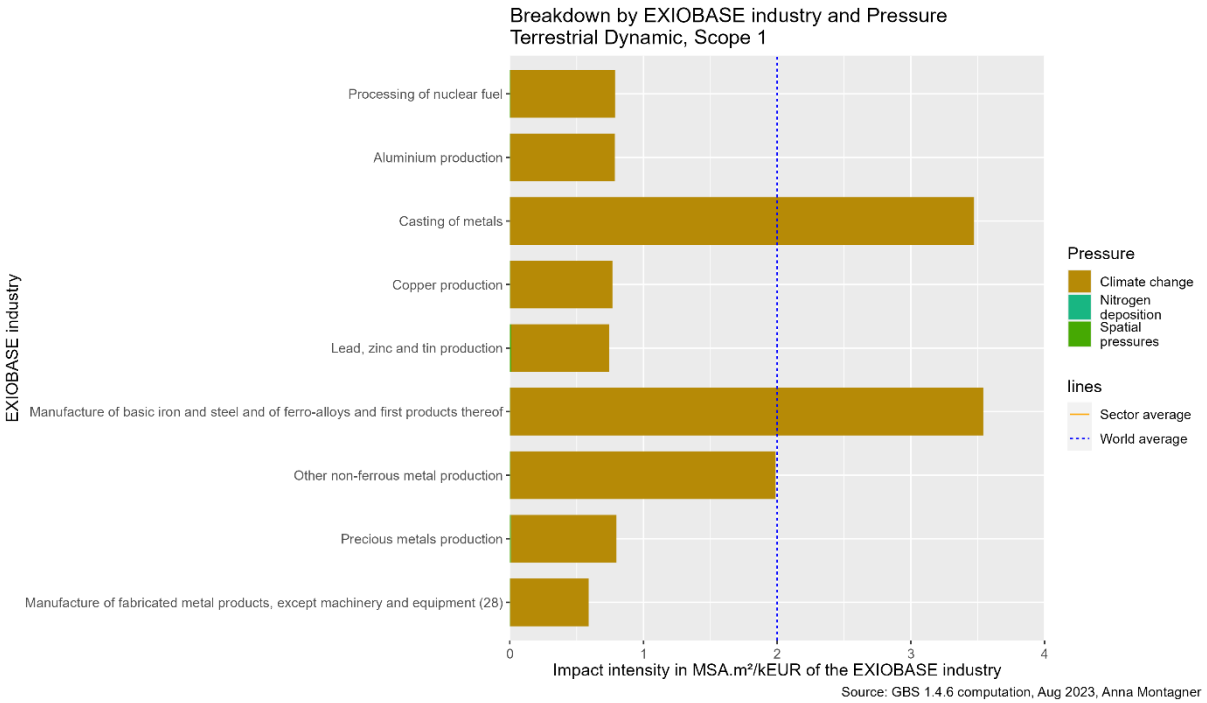

Figure 11: Breakdown by EXIOBASE industry and pressure, Terrestrial dynamic, Scope 1, results by kEUR of each industry turnover

Terrestrial dynamic impacts are high for the sector “Manufacture of metals” in Scope 1, higher than the world average for two industries: “Casting of metals” and “Manufacture of basic iron and steel”.

Scope 1 impacts of all industries of the sector are due to the pressure Climate change and the commodity GHGs. Thus, having an ambitious greenhouse gas reduction policy is a key asset for the sector’s companies to reduce their biodiversity footprint in Scope 1 for dynamic terrestrial impacts.

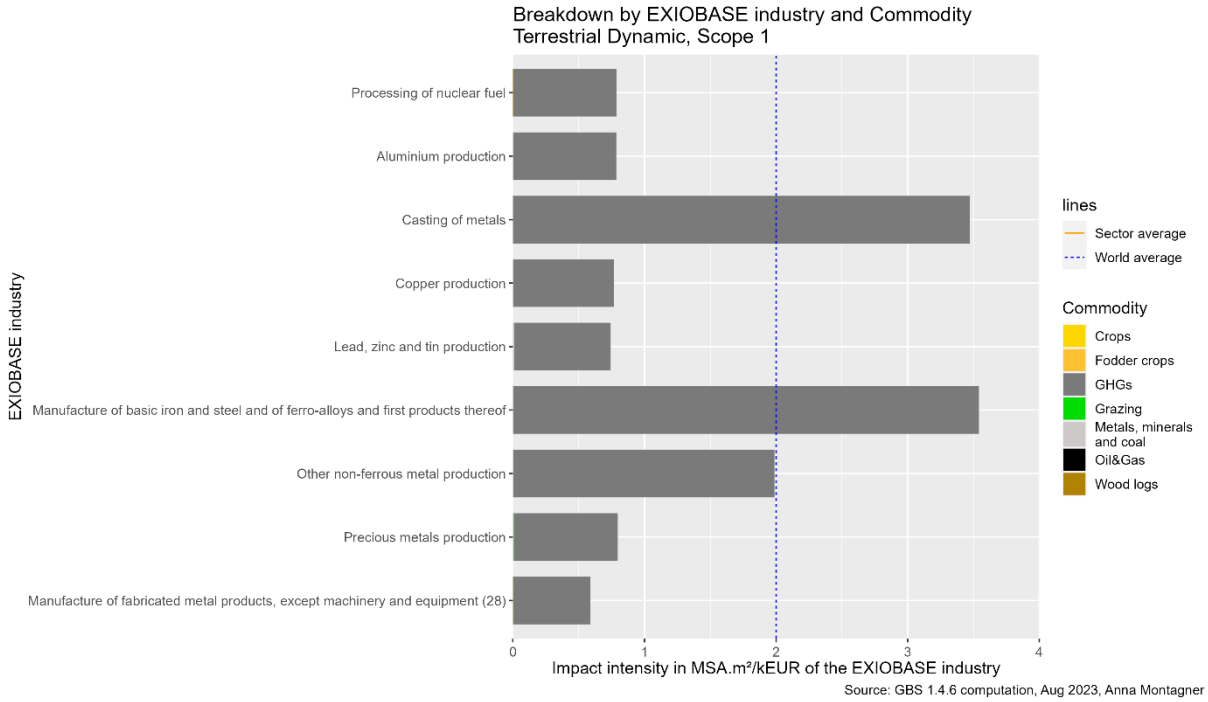

Figure 12: Breakdown by EXIOBASE industry and Commodity, Terrestrial dynamic, Scope 1, results by kEUR of each industry turnover

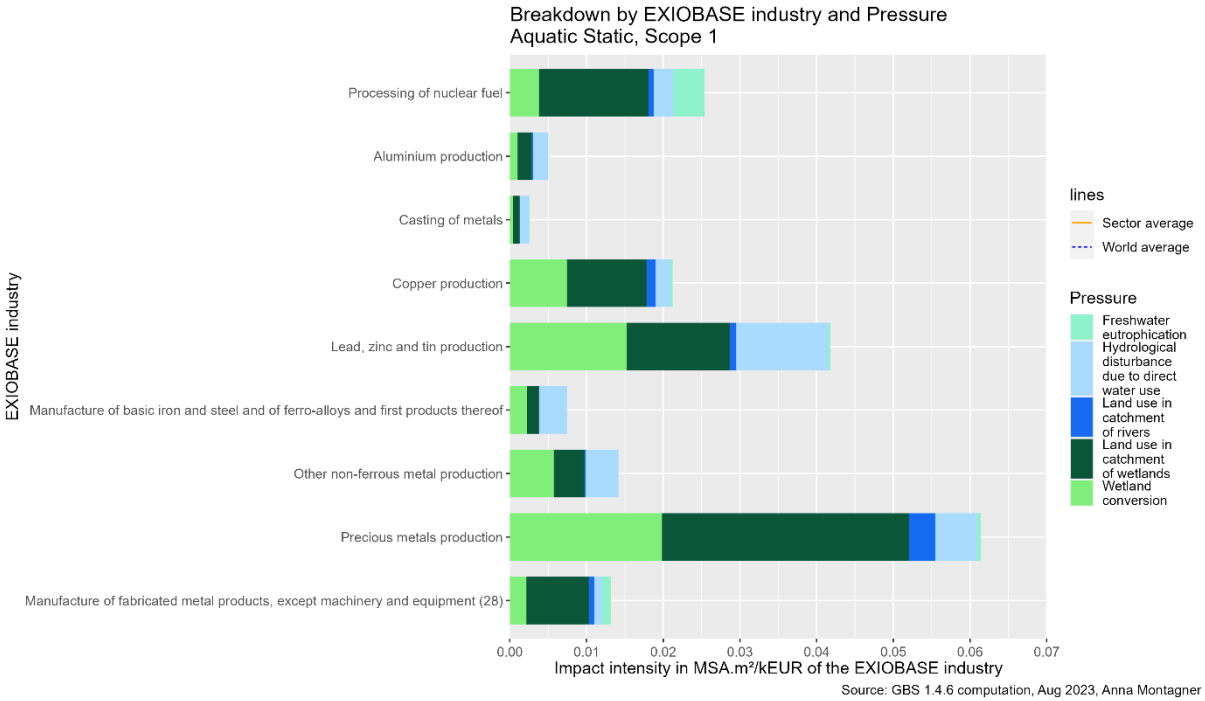

Figure 13: Breakdown by EXIOBASE industry and Scope, Aquatic static, Scope 1, results by kEUR of each industry turnover, presented in the benchmark factsheet

Aquatic static impacts in Scope 1 are relatively low compared to other sectors. However, the tool underestimates some impacts. The impacts due to the pressure "Hydrological disturbance due to direct water use" (HD*water*) are underestimated. Indeed, the EXIOBASE inventory data regarding water consumption and withdrawal in m^3 are not used in the GBS 1.4.6. A focus on this subject is available in section C.7.

Vertically integrated

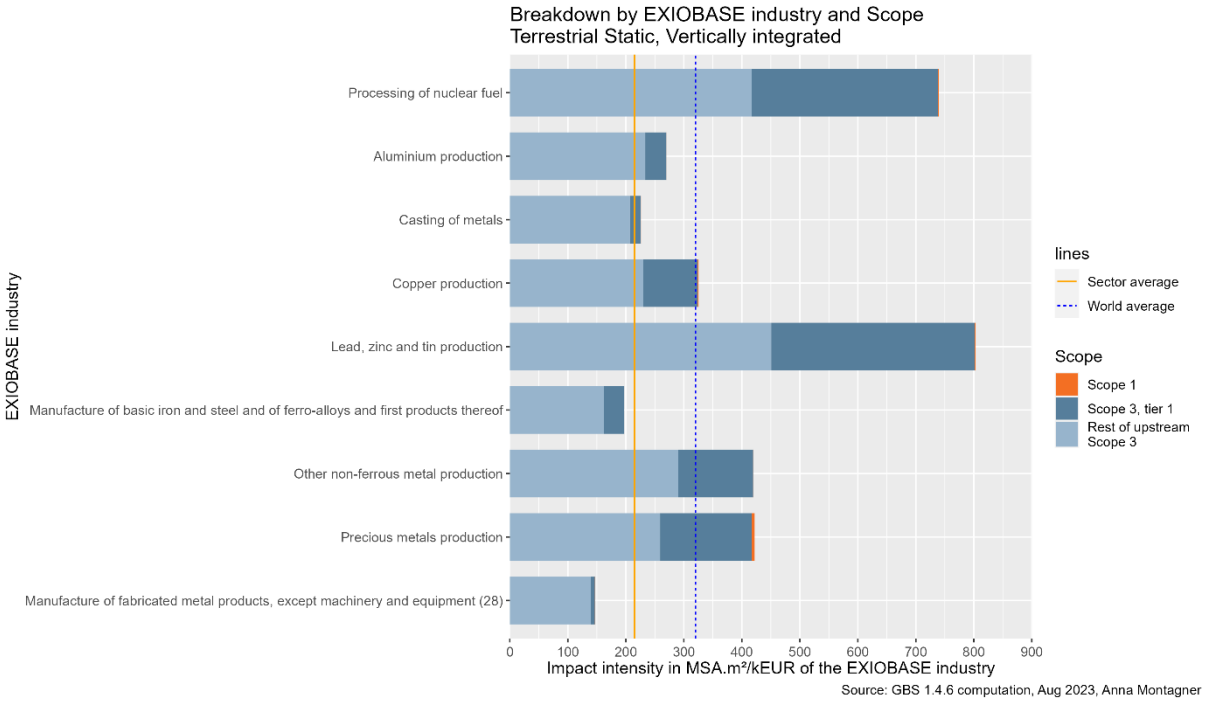

Figure 14: Breakdown by EXIOBASE industry and Scope, Terrestrial static, vertically integrated, results by kEUR of each industry turnover, presented in the benchmark factsheet

Vertically integrated terrestrial static results underline that impacts are concentrated in the Scope 3 (tier 1 and Rest of upstream) for all industries of the sector. As the "Manufacture of metals" sector is downstream mining in the value chain, these results correspond to what might be expected for the sector. Again, it should be noted that Climate change impacts do not appear in this figure which underestimates the impacts, especially Scope 2 impacts (see Section C.6).

The industries with the highest impacts are "Lead, zinc and tin production" and "Processing of nuclear fuel" with 803 MSA.m²/kEUR and 740 MSA.m²/kEUR respectively. The higher impact intensity of "Lead, zinc and tin production" industry can mostly be explained by its lower turnover than other industries such as "Aluminium production" for example. However, in mass intensity, the production of one tonne of tin is higher than most other metals (excluding gold and silver), which can also explain to some extent the results.

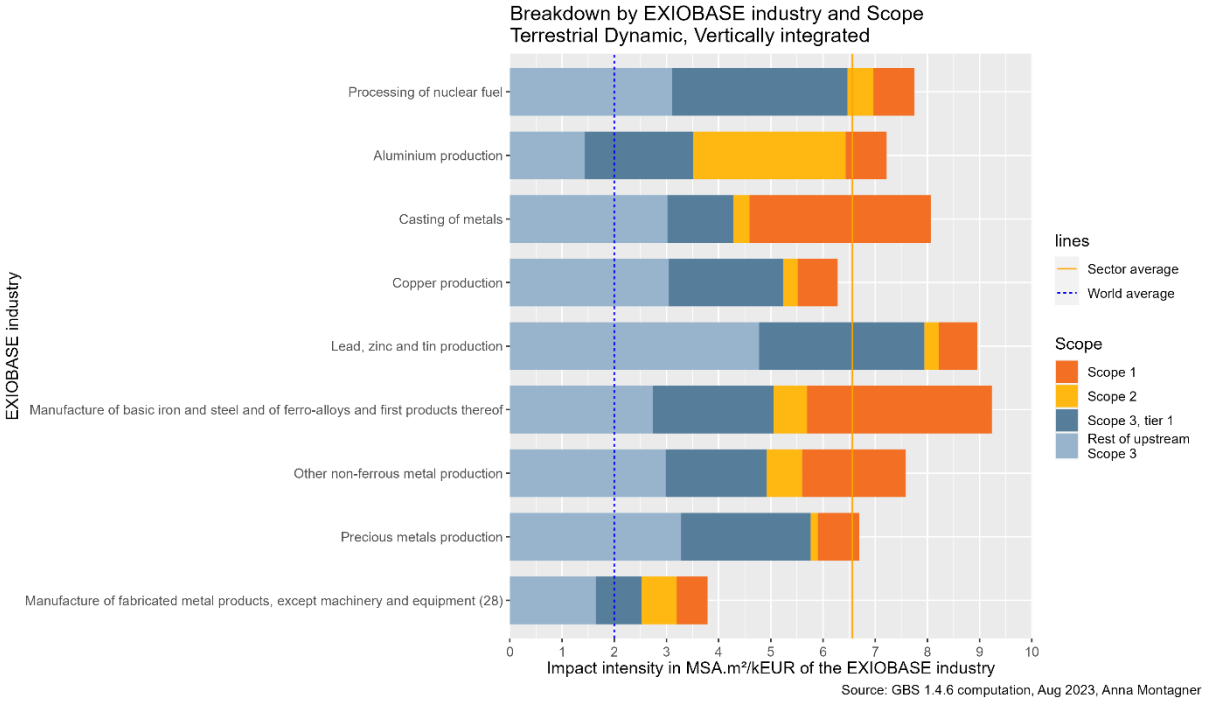

Figure 15: Breakdown by EXIOBASE industry and Scope, Terrestrial dynamic, Vertically integrated, results by kEUR of each industry turnover, presented in the benchmark factsheet

All industries of the sector have higher vertically integrated terrestrial dynamic impacts than the world average (6.6 MSA.m²/kEUR *vs.* 2 MSA.m²/KEUR). Except for "Aluminium production", industry for which Scope 2 is almost equivalent to Upstream Scope 3, most impacts occur in Upstream Scope 3.

Impacts within Scope 2 of "Aluminium production" industry are at least three times more important than the impacts within Scope 2 of the other industries of the sector. It is likely mainly due to the process of electrolysis used in the aluminium production – to transform alumina to aluminium – which is a highly energy-intensive process. The consumption of energy to produce one tonne of primary aluminium may vary from country to country. In China, which is is one of the largest producers of aluminium globally, one tonne of primary aluminium requires 40MWh (Peng et al. 2019).

The industries "Manufacture of basic iron, steel and ferro-alloys and first products thereof", "Casting of metals" and "Other non-ferrous production" have higher intensity impacts in their Scope 1 and Scope 2 than the other industries of the sector. This might be explained by the electrolytic refining and smelting operations in the process of production. The production of steel is also a highly energy-intensive process with coke oven and blast furnace. Purchases of coke are here considered as part of the Scope 3 and the GHG emissions produced during its burning covered by the Scope 1. It explains the fact that the Scope 1 intensity impact of the "Manufacture of basic iron and steel and of ferro-alloys" industry is large compared to the Scope 1 impacts of the other industries.

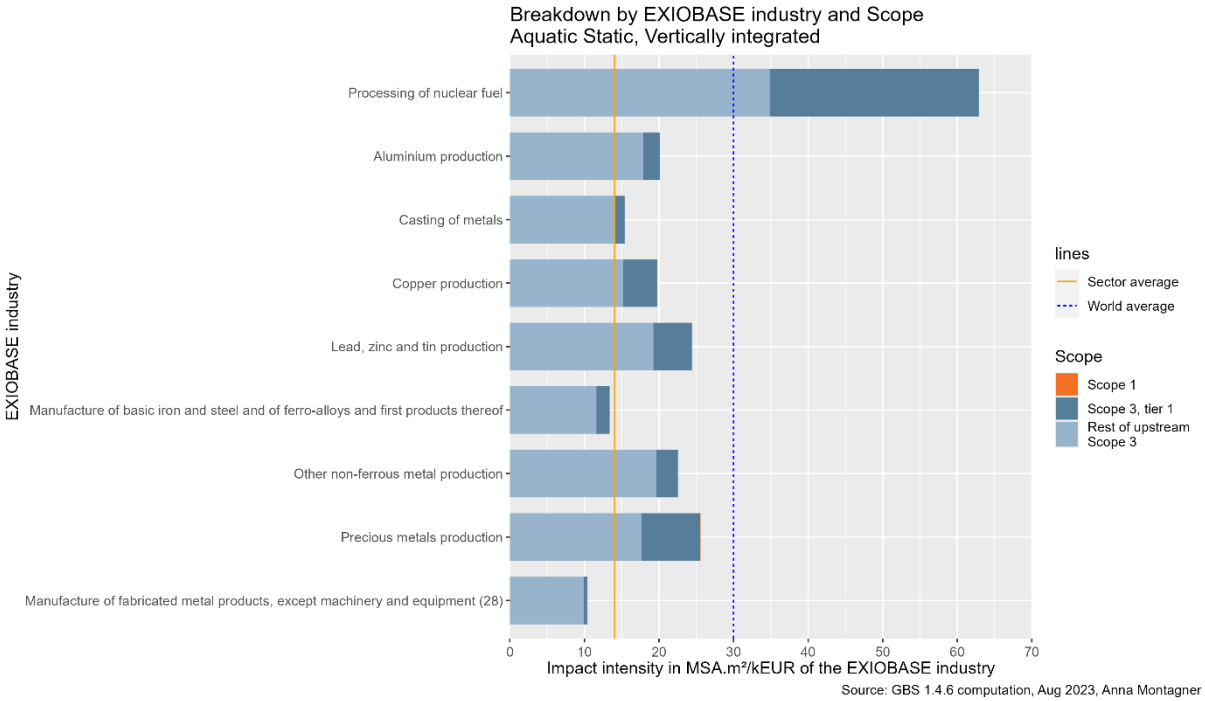

Figure 16: Breakdown by EXIOBASE industry and Scope, Aquatic static, vertically integrated, results by kEUR of each industry turnover

Regarding vertically integrated aquatic static results, the impacts are concentrated in Scope 3 and more specifically on the Rest of upstream Scope 3. Impact intensity of "Processing of nuclear fuel" industry is higher than world average (63 MSA.m²/kEUR). A significant proportion of impact intensity of the "Processing of nuclear fuel" industry is caused by crops and grass commodities, which does not seem consistent. Among potential sources of error, one concerns possible inaccuracies in the way in which purchases are allocated in EXIOBASE for the metal sector. Further research is underway.

Breakdown by pressure

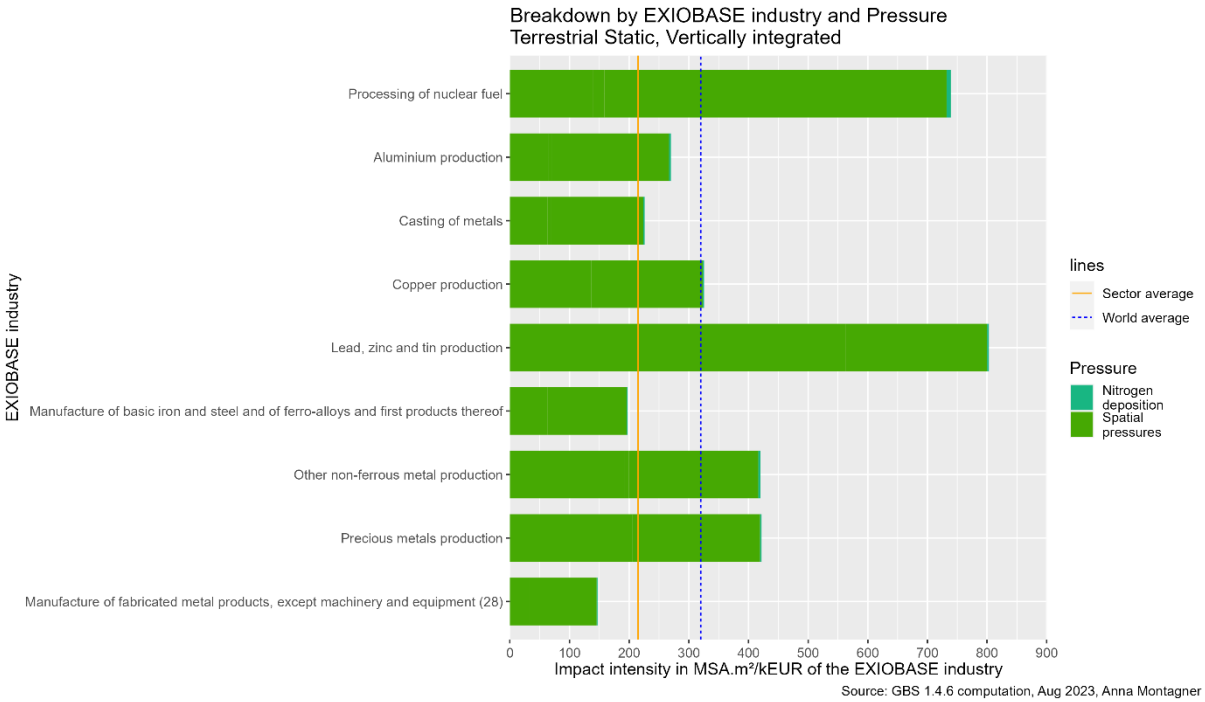

Figure 17: Breakdown by EXIOBASE industry and pressure, Terrestrial static, vertically integrated, results by kEUR of each industry turnover

Spatial pressures are the main drivers of vertically integrated terrestrial static impacts. As already mentioned, (see Figure 14), these impacts are concentrated in the Upstream Scope 3. Spatial pressures are mainly due to mining activities. For further information on the subject, please refer to the factsheet and the technical annex “Raw material extraction” (CDCB).

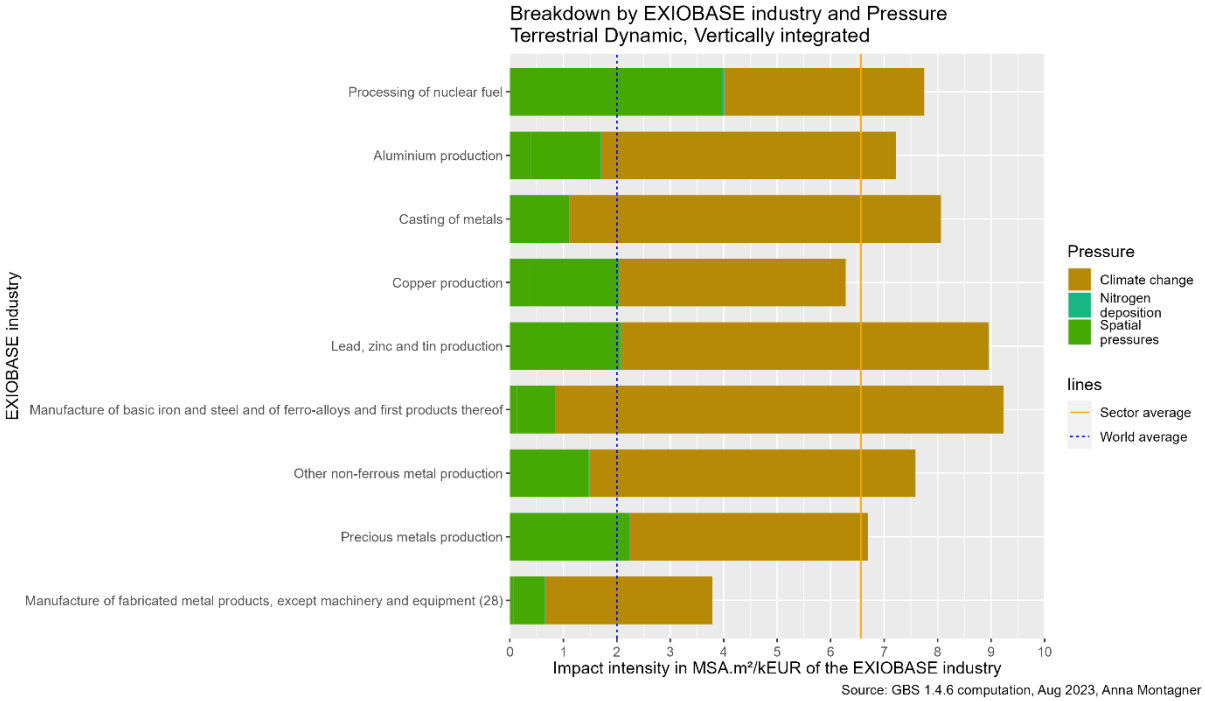

Figure 18: Breakdown by EXIOBASE industry and pressure, Terrestrial dynamic, vertically integrated, results by kEUR of each industry turnover

Climate change is the main driver of vertically integrated terrestrial dynamic impacts, except for the industry "Processing of nuclear fuel" (3.7 MSA.m^2/kEUR for Climate change and 3.9 MSA.m^2/kEUR for Spatial pressures).

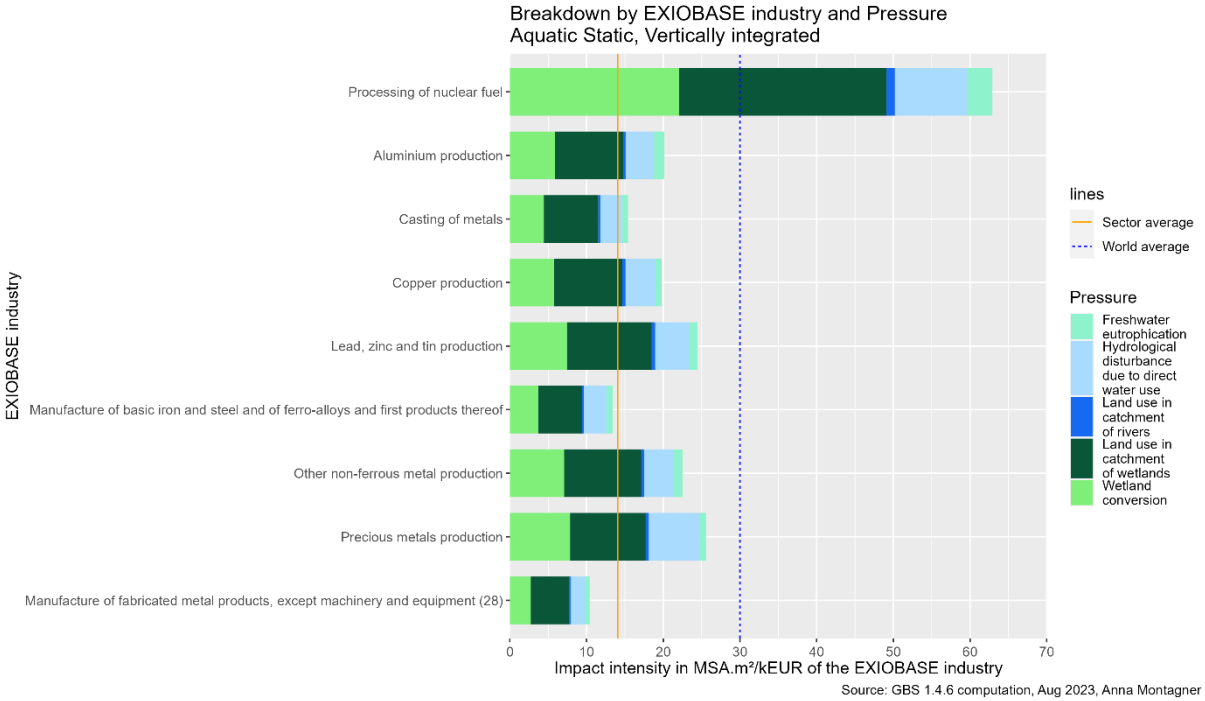

Figure 19: Breakdown by EXIOBASE industry and pressure, Aquatic static, vertically integrated, results by kEUR of each industry turnover

Aquatic static impacts are mainly due to Pollution with the pressure “Land use in catchment of wetlands” but also to the pressure “Wetland conversion”, which corresponds to land use change for all industries of the sector.

Breakdown by commodity

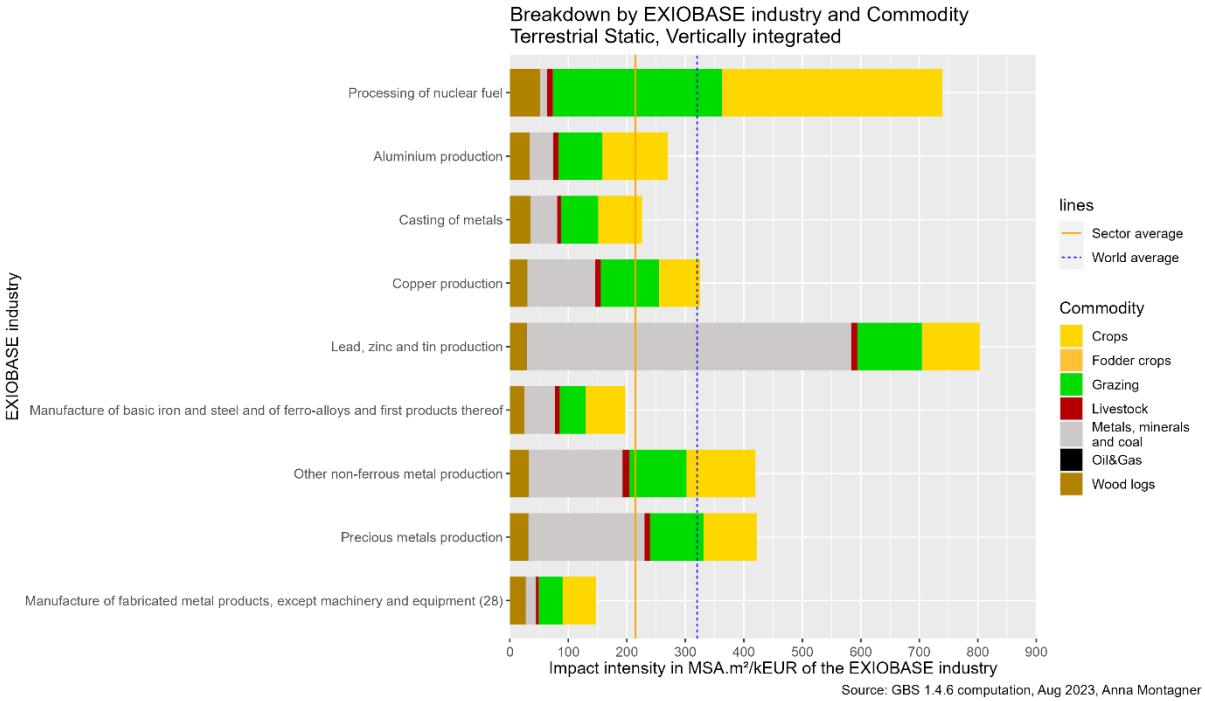

Figure 20: Breakdown by EXIOBASE industry and Commodity, Terrestrial Static, vertically integrated, results by kEUR of each industry turnover

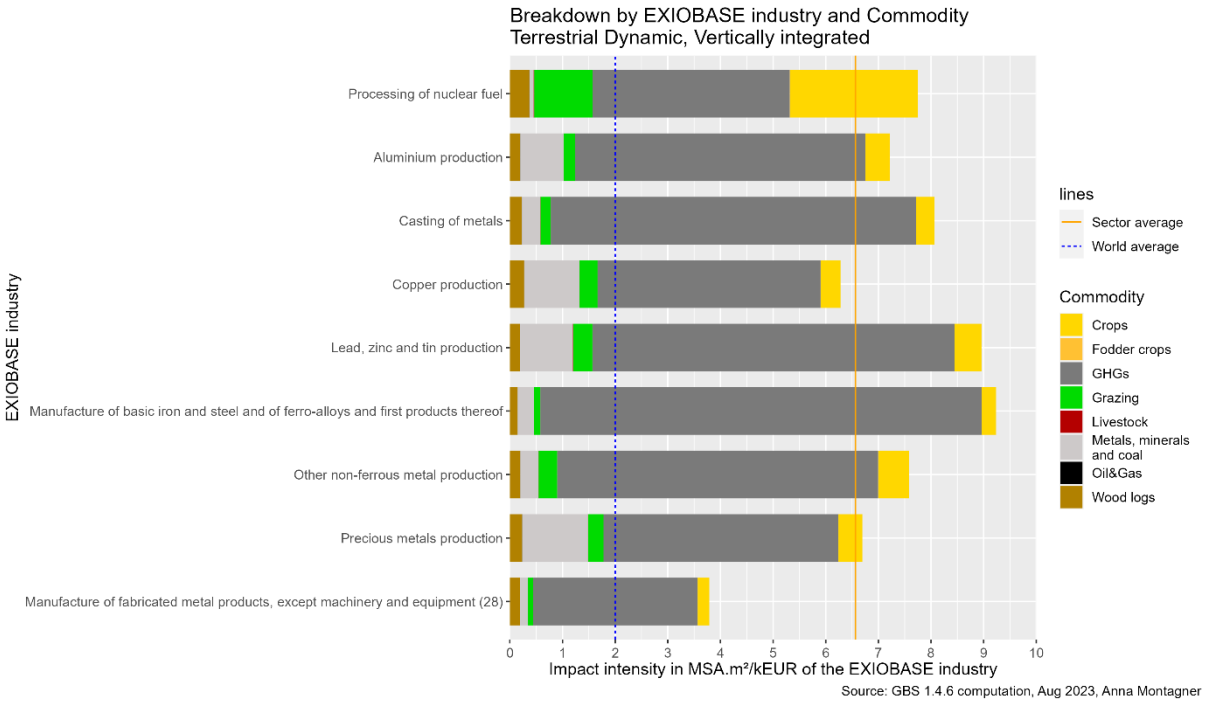

Figure 21: Breakdown by EXIOBASE industry and Commodity, Terrestrial Dynamic, vertically integrated, results by kEUR of each industry turnover

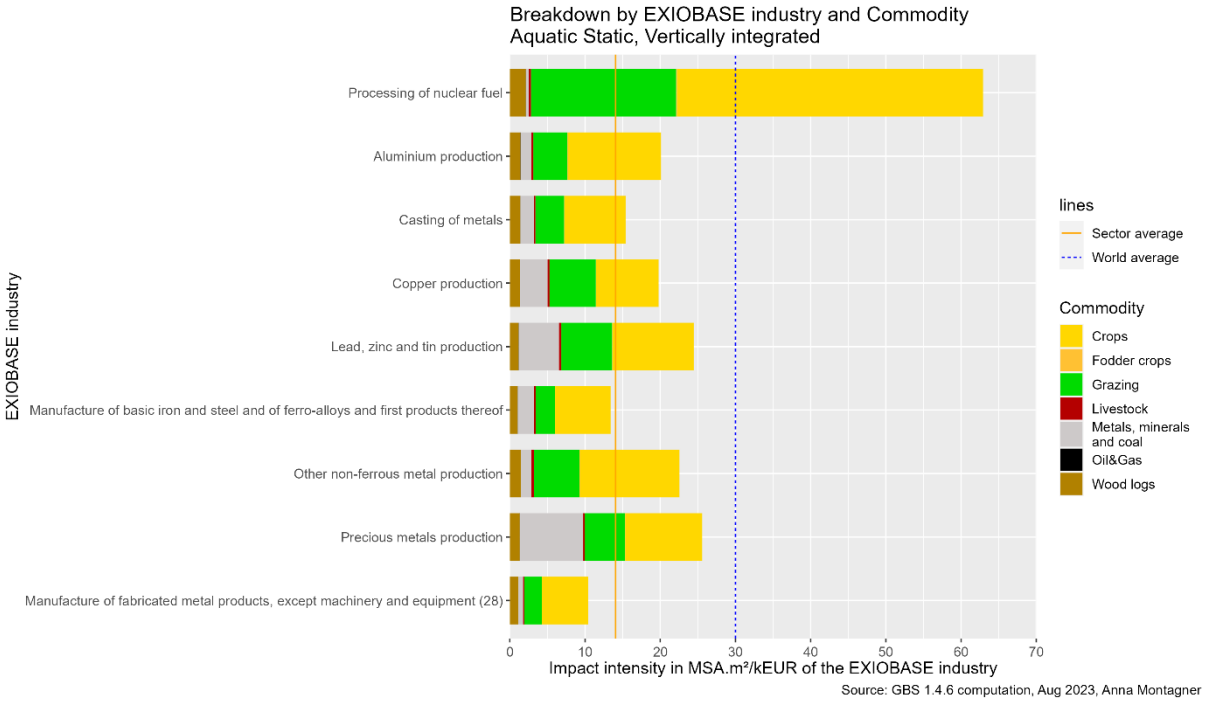

Figure 22: Breakdown by EXIOBASE industry and Commodity, Aquatic Static, vertically integrated, results by kEUR of each industry turnover

4. Limits and uncertainties

The calculations were performed using GBS version 1.4.6 in August 2023.

In this factsheet, results are presented in intensity, in MSA.m²/kEUR. Intensities allow to compare industries to one another. However, as the impacts are divided by the turnover, two industries with same absolute impacts (MSA.km²) may have different intensity (MSA.m²/KEUR) depending on their turnover. **Thus, it is important to not use the results in this factsheet to compare the biodiversity footprint between industries which are producing different metals**. As an example, some industries of the sector have a higher intensity in several graphs than the "Precious metals production" industry. These results hide the fact that the production of gold and silver are the two metals with the highest impacts for 1 tonne of metal produced. If the industry has lower intensity, it is due to a higher turnover.

In fact, if the **terrestrial static impacts of the industry precious metals production is considered to be 100 %**, the impacts of **the industry of production of silver will be 1.9 % in comparison, the industry of production of tin 0.40 %** and all other industries of the sector have lower percentage of impacts. Those rough estimates are also accurate for dynamic terrestrial impacts and aquatic static impacts.

Furthermore, the price of raw materials is highly variable and therefore the turnover of the various industries of production could fluctuate significantly in the coming years. Caution should be taken with the results presented, and a decrease in the MSA.m²/kEUR intensity of a sector in a few years should not be interpreted as a decrease in the impact. The annex provides the turnover and the data in MSA.km² for each industry (Scope 1 and vertically

integrated) in Section C.1. With the impact of declining ore grade or the discovery of a new and more efficient technical solution, tonnes produced by turnover could change**. Thus, if this factsheet is read in few years, it is important to check if the average turnover of the industry and the tonnes of metals produced worldwide is not significantly different** before taking any conclusion.

Results of the benchmark code used for this benchmark factsheet are based on the CommoTool mining (a tool developed internally by CDC Biodiversité to provide the impacts of the production of 1 tonne of metal). This CommoTool has uncertainties presented below:

- Ore grades are global averages. Regional or mine site specific figures would be preferred if available.
- Impacts from prospection (Upstream Scope 3 of the industries of the sector) are not covered (only mining and mineral processing impacts are).
- The impacts of surrounding infrastructures associated to the mine site are only partially covered.

The **pressure Ecotoxicity is not included in the results** because it is subject to great uncertainties. Impacts from pollutants are not covered. This includes pollutant emission from mineral and metallurgical processes (including heap leaching), dusts and particulates, as well as Acid Mine Drainage (AMD). However, as ecotoxicity is an important issue in the sector “manufacture of metals” (vertically integrated) according to literature, a focus with qualitative results has been added to the annex in Section C.8.

Last, a significant proportion of impact intensity of some industries is caused by crops and grass commodities (especially for terrestrial static impact), which does not seem consistent. Among potential sources of error, one concerns possible inaccuracies in the way in which purchases are allocated in EXIOBASE for the metal sector. Further research is underway.

5. Additional results on the sector’s dependencies

In this part are presented additional results on the sector's dependencies, including a breakdown by EXIOBASE industries. A methodological explanation is available in Part 2.4.

Figure 23: Dependency heatmap for Scope 1 dependencies, based on ENCORE data

Processing of metals industries have "low" to "medium" dependency on ecosystem services in their Scope 1. Their aggregated score is between 10 % to 24 %, depending on the industries. However, most of them rely on water-related ecosystem services: ground water, surface water as well as water flow maintenance that keeps water circulating by recharging aquifers and maintaining surface water flows. All industries of the sector ("Processing of nuclear fuel" excluded) have a dependency score of 60 % for these ecosystem services. Most of them also rely on the flood and storm protection provided by ecosystem services (with a dependency score of

60% except for “Aluminium production”, “Manufacture of basic iron and steel and of ferro-alloys and first products thereof” and “Processing of nuclear fuel” with a lower dependency).

Figure 24: Dependency heatmap for Upstream dependencies, based on ENCORE data

Industries of the sector have “very low” to “low” dependency score for their Upstream dependencies (aggregated score between 14 % and 17%). However, the upstream dependency score is a weighted average of each supplier dependency score, meaning that a high dependency for one supplier of the supply chain might be lessened by a low dependency of another supplier on a given ecosystem service. To have a better understanding of the upstream dependencies, please refer to section C.4 Sector’s dependencies on the Raw materials extraction’s sectoral appendix. The figure 22 gives an overview of the level of dependencies on ecosystem services for the extraction of each metal, a very strategic part of the value chain for the “Manufacture of metals” sector.

However, the upstream critical score for industries of the sector is 46 %. Upstream critical dependency score corresponds to the percentage of the value chain which is critically dependent, *i.e.,* not substitutable, on at least one ecosystem service. **For the sector “Manufacture of metals”, 46% of the value chain is critically dependent to at least one ecosystem service (with very few variations of score between the industries).** *Please note that the methodology of critical dependencies for the benchmark factsheets is still under development and these numbers may change at the margin. The methodology is explained in Section 2.4.C of the general technical annex.*

Figure 25: Dependency heatmap for vertically integrated dependencies, based on ENCORE dataEU taxonomy guidelines

Currently, industries of the sector have "low" vertically integrated dependency score to ecosystem services However, the demand for several metals should increase in future decades considering the objectives of reduction of GHGs (grid electrification, electric batteries for cars). This increase in demand could have impact on the dependencies to ecosystem services for the sector, especially in their upstream dependencies (extraction of raw materials and mineral processing).

6. Terrestrial static Climate change calculation

Climate change static impacts are not currently properly assessed by the GBS because historical emissions are needed to compute them. The methodology used to estimate terrestrial static impacts from 2022 dynamic impacts and past emissions is available in 2.5.

$$Sector\ ratio = \frac{Sectoral\ factor_{1990}}{Global\ factor_{1990}}$$

$$Sectoral\ factor_{1750} = Sector\ ratio * Global\ factor_{1750} = 49$$

Thus, Climate change static impacts for the category manufacture of basic metals will be:

$$\boldsymbol{Climate\ change\ static_{2022,\ Manufacture\ of\ metals} = 49 * Climate\ change\ dynamic_{2022,\ Manufacture\ of metals}}$$

The results are presented in Table 8 below:

Table 8: Computation of the terrestrial static impact related to Climate change and comparison with the terrestrial static impact linked to other pressures

Industry Categories	Scope	Impact in MSA.m²/kEUR		
		Climate change terrestrial dynamic	Climate change terrestrial static	Terrestrial static linked to other pressures
Aluminium production	Scope 1	0.78	39	0.19
	Vertically integrated	5.5	280	270
Casting of metals	Scope 1	3.5	170	0.14
	Vertically integrated	6.9	350	230
Copper production	Scope 1	0.77	38	1.6
	Vertically integrated	4.2	210	330
Lead, zinc and tin production	Scope 1	0.73	37	1.8
	Vertically integrated	6.9	340	800
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Scope 1	3.5	180	0.072
	Vertically integrated	8.4	420	200
Manufacture of fabricated metal products, except machinery and equipment (28)	Scope 1	0.59	29	0.47
	Vertically integrated	3.1	160	150
Other non-ferrous metal production	Scope 1	1.9	99	0.48
	Vertically integrated	6.1	305	420
Precious metals production	Scope 1	0.79	39	4.9
	Vertically integrated	4.5	220	420
Processing of nuclear fuel	Scope 1	0.78	39	0.79
	Vertically integrated	3.7	190	740

Figure 26, Figure 27 and Figure 28 present the terrestrial static impacts for the industries of the sector with the computation of the Climate change pressure.

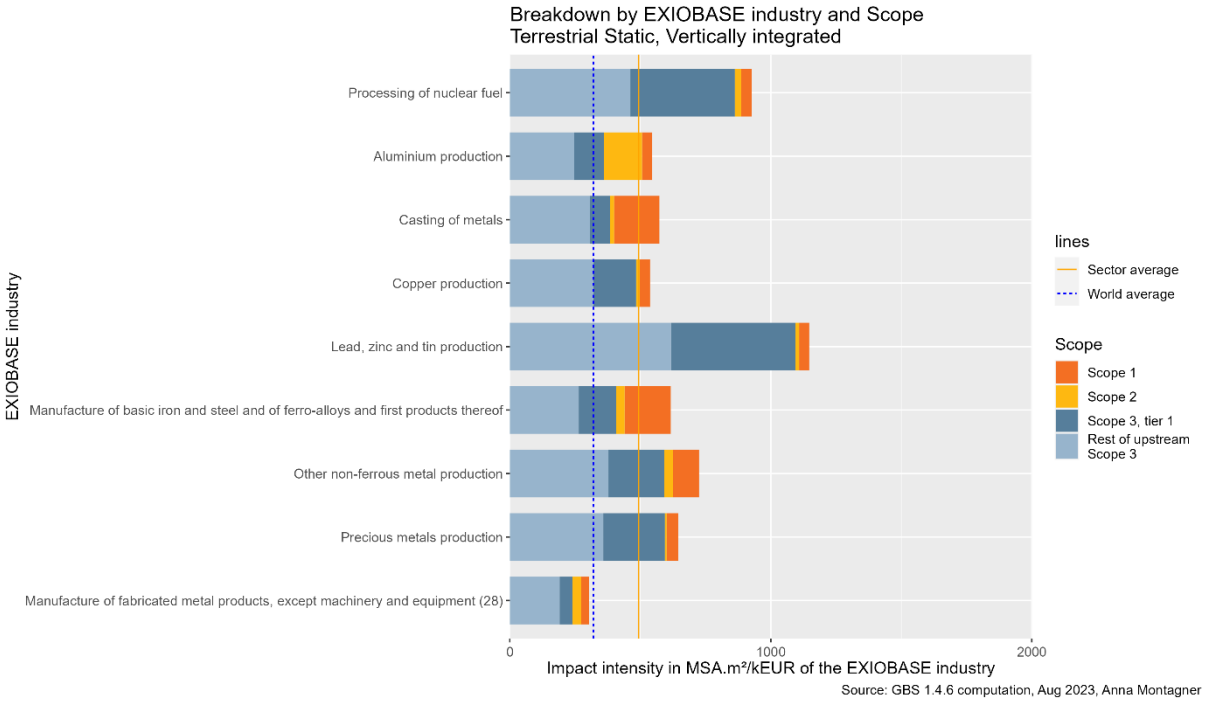

Figure 26: Terrestrial static impact vertically integrated of the "Manufacture of metals" sector with impact related to the Climate change pressure by Scope

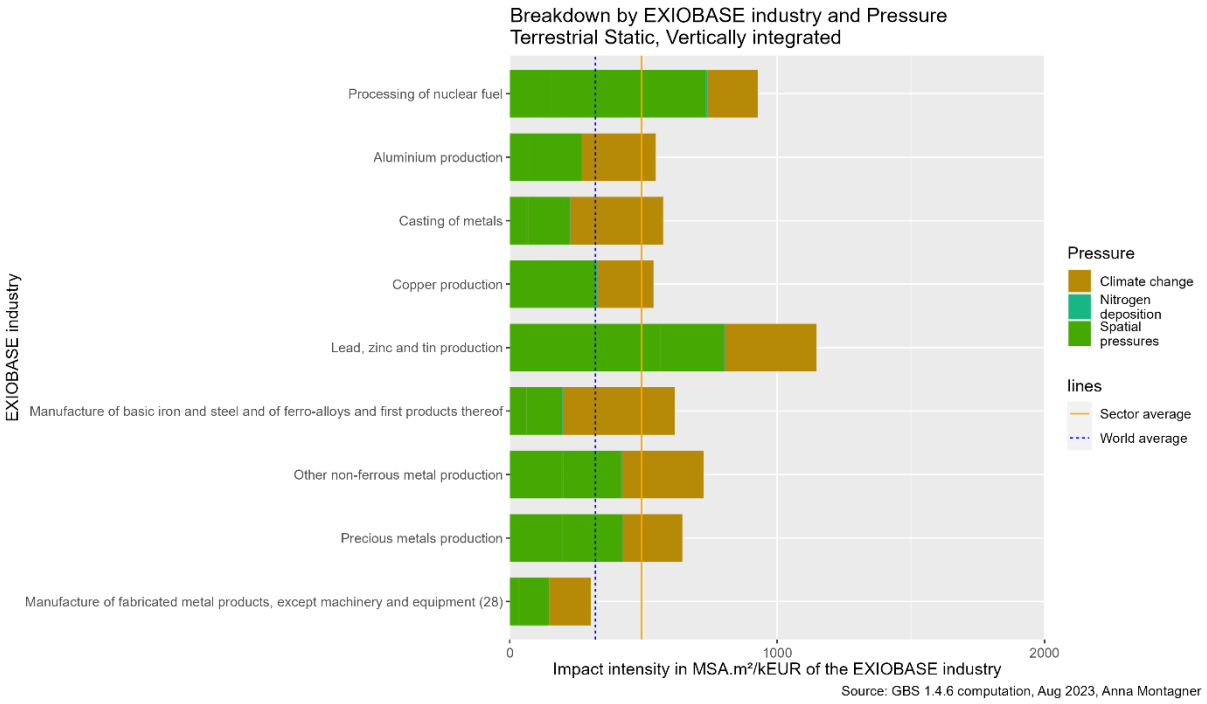

Figure 27: Terrestrial static impact vertically integrated of the "Manufacture of metals" sector with impact related to the Climate change pressure by pressure

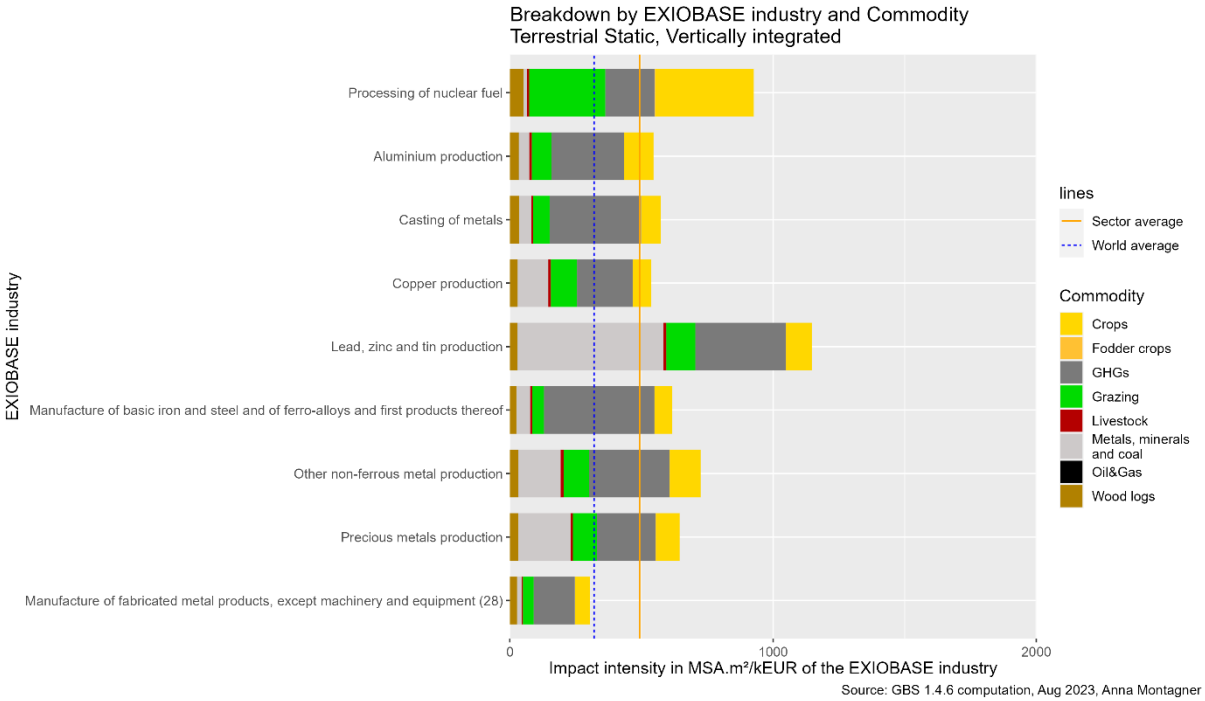

Figure 28: Terrestrial static impact vertically integrated of the "Manufacture of metals" sector with impact related to the Climate change pressure by commodity

With the computation of the pressure Climate change for terrestrial static impacts, Scope 1 and Scope 2 also have impacts on biodiversity for all industries of the sector, even if most of them are still covered by Scope 3. For vertically integrated impacts, the main pressure remains Spatial pressures for most of the industries (or at least half of the impact intensity except for "Casting of metals" and "Manufacture of iron"). Results are particularly interesting considering the industries "Aluminium production", "Casting of metals", "Manufacture of basic iron and steel" and "Manufacture of fabricated metal products". For those industries, the pressure Climate change causes at least half of the terrestrial static impacts.

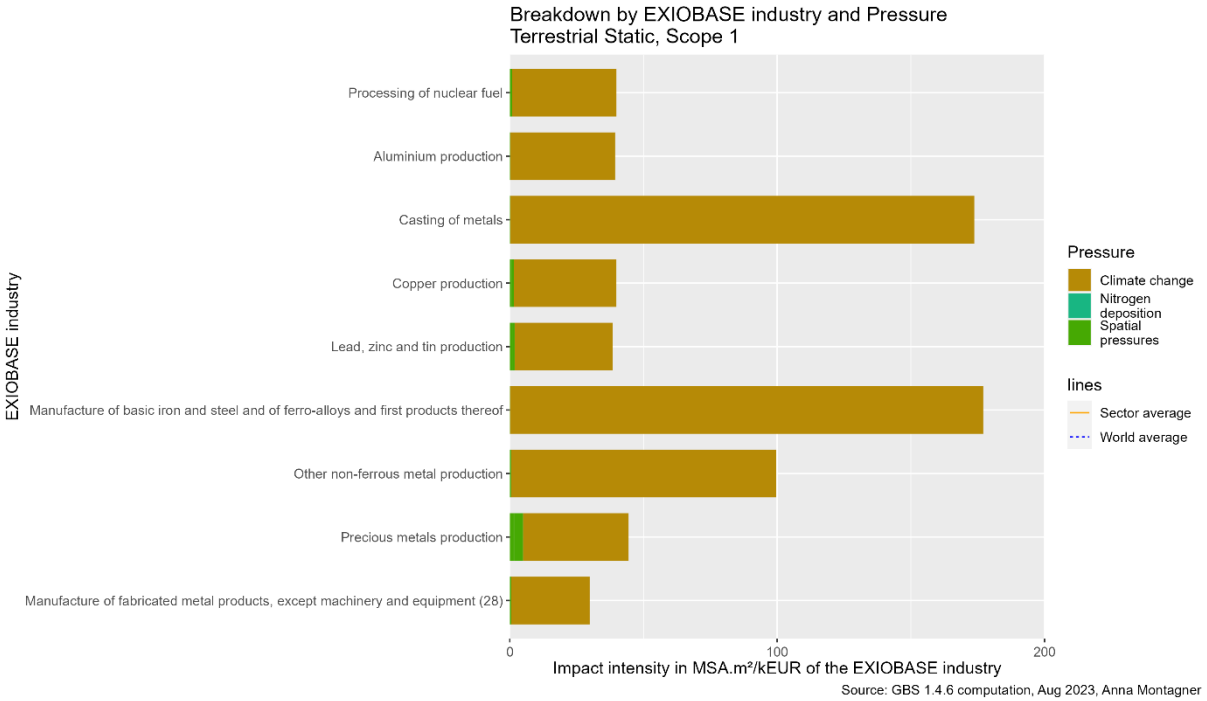

Figure 29: Terrestrial static impact Scope 1 of the "Manufacture of metals" sector with impact related to the Climate change pressure by pressure

Considering Scope 1 of industries of the sector, terrestrial static impacts with the computation of Climate change static are mainly due to the pressure Climate change. Thus, **to reduce both static and dynamic terrestrial impacts on biodiversity in Scope 1 for the sector "Manufacture of metals", an ambitious strategy to reduce the emissions of GHGs is crucial**. **However, as most of the impacts are covered by Scope 3, when the entire value chain is considered, industries of the sector must take actions regarding their purchases and their suppliers to reduce other pressures such as Spatial pressures.**

7. Hydrological disturbance due to direct water use

8. Ecotoxicity and pollution (air pollution, wastewater and solid waste)

As mentioned earlier, the pressure Ecotoxicity is not included in the results because it might be subject to great uncertainties in the version 1.4.6 of the GBS. However, as the literature highlights the importance of this pressure on ecosystems for the production of metals, a qualitative focus is here proposed. As an example, a recent paper (Liu et al. 2020) indicates that over the entire production chain of iron and steel, normalized ecotoxicity impacts are among the most important impacts.

The literature on the impacts on biodiversity of the production of metals focuses on the impacts of the different processes. It is sometimes complicated to have a clear idea of which factsheet covers a particular process. Thus, focus on Ecotoxicity will include the whole value chain from mining to production of metals. Impacts described in those two focuses correspond to Scope 1, Scope 2 and Scope 3 of the industries covered by this current factsheet. Results presented below are qualitative results and have not been added to quantitative results.

Regarding the pressure Ecotoxicity, the mineral resource extraction and processing are particularly critical stages in the overall supply chain. Indeed, these processes have a potential to release gas, liquid and solid emissions, directly or indirectly. A significant amount of energy is required, and the use of reagents, water and fuel exacerbate the impacts. Furthermore, "even metals that are biologically essential may also become toxic at high levels (*e.g.*, zinc and copper)" (Norgate, Jahanshahi, and Rankin 2007).

Table 9 summarizes some of the main pollutions for some industries of the sector, according to the literature. Please note that this table is not exhaustive and further research should be done for each industry to have a better understanding on the pressure Ecotoxicity for a specific industry of production of metals. Pollution can also vary according to the process used and literature consulted are focusing on a specific area of the world (sometimes even on a country), thus it is important to keep in mind that ecosystems can vary, and impacts can be different.

Table 9: Table summarizing some of the main pollutions for some industries producing metals, CDC Biodiversité

Metal	Pollution/emissions	Source
Zinc	- gypsum waste - SO_2 emissions	(Moors, Mulder, and Vergragt 2005)
Lead	- dioxins - furans - polycyclic aromatic hydrocarbons (PAHs) - As (Arsenic) - Cd (Cadmium) - Pb (Lead) - Se (Sélénium)	(Strezov, Zhou, and Evans 2021)
Nickel	- Nox - SO2 - PM10 - PM2.5 - Cu - Ni	(Strezov, Zhou, and Evans 2021)
Aluminium	- red mud - spent pot linings waste - SO_2 - PAHs - fluorides emissions - PAHs	(Moors, Mulder, and Vergragt 2005)
Steel	- NO_X - SO_2 - VOC emissions - dioxins - slag - dust - benzene	(Moors, Mulder, and Vergragt 2005)

	- toluene - xylenes	
Gold	1) mercury vapor and mercury concentration amalgamation (small scale mine) 2) cyanide exceeded environmental quality criteria cyanidation (standard method) - Cd - Pb - Se	1) (Malm 1998) 2) (Tarras-Wahlberg et al. 2001) (Strezov, Zhou, and Evans 2021)

Another risk of pollution must be considered: Acid mine drainage (AMD)[3]. Pollution due to AMD affects historic or current mining sites. "Waters draining active and, in particular, abandoned mines and mine wastes are often net acidic" (Johnson and Hallberg 2005). Additional risks to the environment are caused by such waters as they often contain elevated concentrations of metals (iron, aluminum and manganese, and possibly other heavy metals) and metalloids (of which arsenic is generally of greatest concern). Prevention of the formation of the migration of AMD from its source is the first action to take. Figure 30 presents various approaches that have been evaluated to prevent or minimize the generation of mine drainage waters. Further information can be found in the paper "Acid Mine Drainage remediation options : a review" (Johnson and Hallberg 2005). However, if this is not feasible, it is necessary to collect, treat, and discharge mine water (Johnson and Hallberg 2005). This subject is an important issue and it can be a potential long-term pollution problem. AMD continue years after the closing of the mine.

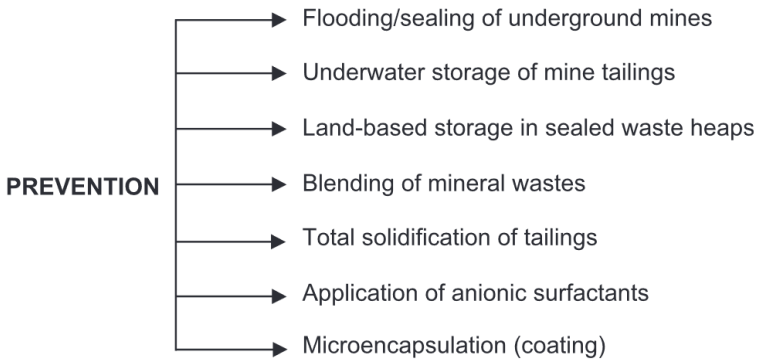

Figure 30: Various approaches that have been evaluated to prevent or minimize the generation of mine drainage waters, source: (Johnson and Hallberg 2005)

[3] Acid mine drainage (AMD) forms when sulphide minerals have been exposed to oxidising conditions during mining and other excavation activities, such as highway construction (Netinger Grubeša et al. 2016)

9. The biodiversity footprint of metals for one tonne of metal produced

In parallel of the results' analysis with monetary intensity, qualitative research has been conducted. Scientific literature highlights that the production of precious metals, and the production of gold in a bigger extent, has important environmental impacts. However, the results by monetary intensity did not underline this difference compared to the production of other metals. On the contrary, other industries such as "Production of zinc, tin and lead" have higher monetary intensity. This assessment raises the question of the pertinence of monetary intensity as the more relevant metric of biodiversity footprint for industries producing metals. It was concluded that an analysis of the biodiversity footprint of these industries by tonne of metal produced should be added to the study.

The biodiversity footprint was only available for zinc concentrate and not zinc after refining. As it does not correspond to the same perimeter studied for the other metals, it has been acted that the metal zinc will be excluded from this section of the study.

To calculate the biodiversity footprint of the production of one tonne of each metal, an in-house tool of CDC Biodiversité has been mobilized: the CommoTool Mining. Input files to produce each metal have been computed to the tool. Results were expressed in MSA.km^2 per tonne of metal produced. Results can be expressed in absolute, or by pressure. A conversion to have the results by MSA.m^2 has been calculated, as it was easier to read the results on charts with this unit.

The assessment of biodiversity impacts of economic activities with the GBS follows a stepwise approach according to the best data available at each step of the impact assessment (CDC Biodiversité 2020a). In default assessments, the results of the Mining CommoTool feed the M matrix dedicated to mining commodities documented in EXIOBASE material account. The M matrices are the tables which gather biodiversity loss factors (in MSA.km²/t of commodity). They are combined to other matrixes which translate monetary data into inventories of raw materials and emissions in the Input-Output modelling (CDC Biodiversité 2020b).

In refined assessments, if "inventory" data, like purchased or produced quantities of mining commodities, are available, biodiversity impact factors linking tonnages of mining commodities to impacts on biodiversity in MSA.km² can be applied directly to the company's inventory. Figure 31 illustrates the Mining CommoTool in the GBS stepwise approach.

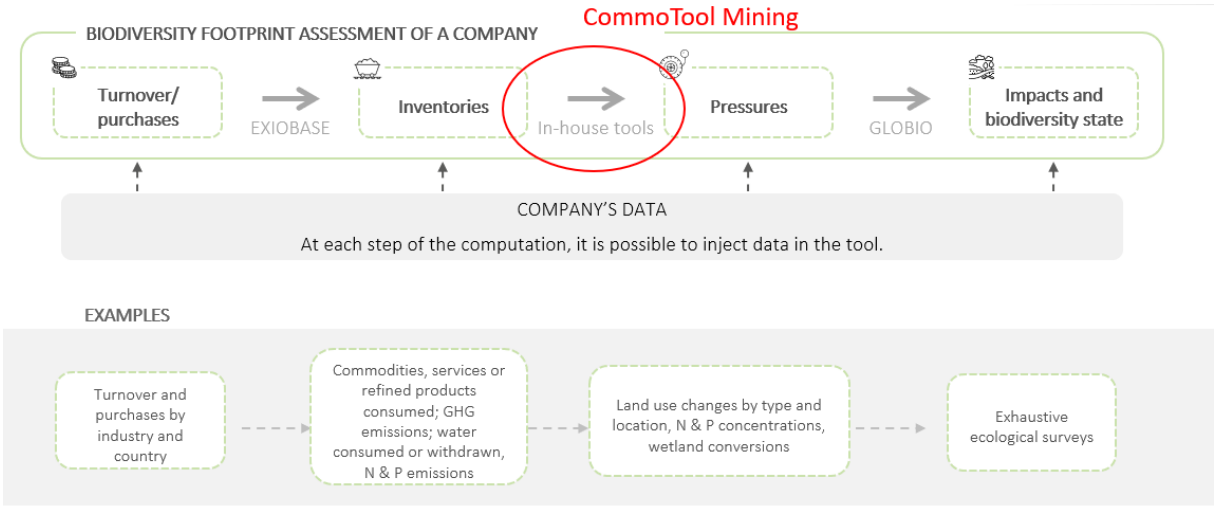

Figure 31: Mining CommoTool in the GBS stepwise approach

The CommoTool Mining has been developed in 2020 by CDC Biodiversité and is under constant development. However, The CommoTool Mining does not cover all these pressures. The detailed status of pressures covered for the extracting and concentrating phases is provided below and summarised in Table 10; As a reminder, the study concentrates on the production of metal processed, which means that it includes extracting and refining.

Table 10: Pressures included in the Mining CommoTool, CDC Biodiversité, 2020

	Pressure	Extracting + concentrating	Refining (excluding concentrating)
Terrestrial	LU		
	E		
	F		
	N		
	CC		
Aquatic	LUR		
	LUW		
	WC		
	HD_{water}		
	HD_{infra}		
	HD_{CC}		
	FE		

Covered
Not covered
Not relevant

Legend:
LU: Land Use
E: Encroachment
F: Fragmentation
N: Atmospheric Nitrogen Deposition
CC: Climate Change
LUR: Land use in catchment of rivers
LUW: Land use in catchment of wetlands
WC: Wetland conversion
HD_{water}: Hydrological disturbance due to direct water use
HD_{CC}: Hydrological disturbance due to climate change
FE: Freshwater eutrophication

Climate change is the only pressure measured by the tool considering refining of metals. This is an important limit. As an example, the literature highlights that refining involve amount of water (for cooling). CDC Biodiversité is currently working on the subject to have an overview of the amount of water that is involved in the process and what does in means in terms of impacts.

Furthermore, in GBS 1.4.6, several significant impacts related to mining are not covered:

• pre operation impacts: exploration phase to assess the feasibility of a mine site involves impacts of various nature on the concession owned by the company: land occupation at mining site, pollution, noise, infrastructure…

• during the operation phase: pollutants are not included, this includes pollutant emissions from mineral and metallurgical processes (including heap leaching), generation of AMD as well as deportment of dusts and particulates. Infrastructure outside of the mine site are not accounted for

• post operation phase: all impacts being positive (mine site rehabilitation) or negative (lasting chemical pollution) occurring after mine closure are not included.

Mining and mineral processing are common to all commodities. For metals, an additional metallurgical mining process is needed. For further information, please consult the critical review of CDC Biodiversité on the subject (CDC Biodiversité 2020c). Some date used in the tool are common to the production of the different metals even if it does represent an approximation. Figure 32 presents the data common of all metals in the CommoTool Mining and those specific to the production of one metal. The Tool presents several limits as it is a tool at macro level. If more precise data are available for an industry, the results might be more accurate. However, the tool allows to have an overview of the biodiversity footprint of several metals.

Characteristics	Different data used for the different metals
Ore grade	Yes
Water withdrawal	No
Surface mining technique	Yes
Mine capacity	Yes
Gangue density	No
Production quality	No
Commodity density	Yes

Figure 32: Data used per metal in the CommoTool Mining

The tool presents the results in static and dynamic impacts. Dynamic impacts correspond to the impacts added on biodiversity, to produce an additional tonne of metal. Static impacts correspond to the cumulative negative impacts on biodiversity to have the possibility to produce an additional tonne of metal. These impacts are based on data of the production of tonnes of metal by mines. Impacts for a mine are divided by the number of tonnes produced. It is then aggregated by states and in our case, aggregated at world level. Thus, static impacts correspond to the allocation of a participation to the constant pressures of the mine (avoid animals to use the land, noise and so on). Results of biodiversity footprint by tonne of metals selected are breakdown by static and dynamic impacts. For each type of impact, charts are presented in absolute (MSA.m^2) and by pressure. Results are presented for terrestrial and aquatic ecosystems. However, results for dynamic aquatic results are not presented due to higher uncertainties.

Terrestrial impacts

Dynamic impacts

Results are here presented in charts to facilitate the comprehension. Impacts presented correspond to dynamic impacts, impacts added on biodiversity to produce an additionnal tonne of metal.

Absolute impacts in MSA.m^2

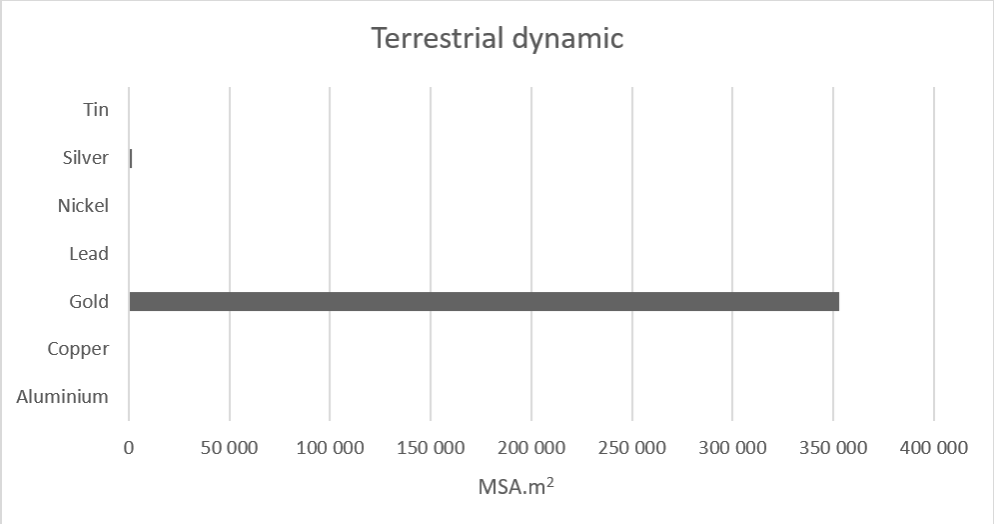

Figure 33: Breakdown by metal produced, Terrestrial dynamic, results by tonne of metal produced

As noticed in the literature, the production of gold has important impacts on biodiversity. If we consider a biodiversity footprint intensity by mass, in tonne, gold is the metal with the higher intensity, with 350 000 MSA.m^2. It means that the production of an additionnal tonne of gold corresponds to the additional artificialization of 350 000 m^2. Dynamic terrestrial impacts of other metals can barely be seen in this chart, expect for silver. Thus, another chart is presented below, without gold.

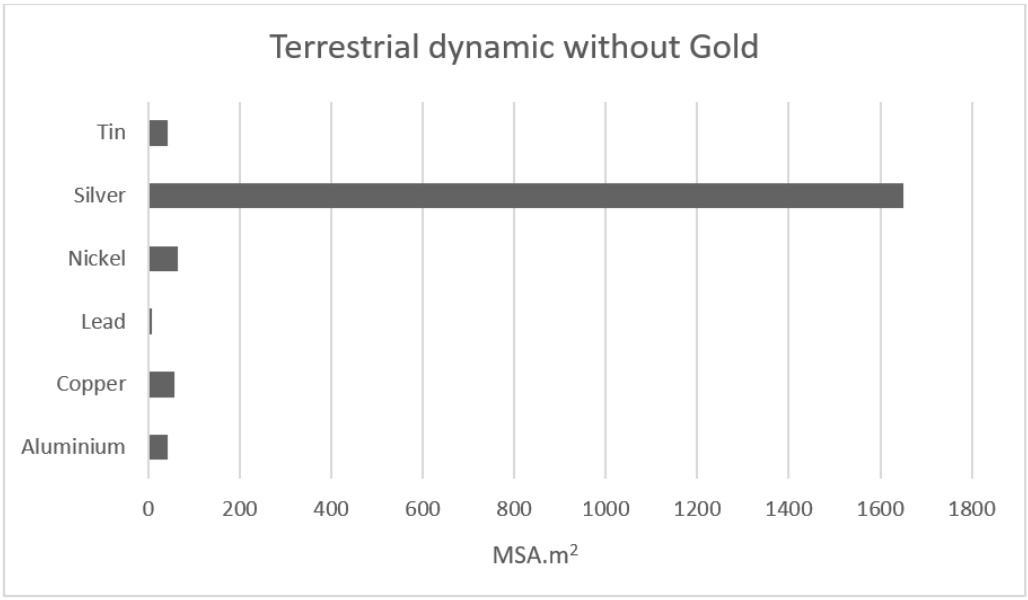

Figure 34: Breakdown by metal produced, Terrestrial dynamic, results by tonne of metal produced, gold excluded

Silver is the second most impacting metal on biodiversity for its production, considering the metals selected for this study, with an intensity of 1 700 MSA.m^2 (results 200 times less important than the production of gold for

terrestrial dynamic impacts). The four remaining metals have intensities between 7,8 MSA.m^2 (for lead) and 64 m^2 (for nickel). Figure 35 below presents the results without gold and silver.

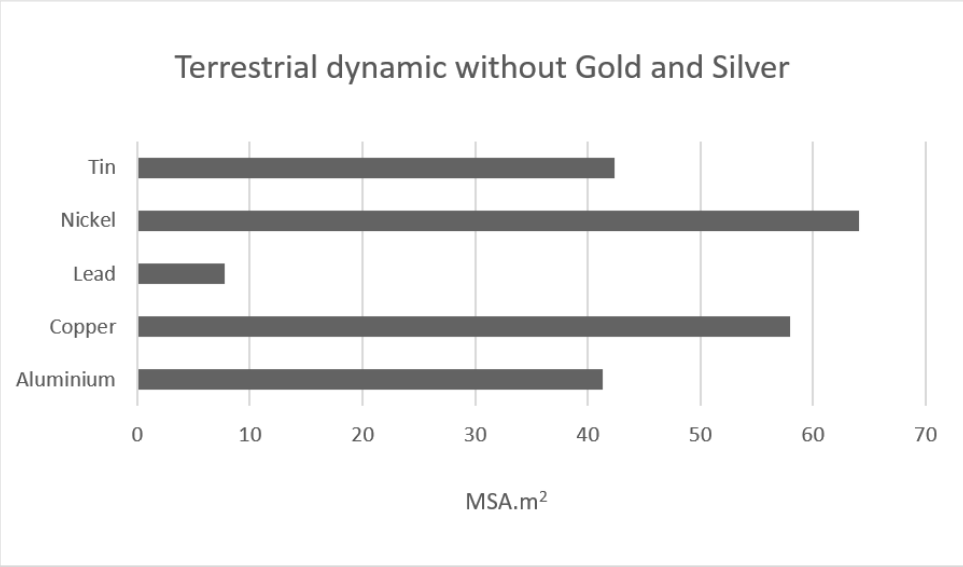

Figure 35: Breakdown by metal produced, Terrestrial dynamic, results by tonne of metal produced, gold and silver excluded

Impacts by pressure

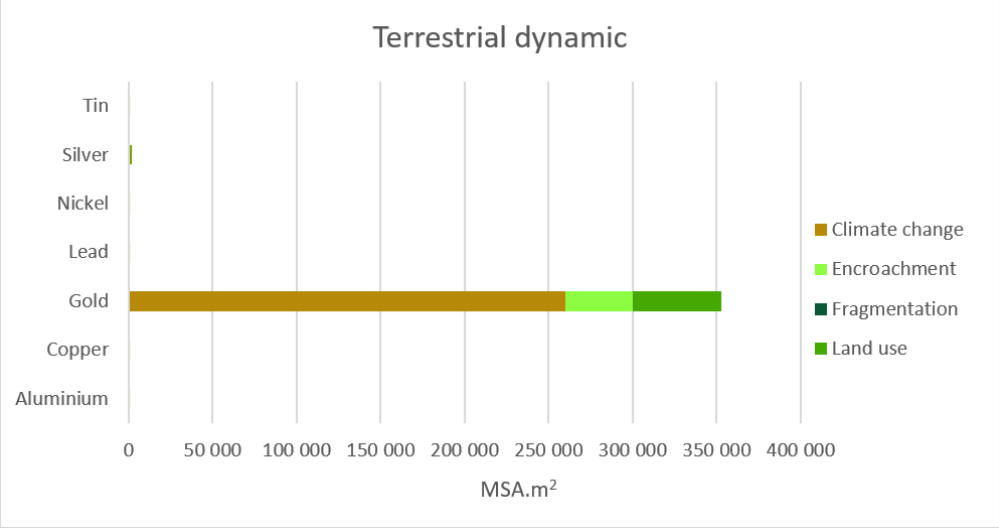

Figure 36: Breakdown by metal produced and pressure, Terrestrial dynamic, results by tonne of metal produced

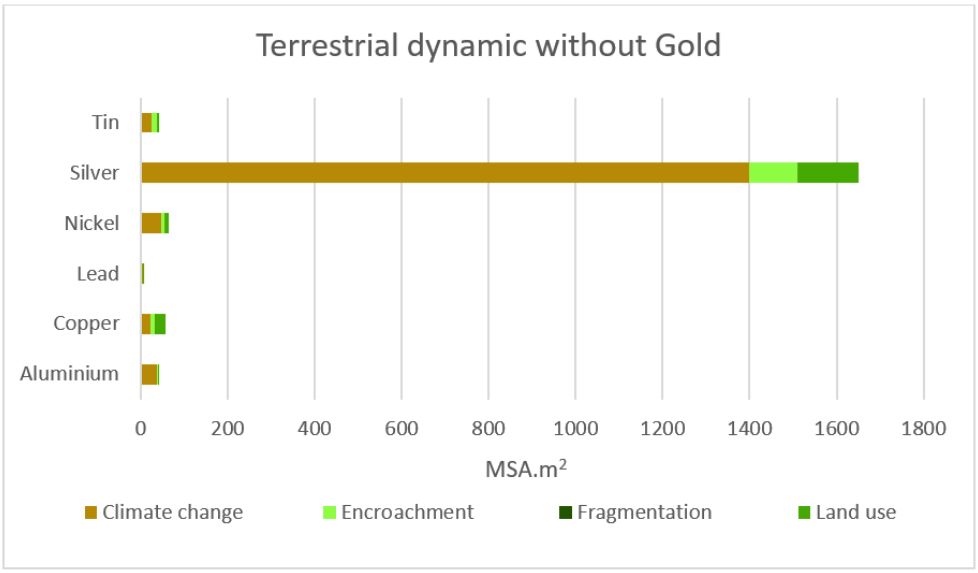

Figure 37: Breakdown by metal produced and pressure, Terrestrial dynamic, results by tonne of metal produced, gold excluded

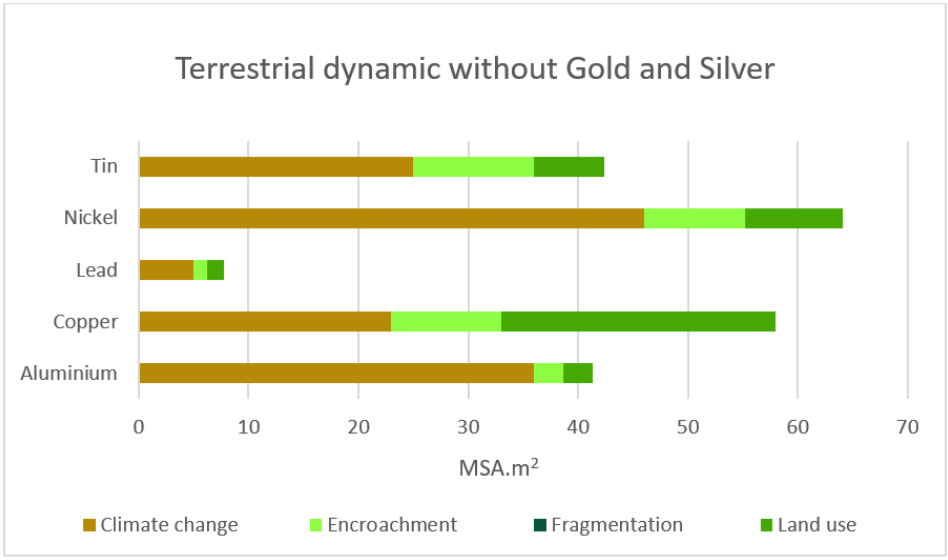

Figure 38: Breakdown by metal produced and pressure, Terrestrial dynamic, results by tonne of metal produced, gold and silver excluded

The breakdown by pressure has already been commented in the previous section (see section C.3) and will not be explained in details in this section. Considering terrestrial dynamic impacts, the main pressure for all the metals is Climate Change (except for Copper). This might be explained by intensive energy processed during the refining phase.

Static impacts

Absolute impacts in MSA.m²

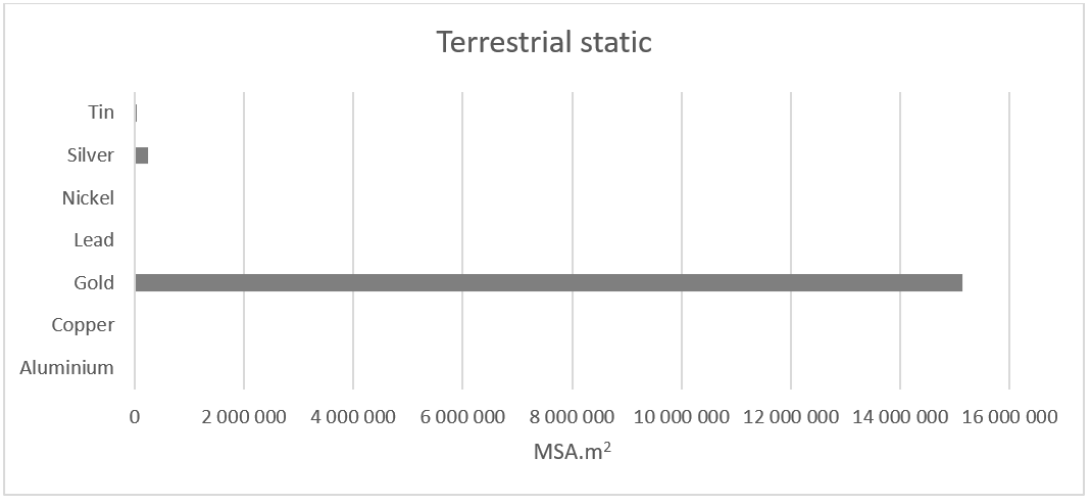

Figure 39: Breakdown by metal produced, Terrestrial static, results by tonne of metal produced

Considering terrestrial static impacts, the biodiversity footprint of gold is also higher than other metals in terms of intensity by mass, with an intensity of 15 130 000 MSA.m². All other metals are under 260 000 MSA.m² as Figure 40 shows.

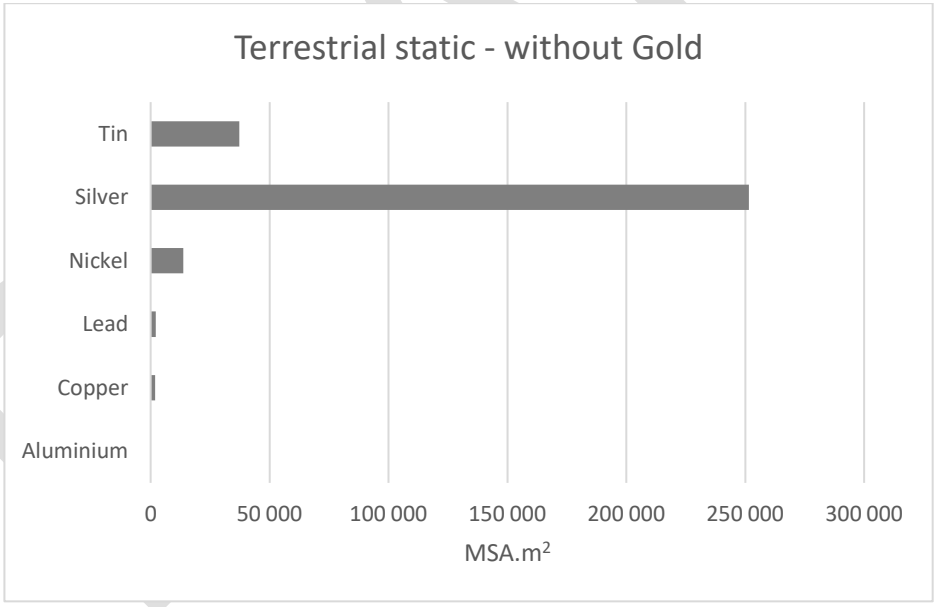

Figure 40: Breakdown by metal produced, Terrestrial static, results by tonne of metal produced, gold excluded

Silver is the second most impacting metal on biodiversity, considering terrestrial static impact, with an intensity of 250 000 MSA.m² (still sixty times less than the production of one tonne of gold).

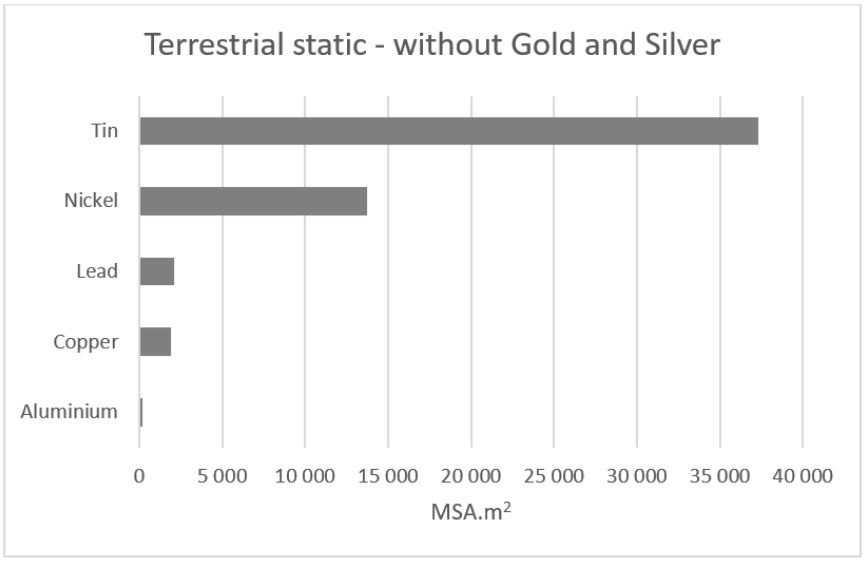

Figure 41: Breakdown by metal produced, Terrestrial static, results by tonne of metal produced, gold and silver excluded

Tin, Nickel, Lead, Copper and Aluminium have an intensity inferior at 40 000 MSA.m^2. Tin has the higher intensity with an intensity of 37 000 MSA.m^2 and Aluminium the lowest with 0,18 MSA.m^2.

Impacts by pressure

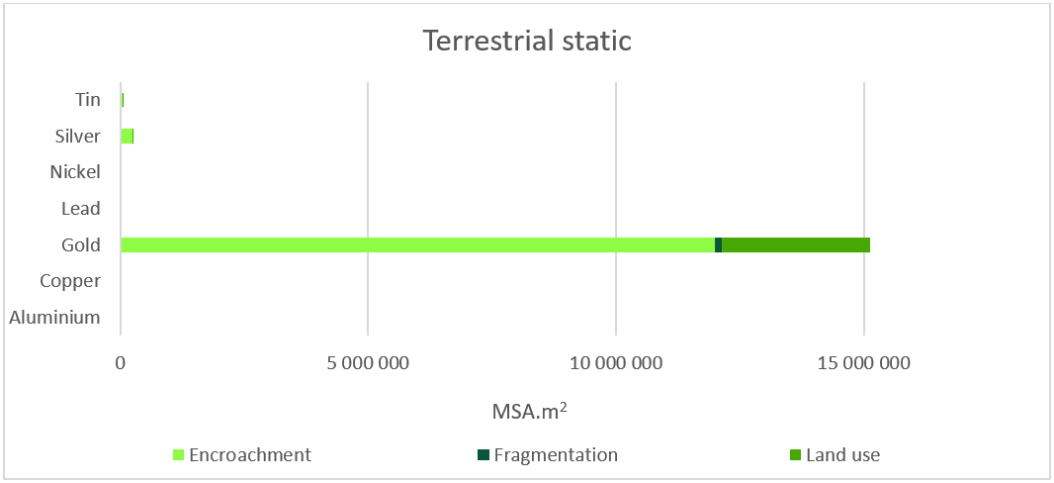

Figure 42: Breakdown by metal produced and pressure, Terrestrial static, results by tonne of metal produced

Figure 43: Breakdown by metal produced and pressure, Terrestrial static, results by tonne of metal produced, gold excluded

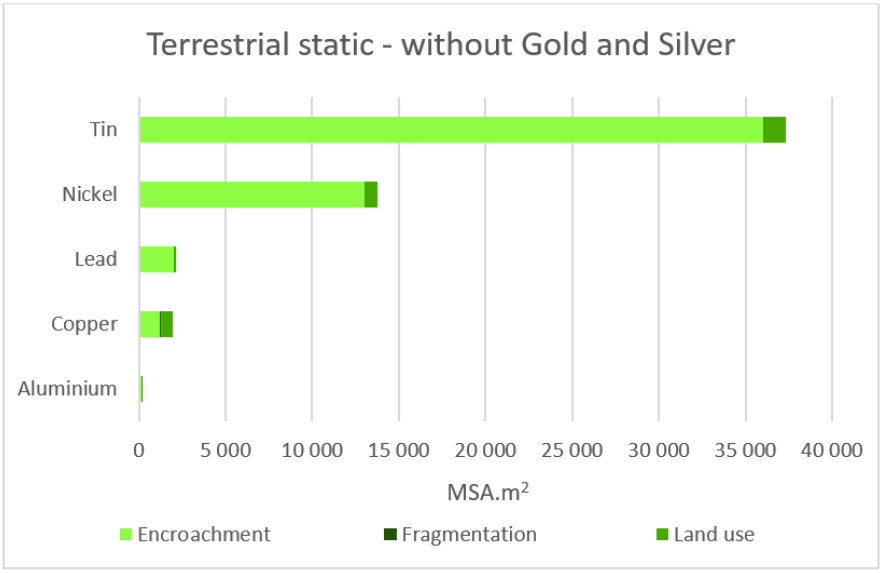

Figure 44: Breakdown by metal produced and pressure, Terrestrial static, results by tonne of metal produced, gold and silver excluded

For all metals, the main pressure is Encroachment. Encroachment corresponds to anthropogenic activities in otherwise natural areas (direct and indirect disturbance). As an example, the noise due to the mine is part of the impacts on biodiversity considered as Encroachment. In the GBS, the Pressure Encroachment is considered as a buffer zone of 10 km^2 around the mine and the metallurgical industries, where the MSA is 85% inferior as the MSA of the original ecosystem. The pressure Land Use is also important to produce gold, with an intensity of 3 000 000 $MSA.m^2$, which corresponds to 3 $MSA.km^2$. Differences between metals can mainly be explained by

metals'ore grade. In the GBS, ore grade of gold is considered to be 0.00018%. To have a comparison, copper's ore grade is 0.45% and tin 1.20%.

Aquatic impacts

Absolute impacts in MSA.m²

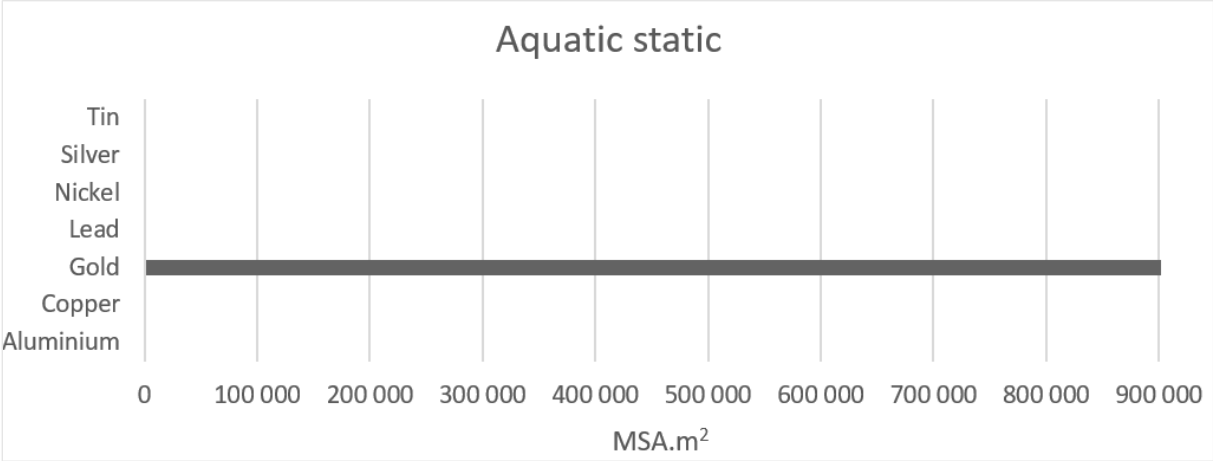

Figure 45: Breakdown by metal produced, Aquatic static, results by tonne of metal produced

Considering aquatic static impacts, gold is also the most impacting metal with an intensity of 900 000 MSA.m². Thus, the production of gold has important impact on biodiversity for both terrestrial and aquatic ecosystems.

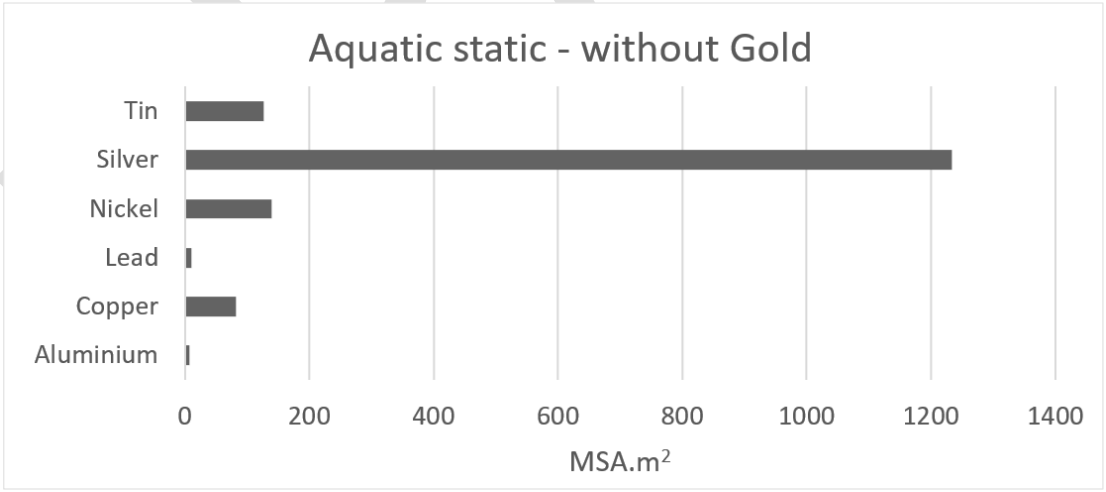

Figure 46: Breakdown by metal produced, Aquatic static, results by tonne of metal produced, gold excluded

Other metals have intensity ranging from 1 200 MSA.m² for Silver to 6.8 for Aluminium.

Impacts by pressure

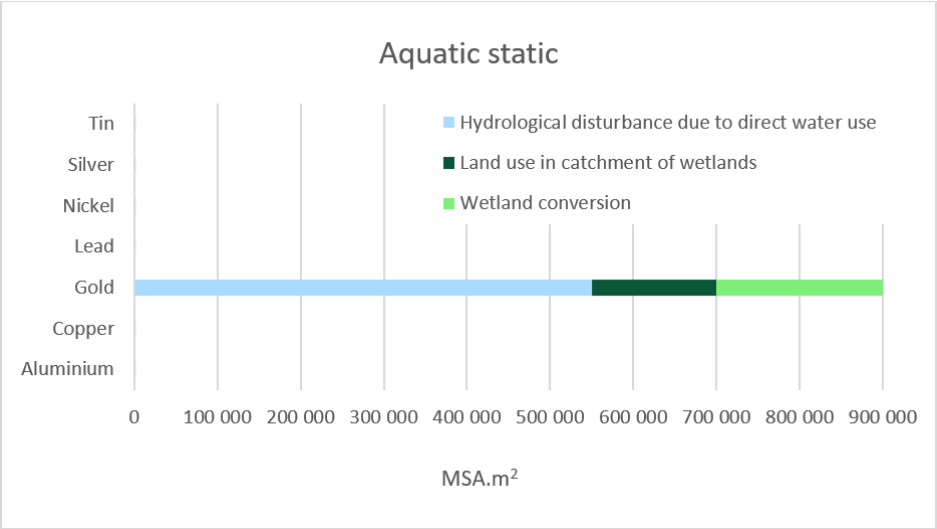

Figure 47: Breakdown by metal produced and pressure, Aquatic static, results by tonne of metal produced

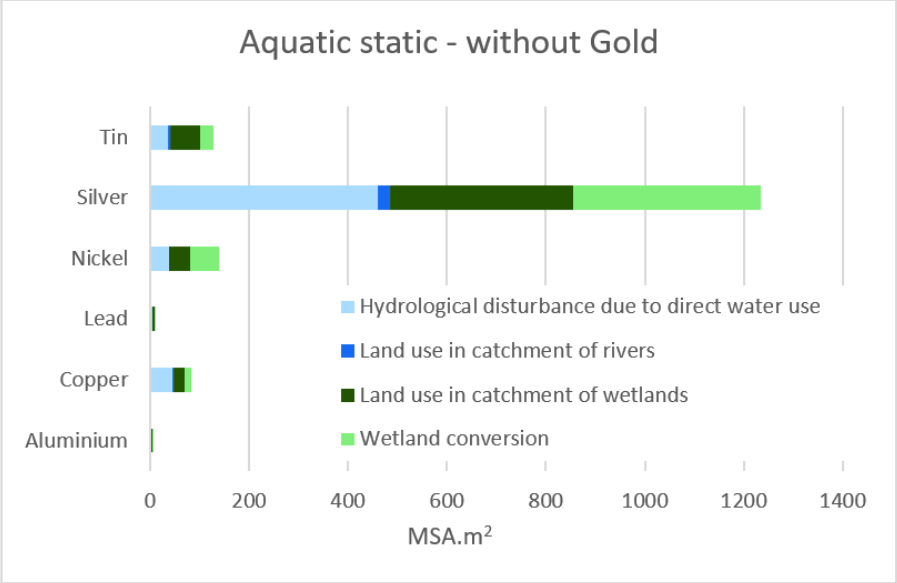

Figure 48: Breakdown by metal produced and pressure, Aquatic static, results by tonne of metal produced, gold excluded

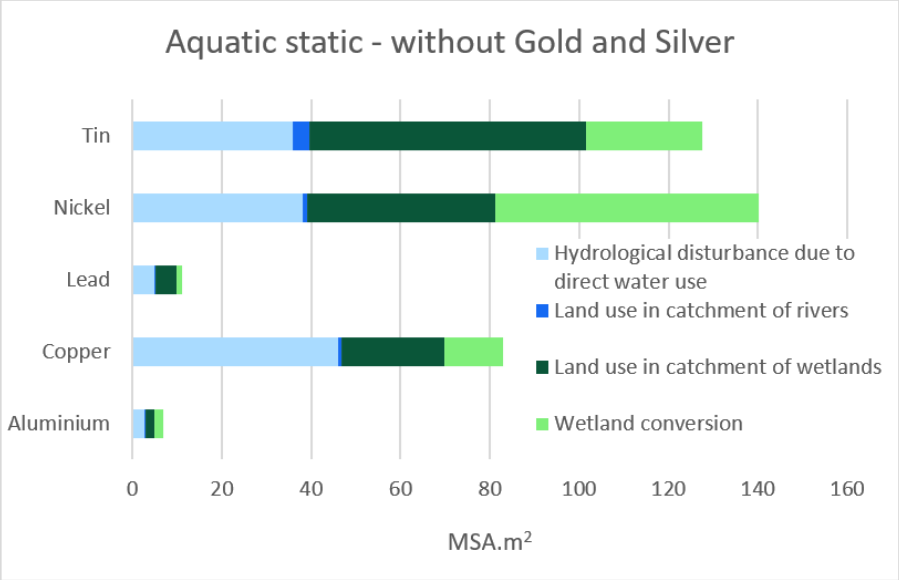

Figure 49: Breakdown by metal produced and pressure, Aquatic static, results by tonne of metal produced, gold and silver excluded

Considering static aquatic impacts, the three main pressures on biodiversity to produce metals are Hydrological disturbance due to direct water use, Land use in catchment of rivers and Wetland conversion. The Hydrological disturbance due to direct water use is not assessed for the refining of metals but only for the extraction process. These impacts might be underestimated as refining industries processes involve water, for cooling for example, with a risk of consumption (water not given back to the ecosystem) with evaporation during the process. Thus, impacts due to Hydrological disturbance due to direct water use corresponds here, in the results, to water use in extraction process and mineral processing (first processing to obtain concentrate before metallurgical process to have the final metal). The pressure Hydrological disturbance due to direct water use is particularly important for gold, with an intensity of 550 000 MSA.m^2. It might be linked to the number of tonnes of ore needed to process one tonne of gold (considering ore grade).

The pressure Land use in catchments of wetland is also important to produce most metals. Watershed's upstream land use changes has an indirect negative impact on downstream water bodies. Land use type is indeed a good proxy for the nutrient emissions leaching from human activities to ecosystems.

The third most important pressure is Wetland conversion. Wetland conversion corresponds to the loss of aquatic ecosystems caused by the conversion and draining of wetlands for human purposes. As an example, the newly mined gold can be divided into two categories: primary and secondary deposits (Fritz, Aichele, and Schmidt 2020). Secondary deposits are mainly mined from water bodies with dredges or by washing old riverbeds using hoses (hydraulic mining) (K.G. McQueen 2005). Even if most secondary deposits are almost solely exploited by ASM[4] and might not be included in the data used, it is not rare to have interesting ore in wetlands.

[4] Artisanal and Small-scale Mining

The pressure Ecotoxicity is not assessed in this study due to higher uncertainties, but emissions of chemical substances are also participating to the pressure Pollution on biodiversity, especially for aquatic ecosystem in extraction processes. A focus on this subject has been realized in section C.8.

D. EU TAXONOMY GUIDELINES

1. Economic activities included in the EU taxonomy

As said in the context, industries of "Manufacture of metals" sector have several impacts on the environment. Thus, some of them are covered by the EU taxonomy (EU technical expert group on sustainable finance 2020):

- Manufacture of aluminium
- Manufacture of Iron and Steel

Manufacturing of aluminium and of iron and steel are considered to make a substantial contribution to Climate change. Both are energy intensive processes with emissions of CO_2 mostly from Scope 2 emissions. It is mainly due to the electricity used for the production of aluminium, to emissions of GHGs during iron casting and to the use of electric arc furnace, for example, for the manufacturing of iron and steel. Furthermore, all aluminium recycling and secondary production of steel (*i.e.*, using scrap steel)) are considered eligible due to significantly lower emissions than primary production."(EU technical expert group on sustainable finance 2020). However re-processing of metals is not covered by this factsheet.

Manufacturing of batteries and accumulators are covered by the EU Taxonomy in the screening criteria published so far in the Delegated Act on climate objectives (Official Journal of the European Union 2021). Nevertheless, the production of metals needed for their manufacture, such as the production of nickel, which is part of the perimeter, is not included. It is also the case for other relevant sectors for the ecological transition such as energy with renewable energies and electrification (copper needed for example).

On 9 March 2022, the Commission adopted a Complementary Climate Delegated Act which is applied since January 2023. This includes, under strict conditions, specific nuclear and gas energy activities in the list of economic activities covered by the EU taxonomy. Pre-commercial stages of advanced technologies to produce energy from nuclear processes, construction and safe operation of new nuclear power plant, electricity generation from nuclear energy in existing installations are now covered. However, processing of nuclear fuel is not covered (which is included in this factsheet).

2. Technical screening criteria for a substantial contribution to Climate change mitigation, extracts from the Delegated Act on climate objectives (Official Journal of the European Union 2021)

Manufacture of aluminium

The economic activities in this category could be associated with NACE code C24.42, C24.53 in accordance with the statistical classification of economic activities established by Regulation (EC) No 1893/2006. To be noted,

secondary aluminium is excluded from the factsheet "Manufacture of metals" and will be treated in the factsheet waste and waste management sector (to come).

Technical Screening Criteria

Substantial contribution to Climate change mitigation

The activity manufactures one of the following:

(a) primary aluminium where the economic activity complies with two of the following criteria until 2025 and with all of the following criteria [137] after 2025:

(i) the GHG emissions do not exceed 1,604 [138] tCO2e per ton of aluminium manufactured [139];

(ii) the indirect GHG emissions do not exceed 270 g CO2e/kWh;

(iii) the electricity consumption for the manufacturing process does not exceed 15,5 MWh/t Al;

(b) secondary aluminium.

Manufacture of Iron and Steel

The economic activities in this category could be associated with several NACE codes, in particular C24.10, C24.20, C24.31, C24.32, C24.33, C24.34, C24.51 and C24.52 in accordance with the statistical classification of economic activities established by Regulation (EC) No 1893/2006. To be noted, secondary metals from those industries are excluded from the factsheet "Manufacture of metals" and will be addressed in the factsheet waste and waste management sector.

Technical Screening Criteria

Substantial contribution to Climate change mitigation

The activity manufactures one of the following:

(a) iron and steel where GHG emissions [111], reduced by the amount of emissions assigned to the production of waste gases in accordance with point 10.1.5(a) of Annex VII to Regulation (EU) 2019/331 do not exceed the following values applied to the different manufacturing process steps:

(i) hot metal = 1,331 [112] tCO2e/t product;

(ii) sintered ore = 0,163 [113] tCO2e/t product;

(iii) coke (excluding lignite coke) = 0,144 [114] tCO2e/t product;

(iv) iron casting = 0,299 [115] tCO2e/t product;

(v) electric Arc Furnace (EAF) high alloy steel = 0,266 [116] tCO2e/t product;

(vi) electric Arc Furnace (EAF) carbon steel = 0,209 [117] tCO2e/t product.

(b) steel in electric arc furnaces (EAFs) producing EAF carbon steel or EAF high alloy steel, as defined in Commission Delegated Regulation (EU) 2019/331 and where the steel scrap input relative to product output is not lower than:

(i) 70 % for the production of high alloy steel;

(ii) 90 % for the production of carbon steel.

3. Recommendations from the Platform for sustainable Finance

In October 2022, the Platform on Sustainable Finance (PSF) provided several recommendations for the Commission in consideration of future work on taxonomy development gained through the two-year (Oct 2020 - Oct 2022) experience.

One of the chapter concerns the production of copper as they consider "the twin energy and digital transition intensive" and "metals production as an energy intensive process"(PLATFORM ON SUSTAINABLE FINANCE 2022). Their recommendations cover both primary and secondary products (the latter one is excluded from the benchmark factsheet "Manufacture of metals").

Here are the Technical Screening Criteria (TSC) they recommend for the production of first copper:

Substantial contribution to climate change mitigation

The economic activity is recognised as substantially contributing to climate change mitigation objective where it manufactures one of the following:

a. **Copper from Primary Resources using Pyrometallurgical Route where the economic activity complies with all of the following criteria:**
   - the direct GHG emissions intensity does not exceed 315 kg CO2 per ton of metal manufactured. *The value is adjusted to reflect ambition required by Paris Agreement.*
   - the electricity consumption for the manufacturing process does not exceed 988 kWh/t metal manufactured. *The value is adjusted to reflect ambition required by Paris Agreement.*
   - the average carbon intensity of the electricity does not exceed 100g CO2e/kWh.

The activities being considered for defining TSC's are roasting, smelting and refining of metals from Primary and Secondary infeed materials from pyrometallurgical route and leaching and refining of metals from Primary resources using hydrometallurgical route and fabrication of products using intermediate refined metals and secondary raw materials.

The following **solutions and corresponding technologies** decrease the carbon intensity of metals production (t CO2/t of metals). (Best Available Techniques (BAT) Reference Document for the Non-Ferrous Metals Industries)

1. By improving energy efficiency
2. By use of more metal containing secondary materials
3. By electrification and consumption of renewable and fossil free electricity,
4. By use of non-fossil reduction agents and alternative fossil free fuels.
5. By roasting of carbon containing fraction of the infeed materials before it enters the smelting operation.
6. By carbon capture and storage or carbon capture and use.
7. Innovating in other breakthrough manufacturing technologies (Artificial intelligence, data mining etc.).

4. Other European initiatives and regulatory

- The Commission implementing decision (EU) 2022/2110 of 11 October 2022

Published in October 2022, the Commission implemented a new decision (COMMISSION IMPLEMENTING DECISION (EU) 2022/2110 of 11 October 2022) to constrain 1 400 ferrous metals processing plants within the EU to reduce their environmental impact. New installations will have to comply immediately, and existing ferrous metals processing installations will have four years to comply with stricter environmental norms.

The Commission has adopted the conclusions on Best Available Techniques (BAT) for the ferrous metals processing industry, in accordance with the Industrial Emissions Directive 2010/75/EU (IED). The decision containing the BAT conclusions sets emission levels associated with best available techniques (BAT-AELs) for certain activities covered by the IED Directive. This decision is a new step towards the Zero Pollution ambition to reduce air, water and soil pollution to harmless levels to health and natural ecosystems.

These BAT conclusions concern the following activities specified in Annex I to Directive2010/75/EU:

2.3. Processing of ferrous metals:

(a) operation of hot rolling mills with a capacity exceeding 20 tonnes of crude steel per hour;
(c) application of protective fused metal coats with an input exceeding 2 tonnes of crude steel per hour; this includes hot dip coating and batch galvanising.

2.6. Surface treatment of ferrous metals using electrolytic or chemical processes where the volume of the treatment vats exceeds 30 m3, when it is carried out in cold rolling, wire drawing or batch galvanising.

6.11. Independently operated treatment of waste water not covered by Directive 91/271/EEC, provided that the main pollutant load originates from the activities covered by these BAT conclusions.

These BAT conclusions also cover the following:

- Cold rolling and wire drawing if directly associated with hot rolling and/or hot dip coating.
- Acid recovery, if directly associated with the activities covered by these BAT conclusions.

- The combined treatment of waste water from different origins, provided that the waste water treatment is not covered by Directive 91/271/EEC and that the main pollutant load originates from the activities covered by these BAT conclusions.
- Combustion processes directly associated with the activities covered by these BAT conclusions provided that:
    - 1. the gaseous products of combustion are put into direct contact with material (such as direct feedstock heating or direct feedstock drying);
    - or 2. the radiant and/or conductive heat is transferred through a solid wall (indirect heating):
        - without using an intermediary heat transfer fluid (this includes heating of the galvanising kettle),
        - or — when a gas (e.g. H2) acts as the intermediary heat transfer fluid in the case of batch annealing.
- These BAT conclusions do not cover the following:
- metal coating by thermal spraying;
- electroplating and electroless plating; this may be covered by the BAT conclusions for Surface Treatment of Metals and Plastics (STM).

- EIT RawMaterials

EIT RawMaterials, initiated and funded by the European Institute of Innovation and Technology, a body of the European Union, is the largest consortium in the raw materials sector worldwide. To achieve its goal to become the first carbon-neutral continent by 2050, Europe relies on sustainable access to strategic critical raw materials. In one of their main innovative areas, lighthouse responsive sourcing, three approaches are at the core: achieving a more targeted and cost-effective exploration and quicker transition to mining operation, reducing the environmental footprint of mining and processing, improving the efficiency of mineral and metallurgical processing. Thus, process of production of metals are included in their strategy with the goal to reduce their environmental footprint but to allow to have enough metals for the ecological transition.

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CDC BIODIVERSITÉ

141 avenue de Clichy
75017 PARIS
T. +33 (0)1 80 40 15 00

contact@cdc-biodiversite.fr
www.cdc-biodiversite.fr

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RCS Paris 501 639 587
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