RAW MATERIALS EXTRACTION

BIODIVERSITY FOOTPRINT

Sectoral appendix

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Version 1 – DRAFT

CDC BIODIVERSITÉ

Table of contents

A. PURPOSE OF THE DOCUMENT

The current **sectoral appendix** supports the **Raw materials extraction 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.

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 covers the raw material extraction sector that includes five EXIOBASE industry groups: "Forestry and logging", "Extraction of crude petroleum and natural gas", "Mining of coal and lignite", "Mining of metal" and “Other mining and quarrying”. These groups are themselves divided into industries listed below with their EXIOBASE code:

- **Forestry and logging**
  i02 - Forestry, logging and related service activities (02) [1]
- **Extraction of crude petroleum and natural gas**
  i11.a - Extraction of crude petroleum and services related to crude oil extraction, excluding surveying
  i11.b - Extraction of natural gas and services related to natural gas extraction, excluding surveying
  i11.c - Extraction, liquefaction, and regasification of other petroleum and gaseous materials
- **Mining of coal and lignite**
  i10 - Mining of coal and lignite; extraction of peat (10) [1]
- **Mining of metal**
  i12 - Mining of uranium and thorium ores (12) [1]
  i13.1 - Mining of iron ores
  i13.20.11 - Mining of copper ores and concentrates
  i13.20.12 - Mining of nickel ores and concentrates
  i13.20.13 - Mining of aluminium ores and concentrates
  i13.20.14 - Mining of precious metal ores and concentrates
  i13.20.15 - Mining of lead, zinc and tin ores and concentrates
  i13.20.16 - Mining of other non-ferrous metal ores and concentrates
- **Other mining and quarrying**
  i14.1 - Quarrying of stone
  i14.2 - Quarrying of sand and clay
  i14.3 - Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.

These EXIOBASE industry groups are consistent with the following parts of the NACE rev 2 classification: the division 02 “Forestry and logging” of the section A “Agriculture forestry and fishing” and the entire section B “Mining and Quarrying”, which also includes the extraction of petroleum and gas. A more comprehensive description of the NACE sections concerned with a detailed listing of the economic activities included and excluded is provided in section 3. NACE rev 2 (EUROSTAT 2008).

Figure 2 below shows the correspondence between the EXIOBASE industries covered by the benchmark factsheet and the NACE subdivisions.

[1] Numbers in brackets are included by default in the official EXIOBASE industry names

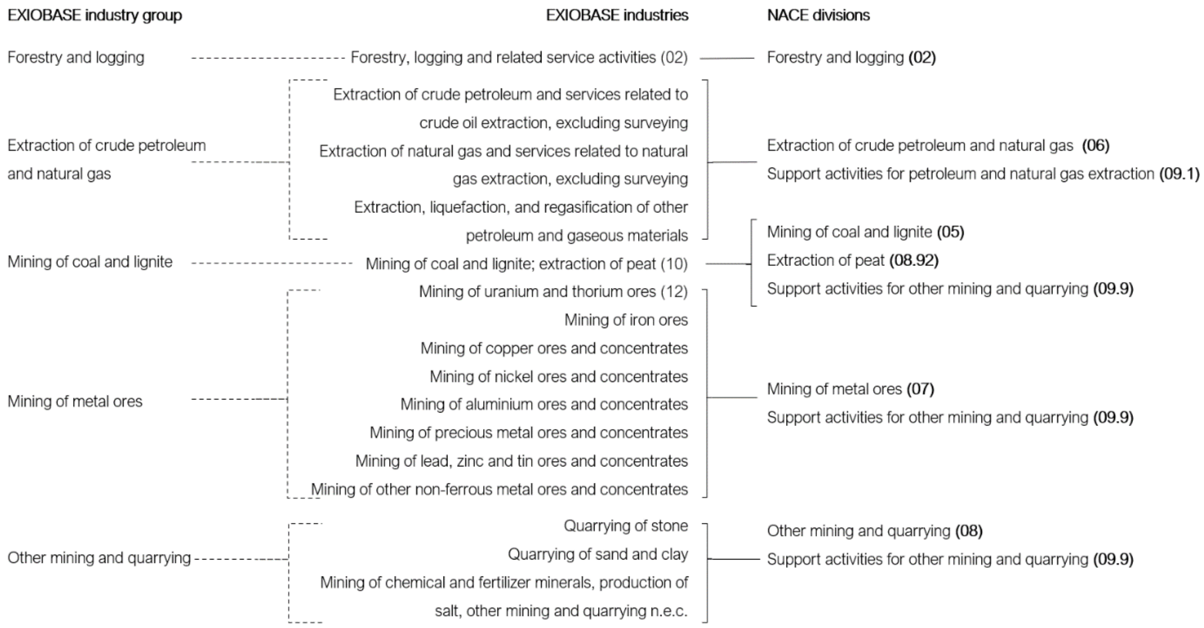


Figure 2: Correspondence between EXIOBASE and NACE rev 2 for the Raw Material Extraction benchmark factsheet

The results in the factsheet are expressed in MSA.m²/kEUR of turnover. The impacts are indeed divided by the turnover of the EXIOBASE industries (the associated unit is therefore the *MSA.m²/kEUR of the EXIOBASE industry*) or by the turnover of a group of industries (expressed in *MSA.m²/kEUR*). Table 1 shows the distribution of the turnovers of the industries included in the Raw materials extraction factsheet. Note that the GBS uses 2011 turnover data and increases it in line with GDP growth.

Table 1:Turnover of the EXIOBASE industries included in the Raw materials extraction benchmark factsheet (data obtained from GBS 1.4.4 and therefore from EXIOBASE 3.8.1)

EXIOBASE industry	Turnover (MEUR)	Share of the EXIOBASE industry in the benchmark perimeter
Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	1 571 000	43 %
Extraction of natural gas and services related to natural gas extraction, excluding surveying	443 000	12 %
Mining of coal and lignite; extraction of peat (10)	437 000	12 %
Forestry, logging and related service activities (02)	260 000	7.2 %
Quarrying of sand and clay	186 000	5.1 %
Mining of iron ores	130 000	3.6 %
Mining of copper ores and concentrates	127 000	3.5 %
Quarrying of stone	117 000	3.2 %
Mining of precious metal ores and concentrates	106 000	2.9 %
Mining of other non-ferrous metal ores and concentrates	90 000	2.5 %
Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	56 000	1.5 %
Mining of lead, zinc and tin ores and concentrates	32 000	0.9 %
Extraction, liquefaction, and regasification of other petroleum and gaseous materials	30 000	0.8 %
Mining of nickel ores and concentrates	21 000	0.6 %
Mining of uranium and thorium ores (12)	15 000	0.4 %
Mining of aluminium ores and concentrates	12 000	0.3 %

EXIOBASE industry	Turnover (MEUR)	Share of the EXIOBASE industry in the benchmark perimeter
Total	**3 633 000**	**100 %**

The Raw materials extraction sector includes the extraction of many different commodities, not leading to the same type of impacts on the environment and not occurring at the same spatial scale. Therefore, and for ease of analysis, the results will always be presented by breaking them down into three main extraction categories: wood harvesting that is related to the EXIOBASE industry group "Forestry and logging"; oil and gas extraction included in the industry group "Extraction of crude petroleum and natural gas"; and finally mining for all other raw materials covered by the industry groups "Mining of coal and lignite", "Mining of metal ores" and "Other mining and quarrying". Moreover, wood burning or the combustion of oil and gas, which are high GHG emitters, are included in Downstream Scope 3 and are not assessed in the perimeter of this factsheet.

Finally, it should also be noted that the raw material extraction sector positions itself upstream of most other economic sectors such as the production of electricity, manufacturing and processing industries. Figure 3 below summarizes the perimeter of the benchmark factsheet.

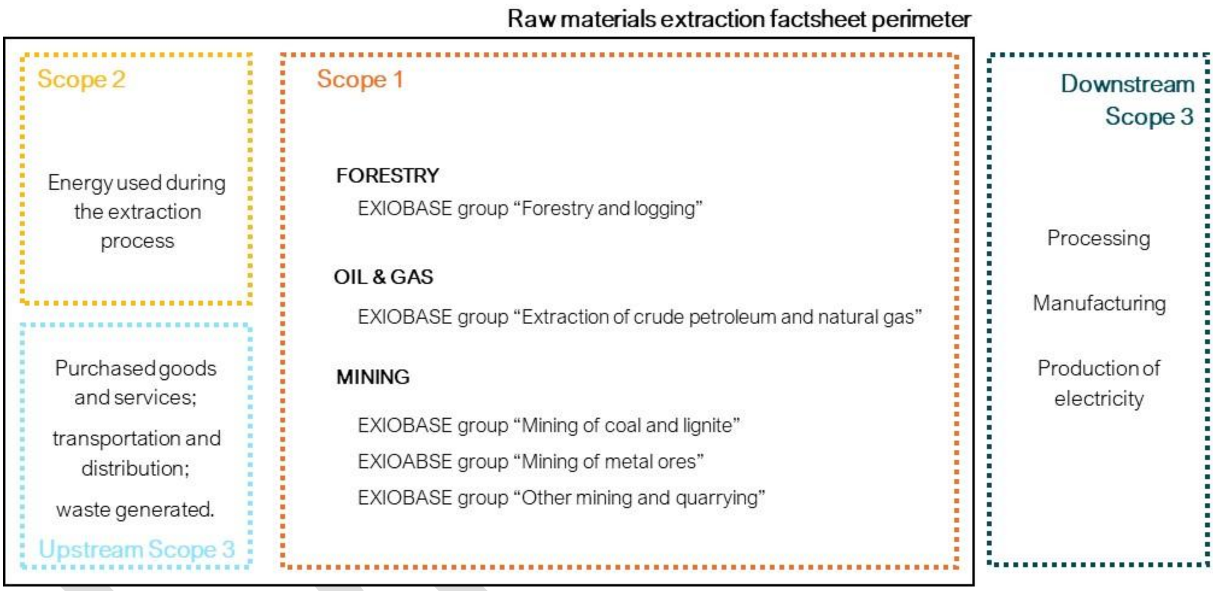


Figure 3: Perimeter of the Raw materials extraction benchmark factsheet and associated Scopes

2. Perimeter of the factsheet for the dependencies analysis

To understand the dependencies of the commodity extraction sector, a correspondence of EXIOBASE and ENCORE is necessary. Figure 4 below illustrates the correspondence between the EXIOBASE industries and the ENCORE sub-industries for the Raw materials extraction sector.

Note that the uranium mining sector is not related to any ENCORE sub-industry because ENCORE does not address the dependencies of uranium mining.

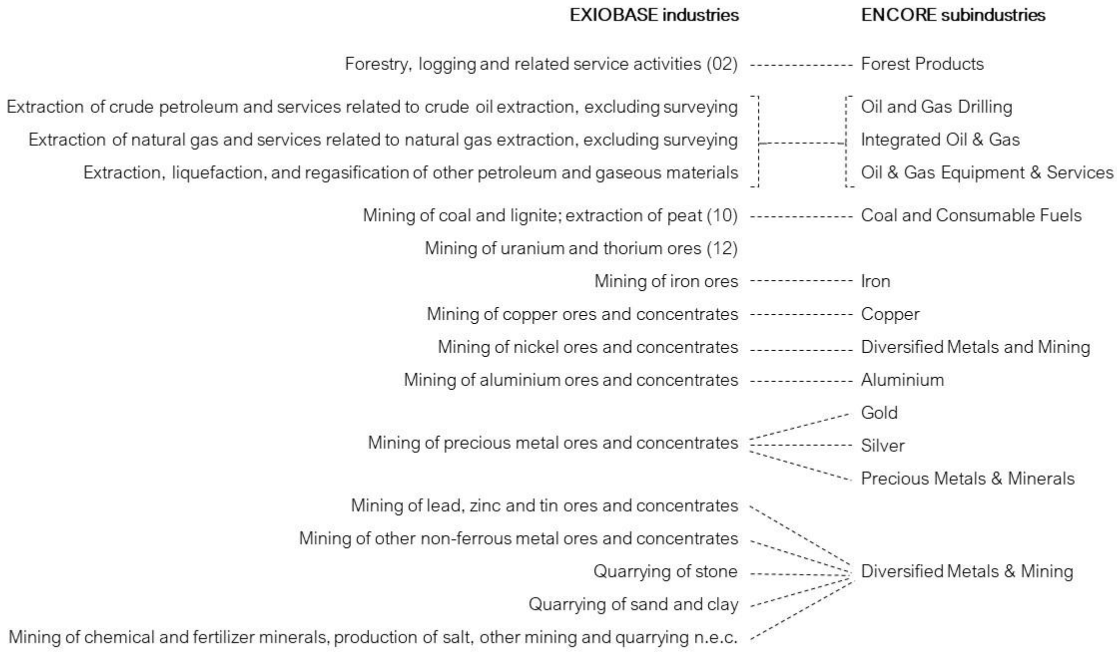


Figure 4: Correspondence between EXIOBASE and ENCORE for the Raw Material Extraction benchmark factsheet

3. NACE rev 2 (EUROSTAT 2008)

This section contains extracts from the NACE rev 2 classification (EUROSTAT 2008) and details the sectors covered by the benchmark factsheet Raw materials extraction.

<u>Section A - Agriculture, forestry and fishing</u>

<u>Forestry and logging **(02)**</u>

This division includes the production of roundwood as well as the extraction and gathering of wild growing non-wood forest products. Besides the production of timber, forestry activities result in products that undergo little processing, such as firewood, charcoal and roundwood used in an unprocessed form (e.g. pit-props, pulpwood etc.). These activities can be carried out in natural or planted forests.

Excluded is further processing of wood beginning with sawmilling and planning of wood, see division 16.

<u>Silviculture and other forestry activities **(02.1)**</u>

<u>Silviculture and other forestry activities **(02.10)**</u>

This class includes:

- growing of standing timber: planting, replanting, transplanting, thinning and conserving of forests and timber tracts
- growing of coppice, pulpwood and fire wood
- operation of forest tree nurseries

These activities can be carried out in natural or planted forests.

This class excludes:

- growing of Christmas trees, see 01.29
- operation of tree nurseries, except for forest trees, see 01.30
- gathering of mushrooms and other wild growing non-wood forest products, see 02.30
- production of wood chips and particles, see 16.10

<u>Logging **(02.2)**</u>

<u>Logging **(02.20)**</u>

This class includes:

- production of roundwood for forest-based manufacturing industries

- production of roundwood used in an unprocessed form such as pit-props, fence posts and utility poles
- gathering and production of wood for energy
- gathering and production of forest harvesting residues for energy
- production of charcoal in the forest (using traditional methods)

The output of this activity can take the form of logs or fire wood.

This class excludes:

- growing of Christmas trees, see 01.29
- growing of standing timber: planting, replanting, transplanting, thinning and conserving of forests and timber tracts, see 02.10
- gathering of wild growing non-wood forest products, see 02.30
- production of wood chips and particles, see 16.10
- production of charcoal through distillation of wood, see 20.14

Gathering of wild growing non-wood products **(02.3)**

Gathering of wild growing non-wood products **(02.30)**

This class includes:

- gathering of wild growing materials:
  - mushrooms, truffles
  - berries
  - nuts
  - balata and other rubber-like gums
  - cork
  - lac and resins
  - balsams
  - vegetable hair
  - eelgrass
  - acorns, horse chestnuts
  - mosses and lichens

This class excludes:

- managed production of any of these products (except growing of cork trees), see division 01
- growing of mushrooms or truffles, see 01.13
- growing of berries or nuts, see 01.25
- gathering of fire wood, see 02.20
- production of wood chips, see 16.10

Support services to forestry **(02.4)**

Support services to forestry **(02.40)**

This class includes carrying out part of the forestry operation on a fee or contract basis. This class includes:

- forestry service activities:
  - forestry inventories
  - forest management consulting services
  - timber evaluation
  - forest fire fighting and protection
  - forest pest control
- logging service activities:
  - transport of logs within the forest

This class excludes:

- operation of forest tree nurseries, see 02.10
- draining of forestry land, see 43.12
- clearing of building sites, see 43.12

Section B – Mining and Quarrying

Mining and quarrying include the extraction of minerals occurring naturally as solids (coal and ores), liquids (petroleum) or gases (natural gas). Extraction can be achieved by different methods such as underground or surface mining, well operation, seabed mining etc.

This section includes supplementary activities aimed at preparing the crude materials for marketing, for example, crushing, grinding, cleaning, drying, sorting, concentrating ores, liquefaction of natural gas and agglomeration of solid fuels. These operations are often accomplished by the units that extracted the resource and/or others located nearby.
Mining activities are classified into divisions, groups and classes on the basis of the principal mineral produced. Divisions 05, 06 are concerned with mining and quarrying of fossil fuels (coal, lignite, petroleum, gas); divisions 07, 08 concern metal ores, various minerals and quarry products.
Some of the technical operations of this section, particularly related to the extraction of hydrocarbons, may also be carried out for third parties by specialised units as an industrial service which is reflected in division 09.
This section excludes:

- processing of the extracted materials, see section C (Manufacturing)
- usage of the extracted materials without a further transformation for construction purposes, see section F (Construction)
- bottling of natural spring and mineral waters at springs and wells, see 11.07
- crushing, grinding or otherwise treating certain earths, rocks and minerals not carried on in conjunction with mining and quarrying, see 23.9

Mining of coal and lignite **(05)**

This division includes the extraction of solid mineral fuels through underground or open-cast mining and includes operations (e.g. grading, cleaning, compressing and other steps necessary for transportation etc.) leading to a marketable product.
This division does not include coking (see 19.10), services incidental to coal or lignite mining (see 09.90) or the manufacture of briquettes (see 19.20).

Mining of hard coal **(05.1)**

Mining of hard coal **(05.10)**

This class includes:

- mining of hard coal: underground or surface mining, including mining through liquefaction methods
- cleaning, sizing, grading, pulverising, compressing etc. of coal to classify, improve quality or facilitate transport or storage

This class also includes:

- recovery of hard coal from culm banks

This class excludes:

- lignite mining, see 05.20
- peat digging, see 08.92
- support activities for hard coal mining, see 09.90
- test drilling for coal mining, see 09.90
- coke ovens producing solid fuels, see 19.10
- manufacture of hard coal briquettes, see 19.20
- work performed to develop or prepare properties for coal mining, see 43.12

Mining of lignite **(05.2)**

Mining of lignite **(05.20)**

This class includes:

- mining of lignite (brown coal): underground or surface mining, including mining through liquefaction methods
- washing, dehydrating, pulverising, compressing of lignite to improve quality or facilitate transport or storage

This class excludes:

- hard coal mining, see 05.10
- peat digging, see 08.92
- support activities for lignite mining, see 09.90
- test drilling for coal mining, see 09.90
- manufacture of lignite fuel briquettes, see 19.20
- work performed to develop or prepare properties for coal mining, see 43.12

Extraction of crude petroleum and natural gas **(06)**

This division includes the production of crude petroleum, the mining and extraction of oil from oil shale and oil sands and the production of natural gas and recovery of hydrocarbon liquids. This division includes the activities of operating and/or developing oil and gas field properties. Such activities may include drilling, completing and equipping wells; operating separators, emulsion breakers, desalting equipment and field gathering lines for crude petroleum; and all other activities in the preparation of oil and gas up to the point of shipment from the producing property.

This division excludes:

- oil and gas field services, performed on a fee or contract basis, see 09.10
- oil and gas well exploration, see 09.10
- test drilling and boring, see 09.10
- refining of petroleum products, see 19.20
- geophysical, geologic and seismic surveying, see 71.12

Extraction of crude petroleum **(06.1)**

Extraction of crude petroleum **(06.10)**

This class includes:

- extraction of crude petroleum oils

This class also includes:

- extraction of bituminous or oil shale and tar sand
- production of crude petroleum from bituminous shale and sand
- processes to obtain crude oils: decantation, desalting, dehydration, stabilisation etc.

This class excludes:

- support activities for oil and natural gas extraction, see 09.10
- oil and gas exploration, see 09.10
- manufacture of refined petroleum products, see 19.20
- recovery of liquefied petroleum gases in the refining of petroleum, see 19.20
- operation of pipelines, see 49.50

Extraction of natural gas **(06.2)**

Extraction of natural gas **(06.20)**

This class includes:

- production of crude gaseous hydrocarbon (natural gas)
- extraction of condensates
- draining and separation of liquid hydrocarbon fractions
- gas desulphurisation

This class also includes:

- mining of hydrocarbon liquids, obtained through liquefaction or pyrolysis

This class excludes:

- support activities for oil and natural gas extraction, see 09.10
- oil and gas exploration, see 09.10
- recovery of liquefied petroleum gases in the refining of petroleum, see 19.20
- manufacture of industrial gases, see 20.11
- operation of pipelines, see 49.50

Mining of metal ores **(07)**

This division includes mining for metallic minerals (ores), performed through underground or open-cast extraction, sea bed mining etc. Also included are ore dressing and beneficiating operations, such as crushing, grinding, washing, drying, sintering, calcining or leaching ore, gravity separation or flotation operations.

This division excludes:

- roasting of iron pyrites, see 20.13
- production of aluminium oxide, see 24.42
- operation of blast furnaces, see division 24

Mining of iron ores **(07.1)**

Mining of iron ores **(07.10)**

This class includes:

- mining of ores valued chiefly for iron content

- beneficiation and agglomeration of iron ores

This class excludes:

- extraction and preparation of pyrites and pyrrhotite (except roasting), see 08.91

Mining of non-ferrous metal ores **(07.2)**

This group includes the mining of non-ferrous metal ores.

Mining of uranium and thorium ores **(07.21)**

This class includes:

- mining of ores chiefly valued for uranium and thorium content: pitchblende etc.
- concentration of such ores
- manufacture of yellowcake

This class excludes:

- enrichment of uranium and thorium ores, see 20.13
- production of uranium metal from pitchblende or other ores, see 24.46
- smelting and refining of uranium, see 24.46

Mining of other non-ferrous metal ores **(07.29)**

This class includes:

- mining and preparation of ores chiefly valued for non-ferrous metal content:
  - aluminium (bauxite), copper, lead, zinc, tin, manganese, chrome, nickel, cobalt, molybdenum, tantalum, vana dium etc.
  - precious metals: gold, silver, platinum

This class excludes:

- mining and preparation of uranium and thorium ores, see 07.21
- production of aluminium oxide, see 24.42
- production of mattes of copper or of nickel, see 24.44, 24.45

Other mining and quarrying **(08)**

This division includes extraction from a mine or quarry, but also dredging of alluvial deposits, rock crushing and the use of salt marshes. The products are used most notably in construction (e.g. sands, stones etc.), manufacture of materials (e.g. clay, gypsum, calcium etc.), manufacture of chemicals etc.

This division does not include processing (except crushing, grinding, cutting, cleaning, drying, sorting and mixing) of the minerals extracted.

Quarrying of stone, sand and clay **(08.1)**

Quarrying of ornamental and building stone, limestone, gypsum, chalk and slate **(08.11)**

This class includes:

- quarrying, rough trimming and sawing of monumental and building stone such as marble, granite, sandstone etc.
- breaking and crushing of ornamental and building stone
- quarrying, crushing and breaking of limestone
- mining of gypsum and anhydrite
- mining of chalk and uncalcined dolomite

This class excludes:

- mining of chemical and fertiliser minerals, see 08.91
- production of calcined dolomite, see 23.52
- cutting, shaping and finishing of stone outside quarries, see 23.70

Operation of gravel and sand pits; mining of clays and kaolin **(08.12)**

This class includes:

- extraction and dredging of industrial sand, sand for construction and gravel
- breaking and crushing of gravel
- quarrying of sand
- mining of clays, refractory clays and kaolin

This class excludes:

- mining of bituminous sand, see 06.10

Mining and quarrying n.e.c. **(08.9)**

Mining of chemical and fertiliser minerals **(08.91)**

This class includes:

- mining of natural phosphates and natural potassium salts
- mining of native sulphur
- extraction and preparation of pyrites and pyrrhotite, except roasting
- mining of natural barium sulphate and carbonate (barytes and witherite), natural borates, natural magnesium sulphates (kieserite)
- mining of earth colours, fluorspar and other minerals valued chiefly as a source of chemicals

This class also includes:

- guano mining

This class excludes:

- extraction of salt, see 08.93
- roasting of iron pyrites, see 20.13
- manufacture of synthetic fertilisers and nitrogen compounds, see 20.15

Extraction of peat **(08.92)**

This class includes:

- peat digging
- preparation of peat to improve quality or facilitate transport or storage

This class excludes:

- service activities incidental to peat mining, see 09.90
- manufacturing of peat briquettes, see 19.20
- manufacture of potting soil mixtures of peat, natural soil, sands, clays, fertiliser minerals etc., see 20.15
- manufacture of articles of peat, see 23.99

Extraction of salt **(08.93)**

This class includes:

- extraction of salt from underground including by dissolving and pumping
- salt production by evaporation of sea water or other saline waters
- crushing, purification and refining of salt by the producer

This class excludes:

- processing of salt into food-grade salt, e.g. iodised salt, see 10.84
- potable water production by evaporation of saline water, see 36.00

Other mining and quarrying n.e.c. **(08.99)**

This class includes:

- mining and quarrying of various minerals and materials:
  - abrasive materials, asbestos, siliceous fossil meals, natural graphite, steatite (talc), feldspar etc.
  - natural asphalt, asphaltites and asphaltic rock; natural solid bitumen
  - gemstones, quartz, mica etc.

Mining support service activities **(09)**

This division includes specialized support services incidental to mining provided on a fee or contract basis. It includes exploration services through traditional prospecting methods such as taking core samples and making geological observations as well as drilling, test-drilling or redrilling for oil wells, metallic and non-metallic minerals. Other typical services cover building oil and gas well foundations, cementing oil and gas well casings, cleaning, bailing and swabbing oil and gas wells, draining and pumping mines, overburden removal services at mines, etc.

Support activities for petroleum and natural gas extraction **(09.1)**

Support activities for petroleum and natural gas extraction **(09.10)**

This class includes:

- oil and gas extraction service activities provided on a fee or contract basis:
  - exploration services in connection with petroleum or gas extraction, e.g. traditional prospecting methods, such as making geological observations at prospective sites

• directional drilling and redrilling; „spudding in“; derrick erection in situ, repairing and dismantling; cementing oil and gas well casings; pumping of wells; plugging and abandoning wells etc.
• liquefaction and regasification of natural gas for purpose of transport, done at the mine site
• draining and pumping services, on a fee or contract basis
• test drilling in connection with petroleum or gas extraction

This class also includes:

- oil and gas field fire fighting services

This class excludes:

- service activities performed by operators of oil or gas fields, see 06.10, 06.20
- specialized repair of mining machinery, see 33.12
- liquefaction and regasification of natural gas for purpose of transport, done off the mine site, see 52.21
- geophysical, geologic and seismic surveying, see 71.12

Support activities for other mining and quarrying **(09.9)**

Support activities for other mining and quarrying **(09.90)**

This class includes:

- support services on a fee or contract basis, required for mining activities of divisions 05, 07 and 08
  • exploration services, e.g. traditional prospecting methods, such as taking core samples and making geological observations at prospective sites
  • draining and pumping services, on a fee or contract basis
  • test drilling and test hole boring

This class excludes:

- operating mines or quarries on a contract or fee basis, see division 05, 07 or 08
- specialized repair of mining machinery, see 33.12
- geophysical surveying services, on a contract or fee basis, see 71.12

C. ADDITIONAL RESULTS

1. Overall sector's impacts

The following calculations were performed using GBS 1.4.4 in March 2023. Note that the results are subject to some uncertainties and that the methodology for calculating impacts has some limitations, which are detailed in Section C.3.

1.1 Impacts of the benchmark sector

Table 2 provides the absolute impact of the Raw materials extraction sector in MSA.km² for Scope 1 and Table 3 for vertically integrated results. The terrestrial static impacts include impacts related to the pressure Climate Change. The methodology to obtain those impacts is detailed in Section 5.

Table 2: Absolute Scope 1 biodiversity impact of the Raw materials extraction sector, computation with GBS 1.4.4

Realm	Accounting category	Scope 1 impact in MSA.km²		
		Forestry	Oil & Gas	Mining
Terrestrial	Static	3 200 000	630 000	890 000
	Dynamic	25 000	12 000	11 000
Aquatic	Static	150 000	1 500	17 000
	Dynamic	*420*	*130*	*230*

Table 3: Absolute vertically integrated biodiversity impact of the Raw materials extraction sector, computation with GBS 1.4.4

Realm	Accounting category	Vertically integrated impact in MSA.km²		
		Forestry	Oil & Gas	Mining
Terrestrial	Static	3 900 000	970 000	1 400 000
	Dynamic	30 000	16 000	17 000
Aquatic	Static	180 000	17 000	42 000
	Dynamic	*580*	*240*	*380*

1.2 Impact intensities of the benchmark sector

Table 4 below displays the Scope 1 biodiversity impact figures of the raw materials extraction sector, and Table 5 displays the vertically integrated figures (sum of Scope 1, Scope 2 and Upstream Scope 3) with results are expressed in MSA.m²/kEUR. Table 6 and Table 7 present the results broken down by extraction category (Forestry, Oil & Gas and Mining). 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 and are then aggregated to MSAppb* per bEUR (See 2.3 for methodology).

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 presented elsewhere than in the four tables below.

Table 4: Scope 1 impact intensities for the Raw materials extraction sector, computation with GBS 1.4.4

Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Terrestrial	Static	1 300	9 700	200
	Dynamic	13	100	
Aquatic	Static	46	4 500	
	Dynamic	*0.21*	*21*	

Table 5: Vertically integrated impact intensities for the Raw materials extraction sector, computation with GBS 1.4.4

Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Terrestrial	Static	1 700	13 000	280
	Dynamic	18	130	
Aquatic	Static	67	6 500	
	Dynamic	*0.33*	*32*	

Table 6: Scope 1 impact intensities for the Raw materials extraction sector, computation with GBS 1.4.4

Extraction category	Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Forestry	Terrestrial	Static	12 000	92 000	1 900
		Dynamic	97	730	
	Aquatic	Static	570	56 000	
		Dynamic	*1.6*	*160*	
Oil & gas	Terrestrial	Static	310	2 300	50
		Dynamic	6.1	46	
	Aquatic	Static	0.68	66	
		Dynamic	*0.063*	*6.1*	
Mining	Terrestrial	Static	670	5 000	100
		Dynamic	8.3	62	
	Aquatic	Static	13	1 300	
		Dynamic	*0.17*	*17*	

Table 7:Vertically integrated impact intensities for the Raw materials extraction sector, computation with GBS 1.4.4

Extraction category	Realm	Accounting category	Footprint in MSA.m²/kEUR	Footprint in MSAppb/bEUR	Aggregated score in MSAppb*/bEUR
Forestry	Terrestrial	Static	15 000	110 000	2 400
		Dynamic	120	880	
	Aquatic	Static	710	69 000	
		Dynamic	*2.2*	*220*	
Oil & gas	Terrestrial	Static	480	3 600	80
		Dynamic	8.1	61	
	Aquatic	Static	8.5	830	
		Dynamic	*0.12*	*11*	
Mining	Terrestrial	Static	1 100	8 200	180
		Dynamic	13	96	
	Aquatic	Static	32	3 200	
		Dynamic	*0.30*	*29*	

1.3 Terrestrial static impacts

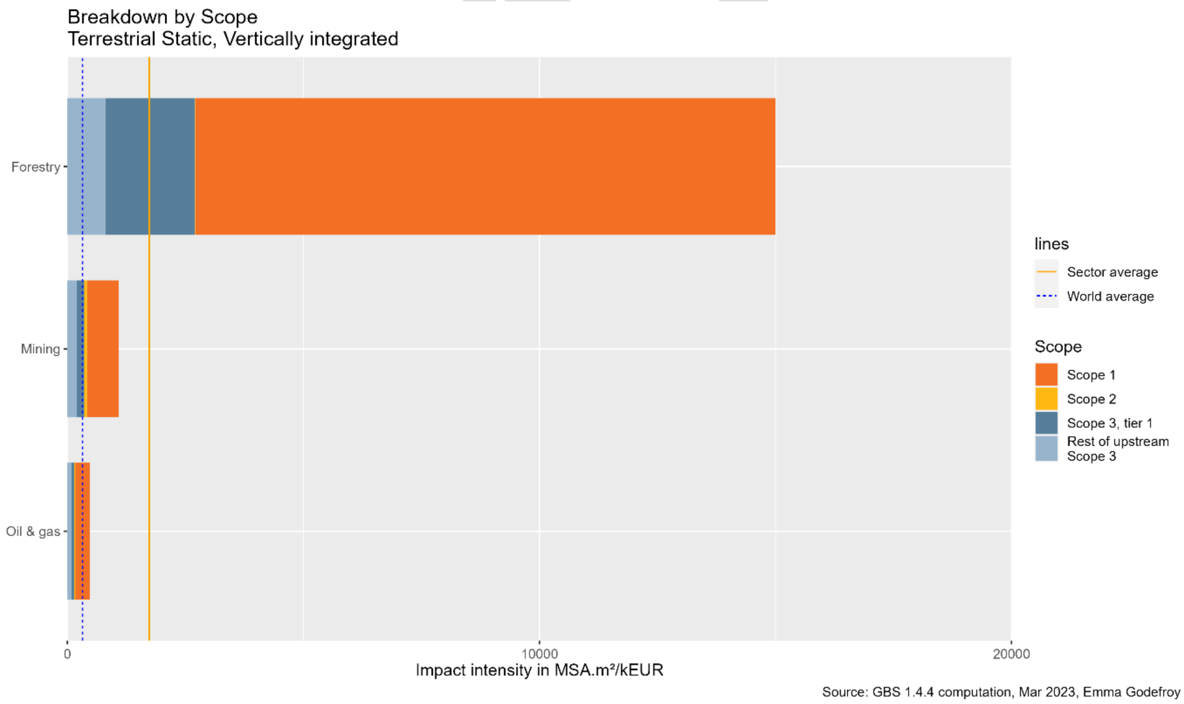


Figure 5: Breakdown by extraction category and Scope, Terrestrial static, Vertically integrated, results by kEUR of each extraction category turnover

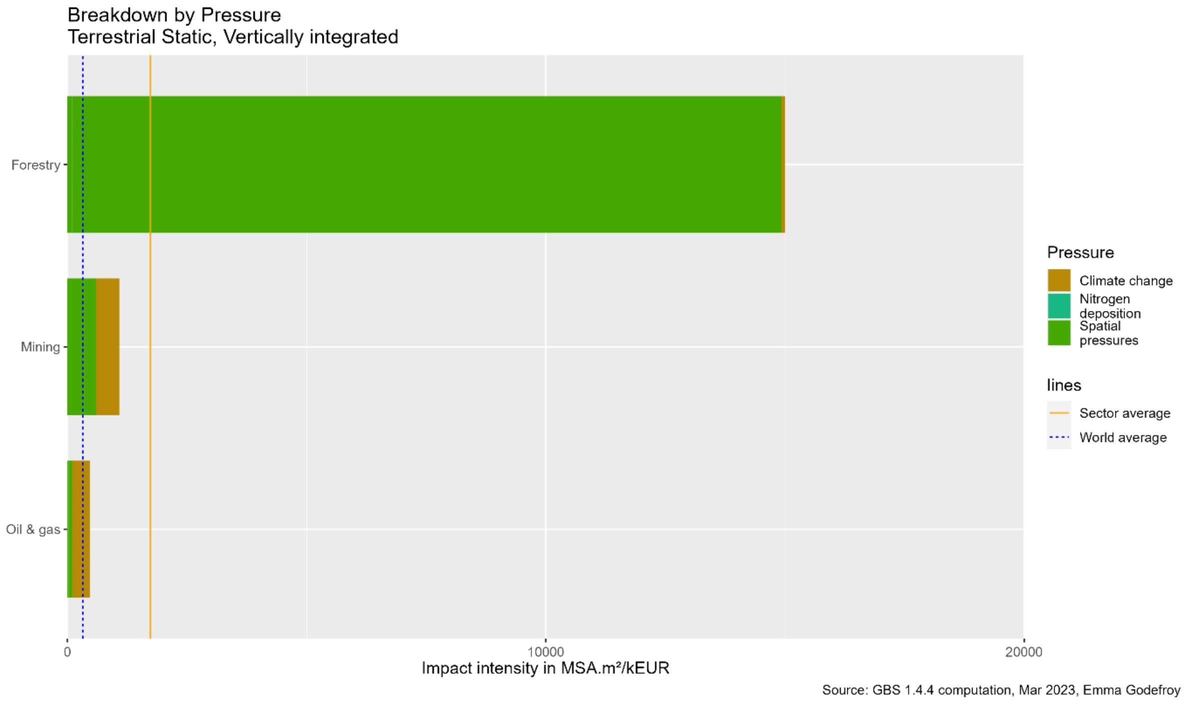


Figure 6: Breakdown by extraction category and pressure, Terrestrial static, Vertically integrated, results by kEUR of each extraction category turnover

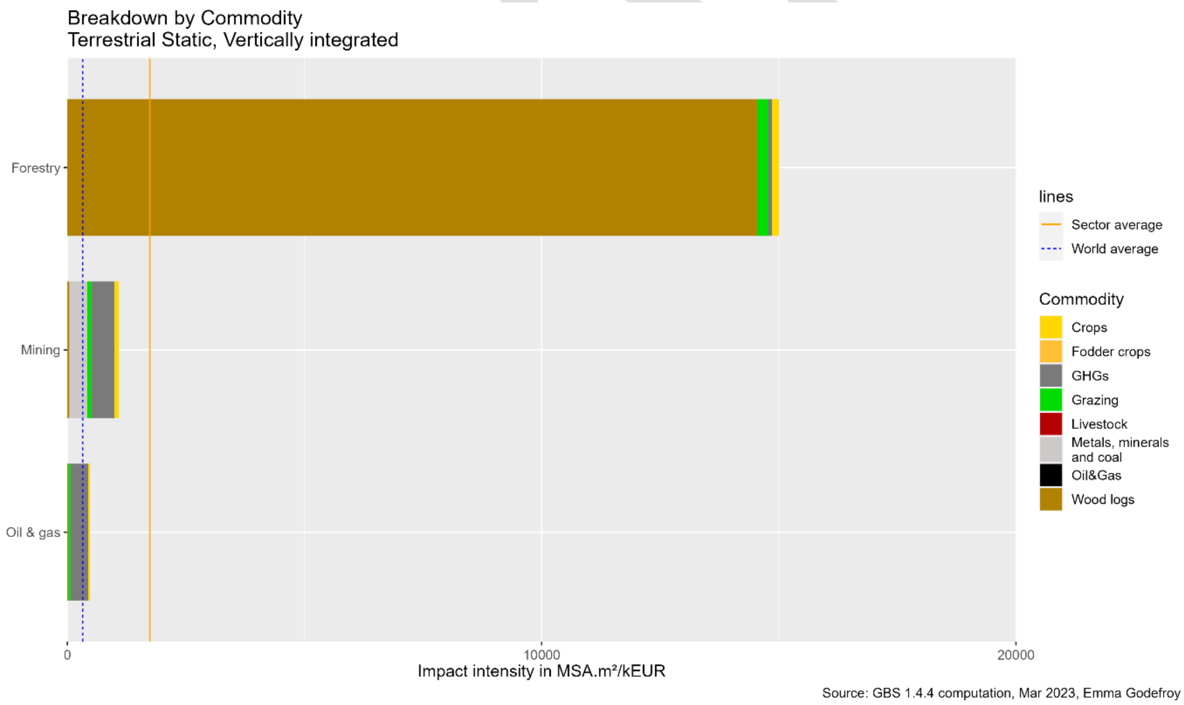


Figure 7: Breakdown by extraction category and commodity, Terrestrial static, Vertically integrated, results by kEUR of each extraction category turnover

The terrestrial static impacts of the forestry category are about ten times greater than those of the mining and oil and gas categories. However, it should be noted that across the entire value chain, the majority of wood impacts occur at the timber harvesting process whereas for oil and gas, most of the impacts occur during the combustion (*i.e.* downstream) through the climate change pressure, and the extraction phase (Scope 1) does not have a significant impact. So the results are not surprising.

Similarly, mining extraction sites are considerably small than logging exploitation areas. It is estimated that mines worldwide cover an area of between 57 000 km² and 102 000 km² (Maus et al. 2022) whereas plantations cover about 1.3 million km² and forests used for production about 11.5 million km² (FAO 2020).

1.4 Terrestrial dynamic impact

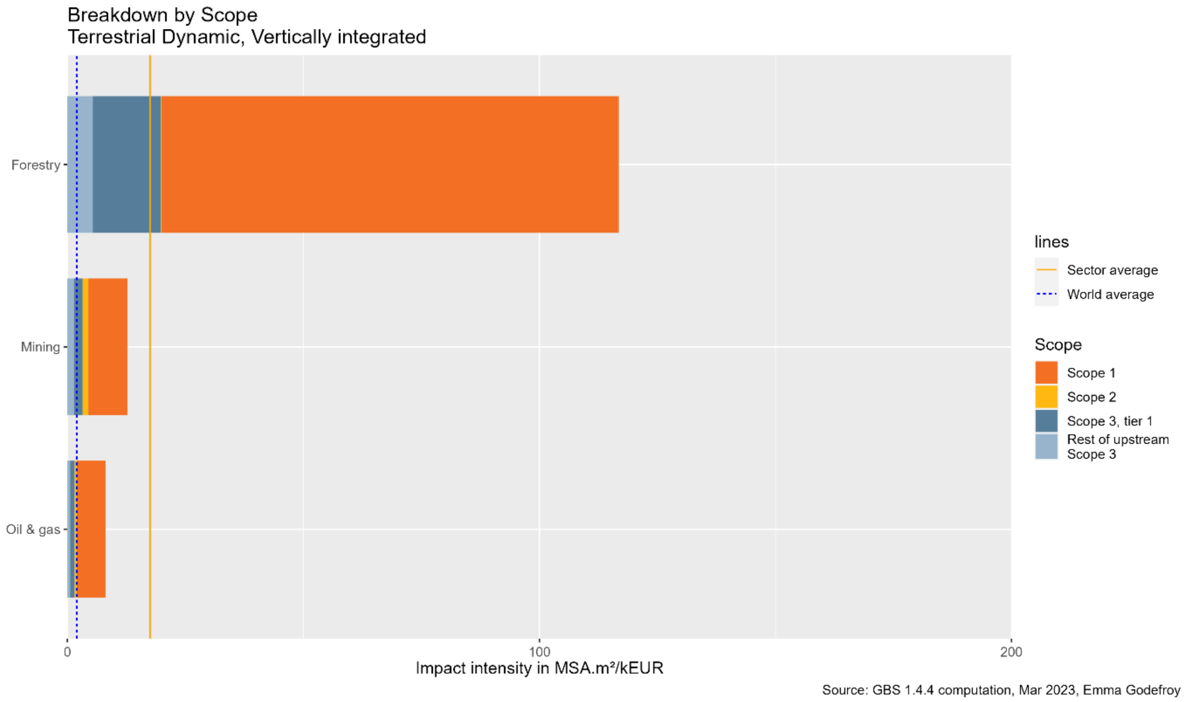


Figure 8: Breakdown by extraction category and Scope, Terrestrial dynamic, Vertically integrated, results by kEUR of each extraction category turnover

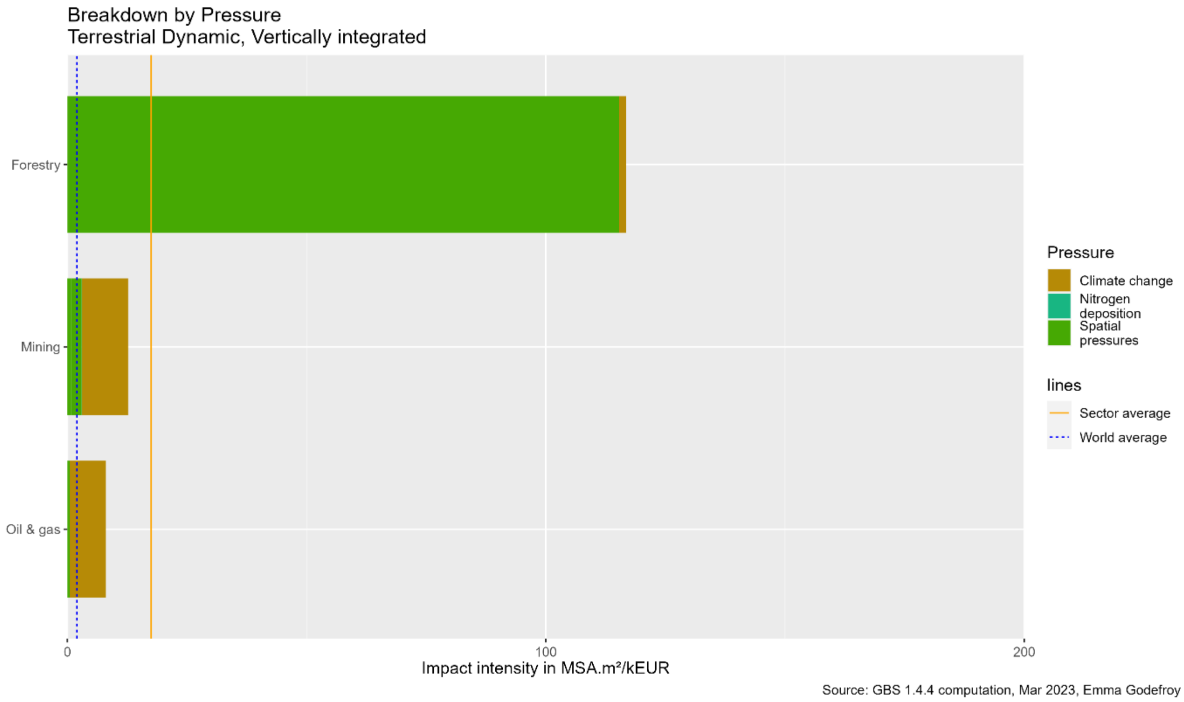


Figure 9: Breakdown by extraction category and pressure, Terrestrial dynamic, Vertically integrated, results by kEUR of each extraction category turnover

Scope 2 impacts account for a significant share of the impacts for the Mining sector and are mainly related to the pressure Climate Change. Mines require significant amounts of energy to operate. A substantial part of the energy is used for the mining equipment: trucks, drills, loaders or dozers. Such machines are mainly powered by fossil fuels. Another source of energy use concerns the comminution process, which consists of crushing and grinding the mines rock into fragments (Engeco, n.d.). It is also important to note that the scarcity of available raw materials will require the deployment of ever-increasing amounts of energy to extract the same amount of raw material and therefore risks increasing the impacts on this pressure in the future.

A large part of the terrestrial dynamic impacts of the Mining and Oil and Gas categories are related to Climate Change pressure, whereas the share of Climate change-related impacts for the forestry sector is low. The impact associated with the destruction of carbon sinks due to logging activities are discussed further in Section C.6.

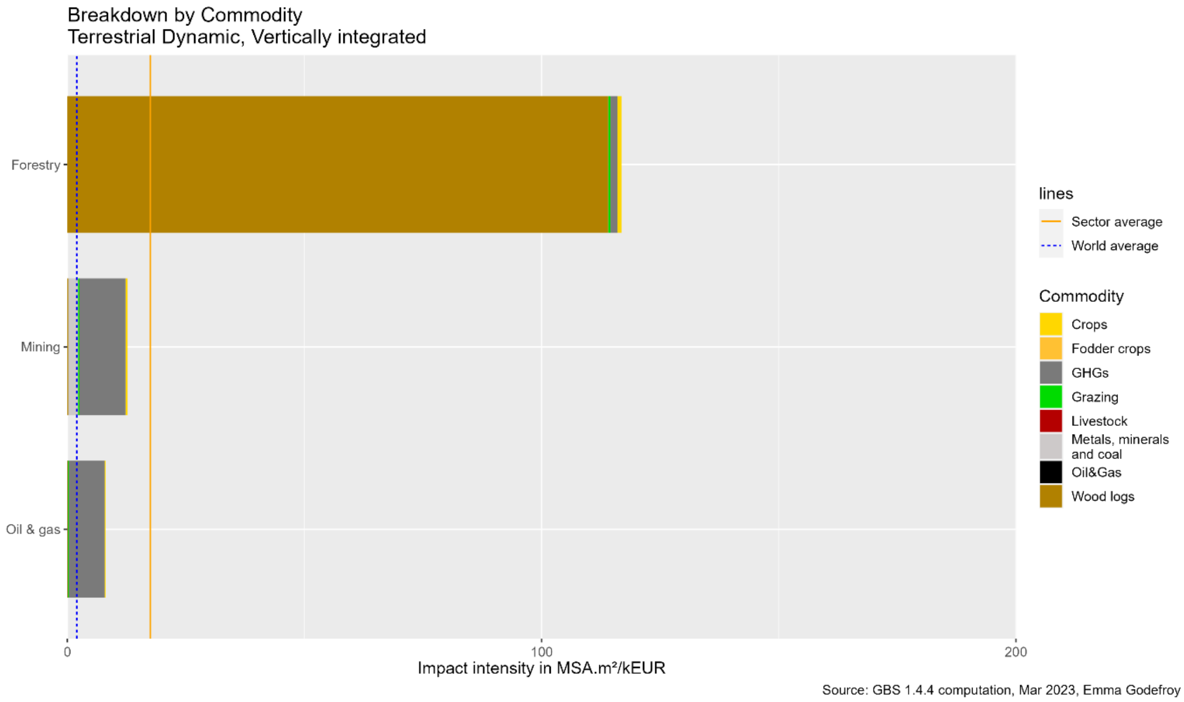


Figure 10: Breakdown by extraction category and commodity, Terrestrial dynamic, Vertically integrated, results by kEUR of each extraction category turnover

1.5 Aquatic static impact

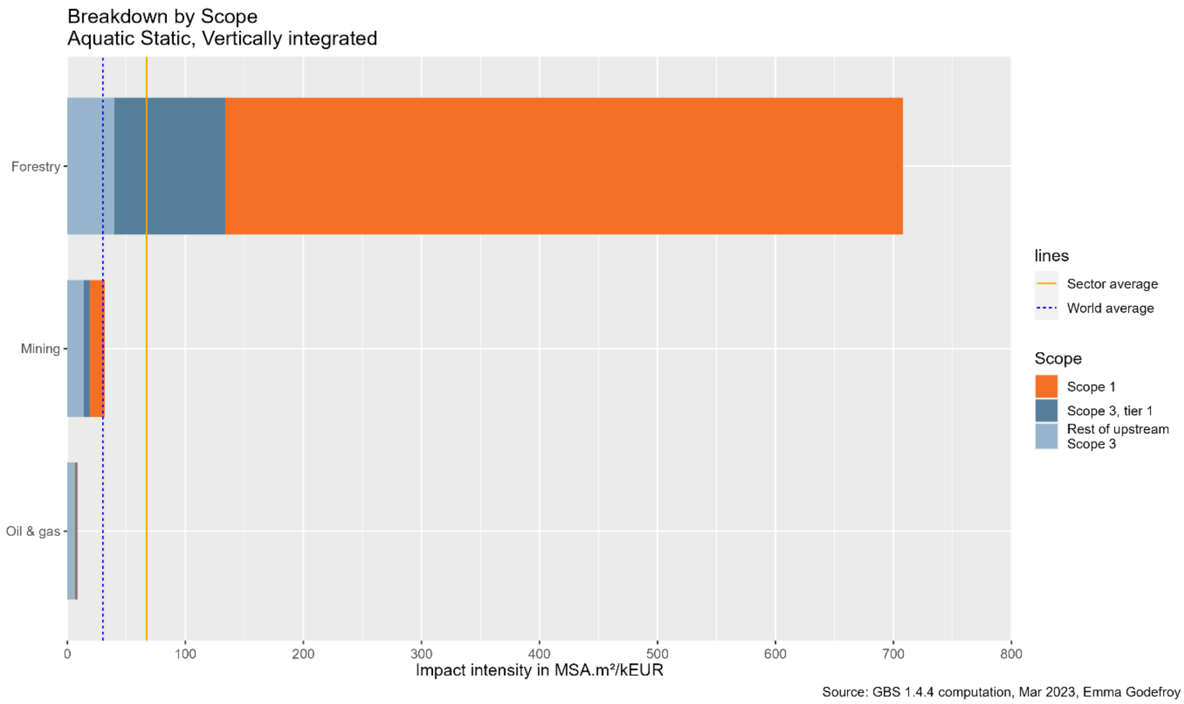


Figure 11: Breakdown by extraction category and Scope, Aquatic static, Vertically integrated, results by kEUR of each extraction category turnover

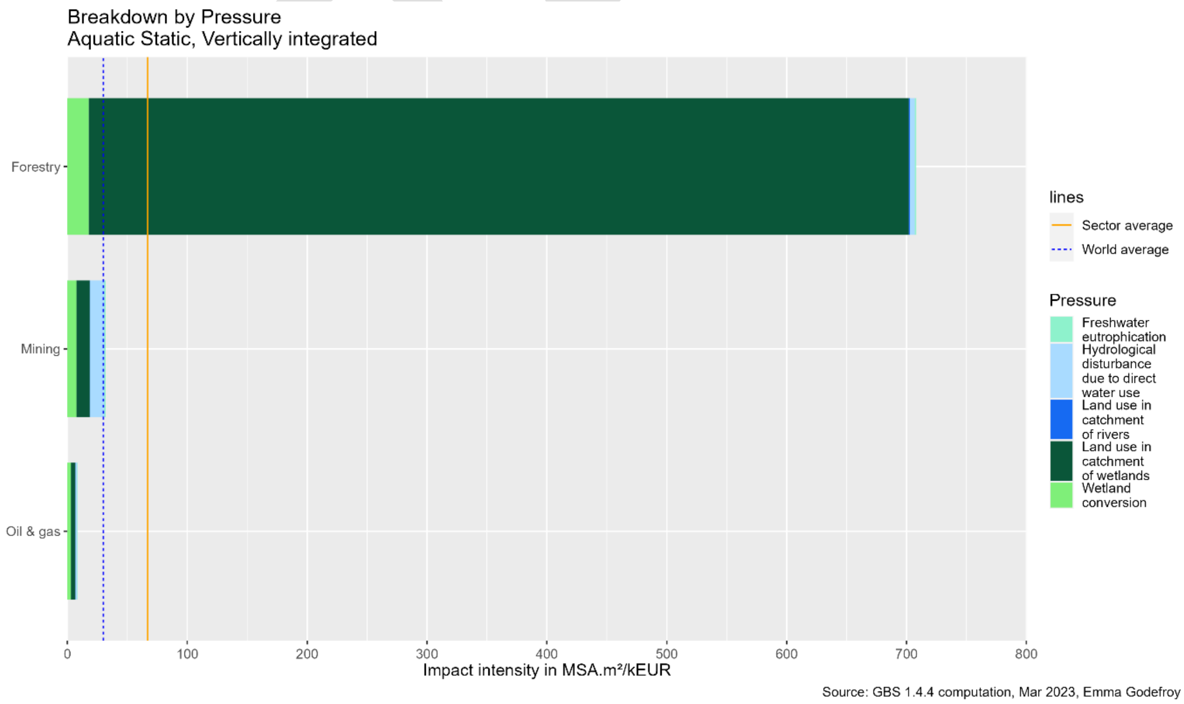


Figure 12: Breakdown by extraction category and pressure, Aquatic static, Vertically integrated, results by kEUR of each extraction category turnover

The most significant impacts are related to the pressure Land use in catchment of wetlands, which is derived from land use data (CDC Biodiversité 2020a). It is therefore consistent that the impacts associated with this pressure are large for the Forestry category.

Impacts related to the pressure Hydrological disturbance due to direct water use are not computed for the Wood logs CommoTool (CDC Biodiversité 2020d). Indeed, very little blue water (ground water and river water for irrigation) is used in forestry systems (which rely mainly on green water from rainfall). The impacts associated to green water use are not yet computed in the GBS, meaning that impacts from direct water use are not calculated. However, the role of green water in forestry will be explored further in Section C.10. The Hydrological disturbance due to direct water use impacts reported for the category are thus caused by other sources in the supply chain.

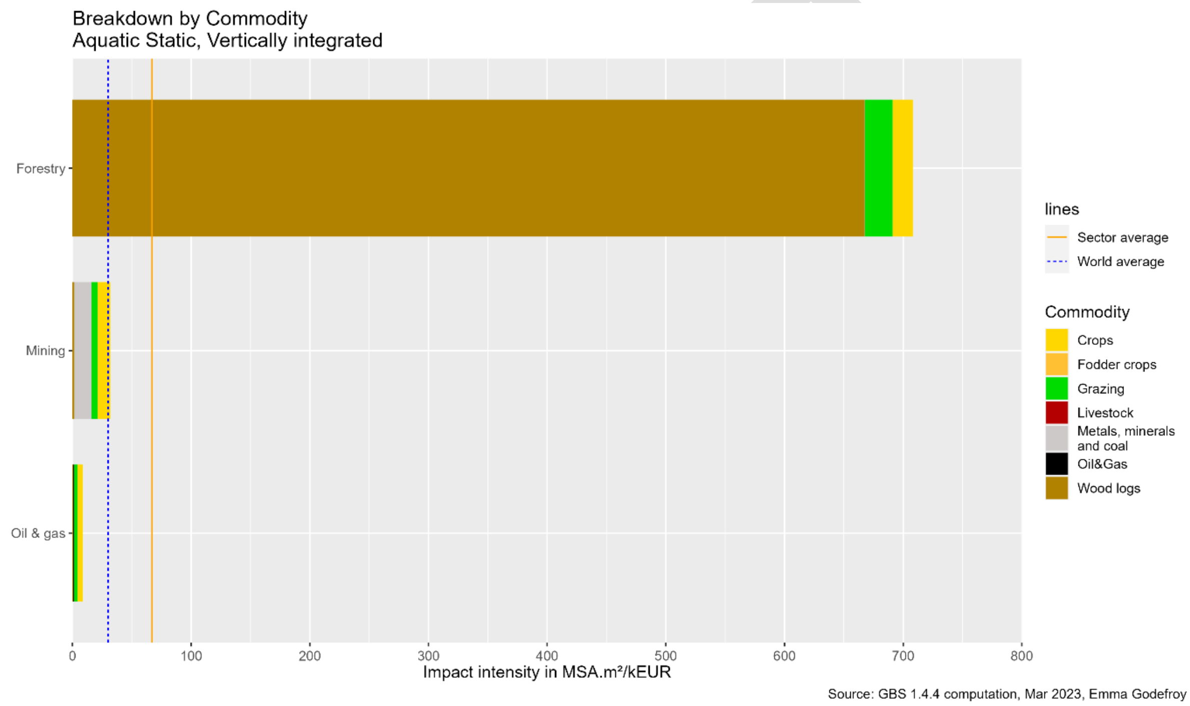


Figure 13: Breakdown by extraction category and commodity, Aquatic static, Vertically integrated, results by kEUR of each extraction category turnover.

A significant portion of the impacts is attributable to the crops and grazing commodities. There is also a small amount of crops and grazing-related impacts in the terrestrial results, but the proportion is higher for the aquatic static impact. The nature of the EXIOBASE financial data used to calculate the benchmark figures can explain these results. Indeed, the impacts related to crops and grazing are Scope 3 impacts of the EXIOBASE industries. The EXIOBASE database reconstitutes the entire upstream value chain of these industries. However, the EXIOBASE data are constructed from small samples and may therefore contain residual materials, which are then integrated into the value chain. For this reason, impacts related to raw materials that are not directly related to the extraction sectors of interest are included.

Those excessive impacts due to the Crops and Grazing commodities are still under examination.

2. 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.

However, the price of raw materials is highly variable and therefore the turnover of the various industries could fluctuate significantly in the coming years (this is the case for fossil fuel commodities for example). Therefore, 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 all the data (turnover and intensity) to reconstruct the impact of the sector in MSA.km².

Two graphs are systematically presented: one with all the EXIOBASE industries of the benchmark sector and one with only the EXIOBASE industries of the Mining and Oil & Gas sectors. Since the high impacts of the Forestry sector tend to flatten the bars of the other industries, the latter helps the reader to see the differences and compare the impacts to the world and sector averages.

2.1 Breakdown by Scope

Figure 14: Breakdown by EXIOBASE industry and Scope, Terrestrial static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

The static terrestrial intensities of metal extraction are very high compared to the intensitiy of industries in other sectors, for example the energy sector.

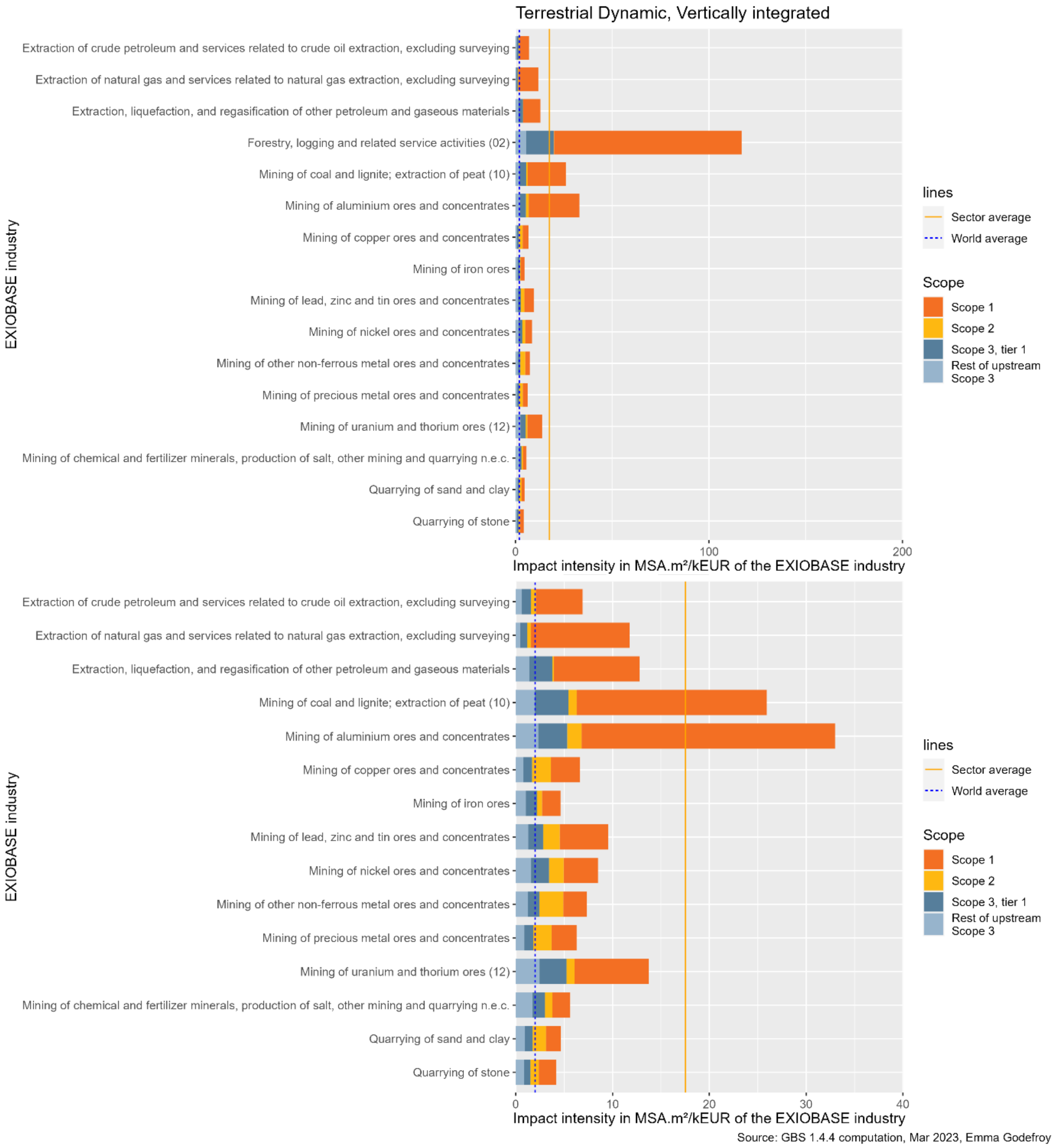


Figure 15: Breakdown by EXIOBASE industry and Scope, Terrestrial dynamic, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

Figure 16: Breakdown by EXIOBASE industry and Scope, Aquatic static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

2.2 Breakdown by pressure

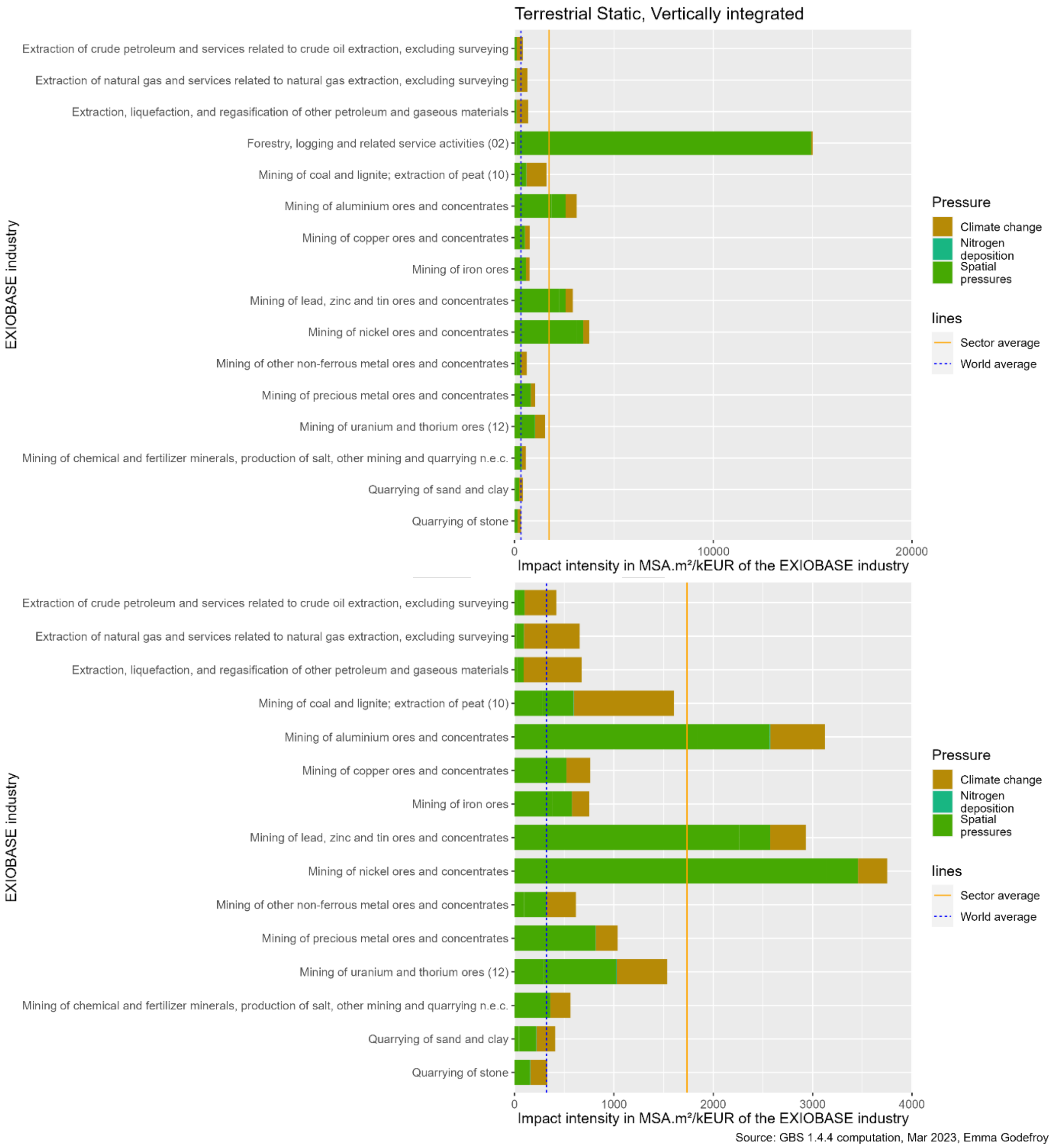
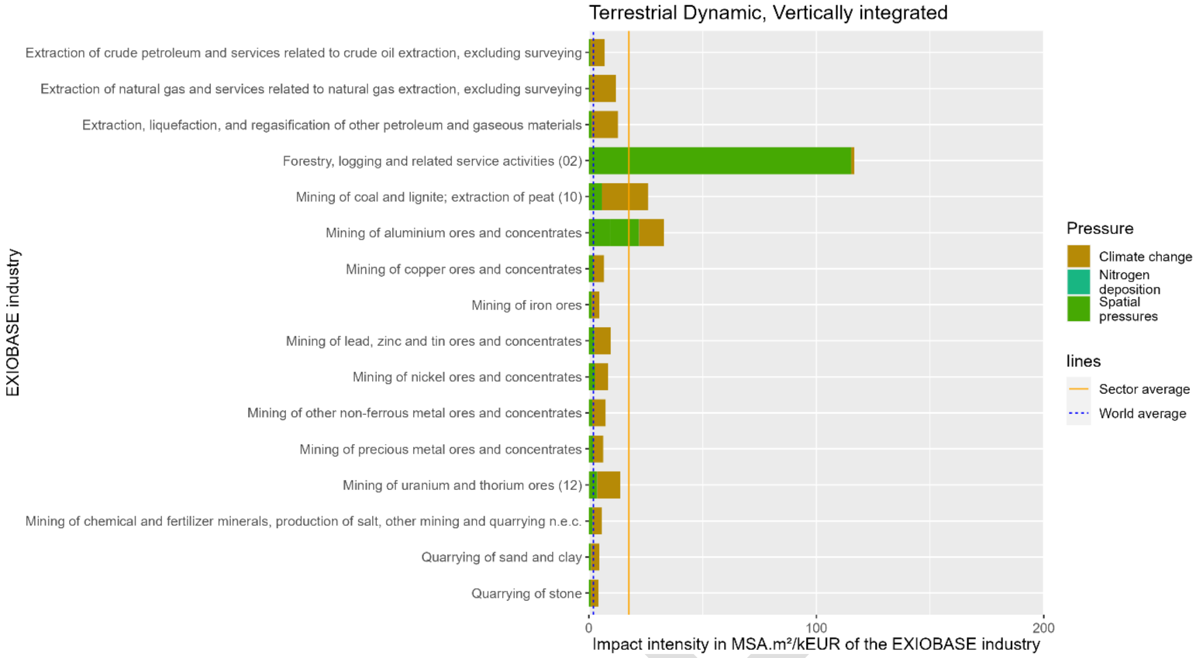


Figure 17: Breakdown by EXIOBASE industry and pressure, Terrestrial static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).



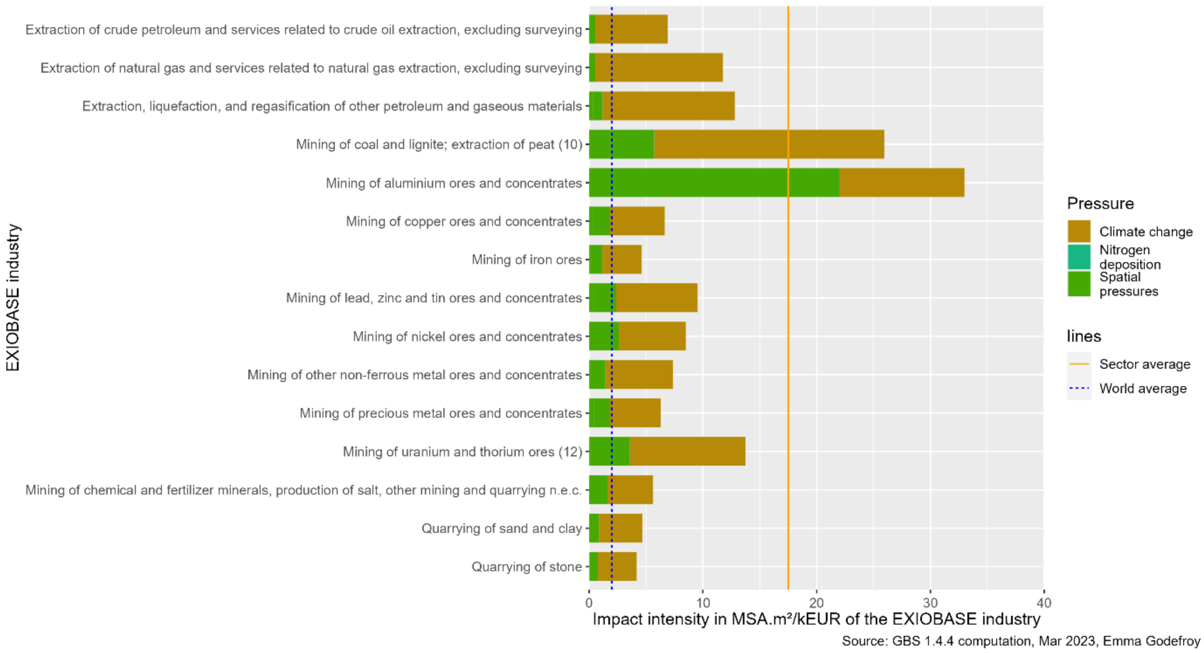


Figure 18: Breakdown by EXIOBASE industry and pressure, Terrestrial dynamic, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

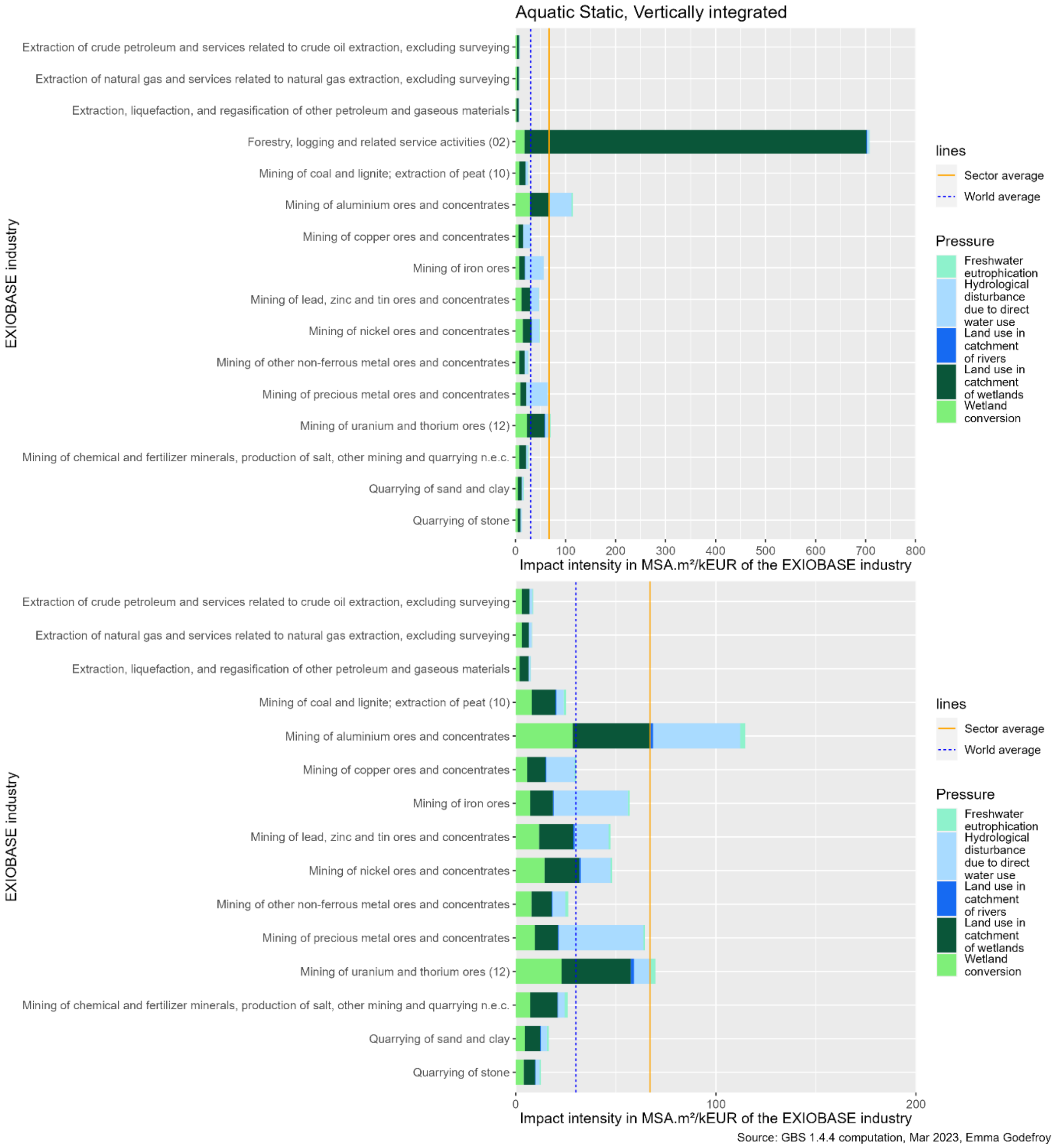
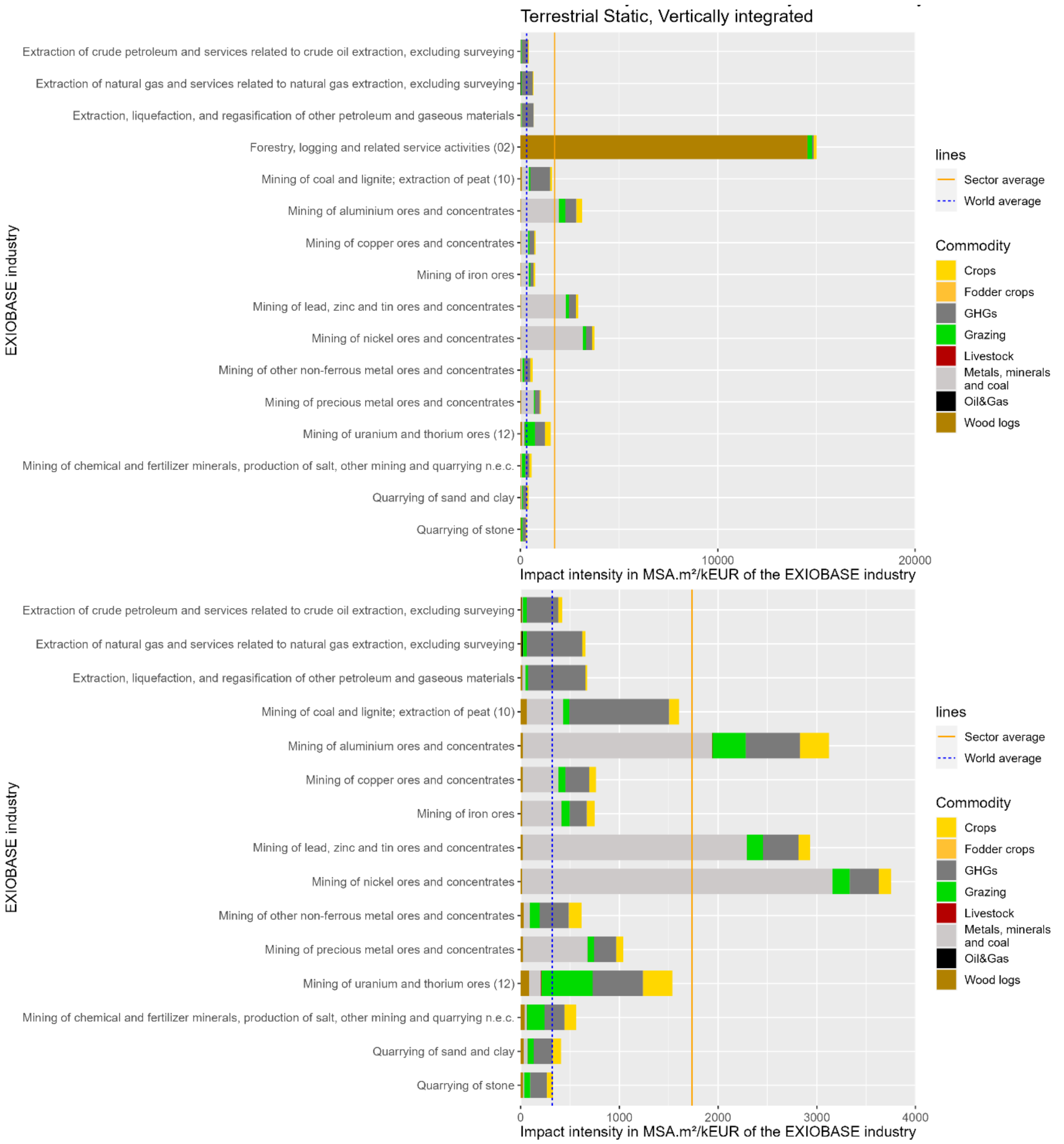


Figure 19: Breakdown by EXIOBASE industry and pressure, Aquatic static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

2.3 Breakdown by commodity



Source: GBS 1.4.4 computation, Mar 2023, Emma Godefroy

Figure 20: Breakdown by EXIOBASE industry and commodity, Terrestrial static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

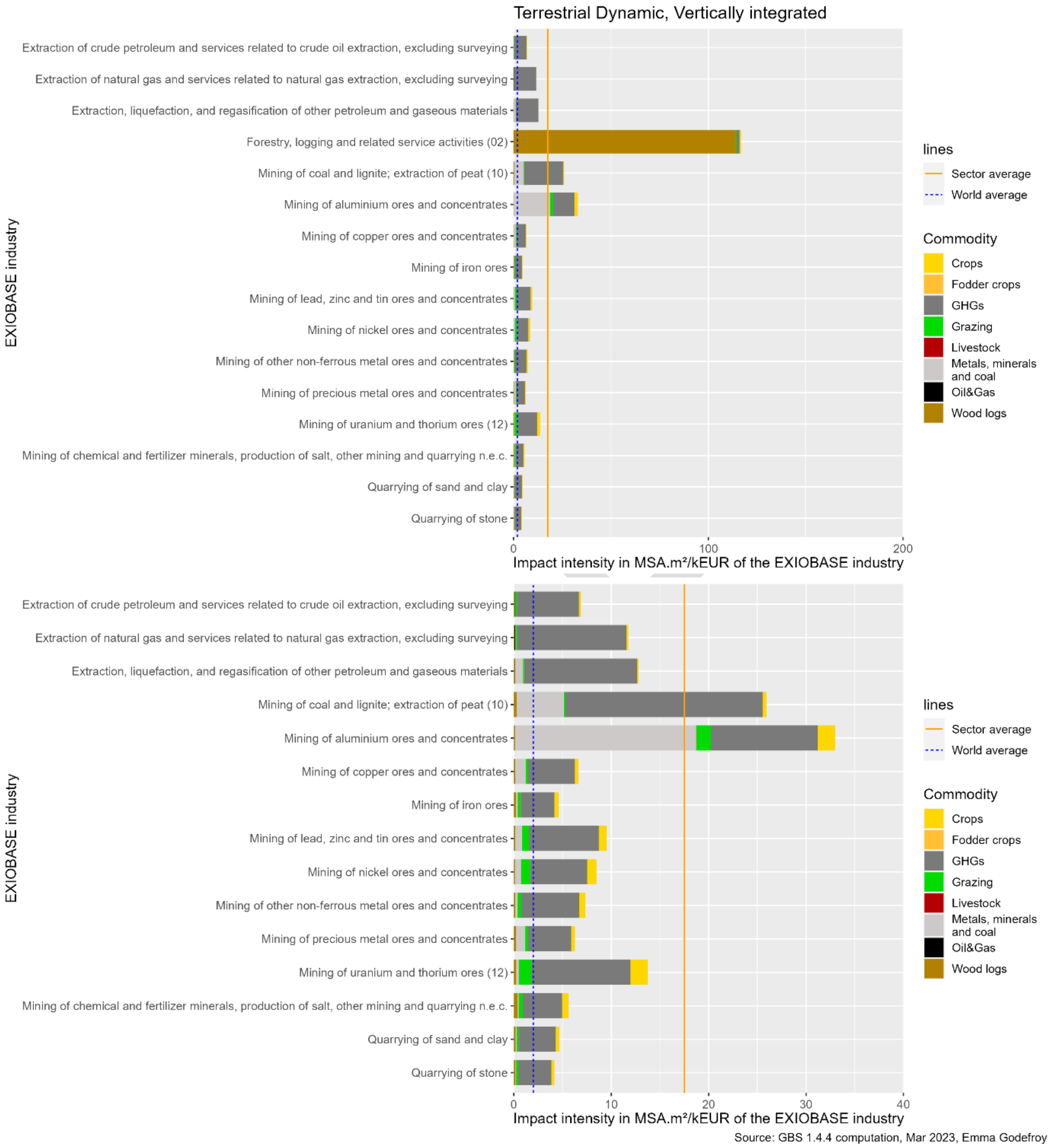


Figure 21: Breakdown by EXIOBASE industry and commodity, Terrestrial dynamic, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

Figure 22: Breakdown by EXIOBASE industry and commodity, Aquatic static, Vertically integrated, results by kEUR of each industry turnover. View of all industries in the benchmark sector (top) and view only of the Mining and Oil & Gas categories (bottom).

3. Limits and uncertainties

The calculations were performed using GBS version 1.4.4 in March 2023.

In this version of the GBS, some impacts factors have not yet been included and therefore some impacts are underestimated. This is the case for the impacts of the EXIOBASE industries “Quarrying of sand and clay” and “Mining of chemicals and fertilizer minerals, production of salt, other mining and quarrying n.e.c.”.

The impacts of surrounding infrastructures associated with a mine site are only partially covered. Indeed, the impacts of infrastructures such as access roads or power lines further away in the mining concession are not assessed even though they can be significant as they fragment natural habitats. In addition, before a mining operation begins, several tests are performed on a much larger perimeter. They may involve heavy work and dedicated infrastructure and be very impactful but are not included in the GBS (CDC Biodiversité 2020b).

Regarding the forestry sector, differentiation between different wood types, locations and management practices is very limited in the GBS (CDC Biodiversité 2020d). This is the subject of a special focus in Section C.7. Carbon storage during tree growth is not considered, mainly due to difficulties in assessing the duration of these impacts (carbon storage occurs at variable rates throughout tree growth, with differences in storage between tree species and management practices). In addition, carbon stored during tree growth is rapidly released to the atmosphere once the wood is burned or later in the life cycle of wood products (CDC Biodiversité 2020d). This topic is discussed further in Section C.6.

The **pressure Ecotoxicity is not included in the results** because it is subject to greater uncertainties. However, because impacts from spills of toxic materials can occur at mining extraction sites, further analyses are available in Section C.9.

4. Sector's dependencies

In this part are presented the results on the sector's dependencies, including a breakdown by EXIOBASE industries. A detailed methodology for calculating dependencies is available in 2.4.

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

For now, Scope 1 dependencies are not computed for the industry "Mining of uranium and thorium ores". This is because ENCORE does not provide any information on ecosystem service dependencies for uranium. In this case, the dependencies of other mining industries were displayed by default.

The industry with the highest dependency score is "Forestry, logging and related services" with a score of 42 % for Scope 1 dependencies, but it is also the one that depends on the greatest number of ecosystem services (14 out of 21). This sector is particularly dependent on ground water and surface water ecosystem services (two red cells in Figure 23: Dependency heatmap for Scope 1 dependencies, based on ENCORE data) and on water flow maintenance that keeps water circulating by recharging aquifers and maintaining surface water flows. Indeed, it is well established that forests rely heavily on water-related ecosystem services to thrive (Schyns, Booij, and Hoekstra 2017).

When calculating the dependence score, ENCORE distinguishes between large-scale forestry and small-scale forestry within the forestry sector. The latter is more dependent on species-related ecosystem services, such as animal-based energy or disease and pest control. However, large-scale forestry is more dependent on the service of flood and storm protection which is provided by the sheltering, buffering and attenuating effects of natural and planted vegetation.

The mining industries and the oil and gas extraction processes also rely heavily on water-related abiotic services: ground water and surface water as well as the ecosystem service of water flow maintenance. Indeed, water plays an important role in the majority of the mining processes. First, it is used to transport the ores and the wastes as slurry. The disposal of tailings can then require very large volumes of water. Then, ore processing uses a lot of water to separate the ore from the gangue and produce concentrates. Finally, some specialized operations can be highly water intensive such as hydraulic and solution mining (Metallurgist & Mineral Processing Engineer 2020).

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

Add a comment on the critical dependency score for the upstream dependency. Two methodologies:
- Average dependency score: average dependency of a company or portfolio on all ecosystem services
- Critical dependency score: share of a company or portfolio that is critically dependent, i.e. not substitutable, on at least one ecosystem service.

5. Terrestrial static Climate change calculation

Climate change static impact 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.

However, for the Raw materials extraction sector, there is no sector-specific data to calculate historical emissions. For the Oil & Gas category, the factor used will be that of fugitive emissions. Indeed, they correspond to the leakage of GHGs into the atmosphere during the oil and gas extraction process. Thus:

$$Global\ factor_{1750,\ Oil\ \&\ Gas} = \frac{global\ historic\ emissions\ from\ 1750\ to\ 2018}{global\ 2019\ emissions} = 64$$

$$Climate\ change\ static_{2022,\ Oil\ \&\ Gas} = 64 * Climate\ change\ dynamic_{2022,\ Oil\ \&\ Gas}$$

For the Forestry and Mining categories, the global factor will be used.

$$Global\ factor_{1750} = \frac{global\ historic\ emissions\ from\ 1750\ to\ 2018}{global\ 2019\ emissions} = 50$$

$$Climate\ change\ static_{2022,\ Mining\ \&\ Forestry} = 50 * Climate\ change\ dynamic_{2022,\ Mining\ \&\ Forestrys}$$

The results are as follows:

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

Category	Scope	Impact in MSA.m²/kEUR		
		Climate change terrestrial dynamic	Climate change terrestrial static (calculated)	Terrestrial static linked to other pressures (for reference)
Forestry	Scope 1	0.61	31	12 000
	Vertically integrated	1.5	73	15 000
Mining	Scope 1	6.6	330	340
	Vertically integrated	9.7	480	600
Oil & Gas	Scope 1	6.0	380	5.9
	Vertically integrated	7.5	480	100

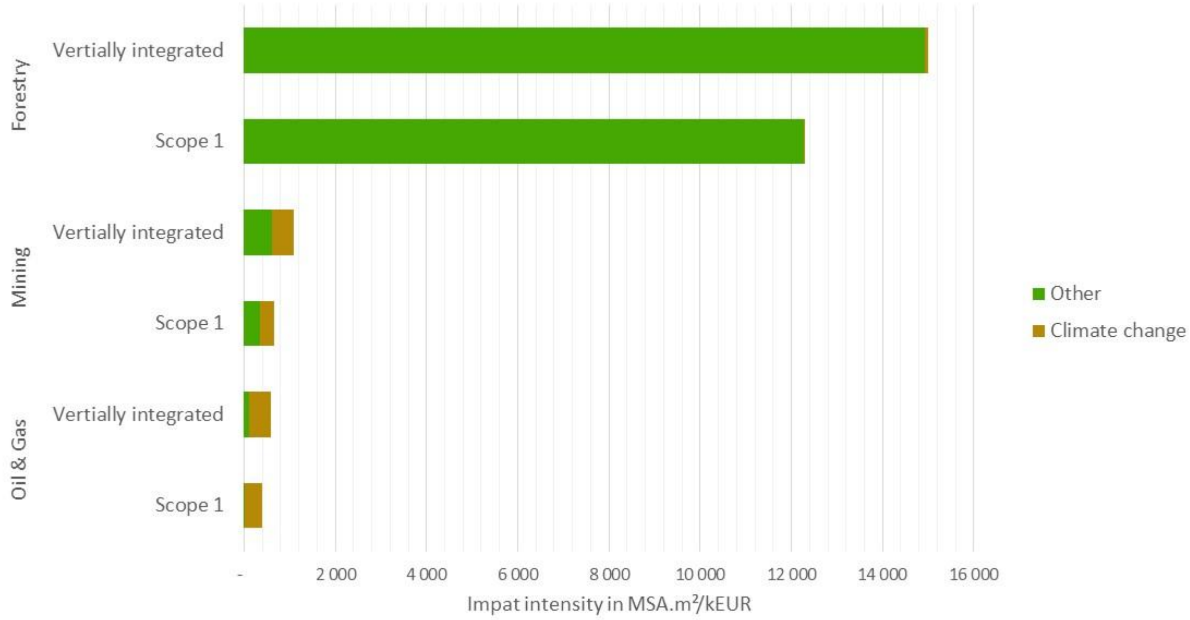


Figure 25: Terrestrial static impact of the Raw materials extraction sector with impact related to the Climate change pressure

The static impacts related to the climate change pressure are very low for the Forestry sector, and even more when compared to the impacts related to spatial pressures. However, it should be remembered that the impacts assessed by GBS do not consider biogenic carbon or emissions due to land use change.

For the Mining sector, the impacts related to the Climate change pressure are roughly equivalent to the impacts related to spatial pressures, whereas the static impacts of the Oil & Gas sector are mainly due to GHG emissions.

6. Carbon sequestration by wood

The impacts of the logging sector have been computed using the Wood logs CommoTool which links tonnages of wood logs to impacts on biodiversity in MSA.km² (CDC Biodiversité 2020d). However, carbon stored during the tree growth are not considered in the CommoTool. This reflects difficulties with the timeframe of such impacts as carbon storage occurs at varying paces along tree growth, with storage difference between tree species and management practices.

The logging sector is different from many industrial sectors about CO_2 as carbon pools can emit or store carbon through the exploitation or during land use change. These carbon stocks can be divided into three categories: the carbon in living biomass, carbon in dead wood and litter, and carbon in soil (FAO 2020). And these carbon stocks are reversible: any carbon sequestered in carbon stocks will be emitted back into the atmosphere if the wood is burnt or later in the life cycle of wood products.

There are two different ways to quantify the changes in carbon stocks that are equally valid according to the GHG Protocol (2014). These two approaches are: i) measure the change in stock size in units of mass of carbon at two points in time or ii) assess the net balance of CO_2 emissions and CO_2 removals to and from a stock in units of mass of CO_2. According to the GHG Protocol's Land sector (Greenhouse Gas Protocol 2022), the stock-change approach is recommended.

The GHG Protocol (2022) recommends the logging sector to report the different CO_2 fluxes for changes in carbon stock in above-ground and below-ground biomass, dead organic matter and soils. When the CO_2 emissions concerns emissions from soils and biomass that result from land use change, these emissions should be reported in Scope 1 because they effectively constitute permanent losses of carbon to the atmosphere. Otherwise, they should be reported outside of the Scopes in a separate category 'Biogenic carbon' divided into three components:

- CO_2 fluxes during land management;
- sequestration during land use change;
- CO_2 emissions from biofuel combustion.

CO_2 emissions from wood energy combustion are accounted for at the time of wood harvesting. This accounting is done in the sector "Land use, land-use change and forestry". To avoid double counting, biogenic emissions are not accounted for in the energy sector (ADEME 2022).

The goal of this section is to **estimate the amount of carbon stored or released each year by the logging sector,** to turn this carbon flow into a **potential Climate Change impact** and to compare it with the already estimated terrestrial dynamic impacts, which are mainly related to spatial pressures.

But estimating carbon storage in the logging sector is more difficult than for natural forests since the temporal dynamics of carbon storage and removal processes must be taken into account. Indeed, increasing harvesting increases biogenic CO_2 emissions (combustion/degradation of wood removed from the forest) while the biological growth of forests does not increase at the same rate or in the same proportions. The time scales are important: on the one hand, regeneration takes time to replenish stocks and, on the other hand, without the increase in harvesting, carbon would have remained sequestered in the forests for longer and the trees would also have been able to continue to grow (this growth peaks at a certain age, which implies that the impact is limited). Moreover, increased harvesting may reduce the dynamics of carbon storage in the soil.

6.1 Impact of wood removals

First, the carbon emitted from wood production is estimated. The Food and Agriculture Organization of the United Nations (FAO) provides data of wood removals by the forestry sector for several regions of the world (see Figure 26). It distinguishes between wood used for industrial purposes and wood used for fuel, but the figures used in this section do reflect the amount of wood extracted directly from the forests.

Figure 26: Wood removals per year for different regions of the world (FAO 2020)

The FAO also provides growing stock data, which allows to establish for each of these regions the share of the total growing stock that is used each year for wood production. Growing stock refers to the amount of living trees and other woody vegetation in a forest or wooded area, expressed as the total volume. It is an important metric for assessing the productivity of forest ecosystems. To calculate the carbon storage of a forest, the growing stock can be used as a proxy for biomass present (Smith et al. 2006). Since the wood harvested by the logging sector is from both planted and naturally regenerating forests, the total growing stock value of these two categories is used.

Finally, the share of wood removals over the global growing stock is applied to the amount of carbon stored by the biomass for each of these regions to get an estimate of the tonnes of carbon associated with wood removal. The factor 3.66 is applied to obtain the results in tons of CO_2 (*i.e.*, 44 g CO_2 over 12 g C). The results are presented in the table below.

Region	Wood removals (million m³)	Total growing stock (million m³)	Part of the wood removals in global growing stock	Carbon stored in living biomass (million tonnes C)	CO_2 from wood removals (million tonnes CO_2)
Eastern and Southern Africa	354	20 453	1.7%	13 248	841
Norther Africa	60	841	7.1%	1 090	285
Western and Central Africa	424	56 419	0.8%	36 229	998
East Asia	387	27 049	1.4%	11 767	617
South and Southeast Asia	733	31 518	2.3%	23 393	1 995
Western and Central Asia	40	3 935	1.0%	2 388	89
Europe	825	116 320	0.7%	54 574	1 419
Caribbean	6	725	0.8%	493	15
Central America	48	4 233	1.1%	1 840	77
North America	638	90 108	0.7%	39 301	1 020
Oceania	87	18 867	0.5%	13 881	235
South America	429	187 455	0.2%	96 331	808
Total	**4 031**	**557 923**		**294 535**	**8 400**

The removal of wood thus constitutes a release of 8.4 billion tons of CO_2 into the atmosphere each year. This figure is consistent with Global Forest Watch estimates of nearly 8 billion tonnes of CO_2 emitted due to deforestation and other disturbances (Harris and Gibbs 2021).

These CO_2 emissions can be converted by the GBS impact factors into biodiversity impacts related to Climate change pressure. The result is 37 000 MSA.km² per year. By comparison, the EXIOBASE logging industry is responsible for an impact of 25 000 MSA.km² in Scope 1 and 30 000 MSA.km² vertically integrated, these impacts being mainly linked to spatial pressures. Taking into account the release of CO_2 during wood removal thus causes the dynamic impact of the sector to double. However, the trees in the logging sector also store carbon every year, and this storage is assessed in the next section.

6.2 Carbon sequestered by the logging sector perimeter

To estimate the potential positive impact on biodiversity related to carbon storage, FAO data are used as well as data from the study that represents the most comprehensive review of published literature on tree growth and CO_2 removals to date (Bernal, Murray, and Pearson 2018). Indeed, the amounts of CO_2 captured have been estimated by Bernal, Murray, and Pearson (2018) for Forest Landscape Restoration (FLR) activities. Removal rates in t $CO_2.ha^{-1}.year^{-1}$ are available for different FLR activities. Removal factors for plantations are broken down by plant species (oak, teak, eucalyptus, broadleaf, pine, conifer) and by climatic regions (boreal, temperate humid, temperate dry, tropical humid or tropical dry). Natural regeneration, agroforestry and mangrove restoration activities detail removal factors by geographic region, climatic region and species year (0-20 years or 20-60 years).

A tool[2] that estimates the amount of sequestered carbon from restoration activities has been developed and draws directly from the above-mentioned database.

The first step is to define the perimeter of the logging sector. According to the NACE classification, the logging activity consists of "the production of roundwood as well as the extraction and gathering of wild growing non-wood forest products […] that can be carried out in natural or planted forests" (EUROSTAT 2008).

The perimeter of the logging sector was determined on the basis of the FAO's classification (FAO 2020). It first differentiates forest according to the "Forest characteristics" by opposing naturally regenerating forests to planted forests. Within the latter category, a distinction is made between plantation forests and other planted forests. Plantation forests are intensively managed and meets all the following criteria: "one or two species, even age class and regular spacing". Plantation forests are established for production purposes. On the contrary, other planted forests may even resemble natural forests at stand maturity and may be established for purposes such as ecosystem restoration or the protection of soil and water. FAO also makes a distinction between different "Designated management objective". The relevant objectives when defining the perimeter of the logging sector are forests for production and forests for multiple use. Indeed, this last category was also selected when delimiting the logging perimeter because the category Forest for production does not seem to include all forests used for timber production. In the case of France, for example, the forests all belong to the multiple use category even though wood is produced in the country. It therefore seemed inconsistent to leave this category out of the perimeter.

The figure below illustrates the perimeter of the sector, which includes these two categories of objective forest management, while Table 9 indicates the surface areas for each region.

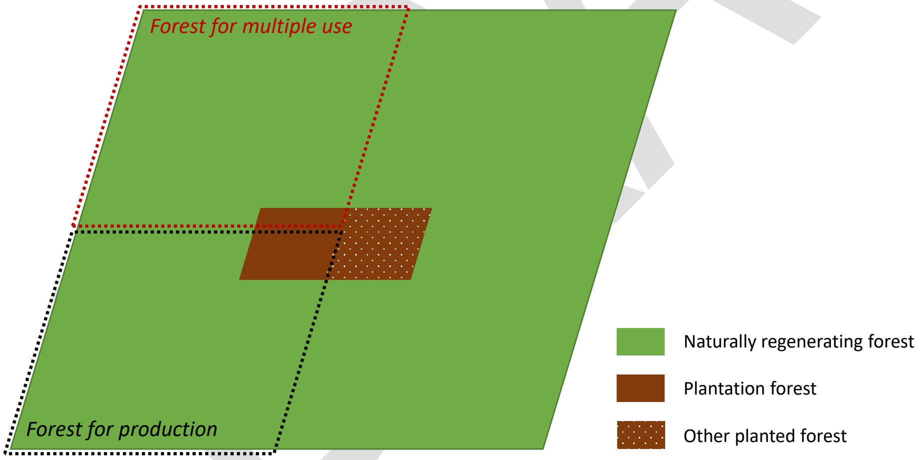


Figure 27: Perimeter of the logging sector. It includes both forests for multiple use and forests for production, whether they are plantation or naturally regenerating forests.

[2] https://winrock.org/document/forest-landscape-restoration-climate-impact-tool/

Table 9: Areas of forests included in the logging perimeter across different regions of the world (FAO 2020)

Region	Plantation forest (million ha)	Forest for production (million ha)	Forest for multiple use (million ha)	Logging sector (million ha)
Eastern and Southern Africa	5.0	30	37	67
Northern Africa	1.2	1.6	4.3	5.9
Western and Central Africa	1.5	68	33	100
East Asia	49	74	79	150
South and Southeast Asia	27	105	47	150
Western and Central Asia	3.7	11	8.4	19
Europe	4.5	510	46	560
Caribbean	0.7	1.1	0.3	1.4
Central America	0.4	3.2	0.8	4.1
North America	14	230	250	480
Oceania	4.4	10	14	24
South America	20	110	230	330
World	**131**	**1 151**	**749**	**1 900**

Removal factors are available for plantations as well as for naturally regenerating forests. They are associated with tree species and climatic regions. In order to apply them to FAO regions, it is therefore necessary to match each of these FAO regions to a climatic region and to the types of trees present in the forests, in order to finally match a removal factor to each geographical region. The correspondence was carried out on the basis of data from Berdin et al. (2018). Data is presented in the following table. It should be noted that removal rates for plantations are higher because the younger trees store a much larger amount of carbon than trees in more mature forests, where the soil is already rich in carbon.

Table 10: Climate, tree species and removal rates for several regions of the world (Berdin et al. 2018)

Region	Climate	Main tree category	Removal rate Plantations (t CO2 / ha / yr)	Removal rate Natural regeneration (t CO2 / ha / yr)
Eastern and Southern Africa	Tropical, humid	Broadleaf	25	7.9
Norther Africa	Temperate, dry	Broadleaf	6.4	7.9
Western and Central Africa	Tropical, humid	Broadleaf	25	7.9
East Asia	Temperate	Broadleaf and Coniferous	11	17
South and Southeast Asia	Tropical, humid	Broadleaf	25	17
Western and Central Asia	Temperate	Broadleaf	12	17
Europe	Temperate and Boreal	Broadleaf	10	4.5
Caribbean	Tropical	Broadleaf	18	3.7
Central America	Tropical	Broadleaf	18	3.7
North America	Temperate and Boreal	Broadleaf and Coniferous	10	10
Oceania	Temperate	Broadleaf	12	3.5
South America	Tropical	Broadleaf	18	5.2

Applying these rates to the areas presented above, the following carbon storages are obtained:

Table 11: Annual carbon storage estimations for both plantations and naturally regenerating forests of the logging sector

	CO_2 stored (million tonnes / year)	
Region	**Plantations**	**Natural regeneration forests**
Eastern and Southern Africa	181	474
Norther Africa	13	31
Western and Central Africa	57	776
East Asia	1 089	941
South and Southeast Asia	796	2 086
Western and Central Asia	66	231
Europe	728	2 185
Caribbean	15	2
Central America	7	13
North America	473	4 148
Oceania	57	65
South America	364	1 626
World	**3 847**	**12 580**

Thus, the total storage potential of logging forests (plantations or naturally regenerating forests) is approximately twice the amount of carbon lost through roundwood production.

It is important to remember that the estimations presented here can only provide orders of magnitude on a global scale and that the actual carbon storage by the forestry sector can be much more difficult to calculate in practice. The first limit of these estimations is that the perimeter of the logging sector is difficult to define because data on areas occupied by logging activities are difficult to find. In addition, land-use changes are not considered here even though they can have strong consequences on the carbon storage potential of the forestry sector. For example, replacing old-growth forests that have stored significant amounts of carbon with plantations can result in a much larger release of carbon, while conversely, plantations on formerly cultivated land result in an increase in carbon stored in the biomass and soils.

7. Sustainable forest management and biodiversity conservation

The Wood logs CommoTool doesn't account for differences between sustainable and non-sustainable wood, and only "non-sustainable" management was retained to develop its impact factors. A future version of the tool will refine data to better account for national differences and varying management practices. An interesting point to consider is whether sustainable forest management practices for the logging sector result in a reduction of biodiversity loss.

Forest certification is known as a tool to support sustainable forest management. Independent forest management certification was introduced in the 1990s as an incentive for companies to respond to public concerns about sustainability, thereby helping to promote sustainable forest management. Certification is voluntary and its legitimacy is based on the support of stakeholders. Today, two major international certification schemes are widely recognized: the Forest Stewardship Council (FSC) and the Programme for the Endorsement of Forest Certification (PEFC). The FSC and PEFC have jointly analyzed areas certified under both schemes, which allows for an estimate of the total area of certified forests without bias due to dual certification. In 2019, 200 million hectares of forests were certified under the FSC, 319 million hectares were certified under the PEFC, and 93 million hectares were certified under both systems. Overall, the net area of certified forests is 426 million hectares of the 1 135 million hectares of forests whose primary purpose is production (FAO 2020).

It is difficult to know whether forest biodiversity in certified forest management units is higher or more undisturbed than in conventionally managed areas in part because of the lack of systematic collection of information to assess the effects of management on biodiversity (Kuijk, Putz, and Zagt 2009). Another major challenge is attributing change to a certification scheme. Assessments that describe large-scale or general impacts often lack specificity in their findings, whereas site-specific assessments reveal biodiversity patterns that are difficult to generalize.

However, conclusions can be drawn from literature reviews. There is evidence that the implementation of good forest management practices through forest certification can lead to positive effects on conserving forest biodiversity, although there may be variations in response among different species and the existence of exceptions. The negative effects of logging on forest species are minimized by reduced-impact logging, as it causes less damage to the forest than conventional logging techniques. Protected areas and high conservation value forests may also protect some species from logging activities, although there is limited data to support this theory. The long-term effects of certified forest management on biodiversity are poorly documented (Kuijk, Putz, and Zagt 2009). Certification standards sometimes differ from national legislation, which enhances the importance of understanding the national context both in terms of forest characteristics and national regulations to assess the contribution of certification (Lehtonen et al. 2021).

Finally, if the biodiversity impact is to be compared for the same tonnage of wood produced by two plots, one being sustainably managed and the other not. if more land is needed to produce certified wood (due to lower productivity per hectare), then in the sustainable production will result in higher impacts. If certified forests held more remaining biodiversity per hectare (which they are not demonstrated to achieve, see above), e.g. due to better ecosystem quality through biodiversity-rich non-productive area, then they would also host greater remaining biodiversity per tonne of wood,. The message could thus be higher accumulated negative impacts (which is negative) but also higher remaining biodiversity (which is positive) per tonne.

8. Trajectories for achieving international biodiversity targets

The objective of this section is to estimate the efforts that need to be provided by the raw material extraction sector to achieve sustainable biodiversity objectives. This section is divided into three parts. The first part develops an approach that distributes among all economic sectors the share of efforts to meet the objectives of the Convention on Biological Diversity (CBD). In the second part, projections of extracted raw materials required for the global ecological transition (to meet climate goals in particular) are translated into pathways for the Raw material industries. Finally, the last part compares the compatibility of the two approaches.

8.1 Construction of different trajectories to achieve the international biodiversity targets

A “central trajectory” to bend the curve of biodiversity loss is built based on an interpretation of the CBD’s Zero draft. It aims to reach at least a global no net loss of biodiversity in 2030 and restore biodiversity between 2030 and 2050. This is interpreted as a global dynamic impact of 0 in 2030 and a return to the “one of functional integrity of the Earth system” by 2050. Thus, a global budget of maximum biodiversity loss (from 2020 to 2030), as well as a minimum biodiversity gain (from 2031 to 2050) are defined. The detailed methodology is available in 2.6. The amount of efforts or the budget are to be allocated to economic sectors and companies. Different allocation approaches described in Table 12 can be used to share efforts and lead to different sectoral trajectories.

Table 12: Allocations and data used to draw sectoral trajectories

Allocation	Approach	Parameter	Data source
Equality	Everyone has the same right	Number of employees in the sector	Eurostat (2010)
Efficiency	Cost-effectiveness	Cost of restoration (EUR/[MSA.m²])	CDC Biodiversité internal estimation
Capability	Industries’ ability to pay	Turnover (MEUR)	EXIOBASE (2011)
Sovereignty	Grandfathering	2020 dynamic impact (MSA.km²/year)	GBS computation

Table 13: Data used and proportion of each allocation for the Raw materials extraction sector

Equality		Efficiency		Capability		Sovereignty	
Number of employees (thousand persons)	*proportion of the sector's effort compared to the overall effort*	Restoration cost (EUR/[MSA.m²])	*proportion of the sector's effort compared to the overall effort*	Turnover (mEUR)	*proportion of the sector's effort compared to the overall effort*	Net Impact 2020 (MSA.km²/year)	*proportion of the sector's effort compared to the overall effort*
1.1E+03	0.4 %	20	1 %	4.1E+06	4 %	5.4E+4	19 %

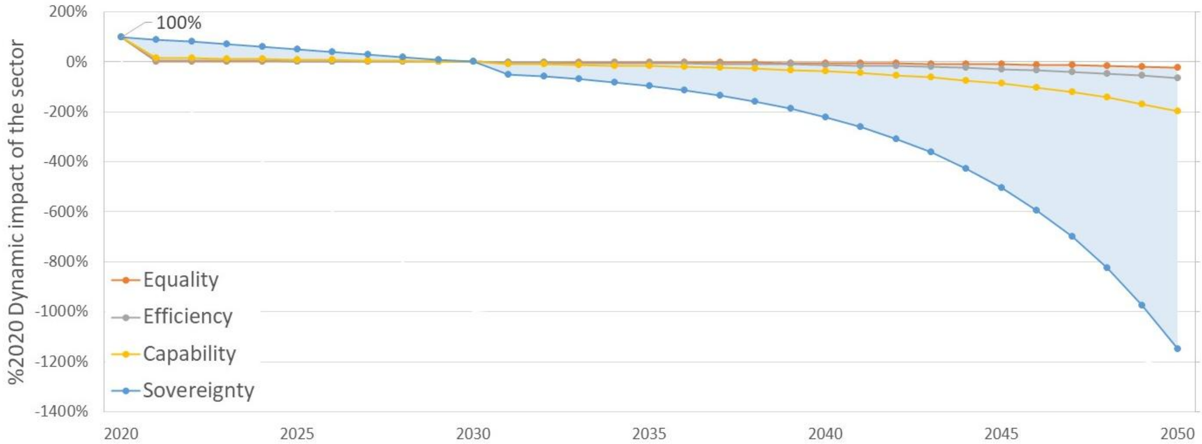


Figure 28: Raw materials extraction sector's dynamic impact per allocation system

The Raw materials extraction sector has the highest effort to achieve in the sovereignty allocation (compared to other allocation system) as the sector represents 19 % of the 2020 global dynamic impact. But due to one of the highest restoration costs in comparison to other sectors and a limited number of employees, the efforts for equality and efficiency allocations are small.

However, this method for assessing the budget of "allowed impacts" of the Raw materials extraction sector is based on parameters that are constant over time. Indeed, it is assumed that the sector's share of global turnover, global number of employees or global costs of restoration will be the same until 2050. However, the structural changes required by the ecological transition are likely to cause these shares to change. In addition, other factors can be taken into account when allocating efforts between the different sectors. For example, the reduction in the use of fossil fuels for renewable energy will require the mining sector to provide more raw materials. This is a broadly accepted societal goal, which would allow the mining sector to increase its impact. Thus, it may be interesting to look at the projections (until 2050) of raw materials extraction required to achieve the ecological transition and see their compatibility with impact reduction trajectories.

The aim of the next section is thus to analyze the impact of raw materials extraction under two pathways: a business-as-usual scenario based on historical trends and a scenario following a more sustainable trajectory. The forestry sector projections will be sourced from a paper by Kok et al. (2018) while the other raw materials projections will be based on the IRP's *Towards Sustainability* scenario (IRP 2020).

8.2 Estimated impacts based on raw materials extraction projections

Scenarios for the forestry sector (Kok et al. 2018)

Kok et al. (2018) discuss in their paper several scenarios of biodiversity footprint reduction and compare them to a baseline scenario, referred to as the *Trend scenario.* This scenario shows the evolution without the introduction of new policies to reach biodiversity or other environmental objectives and is based on the OECD Environmental Outlook for 2050 (OECD 2012). It assumes that the world's population will continue to grow until reaching over 9 billion in 2050, with a significant growth in Sub-Saharan Africa and South Asia. The GDP per capita is also expected to rise, especially in developing countries. Therefore, the use of raw materials will rise and increase the pressures on the environment.

This baseline scenario is compared with other scenarios that have been designed to achieve a reduction of biodiversity loss, including one that focuses on changing human consumption patterns (limiting per capita meat consumption, reducing waste production, and shifting to less energy-intensive lifestyles). It also allows the old Aichi target of protecting at least 17% of ecosystems to be met. Areas for biofuel production and timber plantations are restricted. Climate change is mitigated to avoid a 2-degrees-increase by 2100 and a relatively low use of bioenergy is projected in order to limit trade-offs between biodiversity and climate policies. Finally, to allow for better comparison with the Trend Scenario, it is based on the same assumptions of population growth and economic development. For these different scenarios, Kok et al. provide projections of the area of land used, with various land use types for the forestry industry.

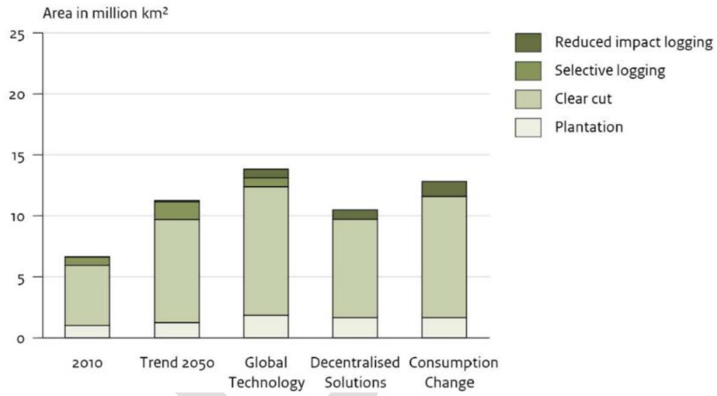


Figure 29: Changes in land areas for the forestry sector in all four scenarios (baseline and three pathways), figures from (Kok et al. 2018)

Other scenarios could have been used to estimate land use changes. For example, the IPCC has developed pathways linking socioeconomic development, mitigation responses and land (Intergovernmental Panel on Climate Change 2022). It gives estimations of land change according to the five SSPs[3] and four mitigation

[3] SSP = Shared Socioeconomic Pathways. SSPs describe a set of alternative plausible trajectories of social development, which are based on hypotheses about which societal elements are the most important determinants of challenges to climate change mitigation and adaptation.

responses for Natural Land, Bioenergy Cropland, Cropland, Forest and Pasture. However, the scenarios of Kok et al. have been selected because their land categories correspond to the GLOBIO categories to which an MSA value is assigned.

International Resource Panel projections (IRP, 2020) for Mining and Oil & Gas categories

The first scenario *Historical Trends* provides projections on resources use, economic activity and key environmental indicators on the assumption that observed trends over the decades to 2015 continue into future decades. It has been constructed to align with Shared Socioeconomic Pathway "Middle of the road" (SSP2) where social, economic and technological trends do not shift markedly from historical patterns. This scenario is nevertheless updated with economic and population parameters (population growth and GDP per capita) based on OECD data. Thus, the two baseline scenarios provided by Kok et al. (2018) and the IRP (2020a) are consistent in having population and GDP data sourced from the OECD. In the baseline scenario, resources extractions are driven by three main factors: the economic growth, the structural changes (which result from rising incomes and democratic changes) and the pace of technological progress in each sector.

The second scenario *Towards Sustainability* is based on measures supporting resource efficiency, a reduction in GHG emissions, the protection of landscapes and life, and a societal shift towards healthy diets and reduced food system waste. It is broadly consistent with SSP1. Similar to the *Consumption Change* pathway from Kok et al. (2018), this *Towards Sustainability* scenario ensures the Aichi target of having at least 17% of each ecoregion protected, bioenergy is limited and GHG emissions are calibrated to achieve RCP2.6 (*i.e.* a high probability of limiting global warming to 2 degrees).

Resource efficiency and actions in favor of a sustainable shift are projected to result in slower growth of natural resource use for the sustainable scenario. Indeed, extraction of fossil fuels is projected to decline from current levels as renewable energy prevail over non-renewable options in both electricity and transport sectors. Resource efficiency policy results in slower growth in the extraction and use of metal ores. Areas of forest and other natural land is expected to increase, enabling carbon capture and a limitation of biodiversity loss. The areas of cropland and pasture are respectively 9% and 30% below *Historical Trends* figures.

Category	2015	2060 *Historical Trends*	2060 *Towards Sustainability*
Fossil fuels	14.5	16.1	7.8
Metals	8.1	17.89	9.2
Non-metallic minerals	40.3	112.3	93.7

Figure 30: Global material extraction in gigatons by materials category in 2015 and 2060 under two development scenarios (baseline and sustainable scenarios) (IRP 2020b)

Combination of the two data sets and calculation of the impacts

Table 14: Overview of the scenarios and data available in the literature

	Forestry (wood and timber)	**Fossil fuels, metals and non-metallic minerals**
Baseline scenario	Trend Scenario (Kok et al. 2018)	Historical Trends (SSP2) (IRP 2020)

Forecast scenario	Consumption change (Kok et al. 2018)	Towards Sustainability (SSP1) (IRP 2020)
Available data	Areas used for forestry (see Figure 29) (Kok et al. 2018)	- Tons of raw materials extracted (by main category: fossil fuels, metals and non-metallic minerals) (IRP 2020) - OECD projections under the baseline scenario (OECD 2019a)

Forestry extraction trends are based on data from Kok et al. (2018) while IRP (IRP 2020, 2020) projections are used for all other raw materials (fossil fuels, metals and non-metallic minerals). The *Trend Scenario* of Kok et al. for the forestry sector data and the *Historical Trend* scenario for the other sectors appear to be broadly compatible and suitable for use as a baseline as they are based on the same OECD projections (OECD 2012).

But it turns out that the IRP tonnage data do not match the commodities available in GBS. To estimate the long-term impact, alternative data will be used. Indeed, the OECD has performed raw material projections for the baseline scenario (on which Kok et al 2018 and IRP 2020 relied for their baseline scenario) and it provides a more precise breakdown by raw material than the IRP for its 2060 projections (OECD 2019a). The figure below shows this breakdown into materials.

Category	Materials	Current	Projected
Fossil fuels	Bituminous coal	39%	54%
	Crude oil	25%	16%
	Natural gas	16%	15%
	Other coal	7%	6%
	Coking coal	8%	6%
	Other fossil fuels	4%	4%
	Total	100%	100%
Metals	Iron ores	38%	35%
	Copper ores	25%	23%
	Other metals	16%	19%
	Tin ores	9%	12%
	Gold ores	12%	11%
	Total	100%	100%
Non-metallic minerals	Sand gravel and crushed rock	64%	64%
	Limestone	16%	17%
	Structural clays	14%	13%
	Other non-metallic minerals	6%	7%
	Total	100%	100%

Figure 31: Share in tonnes of material extracted by material category according to OECD projections for business as usual (OECD 2019)

The approach is to use the IRP data for the three commodity categories (fossil fuels, metals, and non-metallic minerals) and apply these percentages to each category. One limitation of this method is to directly apply the OECD percentages (developed for baseline scenario projections) to the sustainability scenario. Figure 32 presents the final figures. The IRP data, which are for a 2060 horizon, are scaled to a 2050 horizon by a simple cross-multiplication.

			Today	Projection Baseline	Projection Sustainable scenario
	Land use category		*in million km²*		
Forestry	Reduced impact logging		0.03	0.1	1.29
	Selective logging		0.71	1.45	0.05
	Clear-cut harvesting		4.95	8.47	9.92
	Plantation		1.05	1.29	1.66
	Materials	GBS commodity	*in Gt*		
Oil and gas	Crude oil	Crude oil	3.7	2.5	1.2
	Natural gas	Natural gas	2.4	2.5	1.2
	Other fossil fuels	Other	0.6	0.6	0.3
Mining	Bituminous coal	Hard coal	5.7	8.6	4.2
	Coking coal	Hard coal	1.1	0.9	0.4
	Other coal	Lignite	1.0	0.9	0.4
	Iron ores	Iron ore	3.1	6.3	3.2
	Copper ores	Copper cathode	2.0	4.1	2.1
	Other metals	Alumunium, lead, nickel, zinc, uranium, rare earths, other	1.3	3.3	1.7
	Tin ores	Tin	0.7	2.2	1.1
	Gold ores	Gold	1.0	2.0	1.0
	Sand gravel and crushed rock	Gravel and sand	25.7	71.5	59.7
	Limestone	Talc, perlite, other	6.4	19.3	16.1
	Structural clays	Talc, perlite, other	5.7	14.2	11.8
	Other non-metallic minerals	Talc, perlite, other	2.5	7.3	6.1

Figure 32: Final data obtained, which are land area data for the forestry sector and tons of material extracted for the oil and gas and mining sectors

From these raw material and area values, the GBS can estimate the impacts in MSA.km² associated with this rate of raw material extraction. Terrestrial land use impact factors are applied to forest area and the impact factors from the Mining & Oil & Gas CommoTool are applied to commodity tonnages (CDC Biodiversité 2020b and CDC Biodiversité 2020c). The results are presented Figure 33.

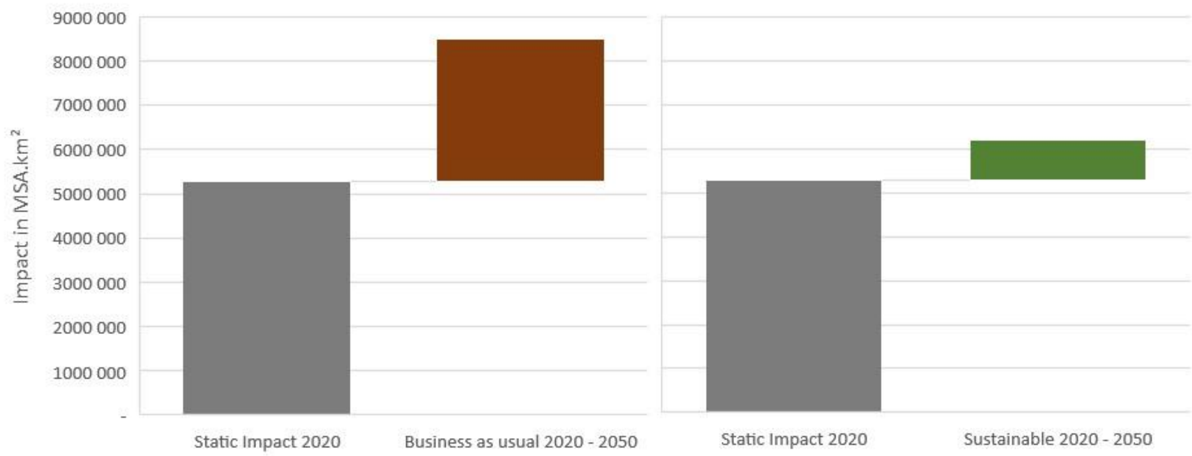


Figure 33: Terrestrial static impact of the Raw materials extraction sector in 2020 and additional impacts for the two scenarios (baseline scenario on the left and sustainable scenario on the right) over the period 2020 – 2050

The graph on the left shows the terrestrial static impact of the sector in 2020 and the additional static impact in 2050 (due to the increase in raw materials extracted) for the baseline scenario. The graph on the right shows the additional terrestrial static impact for the sustainable scenario.

The following figure shows the breakdown of the additional impact between 2020 and 2050 for the two scenarios according to the three main categories.

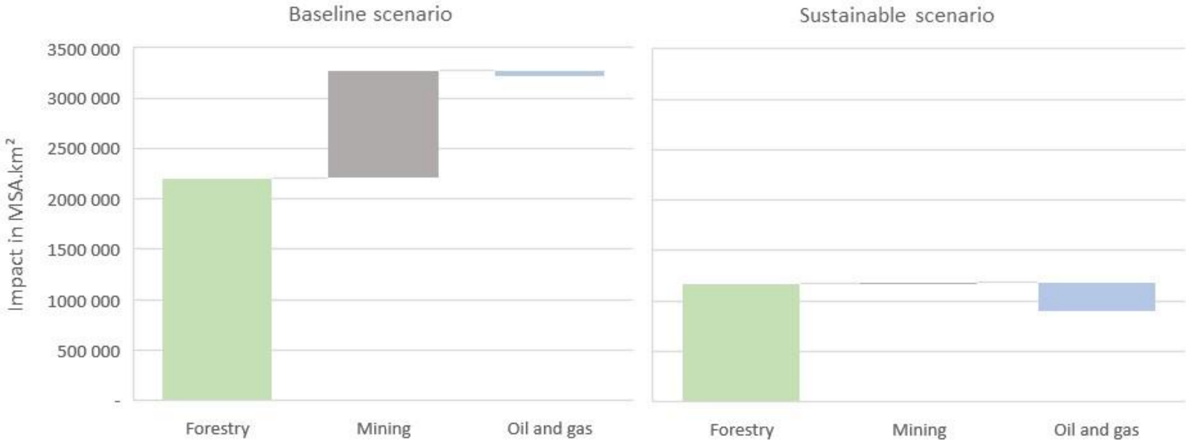


Figure 34: Breakdown of the additional impact for the two scenarios according to the three main categories (Forestry, Mining and Oil & Gas)

The increase in raw materials extracted between today and 2050 inevitably marks an increase in impacts, since only the raw material quantity variables have increased, the impact factors for the projections being the same as those used for today's data.

However, for the raw materials metals, minerals and fossil fuels, the sustainable scenario allows for a decrease in impacts while the baseline scenario allows for a decrease in impacts only for the Oil & Gas category. In the case of forest, the additional impact is positive in both scenarios but almost twice lower in the case of the sustainable scenario. This is because expansion of forest areas in the sustainable scenario occurs more at the expense of cultivated land with a lower MSA.

While the PBL trajectories presented at the beginning of this section call for an overall decrease in the sector's dynamic impacts to align with biodiversity impact reduction targets, the additional challenge for the Raw materials extraction sector is to deal with the global increase in materials extracted, which would structurally tend to increase the sector's impact. The next section intends to compare the results of the two approaches (PBL trajectories and impacts calculated from raw materials projections) to determine whether the material projections appear consistent with the four theoretical allocation modes, and whether those allocation modes are realistic.

8.3 Comparison of the results and conclusion

This section compares the impacts between 2020 and 2050 of the two approaches and the sum of the annual dynamic impacts under the four PBL modes. The results are presented in Figure 35.

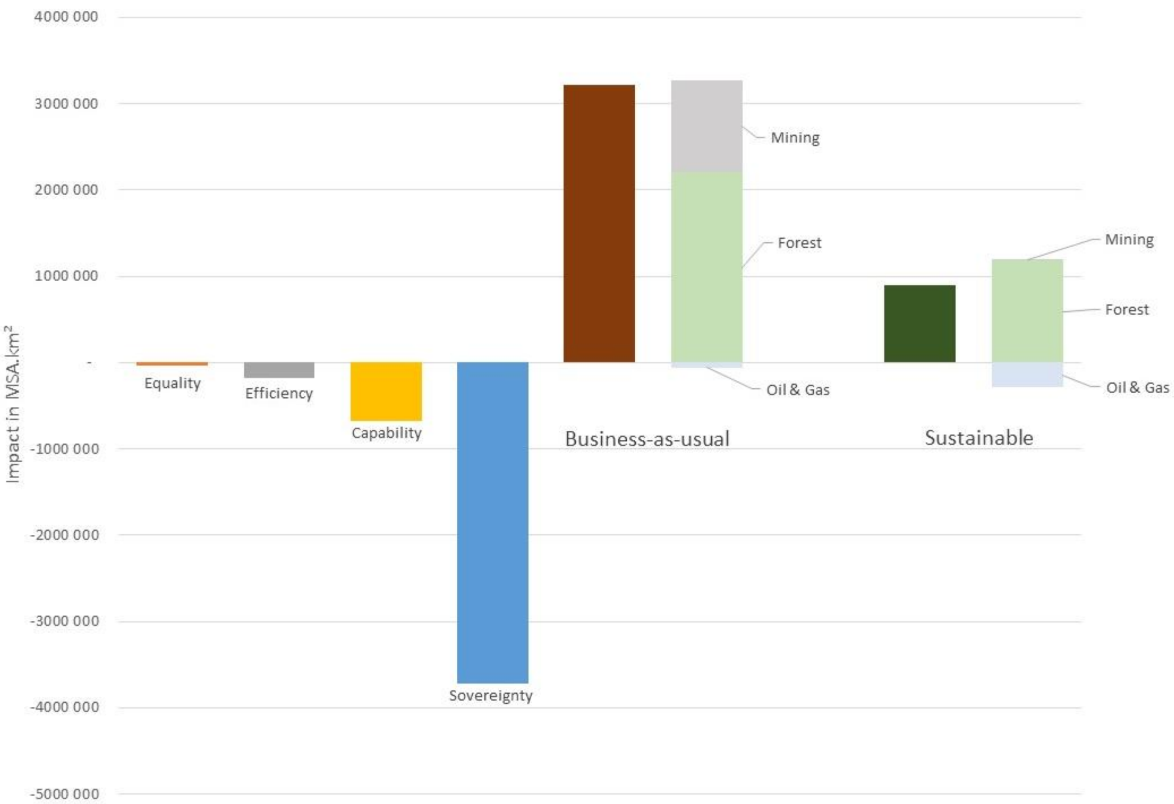


Figure 35: Total effort in MSA.km² between 2020 and 2050 for all allocation modes and the two scenarios' projections

It is also possible to represent the impacts estimated from the projection as a trajectory. The annual dynamic impact is calculated so the annual increase (or decrease) is the same each year and the sum of the annual dynamic impacts over the period 2020 – 2050 is equal to the terrestrial static differential calculated in the previous section. The results are presented in Figure 36.

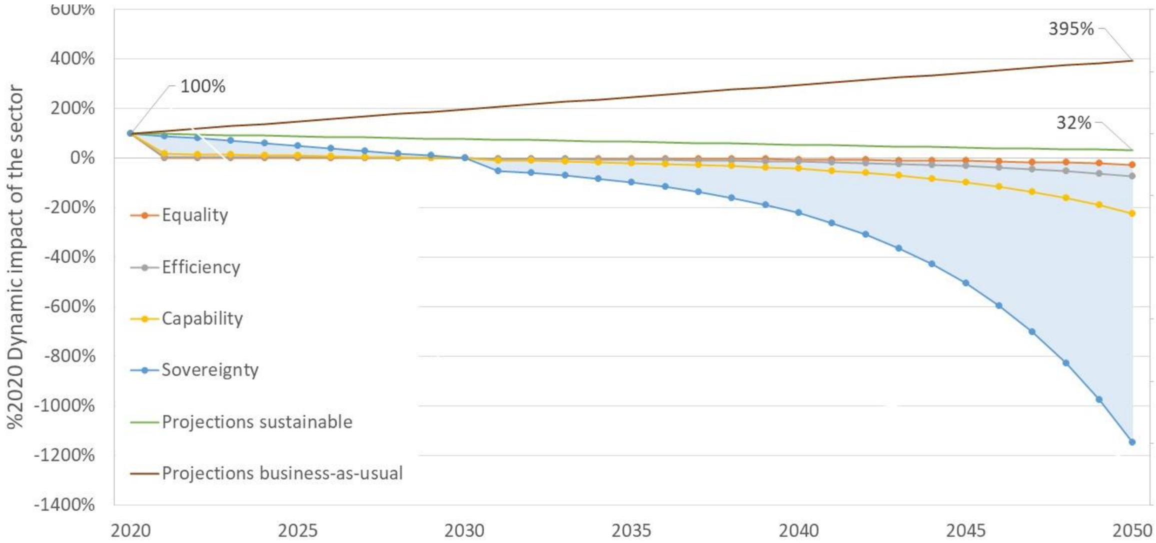


Figure 36: Raw materials extraction sector's dynamic impact per allocation system and with the estimated dynamic impacts calculated with raw materials projections

The increase of the impact in the sustainable scenario is mainly due to the increase of the surfaces exploited by the forest sector. As seen in the results based on the Kok et al. data (2018), the reduction or increase in the impacts of one sector may be strongly correlated with that of another (*e.g.,* the reduction in the impact of the agricultural sector is at the expense of the increase in the impact of the logging sector). In the same way, the impact reduction policies of the energy sector (related on climate change issues) will have a strong impact on the demand for raw materials, which will result on a reduction in fossil fuels and the increase in metals used for electrical storage of vehicles or for renewable energy equipment.

The attribution of impacts by sector operated by our four trajectories does not take into account the dynamics between and the fact that some rely heavily on others but treats each sector separately. Thus, a new attribution method could be developed that would give more "impact rights" to certain sectors if they allow to reduce impacts elsewhere in the value chain, within the perimeter of other sectors.

8.4 Assumptions behind the different scenarios

Table 15: Main assumptions behind the scenarios for the forestry sector (Kok et al. 2018)

	Trend	Consumption Change
Population and GDP	OECD's (2012) projections	
Lifestyle measures	Lifestyle change driven by income trends	Preference for public transport, 20% lower material consumption, recycling of steel, lower heating / cooling demand
Consumption	Income driven consumption trends	Meat consumption levels at a twice the level suggested for a healthy diet
Climate change		Climate change is mitigated to levels not exceeding 2 degrees increase by 2100 with relatively low use of bioenergy, to limit trade-offs between biodiversity and climate policies.
Supply chain waste and losses	At historical values	Waste and losses are halved (to 15% of production)
Agriculture productivity and land	Based on trends in FAO scenarios	In all regions, 15% improvement in crops yields. Biofuels production and wood plantations are only allowed on land currently not used for food production and not assigned as protected areas
Protected areas	No change in protected areas	The protected area network will expand to reach the Aichi biodiversity target of protecting at least 17% of the major ecosystems
Forestry	Wood demand increases driven by increase in income	Forest plantations supply 50% of timber demand. Almost all selective logging
Infrastructure	Impact of infrastructure on biodiversity increases based on historic correlations	Slower expansion of infrastructure (2050 values equal to 2030 values)
Access to modern energy	Access driven by income trends	Grid investments, subsidies for LPG and micro-credit for related stoves and distribution of improved biomass stoves for the poorest households
Energy efficiency	Efficiency trends driven by energy prices	Default efficiency improvement induced by carbon tax
Bioenergy	Defaults bio-energy potential (around 100-200 EJ/yr in 2050)	Constrained by sustainability criteria restricting potential for purposely grown bio-energy crops to less than 100 EJ/yr in 2050
Access to food	Trends driven by historically observed relationships with income	Inequality in the distribution of global per capita consumption rates reduced so that all people are above the minimum consumption level in 2050

Table 16: Main assumptions behind the IRP's scenarios (IRP 2020a)

	Historical trends	Towards sustainability
Shared Socioeconomic Pathway	SSP2: Historical trends continue, with uneven development and a weak focus on sustainability	SSP1: The world shifts to a more sustainable path, emphasizing inclusive development and respecting environmental boundaries. Diet and bioenergy assumptions go beyond SSP1.

Population	10.2 billion in 2060, matching OECD reference scenario	
Economic assumptions	Calibrated to OECD reference scenario	Towards Sustainability accounted for economic impacts of policies and actions set out above, with no additional economic assumptions.
Resource use and efficiency	Historical trends in per capita resource use and resource intensity	Policies achieve a step change in improvement in resource efficiency, slowing the growth of global resource extractions and use
Sustainable production and consumption (SCP)	No specific measures	Towards sustainability interprets SCP as resource efficiency plus action on food, water, energy, climate, life on land food and water, and ensuring levels of non-renewable resource extraction are consistent with managing environmental impacts
Climate and GHG emissions	Scenario calibrated to RCP6.0 cumulative emissions, with historical trends in greenhouse gas emissions	Emissions reductions calibrated to achieve RCP2.6 cumulative emissions
Land	No specific measures	Limit the extension of agricultural land. Eliminate crop-based biofuels by 2020, reducing competition for land and food price pressures. Ensure zero net global deforestation by 2030 with net restoration of native habitat supported by payments for carbon bio sequestration. Ensure Aichi target of at least 17 per cent of each ecoregion protected globally by 2030.
Energy	No specific measures	Emissions reductions actions substantially increase renewable energy share relative to HT. Bioenergy is limited to BECCS and other biofuels not allowed. Rate of energy efficiency improvement at least doubles by 2030, relative to HT.
Water	No specific measures	Eliminate or substantially reduce irrigation-related water stress
Food	No specific measures	Consumer driven shift to healthy diets supported by higher incomes and public policies. Reduce food waste per person by 50 per cent by 2030

9. Tailings dam failures in the mining sector

Tailing dams are engineered structures used in mining operations to contain the waste materials that remain after ore has been extracted. These waste materials, called tailings, can contain a variety of harmful chemicals and minerals, including heavy metals and sulfuric acid which can pose a significant risk to the environmental and human health if not properly contained.

Tailings dam failures occur when these structure breach or collapse, releasing large amounts of toxic tailings into the surrounding environment. The failure can be caused by various factors, including poor design, inadequate maintenance, structural defects and natural disasters such as heavy rainfall or earthquakes.

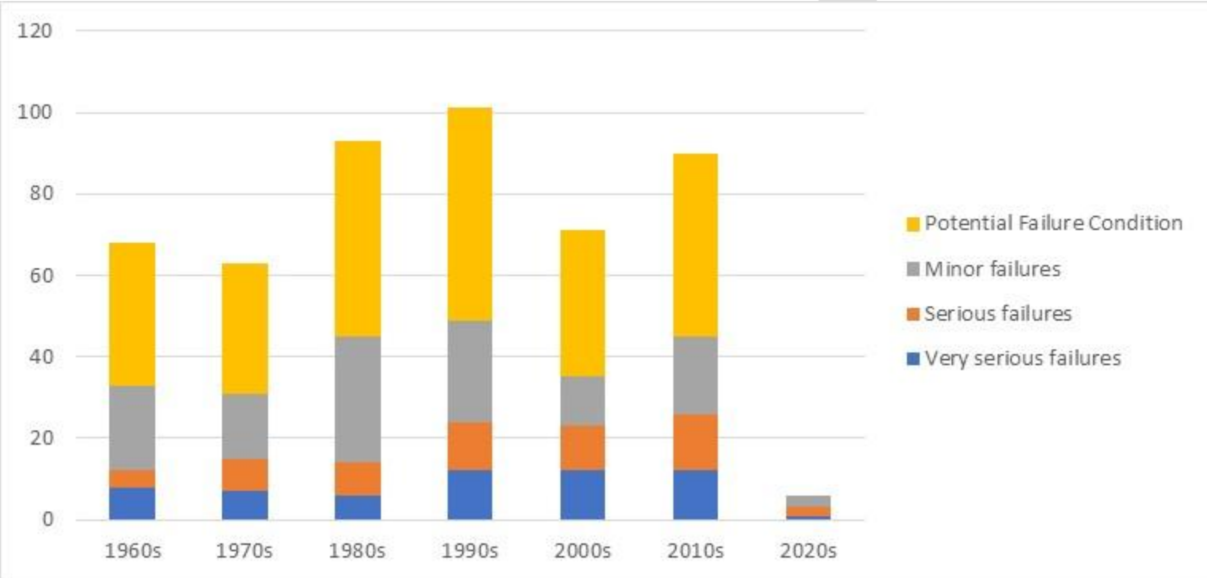


Figure 37: Tailings dams failure events over time and according to the extent of failure

10. Hydrological disturbance due to direct water use

In the GBS, the pressure Hydrological disturbance due to direct water use (HD_{water}) is the share of hydrological disturbance caused by water abstraction and water management on waterbodies (rivers, lakes and wetlands) (CDC Biodiversité 2020d). All water withdrawals should theoretically be taken into account.

However, when assessing the water footprint, it is important to distinguish between blue and green water. Blue water refers to freshwater found in rivers, lakes and underground aquifers. This is the type of water that is most commonly used for irrigation and industrial purposes or domestic water use. Green water on the other hand refers to the water from precipitation that does not run off or recharge the groundwater but is stored in the root zone of soil and used by plants for growth. It is particularly relevant to assess the green water footprint for agricultural and forestry products (Water Footprint Network n.d.).

However, the GBS does not quantify the impacts of green water because of a lack of satisfying method to dimension them, and only blue water consumption is considered (it is more easily available and its impact on the flow of rivers and wetlands is more direct). Therefore, in the Wood logs CommoTool, green water consumption related to vegetation growth is considered to have zero biodiversity impact.

In the logging sector, green water is important because it plays a crucial role in maintaining the health and productivity of forests. It represents more than 90% of the water use in the production of roundwood (Schyns, Booij, and Hoekstra 2017) (see Figure 3.6-31). The green water footprint of wood products can vary greatly depending on the type of forest, the age and density of the trees and the climatic conditions, that have influence on the forest evaporation rates and thus the green water use.

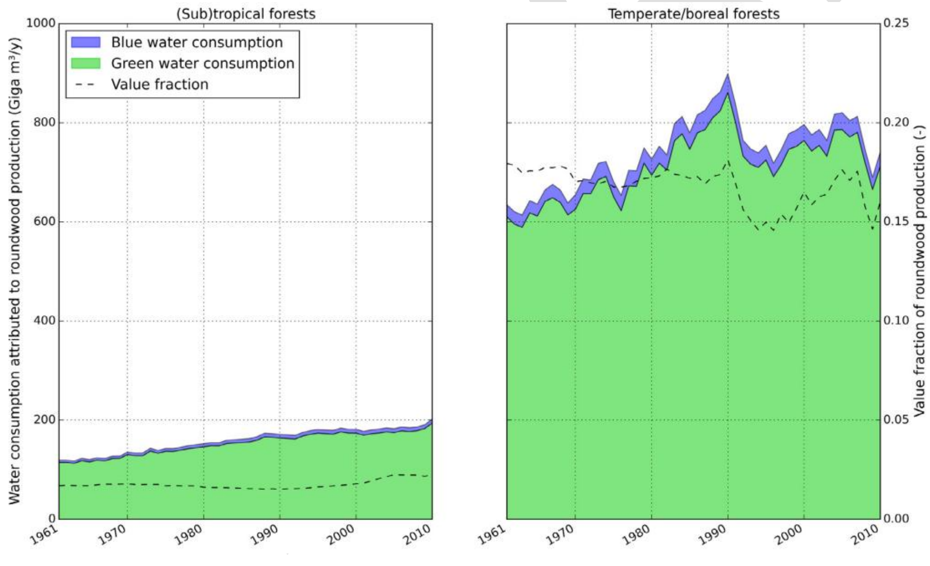


Figure 38: Water consumption attributed to roundwood production for subtropical and temperate/boreal forests between 1961 and 2010 (Schyns, Booij, and Hoekstra 2017)

Though green water is essential for forest, the storage in the soil can have negative impacts on the overall ecosystem. When trees are logged, there is a significant reduction in the amount of green water that is stored in the soil which can result in a loss of food sources, shelter and breeding sites (Olsson et al. 2019). In addition, the loss of green water can also affect the quality and quantity of water in streams and rivers, which can have negative impacts on aquatic ecosystems. Another potential impact of green water use is soil erosion. When there is less green water in the soil, it can become dry and compacted, making it more prone to erosion. This can lead to the loss of valuable topsoil, which can affect the ability of plants to grow and can also impact the overall health of the ecosystem.

Water footprint and life cycle analysis are two different approaches to estimate the impacts of green water used by forests. While both methods can be used to assess the environmental impacts of water use, LCA would consider not only the water footprint of one forest product, but also the potential impacts of changes in water availability on other ecosystem services, such as carbon storage habitat provision and soil erosion. What matters for flow deviation is the change of evapotranspiration between the agricultural or forestry system and the natural vegetation, i.e., the net green water footprint (Gerbens-Leenes, Berger, and Allan 2021).

However, some have provided suggestions for incorporating the impacts of green water use into LCA methodologies. For example, Quinteiro et al. (2015) use different existing methods to assess potential environmental impacts derived from green water flows in LCA at the interface between green water use and soil. All methods focus on changes in long-term blue water availability due to increased green water use. Núñez et al. (2013), on the other hand, use a model to estimate net green water use based on climate data, soil properties, and vegetation characteristics, coupled with a global mapping tool to spatially distribute vegetation and estimate net green water use on a regional or global scale.

Finally, it is important to note that sustainable forest management practices can help reduce the water footprint of wood product by promoting efficient use of water resources and preserving forest ecosystems (UPM 2022).

D. EU TAXONOMY GUIDELINES

1. Economic activities included in the EU taxonomy

The only economic activities belonging to the raw material extraction sector covered directly by the EU taxonomy are forestry-related activities (European Commission 2022, 1). They are associated with NACE code 02. Forestry and logging and include:

- Afforestation
- Rehabilitation and restoration of forests, including reforestation and natural forest regeneration after an extreme event
- Forest management
- Conservation forestry

The screening criteria published so far in the Delegated Act on climate objectives (Official Journal of the European Union 2021) do not specifically address activities related to the extraction of oil and gas, coal, metals or minerals.

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)

1. Afforestation plan and subsequent forest management plan or equivalent instrument

1.1. The area on which the activity takes place is covered by an afforestation plan of a duration of at least five years, or the minimum period prescribed in national law, developed prior to the start of the activity and continuously updated, until this area matches the definition of forest as set out in national law or where not available, is in line with the FAO definition of forest.

The afforestation plan contains all elements required by the national law relating to environmental impact assessment of afforestation.

1.2. Preferably through the afforestation plan, or if information is missing, through any other document, detailed information is provided on the following points:

(a) description of the area according to its gazetting in the land registry;

(b) site preparation and its impacts on pre-existing carbon stocks, including soils and above-ground biomass, in order to protect land with high carbon stock (3);

(c) management goals, including major constraints;

(d) general strategies and activities planned to reach the management goals, including expected operations over the whole forest cycle;

(e) definition of the forest habitat context, including main existing and intended forest tree species, and their extent and distribution;

(f) compartments, roads, rights of way and other public access, physical features including waterways, areas under legal and other restrictions;

(g) measures deployed to establish and maintain the good condition of forest ecosystems;

(h) consideration of societal issues (including preservation of landscape, consultation of stakeholders in accordance with the terms and conditions laid down in national law);

(i) assessment of forest related risks, including forest fires, and pests and diseases outbreaks, with the aim of preventing, reducing and controlling the risks and measures deployed to ensure protection and adaptation against residual risks;

(j) assessment of impact on food security;

(k) all DNSH criteria relevant to afforestation.

1.3. When the area becomes a forest, the afforestation plan is followed by a subsequent forest management plan or an equivalent instrument, as set out in national law or, where national law does not define a forest management plan or equivalent instrument, as referred to in the FAO definition of 'forest area with long-term forest management plan' (4). The forest management plan or the equivalent instrument covers a period of 10 years or more and is continuously updated.

1.4. Information is provided on the following points that are not already documented in the forest management plan or equivalent system:

(a) management goals, including major constraints (5);

(b) general strategies and activities planned to reach the management goals, including expected operations over the whole forest cycle;

(c) definition of the forest habitat context, including main existing and intended forest tree species, and their extent and distribution;

(d) definition of the area according to its gazetting in the land registry;

(e) compartments, roads, rights of way and other public access, physical features including waterways, areas under legal and other restrictions;

(f) measures deployed to maintain the good condition of forest ecosystems;

(g) consideration of societal issues (including preservation of landscape, consultation of stakeholders in accordance with the terms and conditions laid down in national law);

(h) assessment of forest related risks, including forest fires, and pests and diseases outbreaks, with the aim of preventing, reducing and controlling the risks and measures deployed to ensure protection and adaptation against residual risks;

(i) all DNSH criteria relevant to forest management.

1.5. The activity follows the best afforestation practices laid down in national law, or, where no such best afforestation practices have been laid down in national law, the activity complies with one of the following criteria:

(a) the activity complies with Commission Delegated Regulation (EU) No 807/2014 (6);

(b) the activity follows the "Pan-European Guidelines for Afforestation and Reforestation with a special focus on the provisions of the UNFCCC" (7).

1.6. The activity does not involve the degradation of land with high carbon stock (8).

1.7. The management system associated with the activity in place complies with the due diligence obligation and legality requirements laid down in Regulation (EU) No 995/2010 of the European Parliament and of the Council (9).

1.8. The afforestation plan and the subsequent forest management plan or equivalent instrument provide for monitoring that ensures the correctness of the information contained in the plan, in particular as regards the data relating to the involved area.

2. Climate benefit analysis

2.1. For areas that comply with the requirements at forest sourcing area level to ensure that carbon stocks and sinks levels in the forest are maintained or strengthened over the long term in accordance with Article 29(7), point (b), of Directive (EU) 2018/2001 the activity complies with the following criteria:

(a) the climate benefit analysis demonstrates that the net balance of GHG emissions and removals generated by the activity over a period of 30 years after the beginning of the activity is lower than a baseline, corresponding to the balance of GHG emissions and removals over a period of 30 years starting at the beginning of the activity, associated to the business-as-usual practices that would have occurred on the involved area in the absence of the activity;

(b) long-term climate benefits are considered demonstrated by proof of alignment with Article 29(7), point (b), of Directive (EU) 2018/2001.

2.2. For areas that do not comply with the requirements at forest sourcing area level to ensure that carbon stocks and sinks levels in the forest are maintained or strengthened over the long term in accordance with Article 29(7), point (b), of Directive (EU) 2018/2001 the activity complies with the following criteria:

(a) the climate benefit analysis demonstrates that the net balance of GHG emissions and removals generated by the activity over a period of 30 years after the beginning of the activity is lower than a baseline, corresponding to the balance of GHG emissions and removals over a period of 30 years starting at the beginning of the activity, associated to the business-as-usual practices that would have occurred on the involved area in the absence of the activity.

(b) the projected long-term average net GHG balance of the activity is lower than the long-term average GHG balance projected for the baseline, referred to in point 2.2, where long term corresponds to the longer duration between 100 years and the duration of an entire forest cycle.

2.3. The calculation of climate benefit complies with all of the following criteria:

(a) the analysis is consistent with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (10). The climate benefit analysis is based on transparent, accurate, consistent, complete and comparable information, covers all carbon pools impacted by the activity, including above-ground biomass, below-ground biomass, deadwood, litter and soil, relies on the most conservative assumptions for calculations and includes appropriate considerations about the risks of non-permanence and reversals of carbon sequestration, the risk of saturation and the risk of leakage.

(b) the business as-usual practices, including harvesting practices, are ones of the following:

(i) the management practices as documented in the latest version of the forest management plan or equivalent instrument before the start of the activity, if any;

(ii) the most recent business-as-usual practices prior to the start of the activity;

(iii) the practices corresponding to a management system ensuring that carbon stocks and sinks levels in the forest area are maintained or strengthened over the long term as set out in Article 29(7), point (b), of Directive (EU) 2018/2001.

(c) the resolution of the analysis is proportionate to the size of the area concerned and values specific to the area concerned are used.

(d) emissions and removals that occur due to natural disturbances, such as pests and diseases infestations, forest fires, wind, storm damages, that impact the area and cause underperformance do not result in non-compliance with Regulation (EU) 2020/852, provided that the climate benefit analysis is consistent with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories regarding emissions and removals due to natural disturbances.

2.4. Forest holdings under 13ha are not required to perform a climate benefit analysis.

3. Guarantee of permanence

3.1. In accordance with national law, the forest status of the area in which the activity takes place is guaranteed by one of the following measures:

(a) the area is classified in the permanent forest estate as defined by the FAO (11);

(b) the area is classified as a protected area;

(c) the area is the subject of any legal or contractual guarantee ensuring that it will remain a forest.

3.2. In accordance with national law, the operator of the activity commits that future updates to the afforestation plan and the subsequent forest management plan or equivalent instrument, beyond the activity that is financed, will continue to seek the climate benefits as determined in point 2. Besides, the operator of the activity commits to compensate any reduction in the climate benefit determined in point 2 with an equivalent climate benefit resulting from the conduct of an activity that corresponds to one of the forestry activities defined in this Regulation.

4. Audit

Within two years after the beginning of the activity and every 10 years thereafter, the compliance of the activity with the substantial contribution to climate change mitigation criteria and the DNSH criteria are verified by either of the following:

(a) the relevant national competent authorities;

(b) an independent third-party certifier, at the request of national authorities or the operator of the activity.

In order to reduce costs, audits may be performed together with any forest certification, climate certification or other audit.

The independent third-party certifier may not have any conflict of interest with the owner or the funder, and may not be involved in the development or operation of the activity.

5. Group assessment

The compliance with the criteria for substantial contribution to climate change mitigation and with DNSH criteria may be checked:

(a) at the level of the forest sourcing area (12) as defined in Article 2, point (30), of Directive (EU) 2018/2001;

(b) at the level of a group of holdings sufficiently homogeneous to evaluate the risk of the sustainability of the forest activity, provided that all those holdings have a durable relationship between them and participate in the activity and the group of those holdings remains the same for all subsequent audits.

3. Other European initiatives

As demand for raw materials is projected to double by 2060, the European Commission expects that industries will need a secure supply of clean and affordable energy and thus, of raw materials (OECD 2019b). The Raw Materials Initiative launched in 2008 by the European Union was a first step towards this ambition. This strategic policy framework aimed to secure a sustainable supply of raw materials, ranging from metals and minerals to forest-based materials (European Commission 2008).

After the Green Deal publication in 2019, the Raw Materials Supply Group and the European Commission have developed and agreed upon a set of principles for sustainable raw materials in terms of social, environmental and economic performance (European Commission. Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. 2021). The goal is to align the understanding of sustainable raw materials extraction (from exploration to post-closure) and processing operations in the EU amongst Member States and define the general direction towards the Sustainable Development Goals.

Environmental principles (European Commission. Directorate General for Internal Market, Industry, Entrepreneurship and SMEs. 2021)***:***

Sustainable raw materials extraction and processing apply sound environmental management practices. It is ensured by:

a. applying sound science- and knowledge-based environmental management of technical and economic feasibility, which is in alignment with the current legal framework in place and the European Green Deal; the main negative impacts of the operations on the environment (e.g. water, air, soil) as well as resulting damages will be adequately monitored, assessed and minimised;

b. environmental protection and mitigation measures being applied throughout the life of an extraction and processing operation, from exploration to post closure;

c. applying the best available techniques on extractive waste management, in line with the Extractive Waste Directive and the Reference Document for the Management of Waste from Extractive Industries (MWEI) BREF in place;

d. applying, in line with current EU legislation and the European Green Deal and Biodiversity Strategy, the conservation of biodiversity, and any negative impact on biodiversity is minimised and where legally stipulated compensated through implementation of integrated approaches as well as reconciliation of extractive and processing activities in Natura 2000 sites.

Sustainable raw materials extraction and processing improve and promote efficient energy use, support climate change mitigation and adaptation measures through:

a. improving the efficiency of energy use and promoting the use of renewable energy sources in order to minimise greenhouse gas emissions. The CO2 equivalent emissions are measured and/or estimated and reported in line with accepted reporting standards laid down in EU and national/regional legislation;

b. supporting or alignment with the objectives of global climate agreements through science-based targets for the reduction or mitigation of CO2 equivalent emissions and promoting the use of available renewable energy sources;

c. assessing the vulnerability of operations to climate change, improving resilience of operations to climate change through suitable adaptation measures and contributing to the resilience of nearby communities, including indigenous people, in the face of climate change effects.

Sustainable raw materials extraction and processing includes materials stewardship and contributes to the EU's circular economy where possible and within its responsibilities through:

a. facilitating and encouraging the promotion of safe use, recycling and disposal of products through an understanding of their material use or material stewardship in thematic areas;

b. promoting material stewardship in mining and processing, including economic extraction of by products and the recovery of raw materials from mining and processing waste as well as other secondary resources.

Moreover, the European Commission adopted several initiatives in 2020 and 2021 anchored in the European Green Deal and related to raw materials:

- 2020 Industrial Policy for the EU and the 2021 Industrial Strategy Update. The ambitious goal of the European Green Deal will require significant changes in the EU's economies and supply chains, and this includes raw materials supply chains. The EU needs to ensure a secure and sustainable supply of raw materials to meet the needs of clean and digital technologies, and this is part of the industrial strategy of March 2020.

- 2020 Circular Economy Action Plan (CEAP) is a list of interrelated initiatives to establish a consistent product policy framework. As demand for raw materials is projected to double by 2050, the Commission explains that industry will need a secure supply of clean and affordable energy and raw materials. It holds proposals for increasing the circularity and retention of raw materials in the EU economy.

- 2020 Communication "Critical Raw Materials Resilience" charts a path towards greater security and sustainability. This communication building on the EU's Raw Materials Initiative updates the list of raw materials critical for the EU and proposed a Critical Raw Materials Action plan for increased resilience in the EU's supply chains through secure and sustainable supply of critical raw materials.

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