



SECTORAL BIODIVERSITY FOOTPRINT BENCHMARKS

Technical annex

February 2022

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Version

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More information

About the GBS: <https://www.cdc-biodiversite.fr/gbs/>

Benchmark factsheets: <https://www.mission-economie-biodiversite.com/actualites/fiches-benchmark-benchmark-factsheets>

Agriculture and Agrifood factsheet: <https://www.mission-economie-biodiversite.com/downloads/benchmark-factsheet-agriculture-and-agrifood/>

Chemical factsheet: <https://www.mission-economie-biodiversite.com/downloads/benchmark-factsheet-chemical/>

1 General technical elements

1.1 Purpose of this document

This document provides methodological elements to understand how the sectoral benchmark factsheets are built and how computations and charts are obtained. It also provides additional content that could not be included in the factsheet due to space constraints. Such additional content relates to the perimeter of each factsheet, more detailed charts as well as guidance on how to read and use the factsheets.

The factsheets are short 4-page documents condensing information on a sector's biodiversity performance. They provide information on the sector's current contribution to biodiversity loss, its performance, how it compares to other sectors, how it will be affected by biodiversity loss and what possible actions can be taken to reduce its impacts on biodiversity.

The factsheets also provide detailed information on the sectors' impacts on biodiversity, through breakdowns of the impact by both Scope and pressures and by subsectors when relevant.

Factsheets should be used by companies as a first rough assessment of their impact on biodiversity as part of a given sector. Once they have evaluated their own impact with more precise and specific data, factsheets should be used by companies to assess their performance relative to their sectors.

1.2 Required features of the factsheets

The factsheets are intended to be a first lever for companies and sectors to assess and understand their impacts on biodiversity and to implement strategies to achieve biodiversity gains. The specifications required to do so and to ensure that they empower companies and financial institutions to reverse their impact on biodiversity are presented below.

Factsheets are addressed to different types of readers and aim to be useful to all of them. They were thus designed to provide information to both potential users, namely companies and financial institutions, and other potential stakeholders such as consultants, NGOs, public authorities, etc.

Feature	Solution
Relevant aggregation of industries into summary sheets (see section 1.5)	<ul style="list-style-type: none"> - 13 sheets: which can be drafted under a reasonable time (about 12-24 months) - Inclusion of the priority sectors of the French National Biodiversity Plan - Repartition of the EXIOBASE sectors based partly on their location within the value chain → activities with similar characteristics are grouped together. This is to ensure that all industries included in a factsheet have impact values that are within the same range. - Links with NACE codes to ensure the consistency of the repartition, the coverage of the whole economy and to help companies to position themselves
Representative	<ul style="list-style-type: none"> - When aggregating impacts from multiple industries, averages are weighted by the turnover of each industry
Easy communication and interpretation	<ul style="list-style-type: none"> - Choice of the MSA.m²/kEUR of turnover: same unit as in GBS assessments. Enables the comparison of different sectors for the same amount of turnover. Visual: biodiversity impacts are expressed as the surface area of undisturbed ecosystem which are artificialized due to the production of EUR 1000 of turnover. - Graphs and maps - Results in ppb¹/kEUR to facilitate comparison of the impacts on terrestrial and aquatic biodiversity. - Display of the aggregated score used by financial institutions.
Scientifically robust	<ul style="list-style-type: none"> - The factsheets are based on a peer reviewed tool: the GBS (CDC Biodiversité 2020d; 2020e; 2020b; 2020a; 2020f; 2020e) - The factsheets are reviewed by relevant stakeholders and adjusted according to their feedback
Detailed analysis of the impacts	<ul style="list-style-type: none"> - Geographical split, breakdown by activity, pressure, and Scope to understand where the impacts occur and why
Give insight on how to reduce the impact of the sector	<ul style="list-style-type: none"> - The sheets contain a section “Possible actions to reduce the impacts on biodiversity”
Comprehensively cover biodiversity impacts	<ul style="list-style-type: none"> - Biodiversity impacts not covered by the quantitative section are covered by the environmental safeguards section

The aim is to produce benchmark sheets on biodiversity impact of sectors and to progressively cover all sectors. The first sectors studied are the priority ones, as defined by the French National Biodiversity Action Plan. Indeed the 31st action of the Plan states the following:

"[Action 31] By 2022, we will support four priority sectors (namely: the construction, food, energy and chemical sectors) to enable them to significantly reduce their biodiversity footprint along their whole value chain. Each sector will need to identify its own levers and work on trajectories and scenarios enabling the evolution of practices as well as of the necessary regulatory and methodological frameworks (guidance,

¹ ppb (part per billion) is the equivalent of the percentage except that it gives a value per billion and not per hundred.

labels, incentive tools, regulatory measures, green growth commitments, etc.) to support the transition, together with sector strategic committees” (Comité interministériel biodiversité, 2018).

Finally, the biodiversity footprint assessment of Schneider Electric (Schneider Electric and CDC-Biodiversité 2020) was an opportunity to create the factsheet dedicated to the Manufacture of electrical equipment.

The other groups were partly driven by a value chain classification of the industries, as can be seen in Table 24.

1.3 Document content

Selection of figures and tables presented in the factsheets:

A few relevant graphs were selected to keep the factsheet concise and clear. Including all figures would have been too space intensive and confusing for the reader.

Climate change impacts on biodiversity are reported separately. This allows to distinguish between impacts already tackled through the assessed entity’s climate policy and the non-climate impacts it needs to tackle through additional actions ([CDC Biodiversité 2020d](#)).

Nota Bene: the ecotoxicity pressure is considered in the qualitative analysis, but not yet in quantitative figures.

1.4 How to use the benchmark sheet

- NACE codes and sectors descriptions displayed in the first section provide information on the activities covered by the factsheet and its perimeter.
- The main figures presented in the sheet should be used to assess a business or portfolio biodiversity performance compared to the average sectoral performance. However, environmental safeguards should be kept in mind during the assessment.
- It is important to understand that the sector average given by the factsheet is the overall performance of all the sub-sectors included in the factsheet. For instance, the figures presented in the factsheet “Agriculture and Agrifood” represent the impact caused by the EXIOBASE industry groups Manufacture of food products, Manufacture of beverages, Crop and animal production, as well as Hunting and other related service activities.

Impact expressed in MSA.km²/t of raw material may be provided for some sectors. They are calculated as explained in 2.1.

1.5 General information on the Global Biodiversity Score and the Mean Species Abundance

The Global Biodiversity Score (GBS) is a corporate biodiversity footprint assessment tool that enables to evaluate the impact of companies or investments on biodiversity. The footprint is expressed in MSA.m², a unit derived from the Mean Species Abundance (MSA) metric. The latter is given as a percentage representing the intactness of the ecosystems. Indeed, the metric does not consider the genetic nor the species diversity directly but only the ecosystem diversity.

The GBS uses the concept of Scopes to avoid double counting when considering value chain impacts:

- The Scope 1 covers direct operation
- The Scope 2 covers non-fuel energy generation
- The Scope 3 covers all other purchases under Scope 3 upstream and downstream impacts reported under Scope 3 downstream

Finally, the GBS results are also differentiated between static and dynamic impacts, static impacts being persistent ones while dynamic impacts being those occurring within the assessment period.

For additional information see our report “Measuring the contributions of business and finance towards the post-2020 global biodiversity framework”, specially the Figure 2 “Differences between metrics, units, tools and indicators” (CDC Biodiversité, 2020), as well as precedent reports on the GBS (CDC Biodiversité 2019; 2017).

The MSA and thus the GBS connect with both the Natural Capital Protocol, and natural capital assessments. It is especially connected with steps 5 and 6 of the Natural Capital Protocol namely “measure impact drivers and/or dependencies” and “Measure changes in the state of natural capital. It also connects with step 7 “Value impacts and/or dependencies” but only partially.

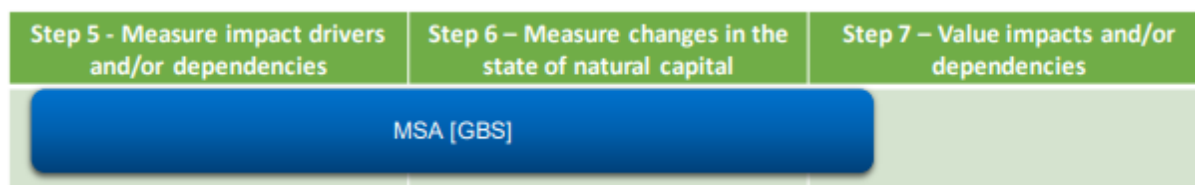


Figure 1: The GBS connects with steps 5 and 6 (and partly 7) of the Natural Capital Protocol (for biodiversity).

The development status of the factsheets is summarized in Table 1.

Table 1: Factsheets' progression and completion

Sector	Status	High-priority sector targeted by the National Biodiversity Action Plan
Agriculture Agri-food	Published	X
Raw material extraction		
Construction	Being drafted	X
Chemicals industry	Published	X
Energy		X
Manufacture of electrical equipment	Under consultation	
Manufacturing industry		
Retail		
Waste and waste management		
Transport		
Financial services		
Non-financial services and other activities		
Processing		

2 Methods

2.1 Methodology to obtain the benchmark values

The GBS tool includes impact factors expressed in MSA.m²/kEUR of turnover. For each factsheet, the results are presented in MSA.m²/kEUR of the turnover of the whole sector.

Unless stated otherwise, the values given in the factsheets and displayed in graphs and tables are global values.

A more thorough explanation of impact factors computations is given in *“Measuring the contributions of business and finance towards the post 2020 global biodiversity framework”*, p.8, *“The GBS in short”*(CDC Biodiversité 2020g).

Impact factors are given by tonne of commodity or by kEUR depending on the purpose of the assessment.

To obtain aggregated results: impact factors by commodity and pressure are summed up.

For each benchmark sector, corresponding worldwide EXIOBASE industries are weighted based on the part of worldwide turnover attributed to a given region, to obtain a regional impact factor for each industry. This first computation gives worldwide impact factors for each industry included in the benchmark sector. Finally, when there are multiple EXIOBASE industries included in the benchmark sector, a weighted average based on the share of the worldwide benchmark sector turnover represented by the EXIOBASE industry is computed.

The results are given in $\text{MSA.m}^2/\text{kEUR}$ and broken down by accounting category (static or dynamic) and biodiversity realm (terrestrial or aquatic), thus yielding four values².

Furthermore, results are split by Scopes. The main figures given are the Scope 1 impact and the vertically integrated impact (equal to the sum of the Scope 1,2 and 3 upstream). This is true of the results presented in the Box “Key Figures” on each factsheet.

In graphs, impact values are further split by pressures as can be seen under the section “Impact drivers breakdown: what are the main ones” on each factsheet.

There are five terrestrial pressure types: climate change (CC), land use (LU), encroachment (E), fragmentation (F) and nitrogen deposition (N). Land use, encroachment and fragmentation can also be grouped under the caption “spatial pressures”. More details about the different pressure types can be found in the GBS review (CDC Biodiversité 2020e).

There are also five types of aquatic pressures: hydrological disturbance due to water use (HD_{water}), hydrological disturbance due to climate change (HD_{CC}), wetland conversion (WC), land use in catchment of rivers (LUR), land use in catchment of wetlands (LUW), freshwater eutrophication (FE). More details about the different pressure types can be found in the GBS review (CDC Biodiversité 2020b).

The pressure ecotoxicity (X) impacting both terrestrial and freshwater biodiversity has been added to the GBS after version 1.1.0 and might be subject to greater uncertainties. Its results are not presented quantitatively in the factsheet, some further analyses are added when relevant.

2.2 Aggregation of the intensities in $\text{MSA.m}^2/\text{kEUR}$

The factsheet also includes two levels of aggregation of impacts.

² At the current state of development (GBS 1.0.0) dynamic aquatic results are less robust and given only for informational purposes

Terrestrial and aquatic ecosystems can be aggregated by expressing both as a fraction of their respective global area. The total emerged land surface is $130 \cdot 10^6 \text{ km}^2$ ³ and the total surface of freshwater ecosystems (lakes, rivers and wetlands) is $11 \cdot 10^6 \text{ km}^2$ (Lehner and Döll 2004). The former is used for impacts regarding terrestrial biodiversity while the latter is used for impacts on aquatic biodiversity. Figures are then expressed in MSA ppb/bEUR. For instance, for an impact intensity of 3200 MSA.m²/kEUR the corresponding aggregated value is $25\,000 = \left(\frac{3200}{130 \times 10^9} \times 10^{12}\right)$.

An aggregated “score” can be computed using the values in MSA ppb/bEUR. The score is defined as: *dynamic impact score* + $\frac{1}{50} \times$ *static impact score*, for both terrestrial and aquatic scores, and then by averaging the terrestrial and aquatic values. The reasoning behind the factor 1/50 is that a static impact is an opportunity cost, *i.e.* the persistence of the impact hindering biodiversity gains. This opportunity cost can be considered equal to the biodiversity gain which would occur over the period (here, one year) if the impact stopped. The following simplifying assumptions are taken: 1) ecosystems can recover over a period of 50 years. This hypothesis made by CDC Biodiversity is in line with scientific studies (Schipper et al. 2016) that ecosystems recovery after land abandonment return to their integrity state after 50 years for non forest biomes. This assumption is also aligned with the ASN bank report (CREM and PRé Consultants 2016); and 2) recovery is linear. The opportunity cost is then 1/50 of the static impact. If we consider the following aggregated values: a terrestrial dynamic value of 75 MSA ppb/bEUR, a terrestrial static value of 25 000 MSA ppb/bEUR, an aquatic dynamic value of 82 and an aquatic static value of 32 000 MSA ppb/bEUR we obtain the following aggregated score: $\frac{75 + \frac{25000}{50}}{2} + \frac{82 + \frac{32000}{50}}{2} = 650$.

Aggregated impacts can be found in the box “Key Figures” on each factsheet.

2.3 Assessing the dependency of a sector on ecosystem services

A sector is dependent on an ecosystem service when at least one of its production processes depends on this service to function properly. The ENCORE (Exploring Natural Capital Opportunities, Risks and Exposure) model (Natural Capital Finance Alliance (Global Canopy, UNEP FI, and UNEP-WCMC) 2021)⁴ assesses dependencies of each sector to each ecosystem service. It is based on existing classifications of ecosystem services and economic sectors and dependencies are assessed through literature review and expert interviews when the literature is not sufficient.

⁴ <https://encore.naturalcapital.finance/en>

A SCOPE 1 DEPENDENCIES

Based on ENCORE database and on the EXIOBASE classification and industries descriptions, sectoral dependency scores were computed for each EXIOBASE industry based on the following methodology (Benchekrout, et al. 2020).

In order to obtain the ecosystem services dependency values, several information are connected: **the sector** (with associated ENCORE sub-industries and production processes), the **global turnover of the sector**, the list of **ecosystem services** and **the materiality of each ecosystem service** for the industry. Three tables are used to do so:

- A table of materialities extracted from the ENCORE database reporting the materialities for each process of each ENCORE sub industry (classification based on the GICS classification). Materialities were converted into percentage: 0% for no dependency, 20% for Very Low, 40% for Low, 60% for Medium, 80% for High and 100% for Very High dependency.
- A table of EXIOBASE industries, with their global production, the corresponding GBS benchmark sector and their share in the production within the GBS benchmark sector (used as weight).
- A correspondence table between EXIOBASE and ENCORE industries. ENCORE sub-industries which have no equivalent in EXIOBASE are excluded. For each ENCORE sub-industry corresponding to an EXIOBASE industry, only the processes included in the definition of the EXIOBASE industry are kept. A weight was attributed to each ENCORE production process depending on its importance in the sub-industry.

The first and second tables are joined thanks to the third (correspondence table).

Finally, the dependency of the benchmark sector i on the ecosystem service j is calculated as:

$$Dependency_{i,j} = \sum_{\substack{k \in EXIOBASE \text{ industries} \\ \text{in benchmark sector } i}} \sum_{\substack{l \in \text{processes} \\ \text{in industry } k}} Weight_l \times Materiality_l \times \frac{Turnover_k}{Turnover_i}$$

This formula gives more weight to the most important processes of an industry and to industries with the largest turnovers. A single score (in percentage) is obtained by averaging the dependencies on all ecosystem services, in line with (Crépin 2020).

B UPSTREAM DEPENDENCIES

Industries' reliance on biodiversity is complex because their supply chains also depend on ecosystem services. For instance, even though the food-processing sector has a limited dependency on ecosystem services such as pollination through its direct operations, it relies heavily on other sectors in its supply chain, such as the agricultural sector, which are highly dependent on pollination, but also on other ecosystem

services. As a result, to fully capture the dependency of one sector on services provided by nature it is necessary to consider the dependency of its whole supply chain (World Economic Forum and PwC 2020).

Using the EXIOBASE Input-Output table, and more specifically the Leontief Inverse Matrix that exhibits all the value chain interrelations required to produce an output, the upstream dependencies of each sector can be identified. More information on the EXIOBASE Input-Output Table and the Leontief Inverse Matrix, is available in the GBS' Input Output critical review report (CDC Biodiversité 2020c).

To obtain the upstream dependencies (without Scope 1), the Scope 1 interrelations needs to be subtracted from the Leontief Inverse Matrix. This is done by subtracting the Identity matrix from the Leontief matrix. Besides, since the dependency scores cannot be summed up, the Leontief matrix needs also needs to be normalized. It would otherwise result in upstream dependency scores, sometimes exceeding 100%. To do so, the coefficients of the Leontief inverse matrix are divided by the sum of the purchases.

$$\begin{aligned} & (\text{Leontief inverse matrix} - \text{Identity matrix})_{\text{normalised}} \\ & = (\text{Leontief inverse matrix} - \text{Identity matrix}) \times \text{diag}(1/\text{Purchases}) \end{aligned}$$

Considering the direct operations (Scope 1)' dependency matrix constructed using the ENCORE materiality scores mentioned in the previous section, the upstream dependencies of the EXIOBASE industries on the different ecosystem services are computed thanks to the following formula:

$$\begin{aligned} & \text{Upstream dependency matrix} \\ & = \text{Scope 1 dependency matrix} \\ & \times (\text{Leontief inverse matrix} - \text{Identity matrix})_{\text{normalised}} \end{aligned}$$

The following table shows the shape of the Scope 1 dependency matrix

Table 2: Scope 1 dependency matrix

	Country _r		Country _s				...
	Industry _g	Industry _k	Industry _g	Industry _k			...
Ecosystem service j	Scope 1 dependency _{g,j}	Scope 1 dependency _{k,j}	Scope 1 dependency _{g,j}	Scope 1 dependency _{k,j}			...
Ecosystem service m	Scope 1 dependency _{g,m}	Scope 1 dependency _{k,m}	Scope 1 dependency _{g,m}	Scope 1 dependency _{k,m}			...
Ecosystem service n	Scope 1 dependency _{g,n}	Scope 1 dependency _{k,n}	Scope 1 dependency _{g,n}	Scope 1 dependency _{k,n}			...
...

With $\text{Scope 1 dependency}_{k,j} = \sum_{l \in \text{processes in industry } k} \text{Weight}_l \times \text{Materiality}_l$

Since there are 21 ecosystem services, 163 industries, and 49 regions, the Scope 1 dependency matrix is of size (21; 7987). It is important to note that there is no information on regional dependency and thus the dependencies of each EXIOBASE industry on each ecosystem service is the same over all EXIOBASE regions, meaning that direct dependency_{g,j} in country_r is equal to direct dependency_{g,j} in country_s.

The resulting Scope 1 dependency matrix is of the same shape and size but reversed (7987; 21) and for industry k within country s dependency on ecosystem service j is the upstream dependency k,j instead of the Scope 1 dependency k,j .

Even though there is no information on regional dependency in the Scope 1 dependency matrix, the Leontief matrix contains information on differences in the regional mix of purchases depending and so once the two matrices have been multiplied to compute the upstream dependency matrix, regional granularity appears. For the sectoral benchmarks, a global dependency score is calculated based on the average dependency scores over all regions weighted by the total turnover in the region and sector of interest. This results in one single value for each couple $\{Benchmark\ Sector; Ecosystem\ service\}$.

The upstream dependencies of the benchmark sectors (which include several EXIOBASE industries each) can then be computed thanks to the following formula:

$$Upstream\ Dependency_{i,j} = \sum_{k \in EXIOBASE\ industries\ in\ sector\ i} \times Upstream\ dependency_{k,j} \times \frac{Turnover_k}{Turnover_i}$$

As for Scope 1 dependencies, a single score is finally calculated by averaging the dependencies on all ecosystem services.

3 Supplementary information for each factsheet

3.1 Agriculture and Agrifood

A. WHAT DOES THE SECTOR INCLUDE?

The factsheet covers the Agriculture and Agrifood sector which is made of three EXIOBASE industries: “Crop and animal production, hunting and related service activities” (45% of the Agriculture and Agrifood sector), “Manufacture of food products” (47% of the Agriculture and Agrifood sector), and “Manufacture of beverages” (7% of the Agriculture and Agrifood sector).

The name of the industry group “Crop and animal production, hunting and related service activities” was changed to “Crop and animal production” for simplification purposes. The impact of commercial hunting is not assessed by the GBS 1.0.0.

As can be seen on the Figure 2, Figure 3, Figure 4, Figure 7; the “Fishing, operating of fish hatcheries and fish farms” and “Manure treatment (biogas), storage and land application, Manure treatment (conventional), storage and land application” have been removed. The fishing sector was excluded from the GBS assessment because of the current lack of sufficient data and methods on marine biodiversity in the GBS (CDC Biodiversité 2020d). As for the manure sector, it was excluded due to a lack of information for most EXIOBASE regions, rendering averaged results biased.

These EXIOBASE industries correspond to divisions 1: Crop and animal production, hunting and related service activities 10: Manufacture of food products and 11: Manufacture of beverages of the NACE rev 2 classification.

The division 1 gathers all activities under “Crop and animal production, hunting and related service activities”, namely:

- Growing of non-perennial crops (1.1).

Which excludes:

- Growing of oleaginous fruits (included in 1.2)
- Growing of chillies, peppers (capsicum sop.) and other spices and aromatic crops (included in 1.2)
- Growing of mushroom sp
- awn (included in 1.3)
- Manufacture of tobacco products
- Growing of non-perennial spices, aromatic, drug and pharmaceutical crops (included in 1.2)

- Growing of perennial crops (1.2).

Which excludes:

- Manufacture of wine
- Growing of soya beans, groundnuts and other oil seeds (included in 1.1)
- Gathering of tree sap or rubber-like gums in the wild
- Growing of flowers, production of cut flower buds and growing of flower seeds (included in 1.1)

- Plant propagation (1.3).

Which excludes:

- Growing of plants for the purpose of seed production (included in 1.1 and 1.2)
- Operation of forest tree nurseries
- Farm animal boarding and care, (included in 1.6)
- Production of hides and skins from slaughterhouses

- Animal production (1.4).

Which excludes:

- Processing of milk
- Operation of racing and riding stables
- Sheep shearing on a fee or contract basis (included in 1.6)
- Production of pulled wool
- Processing of milk
- Production of feathers or down
- Production of hides and skins originating from hunting and trapping (included in 1.7)
- Operation of frog farms, crocodile farms, marine worm farms
- Operation of fish farms
- Boarding and training of pet animals
- Mixed farming (1.5)

Which excludes:

- Mixed crop farming (included in 1.1 and 1.2)
- Mixed animal farming (included in 1.4)
- Support activities to agriculture and post-harvest crop activities (1.6).

Which excludes:

- Drainage of agricultural land
- Landscape architecture
- Activities of agronomists and agricultural economists
- Landscape gardening, planting
- Organisation of agricultural shows and fairs
- Provision of space for animal boarding only
- Veterinary activities
- Vaccination of animals
- Renting of animals (e.g. herds)
- Pet boarding
- Preparation of agricultural products by the producer, see corresponding class in groups (included in 1.1, 1.2 and 1.3)
- Stemming and redrying of tobacco
- Marketing activities of commission merchants and cooperative associations
- Wholesale of agricultural raw materials
- Growing of seeds, see groups (included in 1.1 and 1.2)
- Processing of seeds to obtain oil
- Research to develop or modify new forms of seeds
- Hunting, trapping and related service activities (1.7)

Which excludes:

- Production of fur skins, reptile or bird skins from ranching operations (included in 1.4)
- Raising of game animals on ranching operations (included in 1.4)
- catching of whales
- Production of hides and skins originating from slaughterhouses
- Hunting for sport or recreation and related service activities
- Service activities to promote hunting and trapping

The division 10 gathers all activities under “Manufacture of food products”, namely:

- Processing and preserving of meat and production of meat products (10.1)

Which excludes:

- Packaging of meat
- Manufacture of prepared frozen meat and poultry dishes
- Manufacture of soup containing meat
- Wholesale trade of meat

- Processing and preserving of fish, crustaceans and molluscs (10.2)

Which excludes:

- Processing and preserving of fish on vessels engaged in fishing
- Processing of whales on land or specialised vessels (included in 10.1)
- Production of oils and fats from marine material (included in 10.4)
- Manufacture of prepared frozen fish dishes (included in 10.8)
- Manufacture of fish soups,

- Processing and preserving of fruit and vegetables (10.3)

Which excludes:

- Processing manufacture of flour or meal of dried leguminous vegetables (included in 10.6)
- Preservation of fruit and nuts in sugar (included in 10.8)
- Manufacture of prepared vegetable dishes (included in 10.8)
- Manufacture of artificial concentrates (included in 10.8)

- Manufacture of vegetable and animal oils and fats (10.4)

Which excludes:

- Rendering and refining of lard and other edible animal fats (included in 10.1)
- Wet corn milling (included in 10.6)
- Manufacture of corn oil (included in 10.6)
- Production of essential oils
- Treatment of oil and fats by chemical processes

- Manufacture of dairy products (10.5)

Which excludes:

- Production of raw milk (cattle)
- Production of raw milk (sheep, goats, horses, asses, camels, etc.)
- Manufacture of non-dairy milk and cheese substitutes (included in 10.8)
- Activities of ice cream parlours
- Manufacture of grain mill products, starches and starch products (10.6)

Which excludes:

- manufacture of potato flour and meal (included in 10.3)
- manufacture of lactose (milk sugar) (included in 10.5)
- Production of cane or beet sugar (included in 10.8)
- Manufacture of bakery and farinaceous products (10.7)

Which excludes:

- Heating up of bakery items for immediate consumption
- Manufacture of potato snacks (included in 10.3)
- Manufacture of prepared couscous dishes (included in 10.8)
- Manufacture of soup containing pasta (included in 10.8)

- Manufacture of other food products (10.8)

Which excludes

- manufacture of glucose, glucose syrup, maltose (included in 10.6)
- Manufacture of inulin (included in 10.6)
- Manufacture of spirits, beer, wine and soft drinks (included in 11)
- Preparation of botanical products for pharmaceutical use
- Growing of spice crops (included in 1.2)
- Retail sale of prepared meals and dishes in stores
- Wholesale of prepared meals and dishes
- Activities of food service contractors
- Manufacture of perishable prepared foods of fruit and vegetables (included in 10.3)
- Manufacture of spirits, beer, wine and soft drinks (included in 11)
- Production of fishmeal for animal feed, see 10.20
- Production of oilseed cake (included in 10.4)
- Activities resulting in by-products usable as animal feed without special treatment, e.g. oilseeds (included in 10.4), grain milling residues (included in 10.6) etc.
- Manufacture of prepared animal feeds (10.9)

Which excludes

- Production of fishmeal for animal feed (included in 10.20)
- Production of oilseed cake (included in 10.4)

- Activities resulting in by-products usable as animal feed without special treatment, e.g. oilseeds (included in 10.4)
- Grain milling residues (included in 10.6) etc.

The division 11 gathers all activities under “Manufacture of beverages”, namely:

Manufacture of beverages (11)

Which excludes:

- Production of fruit and vegetable juices (included in 10.3)
- Manufacture of milk-based drinks (included in 10.5)
- Manufacture of coffee, tea and mate products (included in 10.8)
- Manufacture of synthetic ethyl alcohol (included in 20.1)
- Manufacture of ethyl alcohol from fermented materials (included in 20.1)
- Merely bottling and labelling
- Manufacture of ice

A. ADDITIONAL RESULTS

The following calculations presented in the tables were made with the GBS 1.2.2 by Alexis Costes in October 2021. As a reminder, the genetic diversity of seeds, cultivated plants, farmed, and domesticated animals are not included in the calculations as the GBS is focused on functional diversity and not generic diversity.

Table 3: Scope 1 impact intensities for the Agriculture and Agrifood sector benchmark, computation with GBS 1.2.2 in October 2021, by Alexis Costes

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/ bEUR	Footprint in MSAppb/bEUR
Dynamic	Aquatic	1.3	130	250
	Terrestrial	16	120	
Static	Aquatic	290	28 000	56 000
	Terrestrial	3 800	28 000	

Table 4: Vertically integrated⁵ impact intensities for Agriculture and Agrifood, computation with GBS 1.2.2 in October 2021, by Alexis Costes

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR
Dynamic	Aquatic	2.8	270	510
	Terrestrial	32	240	
Static	Aquatic	550	53 000	106 000
	Terrestrial	7 100	53 000	

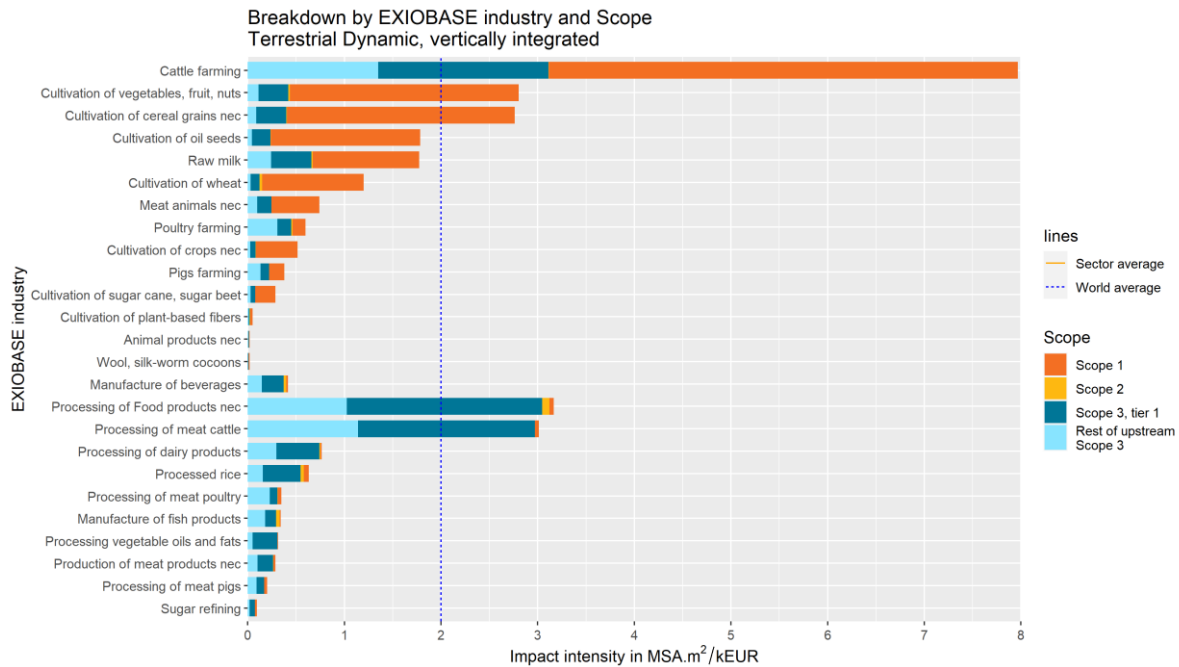


Figure 2: Breakdown by EXIOBASE industry and Scope, terrestrial dynamic, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Agriculture and Agrifood sector

⁵ Vertically integrated = Scope 1 + Scope 2 + Scope 3 upstream

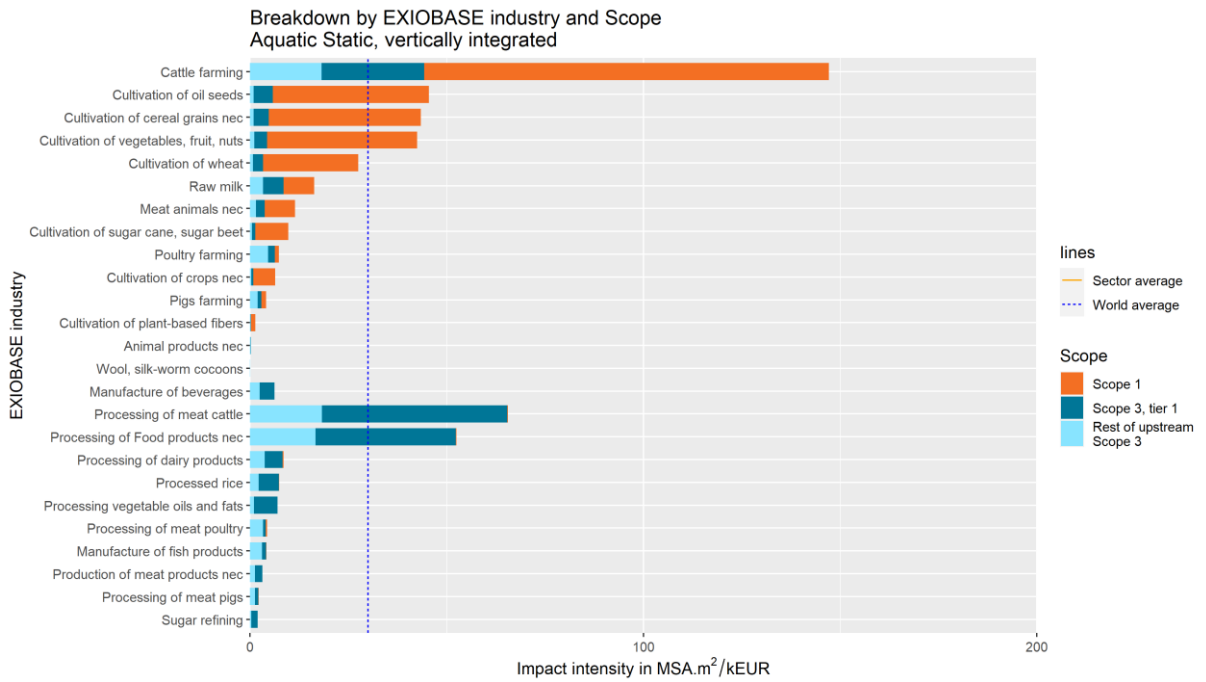


Figure 3: Breakdown by EXIOBASE industry and Scope, aquatic static, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Agriculture and Agrifood sector

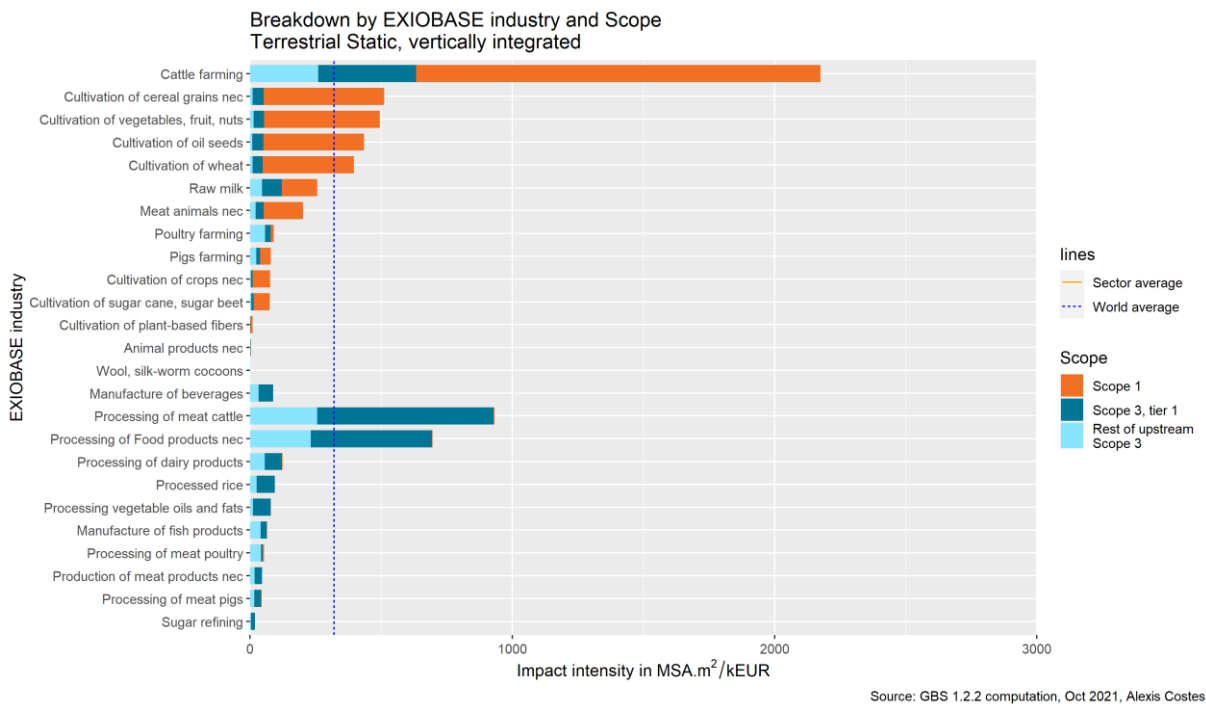
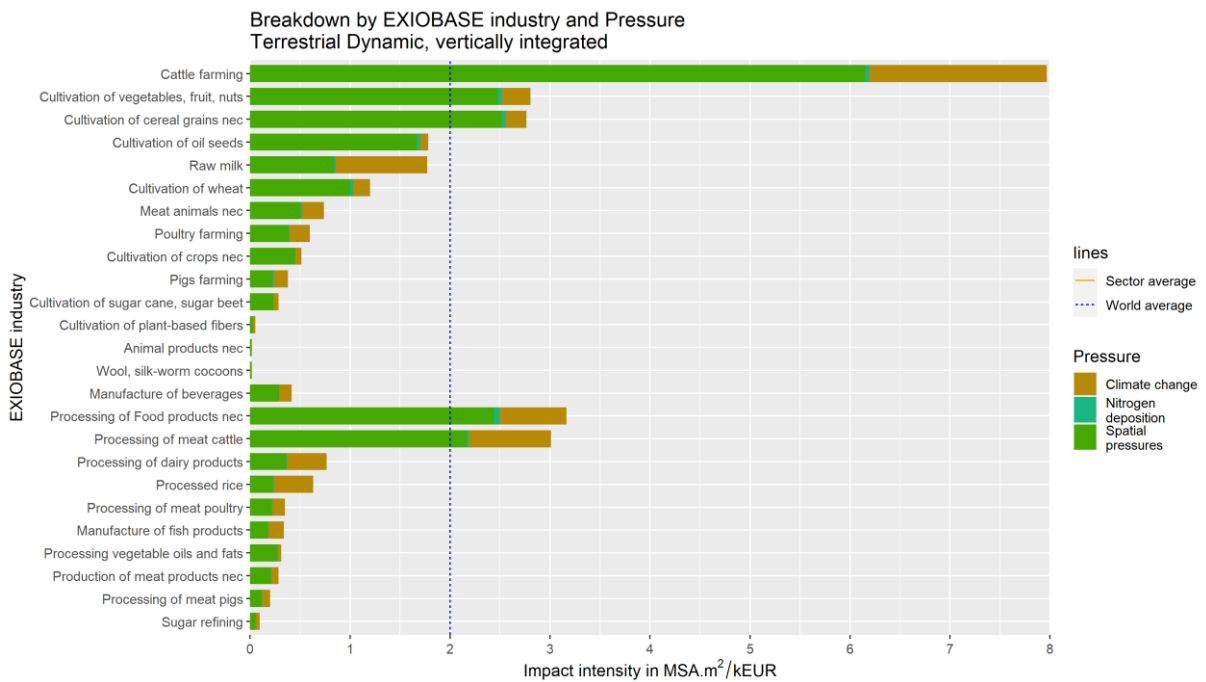
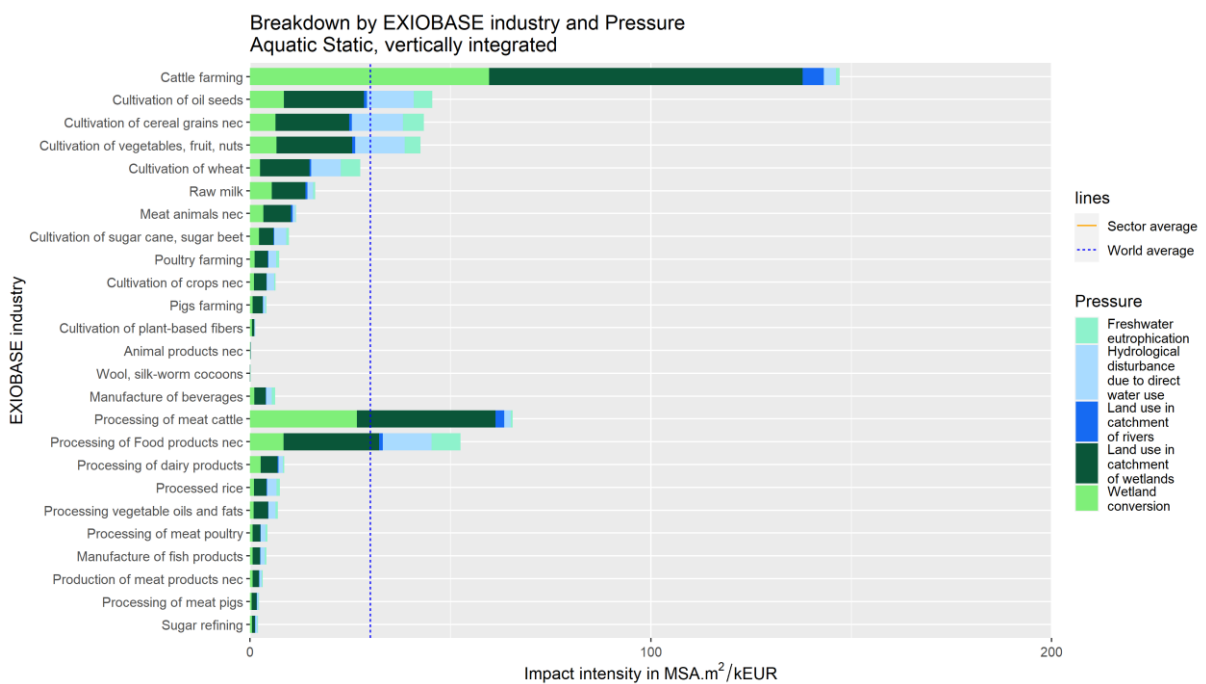


Figure 4: Breakdown by EXIOBASE industry and Scope, terrestrial static, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Agriculture and Agrifood sector



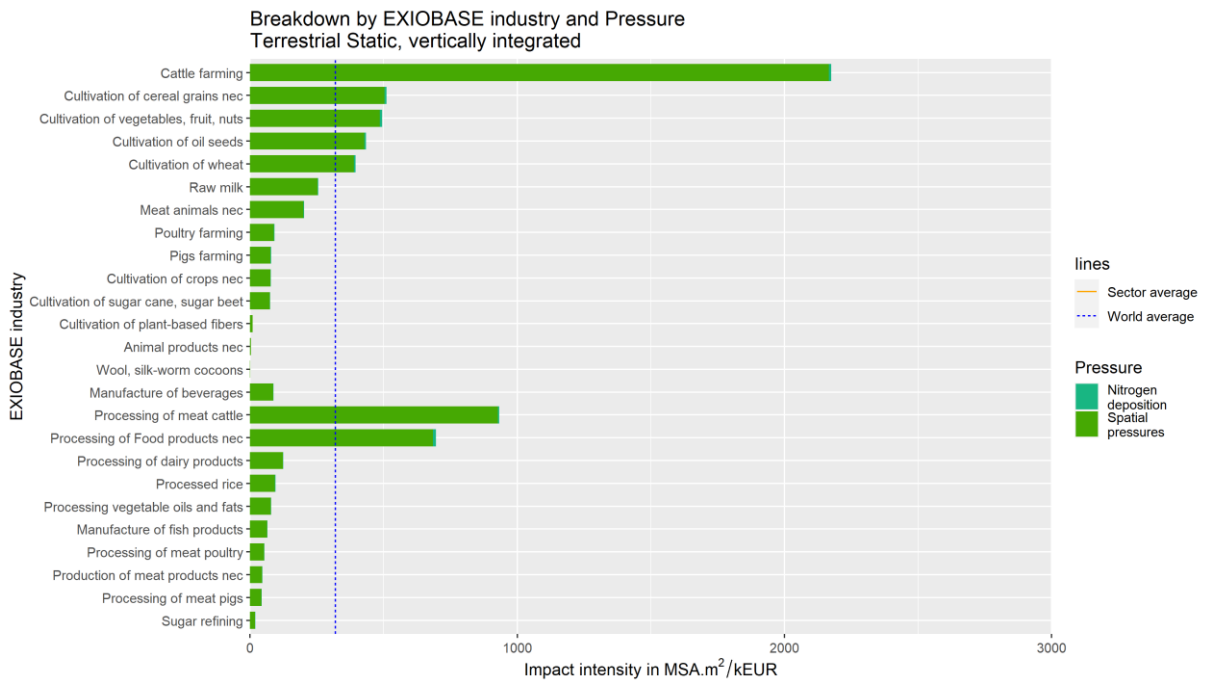
Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 5: Breakdown by EXIOBASE industry and pressure, terrestrial dynamic, vertically integrated. $MSA.m^2/kEUR$ means $MSA.m^2$ per $kEUR$ of turnover of the whole Agriculture and Agrifood sector



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 6: Breakdown by EXIOBASE industry and pressure, aquatic static, vertically integrated. $MSA.m^2/kEUR$ means $MSA.m^2$ per $kEUR$ of turnover of the whole Agriculture and Agrifood sector



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 7: Breakdown by EXIOBASE industry and pressure, terrestrial static, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Agriculture and Agrifood sector

B. ADDITIONAL DNSH GUIDELINES

The main Do No Significant Harm criteria for the sector (EU Technical Expert Group on Sustainable Finance 2020a) are provided in the factsheets. Additional criteria which did not fit within the factsheet are listed below (EU Technical Expert Group on Sustainable Finance 2020b).

To not harm the objective of Circular economy and waste prevention and recycling, activities should:

Minimize raw material use per unit of output, including energy through increased resource use efficiency.

Minimize the loss of nutrients (in particular nitrogen and phosphate) leaching out from the production system into the environment.

Use residues and by-products of the production or harvesting of crops to reduce demand for primary resources, in line with good agricultural practice.

For Livestock production: activities should use residues and by-products and take any other measures to minimize primary raw material use per unit of output, including energy.

To not harm the objective of Pollution prevention and control:

Nutrients (fertilizers) and plant protection products (e.g. pesticides and herbicides) should be targeted in their application (in time and area treated) and be delivered at appropriate levels (with

preference to sustainable biological, physical or other non-chemical methods if possible) and with appropriate equipment and techniques to reduce risk and impacts of pesticide use on human health and the environment (e.g. water and air pollution) and the loss of excess nutrients.

The use only of plant protection products with active substances that ensure high protection of human and animal health and the environment through leaching, volatilization or oxidation.

Ensure emissions to air, water and soil are within the BATAEL ranges / are prevented or reduced by using a combination of BAT techniques as set out in the BREF for the Intensive Rearing of Poultry or Pigs, and by using similar emission reducing techniques for dairy farming.

Ensure that mitigation and emission reduction techniques for feeding and housing of livestock and for manure storage and processing are applied, as recommended in the UNECE Framework Code for Good Agricultural Practice for Reducing Ammonia.

Where manure is applied to the land, activities should comply with the limit of 170kg nitrogen application per hectare per year, or alternatively, the derogated threshold where one has been set in that member state.

C. SOURCES

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3.2 Chemical

A. WHAT DOES THE SECTOR INCLUDE?

The factsheet covers the chemical sector which is made of four EXIOBASE industries: “Chemicals nec” (82% of the chemical sector), “Plastics, basic” (14% of the chemical sector), “P- and other fertiliser” (3% of the chemical sector) and “N-Fertiliser” (less than 1% of the chemical sector). After reflexion it was decided not to include the EXIOBASE sector “Manufacture of rubber and plastic products” and to assign it to a future benchmark factsheet covering the manufacturing industry. This decision was made based on the EXIOBASE classification that groups all four industries mentioned above in one industry group: “Manufacture of chemicals and chemical products” but keeps “Manufacturing of rubber and plastic products” in a separate industry group “Manufacture of rubber and plastic products”. The EXIOBASE industry “Chemical and fertilizer minerals, salt and other mining and quarrying products n.e.c” is not covered due to the lack of robustness of the mineral extraction impact factors (such as phosphorous extraction). Finally, the reason for including the NACE division basic pharmaceutical products and pharmaceutical preparations in the chemical factsheet is that it is covered by the EXIOBASE industry “chemicals nec”.

The figure below illustrates the correspondence between the EXIOBASE industry group and NACE divisions covered by the factsheet.

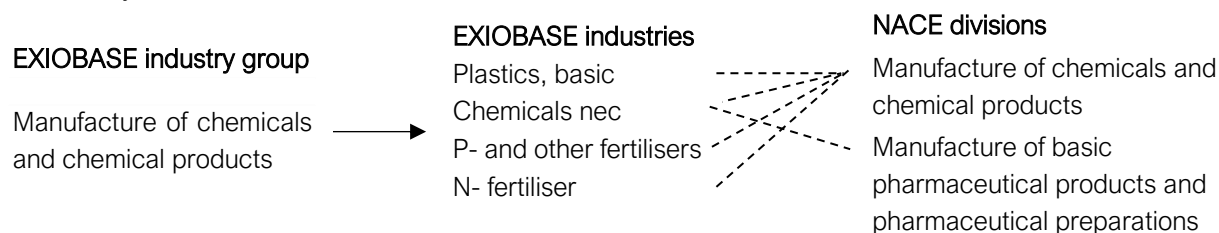


Figure 8: Correspondence between EXIOBASE industry groups and NACE divisions

These EXIOBASE industries correspond to divisions 20: Manufacture of chemicals and chemical products and 21: Manufacture of basic pharmaceutical products and pharmaceutical preparations of the NACE rev 2 classification.

The division 20 gathers all activities under “Manufacture of chemicals and chemical products”, namely:

- Manufacture of basic chemicals, fertilisers and nitrogen compounds, plastics and synthetic rubber in primary forms (20.3).

Which excludes:

- Extraction of methane, ethane, butane or propane
- Manufacture of fuel gases such as ethane, butane or propane in a petroleum refinery
- Manufacture of gaseous fuels from coal, waste etc.
- Manufacture of prepared dyes and pigments (included in 20.3)
- Manufacture of aromatic distilled water (included in 20.5)

- Manufacture of crude glycerol (included in 20.4)
 - Manufacture of natural essential oils (included in 20.5)
 - Manufacture of basic metals
 - Manufacture of salicylic and O-acetylsalicylic acids (included in 21)
 - Mining of guano
 - Manufacture of agrochemical products, such as pesticides (20.2)
 - manufacture of artificial and synthetic fibres, filaments and yarn (included in 20.6)
 - Shredding of plastic products
- Manufacture of pesticides and other agrochemical products (20.3).
 - Manufacture of paints, varnishes and similar coatings, printing ink and mastics (20.3).
Which excludes:
 - Manufacture of fertilisers and nitrogen compounds (included in 20.1)
 - Manufacture of dyestuffs and pigments (included in 20.1)
 - Manufacture of writing and drawing ink (included in 20.5)
- Manufacture of soap and detergents, cleaning and polishing preparations, perfumes and toilet preparations (20.4).
Which excludes:
 - Manufacture of separate, chemically defined compounds (included in 20.1)
 - Manufacture of glycerol, synthesised from petroleum products (included in 20.1)
 - Extraction and refining of natural essential oils (included in 20.5)
 - Manufacture of other chemical products, including the manufacture of explosives and pyrotechnic products, glues, essential oils and chemical products n.e.c. such as photographic chemical material or composite diagnostic preparations (20.5).
Which excludes:
 - Manufacture of synthetic aromatic products (included in 20.1)
 - Manufacture of perfumes and toilet preparations (included in 20.4)
 - Manufacture of chemically defined products in bulk included in 20.1)
 - Manufacture of distilled water (included in 20.1)
 - Manufacture of other organic basic chemicals (included in 20.1)
 - Manufacture of printing ink (included in 20.3)
 - Manufacture of asphalt-based adhesives
 - Manufacture of man-made fibres (20.6).
Which excludes:
 - Spinning of synthetic or artificial fibres
 - Manufacture of yarns made of man-made staple

The division 21 gathers all activities under manufacture of basic pharmaceutical products and pharmaceutical preparations.

Which excludes:

- manufacture of herb infusions (mint, vervain, chamomile etc.)
- manufacture of dental fillings and dental cement
- manufacture of bone reconstruction cements
- manufacture of surgical drapes
- wholesale of pharmaceuticals
- retail sale of pharmaceuticals
- research and development for pharmaceuticals and biotech pharmaceuticals
- packaging of pharmaceuticals

Note that for all industries covered in the factsheet, downstream impacts are not taken into account within the computations and graphs included in the chemical factsheet. However, some of these downstream impacts may be accounted for in the computations and graphs of other factsheets. For instance, the downstream impacts of the P- and other fertiliser and N-fertiliser EXIOBASE industries are Scope 1 impacts for the agriculture sector.

B. ADDITIONAL DATA

1. Bio-based chemicals market

Bio-based chemicals are important to consider because of their high potential biodiversity impact. Biomass production contributes significantly to land use and pollution pressures and bio-based products are estimated to represent about 7.2% of the chemicals and chemical products industry (Piotrowski, Stephan, Carus, Michael, and Dr. Carrez, Dirk 2019) making the potential impact of the chemical bioeconomy significant.

The following figures (Figure 9 and Figure 10) show the European turnover of the bioeconomy and the production volumes of bio-based chemicals respectively.

When analysing results computed with the GBS™ it is important to consider bio-based products in the interpretation. The GBS uses EXIOBASE data from 2011 and the production volumes of bio-based products as well as the share of bio-based chemicals within the overall chemical industry were already significant before 2011. Furthermore, as can be seen on Figure 9 and Figure 10 if production volumes increased of about 3.5 million tonnes since 2011, the turnover of the bio-based chemicals and plastics industry remained approximately the same. Thus, it can be reasonably assumed that EXIOBASE data used in the GBS reflect the current bio-based market situation. You can find the results of a comparative impact study between bio-based and fossil-based ethanol in the additional results parts (3.3.C.3).

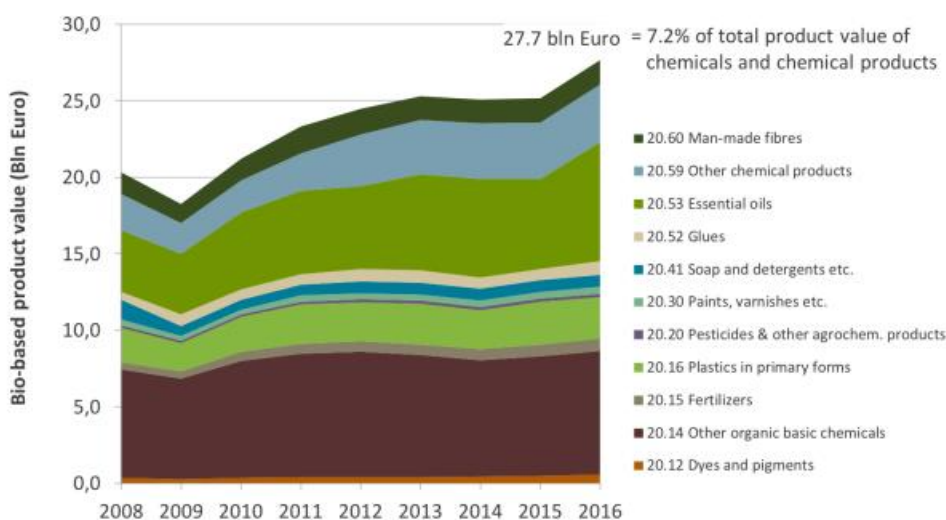


Figure 9 : Contribution of NACE sub-industries to the total product value of bio-based chemicals in billion euros in the EU-28, 2008-2016. (Piotrowski, Stephan, Carus, Michael, and Dr. Carrez, Dirk 2019).

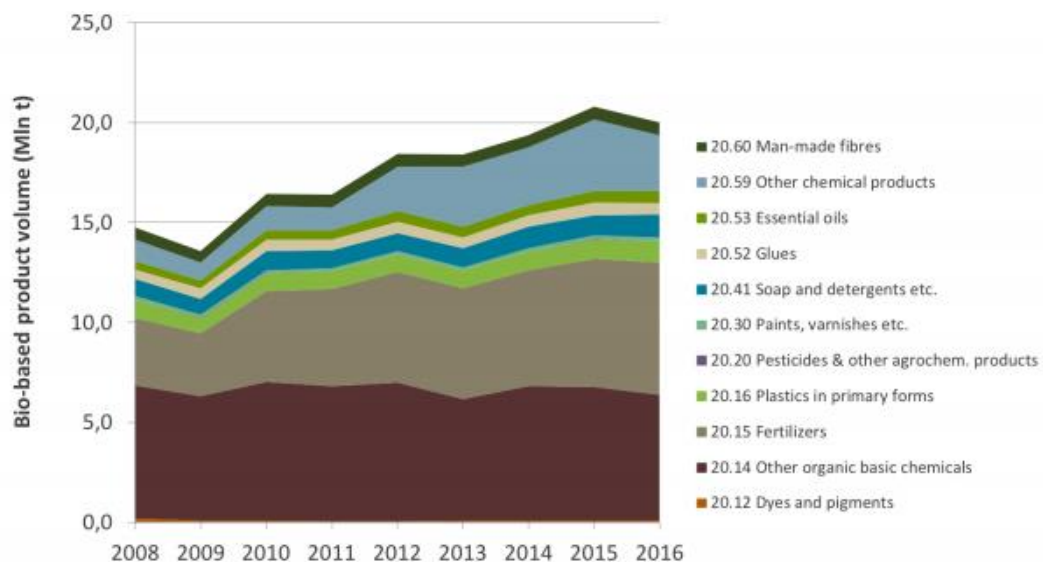


Figure 10: Contribution of NACE sub-industries to the total product volume of bio-based chemicals in million t, EU-28, 2008-2016. (Piotrowski, Stephan, Carus, Michael, and Dr. Carrez, Dirk 2019)

Values displayed in Figure 10 are volumes of finished goods. To better assess the biomass production, impacts tonnages of raw materials required to produce the goods must be made available.

In the European Union, the total biomass volume used in 2018 was 1 021 577 000t and the bio-based chemical sector used 0.1% of this domestic consumption, or about 1022 thousand tonnes. It also shows the highest growth rate of 48.4% between 2010 and 2015 (European Commission. Joint Research Centre. 2017)

Table 5 displays European production and consumption of ten bio-based chemical product categories representative of the European market for bio-based chemicals. The difference between production and consumption figures is solely due to imports and exports. There are significant variations in terms of

production volumes and especially in the share of total production between product categories. Bio-based surfactants and cosmetics represent about 50% of their product categories production, while for platform chemicals and polymers for plastic, bio- based production only accounts for about 0.4%.

Table 5: Bio-based volumes and growth perspectives for 10 chemical product categories in the EU-28, 2018 (Spekreijse et al. 2019), consumption volumes are given in kilo tonnes per annum

Product categories	Bio-based production	Bio-based consumption	Bio-based share in total production (%)	Expected annual growth (2018 -2025)
Platform chemicals ⁷	181	197	0.3	10
Solvents	75	107	1.5	1
Polymers for plastics	268	247	0.4	4
Paints, coatings, inks &	1 002	1 293	12.5	2
Surfactants	1500	1800	50	4
Cosmetics & personal	558	558	44	3
Adhesives	237	320	9	10
Lubricants	237	220	3.5	1
Plasticizers	67	117	9	3
Man-made fibres	600	630	13	3

When considering all pressures on biodiversity bio-based products that are not produced from agricultural waste are likely to have higher impacts than equivalent petroleum products. However, in some cases bio-based products can provide environment-friendly solutions and lead to lower GHG emissions, but it is not always true as transformation processes may be responsible for significant GHG releases. For instance for packaging material, there is a bio-based resin that requires 65% less energy for production compared to fossil-fuel equivalents and a substitute to expanded polystyrene (EPS) made from potato residues and wood-fibers that produces 65% less CO₂ along its life cycle (van Crevel Rubie 2016).

2. Chemical release from the sector

The United States Environmental Protection Agency provides data on chemical released by industry according to the North American industry classification system (NAICS) code through its Toxic Release

⁷ A platform chemical is defined as a chemical that can serve as a substrate for the production of various other higher value-added products. (Takkellapati, Li, and Gonzalez 2018)

Inventory (TRI) programme. To represent the chemical sector defined by the factsheet only the NAICS sector chemicals (code 325) was selected. The factsheet does cover some sub-industry groups NAICS codes 312, 332 and 339 but it was considered more accurate not to include them in the selection for two reasons. First because only a minor portion of the subsectors from these NAICS industry groups were covered by the factsheet and second because the Toxics Release Inventory (TRI) website does not provide a level of detail sufficient to select only the sub-industry groups covered by the factsheet. Out of the NAICS group 312, only 1 out of 9 subsectors is covered by the factsheet, of the group NAICS 332, only 3 out of 72 subsectors are covered by the factsheet, and of the group NAICS 339, only 3 out of 58 are covered by the factsheet.

The factsheet focuses on metal and metal compounds releases and only results for these chemicals are displayed. It was decided to focus on metals pollution in the factsheet due to their toxicity, persistence in the environment, and bio accumulative nature. However, the sector is also responsible for other chemical releases not displayed in the factsheet such as OSHA carcinogen, CERCLA hazardous substances, hazardous air substances or PBT chemicals. The following table displays the amount of the most significant chemicals released by the sector as given by the Environmental Protection Agency (EPA) during 2019. The following table displays the main metal and metal compounds emissions from the chemical sector per type, in tonnes for the year 2019².

Table 6: Metal and metal compounds releases in tonnes in 2019, EPA

Metal & metal compounds	Tonnes
Aluminum phosphide	42 168
Antimony & antimony compounds	22 898
Arsenic & arsenic compounds	7 548
Asbestos (friable)	2 857
Other metal & metal compounds	10 294

Table 7: Hazardous air pollutants releases in tonnes in 2019, EPA

Hazardous air pollutants	Tonnes
Methanol	17 134
Manganese compounds	16 907
Formaldehyde	7 094
Acetonitrile	6 257
Other hazardous air pollutants	54 424

Table 8: CERCLA chemicals releases in tonnes in 2019, EPA

CERCLA Chemicals	Tonnes
------------------	--------

Ammonia	48 562
Nitrate compounds	32 710
Methanol	17 134
Manganese compounds	16 907
Other CERCLA chemicals	93 679

Table 9: PBT chemicals releases in tonnes in 2019, EPA

PBT Chemicals	Tonnes
Lead & lead compounds	766
Tetrabromobisphenol A	96
Polycyclic aromatic compounds	24
Mercury & mercury compounds	36
Other PBT chemicals	10

Table 10: OSHA chemicals releases in tonnes in 2019, EPA

OSHA chemicals	Tonnes
Formaldehyde	7 094
Acrylamide	2 751
Acrylonitrile	2 201
Styrene	1 451
Other OSHA chemicals	10 815

Table 11: Other material chemicals releases in tonnes in 2019, EPA

Other relevant chemicals	Tonnes
Ethylene	6 374
Zinc compounds	5 991
Formic acid	5 874
Carbonyl sulfide	4 128

3. N-fertiliser production process and emissions

Nitrogen-based fertilisers are manufactured by mixing nitrogen from the air and hydrogen from natural gas at high temperature and pressure so that ammonia is created. The ammonia is used to make nitric acid, with which it is then mixed to produce nitrate fertilisers such as ammonium nitrate (Fertilisers Europe 2019), the most used N-fertiliser in Europe. The energy consumed to produce it, mostly natural gas (Woods et al. 2010), the feedstock used to produce ammonia, N₂O emissions from nitric acid production and energy used to manufacture the fertiliser all contribute to GHG emissions. The feedstock is made from nitrogen and

hydrogen which are combined using the Haber Bosch process which operates at high temperature and pressure leading the process to have high CO₂ emissions, about 1% of global emissions, and high energy consumption, about 28 GJ per tonne of ammonia produced (Pattabathula and Richardson 2016).

Under the best available techniques defined by the EU and when using ammonium nitrate as a nitrogen compound, the overall manufacturing process emits 3.6 kg CO₂-eq per kg of nitrogen. Without best available techniques average emissions from European plants double (Yara 2020).

Greenhouse gas emission factors for Urea and Urea Ammonium Nitrate (UAN) production are between 1326 and 4019 g CO₂-eq per kg of N and between 1310 and 1844 g CO₂-eq per kg of N respectively.

Greenhouse gas emission factors for Ammonium Nitrate (AN) and Calcium Ammonium Nitrate production are between 2280 and 2461 g CO₂-eq per kg of N 1820 and 1983 g CO₂-eq per kg of N respectively (Wood and Cowie 2004).

C. ADDITIONAL RESULTS

1. Without ecotoxicity

The following calculations presented in the tables were made with the GBS 1.2.2 (October 2021 by Alexis Costes).

The figures and graphs do not include the Land-Use impact drivers in Scope 1 because no available data on land used by buildings was found. The Scope 1 impact is thus underestimated.

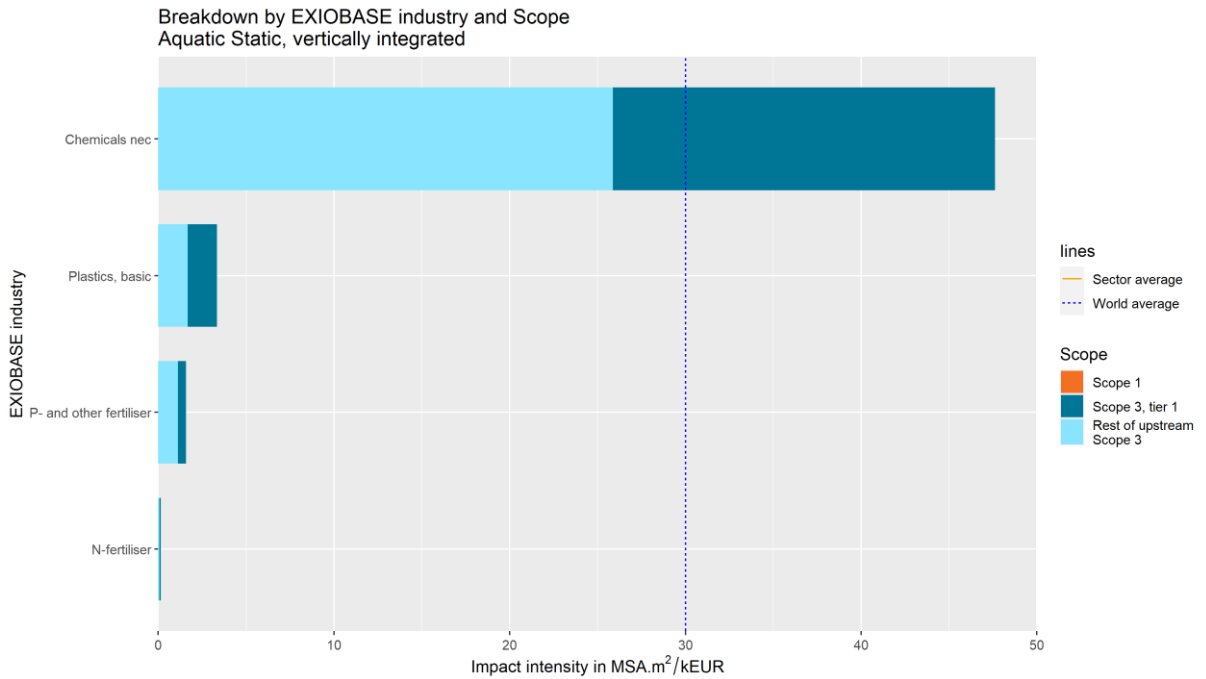
Table 12: Scope 1 impact intensities for the chemical benchmark, excluding ecotoxicity impacts, computation with GBS 1.2.2 in October 2021, by Alexis Costes

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/bEUR R	Footprint in MSAppb/bEUR
Dynamic	Aquatic	0.00021	0.02	9.9
	Terrestrial	1.3	9.9	
Static	Aquatic	0.0082	0.8	2.8
	Terrestrial	0.26	2.0	

Table 13: Vertically integrated impact intensities for the chemical benchmark, excluding ecotoxicity impacts, computation with GBS 1.2.2 in October 2021, by Alexis Costes

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR
Dynamic	Aquatic	0.24	24	73
	Terrestrial	6.5	49	

Static	Aquatic	53	5100	9800
	Terrestrial	630	4700	



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 11: Breakdown by EXIOBASE industry and Scope, aquatic static, vertically integrated⁸. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Chemical sector

⁸ The figures and graphs do not include the Land-Use impact drivers in Scope 1 because no available data was found. The Scope 1 impact is thus underestimated.

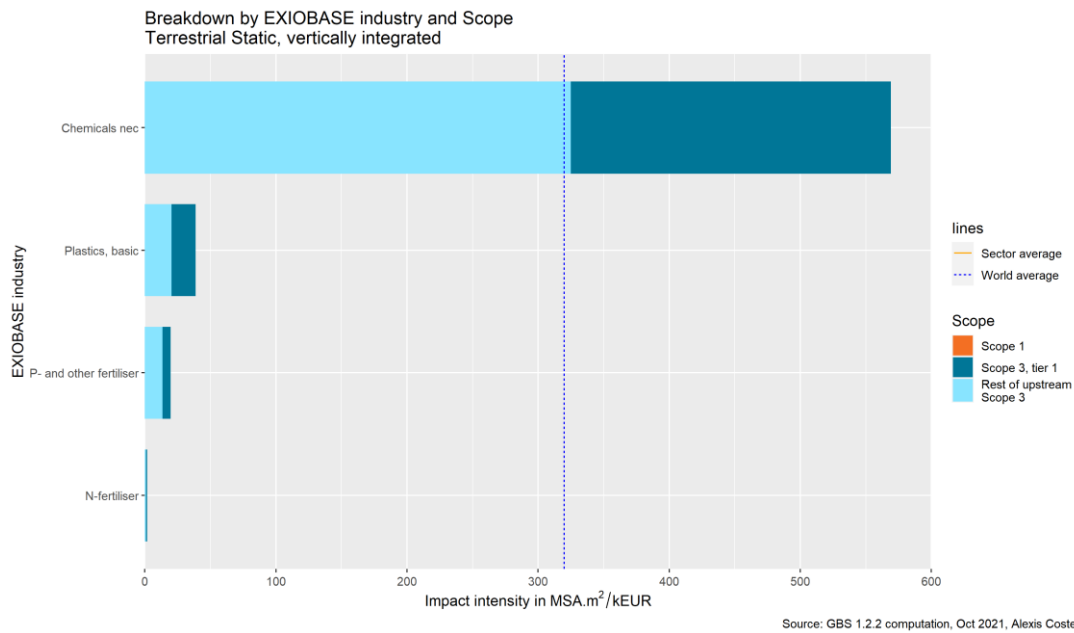


Figure 12: Breakdown by EXIOBASE industry and Scope, terrestrial static, vertically integrated⁹. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Chemical sector

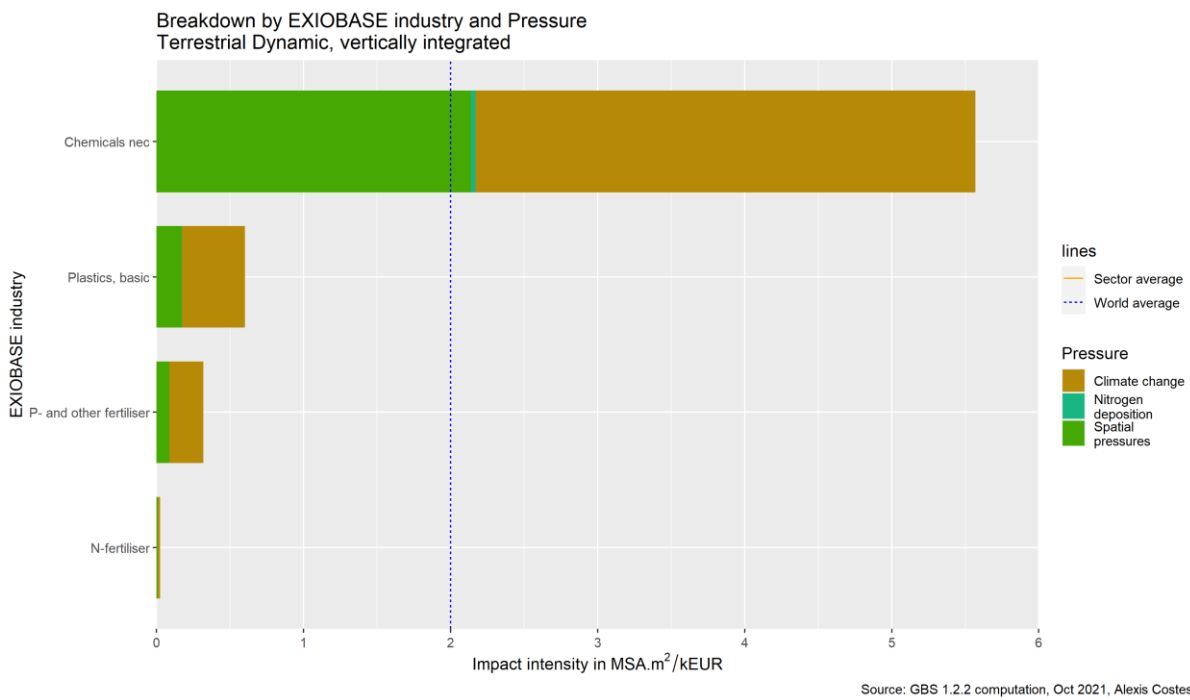


Figure 13: Breakdown by EXIOBASE industry and pressure, terrestrial dynamic, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Chemical sector

⁹ The figures and graphs do not include the Land-Use impact drivers in Scope 1 because no available data was found. The Scope 1 impact is thus underestimated.

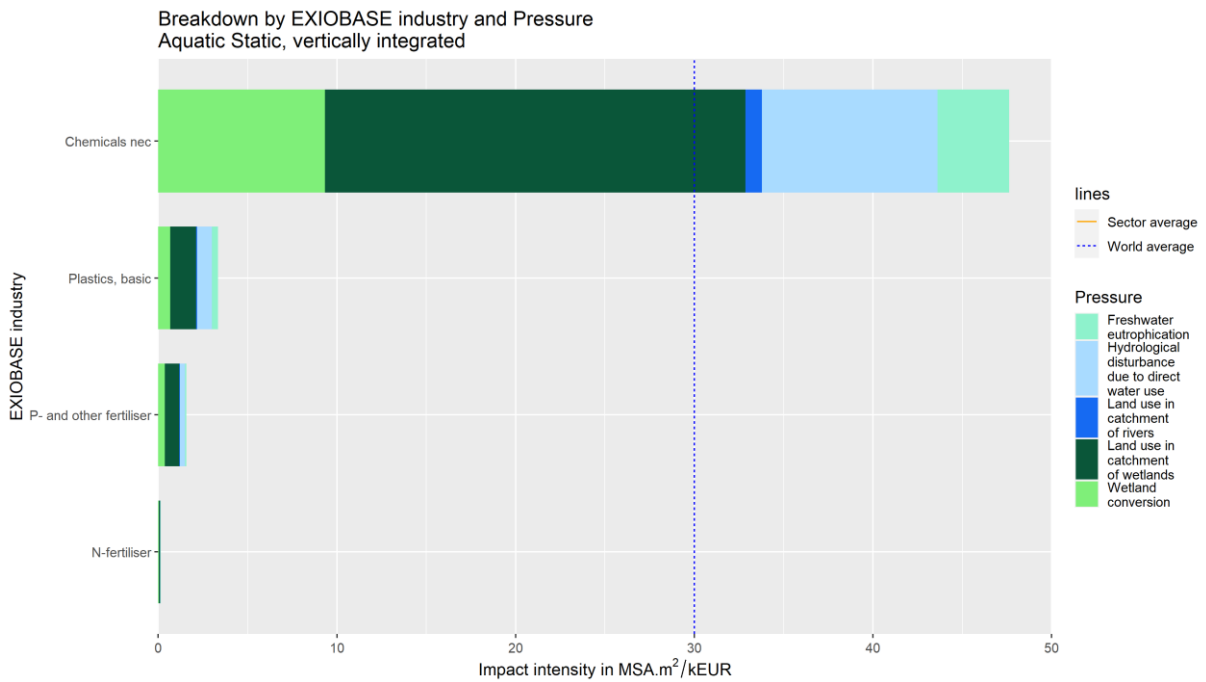


Figure 14: Breakdown by EXIOBASE industry and pressure, aquatic static, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Chemical sector

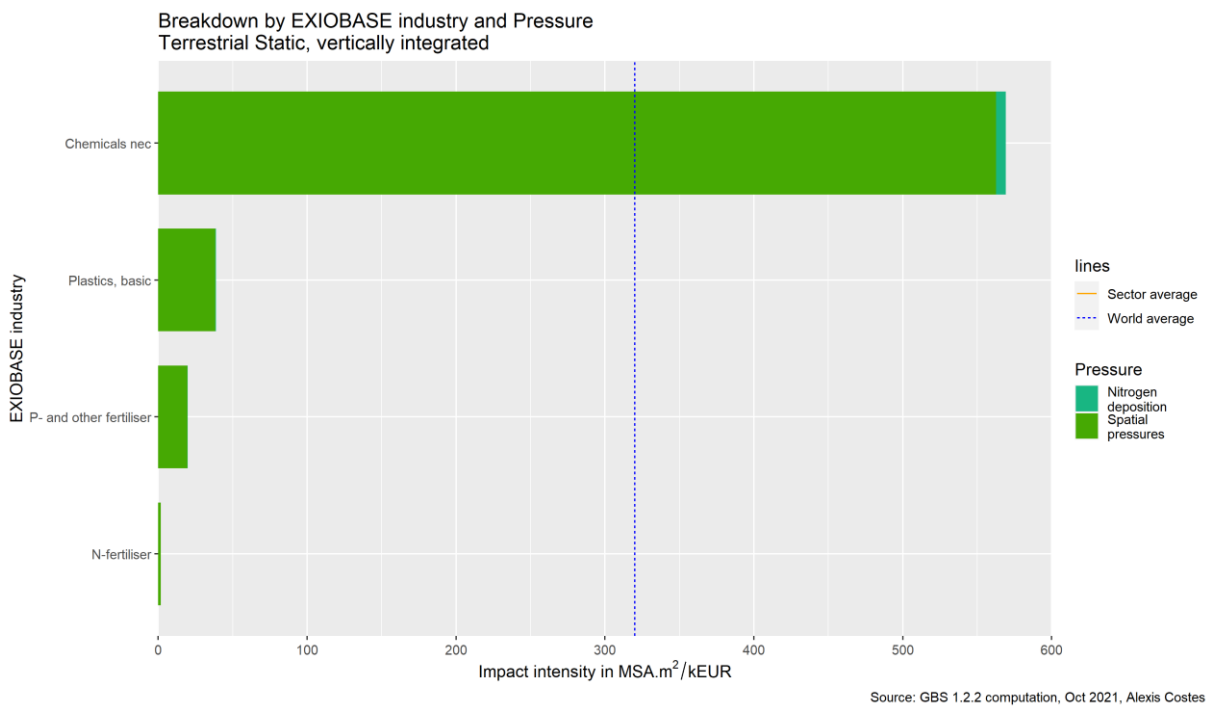


Figure 15: Breakdown by EXIOBASE industry and pressure, terrestrial static, vertically integrated. MSA.m²/kEUR means MSA.m² per kEUR of turnover of the whole Chemical sector

MSA.m ² /kEUR	Crops	GHGs	Grazing	Oil and Gas	Wood logs	Metals, minerals and coal	Total
Chemicals nec	1.1	3.4	0.2	0.2	0.6	0.1	5.6
Plastics, basic	1,1	4,9	0,0	0,3	0,1	0,0	6,5

Table 14: Breakdown for the most intensive EXIOBASE industries, per commodity type, terrestrial dynamic, vertically integrated (in MSA.m²/kEUR of the whole Chemical sector), computation with GBS 1.2.2 in October 2021, by Alexis Costes

MSA.m ² /kEUR	Crops	GHGs	Grazing	Oil and Gas	Wood logs	Metals, minerals and coal	Total
Chemicals nec	32	0	12	0.5	3	0.5	48
Plastics, basic	2.5	0	1	0	0	0	3.5

Table 15: Breakdown for the most intensive EXIOBASE industries, per commodity, aquatic static, vertically integrated (in MSA.m²/kEUR of the whole Chemical sector), computation with GBS 1.2.2 in October 2021, by Alexis Costes

MSA.m ² /kEUR	Crops	GHGs	Grazing	Oil and Gas	Wood logs	Metals, minerals and coal	Total
Chemicals nec	335	0	145	10	75	10	575
Plastics, basic	35	0	10	0	0	0	45

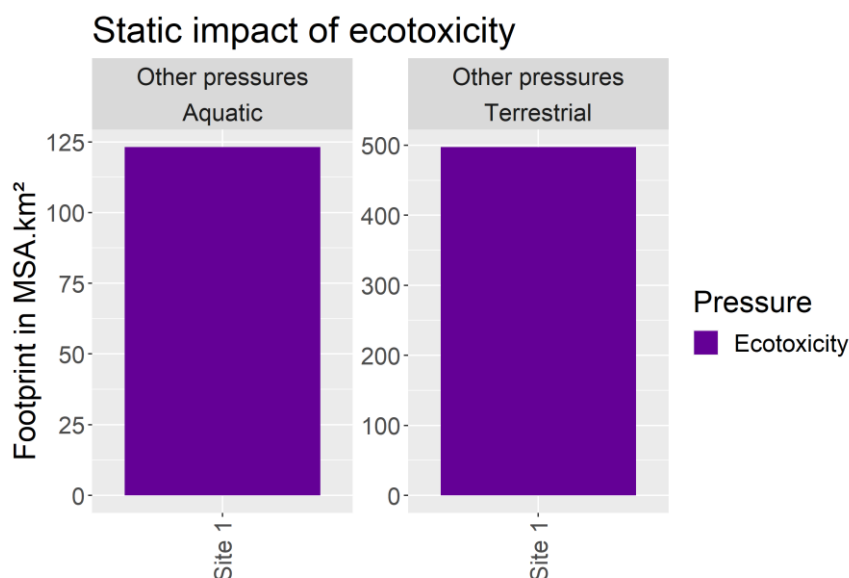
Table 16: Breakdown for the most intensive EXIOBASE industries, per commodity, terrestrial static, vertically integrated (in MSA.m²/kEUR of the whole Chemical sector), computation with GBS 1.2.2 in October 2021, by Alexis Costes

A significant proportion of the static and dynamic impacts is caused by crops and grass commodities, which does not seem consistent. Among potential sources of error, one concerns possible inaccuracies in EXIOBASE purchases. In all cases, these impacts are not that material compared to other sectors (e.g. the crops and grass impact for the Cattle Farming sector within the industry group "Manufacture of food & beverage").

2. With ecotoxicity

Ecotoxicity impacts computed with the GBS should be interpreted with caution, as considered ecotoxic substances are limited to metallic elements emissions from fossil fuels combustion.

Ecotoxicity impacts of the sector was computed with the GBS™, using EPA data on chemical substances releases in the United States in 2019 (see Paragraph B). It avoids to only consider financial data only, as it is a current limitation for ecotoxicity computations using the GBS™. The following graph shows the ecotoxicity impacts of chemical substances released in the environment by the chemical industry in MSA.km². The corresponding static aquatic and static terrestrial impacts linked to these releases are 500 MSA.km² and 120 MSA.km² respectively.



Source: GBS 1.1.0 computation, Jan 2021, Juliette Cocault

Figure 16: Static impact of the ecotoxicity pressure, aquatic and terrestrial, in MSA.km²

We used the great level of details provided by the US EPA to split emissions between air, water and soil emissions compartments in the most accurate manner, as can be seen in Table 17.

All substance releases to soil and water were classified under industrial soil and urban air respectively even in the case of “Off-site disposal” categories, as it was assumed that releases happened close to industrial sites and thus in areas that would still be classified as industrial soil and urban.

For most TRI disposal and release categories correspondences with GBS™ emissions compartments were evident: all injection wells, water discharges and wastewater treatment categories were classified as freshwater emission compartments, all landfill, land treatment, land disposal and impoundments categories as industrial soil compartments. Finally, all air categories were classified as urban and rural air compartments. Some categories were less straightforward and their classification as GBS emissions compartments rely on the United States Environmental Protection Agency (EPA) definitions¹⁰ of the categories but are more arbitrary. It was decided to select the industrial soil emission compartments as the default choice. Thus, categories whose definitions did not provide enough information about the release media: POTW transfer- other releases, other off-site management, waste broker and unknown were assigned to industrial soil compartment.

¹⁰ All categories definition can be found on the EPA TRI explorer website. After selecting the highest detail level for “report columns to include” and clicking on “generate report” it is possible to click on the heading of each column to see the definitions.

Lastly for the remaining categories, storage only and solidification/stabilization, it was decided not to include them in the assessment as it is difficult to estimate if these chemicals will be released in the environment, in which medium and when.

For some TRI disposal and release categories, see Table 17, two GBS emission compartments correspondences were found and it was chosen to run various scenarios with different classification choices for relevant substances releases.

Table 17: Correspondence between TRI disposal and release categories and the GBS emissions compartments

TRI release media		GBS compartment	
		Option 1	Option 2
On-site Disposal to Class I	Underground Injection Class I Wells	Freshwater	
	RCRA Subtitle C Landfills	Industrial soil	
	Other On-Site Landfills	Industrial soil	
Other On-site Disposal or Other Releases	Fugitive Air Emissions	Urban air	Rural air
	Point Source Air Emissions	Urban air	Rural air
	Surface Water Discharges	Freshwater	
	Underground Injection Class II-V Wells	Freshwater	
	Land Treatment	Industrial soil	
	RCRA Subtitle C Surface Impoundments	Industrial soil	
	Other Surface Impoundments	Industrial soil	
Other Land Disposal	Industrial soil		
Off-site Disposal to Class I Underground Injection	Underground Injection to Class I Wells	Freshwater	
	RCRA Subtitle C Landfills	Industrial soil	
	Other Landfills	Industrial soil	
	POTW Transfers - Releases to Class IUI Wells and Landfills	Industrial soil	Freshwater
Other Off-site Disposal or Other Releases	Storage Only	No release	
	Solidification/Stabilization (metals only)	No release	
	Wastewater Treatment-Metals Only	Freshwater	
	POTW Transfers - Other Releases	Freshwater	
	Underground Injection Class II-V Wells	Freshwater	
	RCRA Subtitle C Surface Impoundments	Industrial soil	
	Other Surface Impoundments	Industrial soil	
	Land Treatment	Industrial soil	
	Other Land Disposal	Industrial soil	
	Other Off-site Management	Industrial soil	
	Waste Broker	Industrial soil	
Unknown	Industrial soil		

Some shortcomings of the GBS computation must be kept in mind when analyzing the results:

- 25 % of the overall volume of chemical releases reported by EPA were not taken into account by the GBS due to a lack of correspondence between ReCiPe substances and some CAS identification numbers.
- Of the remaining 75%, 21% of the volume of chemicals released assigned to the urban air compartment (representing 4% of remaining releases volume) were not taken into account by the GBS for aquatic pressures.

The equivalent of the EPA TRI tool for Europe is the European pollutant release and transfer register tool from the European Environment Agency¹¹. This tool has not yet been used but provides opportunities to better integrate chemicals released by different sectors and regions.

3. Comparison of the impact of bio-based and fossil-based ethanol

This comparative analysis of the biodiversity impact of a fossil based and a bio-based product aims at presenting the different pressures induced by bio-based and fossil-based chemicals and provide a starting point to reflect on the biodiversity impact of the chemicals sector shift to bio-based products, and whether this shift could be a solution for reducing biodiversity loss. This analysis only focuses on the production of ethanol and considers only six scenarios: fossil-based ethanol produced in Europe, wheat-based and sugar beet-based ethanol produced in France, sugar cane-based ethanol produced in Brazil (average between Centre-South and North-East region), maize grain-based and maize stover-based ethanol produced in the US.

To compare the biodiversity impact of a fossil based chemical and of its bio-based equivalent, the impacts of different production pathways of ethanol were evaluated, based on a comparative Life Cycle Assessment from (Muñoz et al. 2014). The midpoint indicators related to the production of 1kg of Ethanol under different scenarios were used as pressure data in the GBS to compute the related biodiversity impact.

The six scenarios assessed consider three indicators account: “Global warming potential (GWP)”, “Agricultural land occupation (ALO)”, “Freshwater eutrophication potential (FEP)”. For wheat-based and sugar cane-based ethanol, land transformation data was available in the report from Muñoz (2.6.3). In the study, the crop expansion took place directly in forest without further details on the quality of the forest or the meadows, so we made a conservative assumption that natural areas were converted into natural forest, note that in the GBS, grasslands or natural forests both have a MSA of 100%.

The midpoint indicators show that bio-based ethanol production generates higher terrestrial static impacts than fossil-based ethanol. The GHG emissions generated by fossil-based ethanol are however two to three times more important as those generated by bio-based ethanol. Freshwater eutrophication potential is also superior for fossil-based ethanol than for bio-based ethanol.

Only three midpoint indicators were used out of six in the paper since other midpoint indicators are not covered by correspondent pressures in the GBS. Indeed, photochemical oxidant formation potential, terrestrial acidification potential and marine water eutrophication potential are indicators that do not correspond to pressure covered by the GBS and can thus not be entered as input data.

The following table shows the midpoint indicators mentioned above for the six scenarios, using fossil-based ethanol as the reference scenario: bio-based scenarios midpoint indicators are expressed relative to the fossil-based ethanol midpoint and endpoint indicators. This is to show the relative impact of ethanol

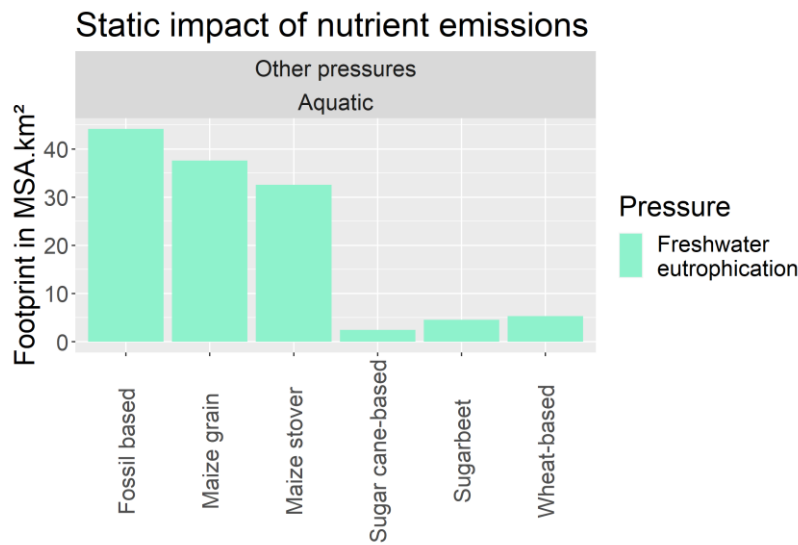
¹¹ <https://prtr.eea.europa.eu/#/industrialactivity>

production under the scenarios but does not illustrate the impact of a specific production volume. Endpoint indicators are those computed with the GBS using the midpoint indicators from Muñoz et al. research.

		Sugarcane-based ethanol	Wheat-based ethanol	Maize grain-based ethanol	Maize stover-based ethanol	Sugar beet-based ethanol	Fossil-based ethanol
Midpoint indicator	Global warming potential	0.43	0.55	0.43	0.33	0.34	1
Midpoint indicator	Freshwater eutrophication potential	0.28	0.45	0.96	0.83	0.38	1
Midpoint indicator	Land use occupation	251	278	123	93	87	1
Endpoint indicator	Climate change (dynamic)	0.44	0.56	0.44	0.34	0.34	1
Endpoint indicator	Hydrological disturbance due to climate change (dynamic)	0.43	0.56	0.43	0.34	0.34	1
Endpoint indicator	Freshwater eutrophication (static)	0.06	0.12	0.86	0.75	0.10	1
Endpoint indicator	Freshwater eutrophication (dynamic)	0.08	0	0	0	0	1
Endpoint indicator	Land use (static)	211	278	122	93	87	1

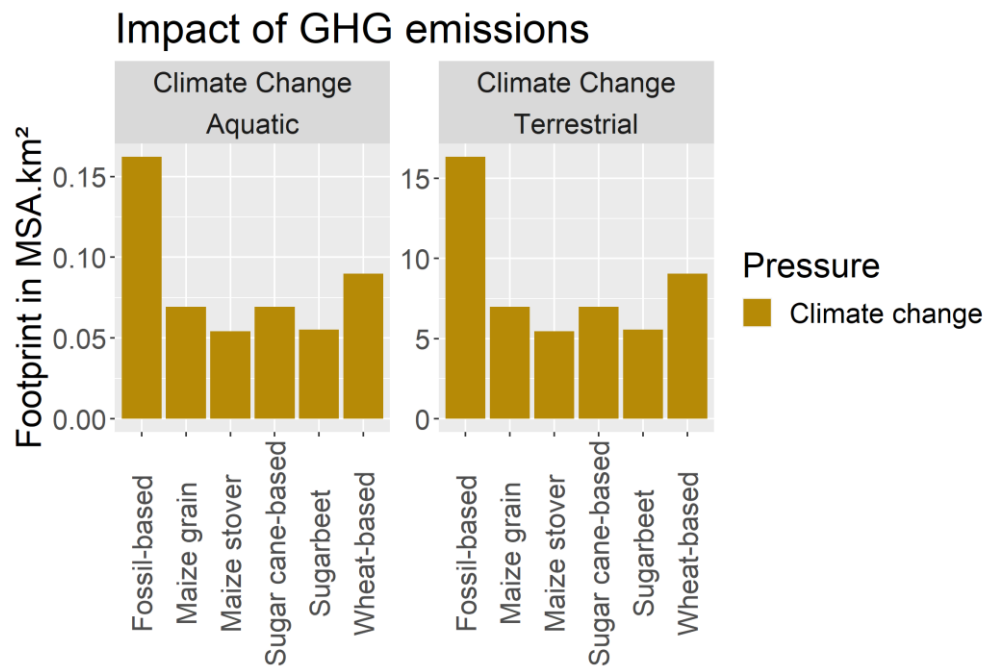
Table 18: Midpoint and endpoint indicators for sugarcane-based ethanol, wheat-based ethanol and fossil-based ethanol

The following graphs show the biodiversity impacts resulting from the production of a million tonnes of ethanol under the six different scenarios and for the three main pressures. The impacts are computed with the GBS.



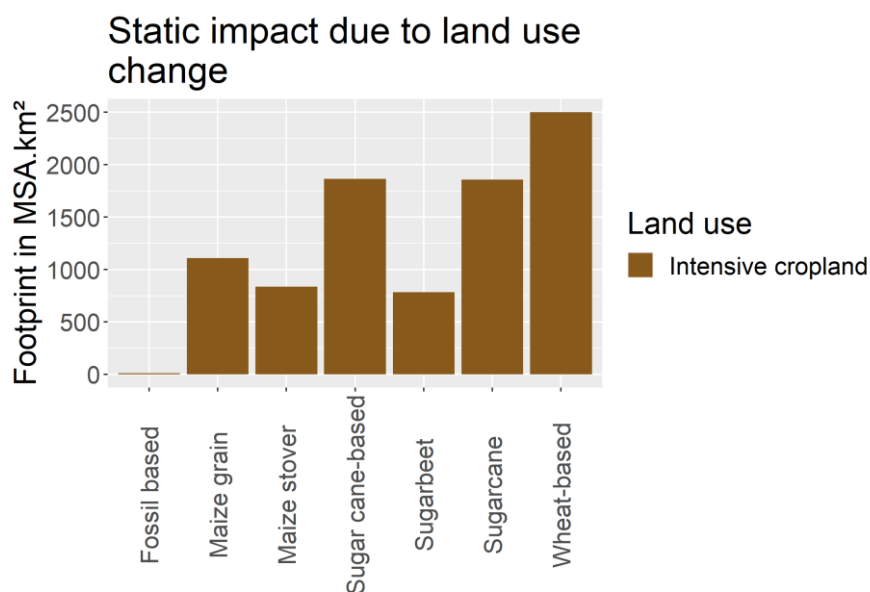
Source: GBS 1.2.0.0 computation, May 2021, Alexis Costes

Figure 17: Static freshwater eutrophication impacts for fossil-based ethanol and different bio-based ethanol



Source: GBS 1.2.0.0 computation, May 2021, Alexis Costes

Figure 18: Dynamic climate change impacts for fossil-based ethanol and different bio-based ethanol



Source: GBS 1.2.0.0 computation, May 2021, Alexis Costes

Figure 19: Static land use impacts for fossil-based ethanol and different bio-based ethanol

The graphs show that regarding terrestrial biodiversity, the best alternative is fossil-based ethanol while for aquatic biodiversity the best alternative is bio-based ethanol (note that maize-based ethanol freshwater eutrophication impact is close to the fossil-based one).

	Fossil-based ethanol	Maize grain-based ethanol	Sugar beet-based ethanol	Wheat-based ethanol	Sugar cane-based ethanol	Maize stover-based ethanol
Static	4100	12000	6400	20000	15000	9500
Dynamic	150	60	47	100	100	47

Table 19: Results of the comparative analysis between fossil-based and bio-based ethanol in MSA ppb

Results must be read with caution, only three midpoint indicators are considered in this analysis. For example, pesticide use is not included in the analysis, which could lead to underestimate bio-based ethanol impacts. Also, land use data from Muñoz et al. (2014) considers only the agricultural sector and not the extraction one, which means that impacts for fossil-based ethanol could also be underestimated.

This overall analysis has mixed results. Impacts are mainly due to land use pressures for bio-based ethanol, while fossil-based ethanol exerts greater pressures on climate change and freshwater eutrophication.

D. ADDITIONAL DNSH GUIDELINES

The main Do No Significant Harm criteria for the sector (EU Technical Expert Group on Sustainable Finance 2020a) are provided in the factsheets. Additional criteria which did not fit within the factsheet are listed below (EU Technical Expert Group on Sustainable Finance 2020b).

To not harm the objective of Circular economy and waste prevention and recycling, activities should:

Ensure that wastes and by-products, especially hazardous manufacturing wastes, are managed in line with the Waste Treatment Reference Document on Best Available Techniques (BREF) and the requirements set out in BREF LVIC- S

Ensure that wastes and by-products, especially hazardous wastes, are managed in line with the BREF for Waste Treatment. A minimum requirement is the implementation and adherence to a recognized environmental management system (ISO 14001, EMAS, or equivalent).

To prevent damage of vulnerable ecosystems activities should:

Ensure an Environmental Impact Assessment (EIA) has been completed in accordance with the EU Directives on Environmental Impact Assessment (2014/52/EU) and Strategic Environmental Assessment (2001/42/EC) (or other equivalent national provisions or international standards (e.g. IFC Performance Standard 1: Assessment and Management of Environmental and Social Risks) – whichever is stricter - in the case of sites/operations in non-EU countries) for the site/operation (including ancillary services, e.g. transport infrastructure and operations, waste disposal facilities, etc.) and any required mitigation measures for protecting biodiversity/eco-systems, particularly UNESCO World Heritage sites and Key Biodiversity Areas (KBAs), have been implemented.

For operations located in or near to biodiversity-sensitive areas, ensure that an appropriate assessment has been conducted in compliance with the provisions of the EU Biodiversity Strategy (COM (2011) 244), the Birds (2009/147/EC) and Habitats (92/43/EEC) Directives (or other equivalent national provisions or international standards– whichever is stricter - in case of sites/operations in non-EU countries) based on the conservation objectives of the protected area. For such sites/operations, ensure that:

- a site-level biodiversity management plan exists and is implemented in alignment with the IFC Performance Standard 6: Biodiversity Conservation and Sustainable Management of Living Natural Resources;
- all necessary mitigation measures are in place to reduce the impacts on species and habitats;
- a robust, appropriately designed and long-term biodiversity monitoring and evaluation programme exists and is implemented.

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3.3 Construction

A. WHAT DOES THE SECTOR INCLUDE?

To understand the **dependencies** of the construction sector expressed in score by ENCORE, a first correspondence of the sectors of EXIOBASE and ENCORE is necessary. The Construction sector corresponds in ENCORE to the sectors "Consumers discretionary" and "Industrial" and includes the sub-industries "Homebuilding" and "Construction & Engineering". The figure below Figure shows the correspondence between EXIOBASE and ENCORE.

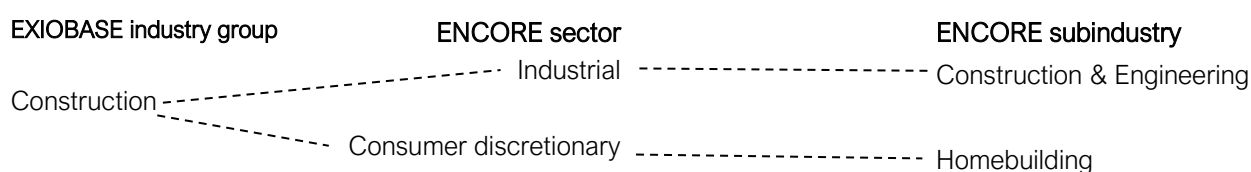


Figure 20 Correspondence between EXIOBASE and ENCORE

In terms of **impact calculation**, the factsheet covers the construction sector consisting of a single EXIOBASE industry: "Construction (45)". In the NACE rev 2 classification, this EXIOBASE industry corresponds to section F including divisions 41: Construction of buildings, 42: Civil engineering and 43: Specialized construction activities. Furthermore, construction activity in the perimeter of this factsheet only includes the construction work phase. All activities which take place after completion of construction are attributed to another section of NACE such as the real estate activity which is classified in section L and linked to the EXIOBASE industry "Real estate activities (70)", and thus are not tackled in this section.

The figure below shows the correspondence between EXIOBASE and NACE rev 2:

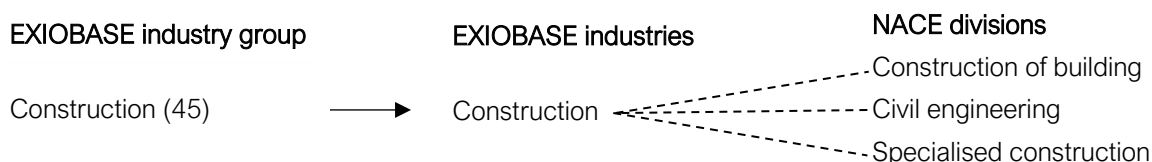


Figure 24 Correspondence between EXIOBASE and NACE rev 2

A detailed description of section F of NACE rev 2 listing its divisions and sub-divisions extracted from (EUROSTAT 2008) is presented below.

Section F - Construction

Construction of building (41)

The division 41 gathers all activities under “Construction of buildings”. Are concerned: new work, repair, addition and alteration, erection of prefabricated building and structure as well as construction of temporary nature.

- Development of building projects (41.1)

- Development of building projects (41.10)

This class includes:

- Development of building projects for residential and non-residential building by bringing together financial, technical, and physical means to realise the building projects for later sale

This class excludes:

- Construction of buildings (included in 41.2)
- Architectural and engineering activities
- Project management services related to building projects

- Construction of residential and non-residential buildings (41.2)

This group includes the construction of complete residential or non-residential building, on own account for sale or on a fee or contract basis. Outsourcing parts or even the whole construction process is possible. If only specialised part of the construction process is carried out, the activity is classified in division 43.

- Construction of residential and non-residential building (41.20)

This class includes:

- Construction of all type residential building like single family houses, multi-family buildings, including high-rise buildings
- Construction of all type of non-residential building like buildings for industrial production, factories, workshop, assembly plants... hospitals, schools, office buildings, hotels, stores, shopping mall, restaurants, airport buildings, indoor sports facilities, parking garages, including underground parking garages, warehouses, religious buildings
- Assembly and erection of prefabricated constructions on the site
- Remodelling or renovating existing residential structures

This class excludes:

- Construction of industrial facilities, except buildings (included in 42.9)
- Architectural and engineering activities
- Project management for construction

Civil engineering (42)

The division 42 gathers all activities under “Civil engineering”. Are concerned in that division, general construction for civil engineering objects like new works, repair additions and alterations, erection of prefabricated structures on the site and construction of temporary nature.

That division included for instance: heavy construction such as motorways, streets, bridges, tunnels, railways, airfields, harbours and other water projects, irrigation systems, sewage systems, industrial facilities, pipelines and electric lines, out-door sports facilities... This work can be carried out for own account or on a fee of contract basis. Portion of the work and sometimes even the whole practical work can be subcontracted out.

- **Construction of roads and railways (42.1)**
 - **Construction of road and motorways (42.11)**

This class includes:

 - Construction of motorway, streets, road, other vehicular and pedestrian ways
 - Surface work on streets, road, highways, bridge, or tunnel like asphalt paving of roads, road painting and other marking, installation of crash barriers, traffic signs and the like
 - Construction of airfield runway

This class excludes:

 - Installation of lighting and electrical signals (included in 43.2)
 - Architectural and engineering activities
 - Project management for construction
 - **Construction of railways and underground railways (42.12)**

This class includes:

 - Construction of railways and subways

This class exclude:

 - Installation of lightning and electrical signals
 - Architectural and engineering activities
 - Project of management for construction
 - **Construction of bridges and tunnels (42.13)**

This class includes:

 - Construction of bridges, including those for elevated highways
 - Construction of tunnels

This class excludes:

 - Installation of lightning and electrical signals
 - Architectural and engineering activities
 - Project of management for construction

- **Construction of utility projects (42.2)**

- **Construction of utility projects for fluids (42.21)**

This class includes the construction of distribution lines for transportation of fluids and related building and structures that are integral part of these systems.

This class includes:

- Construction of civil engineering construction for long-distance and urban pipelines, water main and line construction, irrigation systems (canals), reservoirs
- And construction of sewer systems, including repair, sewage disposal plants, pumping stations
- Water well drilling

This class excludes:

- Project management activities related to civil engineering works

- **Construction of utility projects for electricity and telecommunications (42.22)**

This class includes:

- Construction of civil engineering construction for long-distance and urban communication and power lines, power plants

This class excludes:

- Project management activities related to civil engineering works

- **Construction of other civil engineering projects (42.9)**

- **Construction of water projects (41.91)**

This class includes:

- Construction of waterway, harbour and river work, pleasure port, locks, dams, and dikes
- Dredging of waterway

This class excludes:

- Project management activities related to civil engineering works

- **Construction of other civil engineering projects n.e.c (42.99)**

This class includes:

- Construction of industrial facilities except building such as refineries and chemical plants
- Construction work, other than building such as outdoor sports facilities
- Land subdivision with improvement

This class excludes:

- Project management activities related to civil engineering works
- Installation of industrial machinery and equipment
- Land subdivision without land improvement

Specialised construction activities (43)

The division 43 gathers all activities under “Specialized construction activities”. It concerns construction of part of building and civil engineering works or preparation. These activities concern similar work for different structures, which requires specialised skill or equipment such as scaffolding, stone setting brick laying... Specialised construction activities are mostly carried out under subcontract. However, in the case of repair construction, projects are carried out directly for the owner of property. Furthermore, this division includes the installation of all kinds of utilities that make the construction function as such even if all or part of work is done in a special shop Jsuch as plumbing, installation of heating air-conditioning system, antennas, electrical work, insulation (water, heat, sound) work, installation of illumination and signalling system of road etc... and include their repair activities. Are also included finishing work of construction such as glazing, plastering, painting, carpets, wallpaper etc.. The renting of equipment with operator is classified within the associated construction activities.

- Demolition and site preparation (43.1)

This group includes activities of preparing a site for subsequent construction activities, including the removal of previously existing structures.

- Demolition (43.11)

This class includes:

- Demolition or wrecking of buildings and other structures

- Site Preparation (43.12)

This class includes:

- Clearing of building sites
- Earth moving, excavation, landfill, levelling, and grading of construction sites, trench digging, rock removal, blasting etc...
- Site preparation for mining, overburden removal and other development and preparation of mineral properties and sites, except oil and gas sites
- Building site drainage
- Drainage of agricultural or forestry land

This class excludes:

- Drilling of production oil or gas wells
- Decontamination of soil
- Water well drilling
- Shaft sinking

- Test drilling and boring (43.13)

This class includes:

- Test drilling, test boring and core sampling for construction, geographical or similar purposes

This class excludes:

- Drilling of production oil or gas wells
- Test drilling and boring support services during mining activities
- Water well drilling
- Shaft sinking
- Oil and gas field exploration, geophysical, geological, and seismic surveying

- **Electrical, plumbing, and other construction installation activities (43.2)**

This group includes installation activities that support the functioning of a building as such, including installation of electrical system, plumbing (water, gas and sewage systems), heat and air-conditioning system, elevator etc.

- **Electrical installation (43.21)**

This class includes the installation of electrical systems in all kinds of building and civil engineering structures of electrical systems.

This class includes:

- Installation of electrical wiring and fitting, telecommunication wiring, computer network and cable television wiring, including fibre optic, satellite dishes, lighting systems, fire alarms, burglar alarm systems, street lighting and electrical signals, airport runway lighting, electric solar energy collector
- Connecting of electric appliance and household equipment, including baseboard heating

This class excludes:

- Construction of communications and power transmissions lines
- Monitoring and remote monitoring of electronic security systems, such as burglar alarms, including their installation and maintenance

- **Plumbing, heat, and air-conditioning installation (43.22)**

This class includes the installation of plumbing, heating, and air-conditioning systems, including additions, alterations maintenance and repair.

This class includes:

- Installation in building or other construction projects of heating systems (electric, gas and oil), furnace, cooling tower, non-electric solar energy collector, plumbing and sanitary equipment, ventilation and air conditioning equipment and ducts, gas fitting, steam piping, fire sprinkler systems, lawn sprinkler systems
- Duct work installation

This class excludes:

- Installation of electric baseboard heating

- **Other construction installation (43.29)**

This class includes:

- Installation in buildings or other construction projects of elevator, escalators, including repair and maintenance, automated and revolving doors, lightning conductors, vacuum cleaning systems, thermal, sound or vibration insulation

This class excludes:

- Installation of industrial machinery

- **Building completion and finishing (43.3)**

- **Plastering (43.31)**

This class includes:

- Application in buildings or other construction projects of interior plaster or stucco, including related lathing materials

- **Joinery installation (43.32)**

This class includes:

- Installation of doors (except automated and revolving), windows, door and window frames, of wood or other materials
- Installation of fitted kitchens, built-in cupboards, staircases, shop fitting and the like
- Interior completion such as ceiling, movable partitions etc...

This class excludes:

- Installation of automated and revolving doors

- **Floor and wall covering (43.33)**

This class includes:

- Laying, tiling, hanging, or fitting in buildings or other construction projects of ceramic, concrete or cut stone wall or floor tiles, ceramic stove fitting, parquet and other wooden floor coverings, wooden wall coverings, carpets and linoleum floor coverings, including of rubber or plastic, terrazzo, marble, granite or slate floor or wall coverings, wallpaper.

- **Painting and glazing (43.34)**

This class includes:

- Interior and exterior painting of buildings
- Painting of civil engineering structures
- Installation of glass, mirror etc...

This class excludes:

- Installation of windows

- **Other specialised construction activities (43.9)**

- **Roofing activities (43.91)**

This class includes:

- Erection of roofs
- Roof covering

This class excludes:

- Renting of construction machinery and equipment without operator

o Other construction specialised activities n.e.c (43.99)

This class includes:

- Construction activities specialising in one aspect common to different kind of structures, requiring specialised skill or equipment such as construction of foundation, including pile driving damp proofing and water proofing work, dehumidification of buildings, shaft sinking, erection of steel elements, steel bending, bricklaying and stone setting, scaffolds and work platform erecting and dismantling, excluding renting or scaffolds and work platforms, erection of chimney and industrial ovens, work with specialist access requirements necessitating climbing skills and the use of related equipment, working at height on tall structures
- Surface work
- Construction of outdoor swimming pools
- Steam cleaning, sand blasting and similar activities for building exteriors
- Renting of cranes and other building equipment, which cannot be allocated to a specific construction type, with operator

This class excludes:

- Renting of construction machinery and equipment without operator

B. ADDITIONAL RESULTS

1. Additional results on the sector's impacts

The following calculations presented in the tables were performed using GBS version 1.2.2 by Alexis Costes in October 2021.

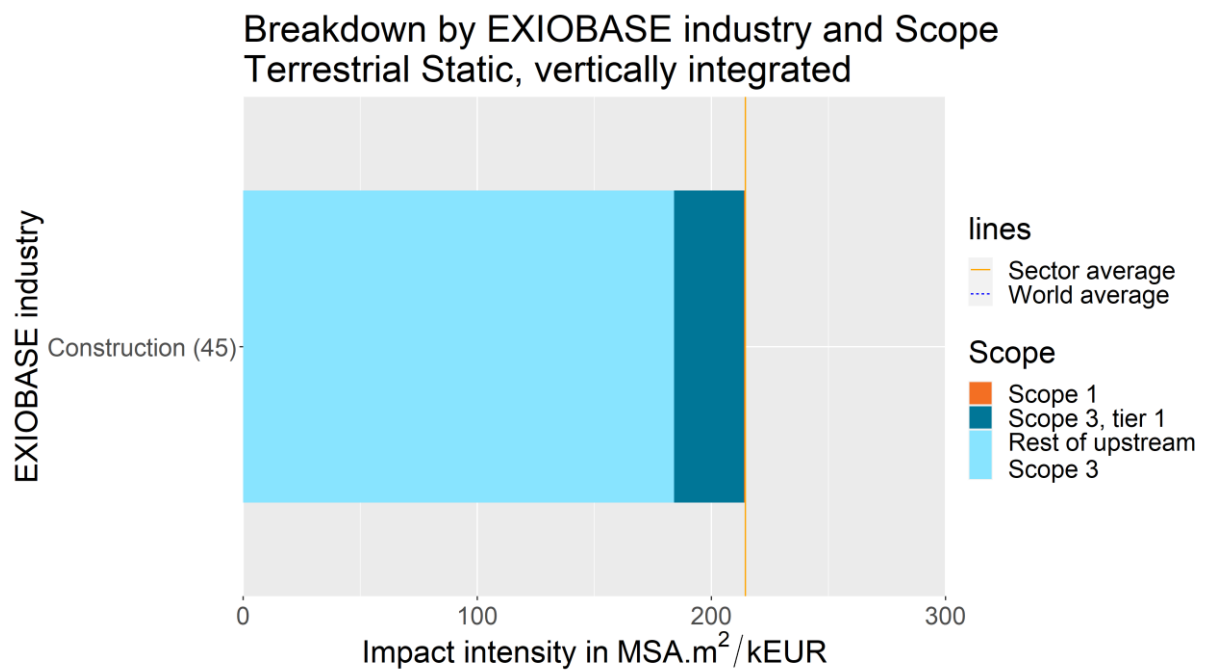
Table 20 displays biodiversity impact figures of the sector but underestimates the land use impact in Scope 1. Only the impacts linked with raw material extraction are included in the results below, which should not represent an important proportion of the Scope 1 impacts. An estimation of the land use Scope 1 impacts is made in the section “The sector’s Scope 1 impact on land use”. Results in Table 21 do not include impacts linked to sand and gravel in the version 1.2.2 of the GBS, this issue is under investigation. This leads to overrepresentation of commodities such as crops and grazing in the results in Figure 23 and Figure 24.

Table 20: Scope 1 impact intensities for the construction benchmark, excluding ecotoxicity impacts and underestimating Scope 1 land use impacts

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR
Dynamic	Aquatic	3.8*10 ⁻⁵	0.004	4.5
	Terrestrial	0.59	4.5	
Static	Aquatic	0.018	1.8	5.9
	Terrestrial	0.55	4.2	

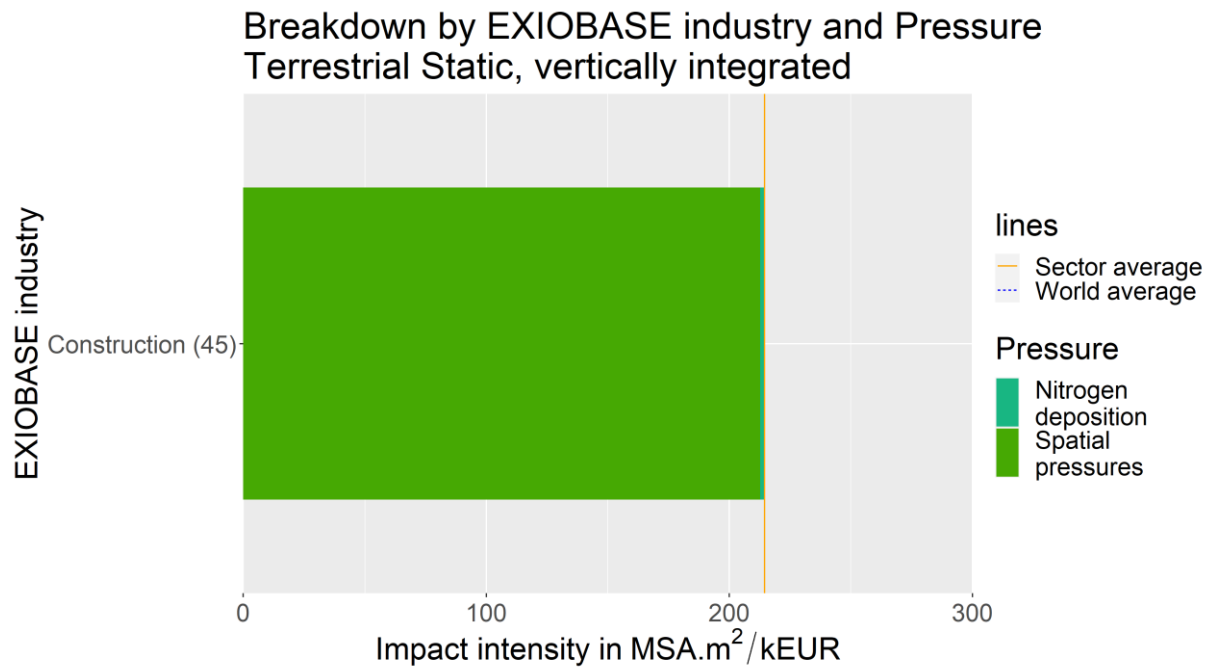
Table 21: Vertically integrated impact intensities for the construction benchmark, excluding ecotoxicity impacts and underestimating Scope 1 land use impacts and some commodities' impacts

		Footprint in MSA.m ² /kEUR	Footprint in MSAppb/bEUR	Footprint in MSAppb/bEUR
Dynamic	Aquatic	0.08	7.8	45
	Terrestrial	4.9	37	
Static	Aquatic	15	1 500	3100
	Terrestrial	210	1 600	



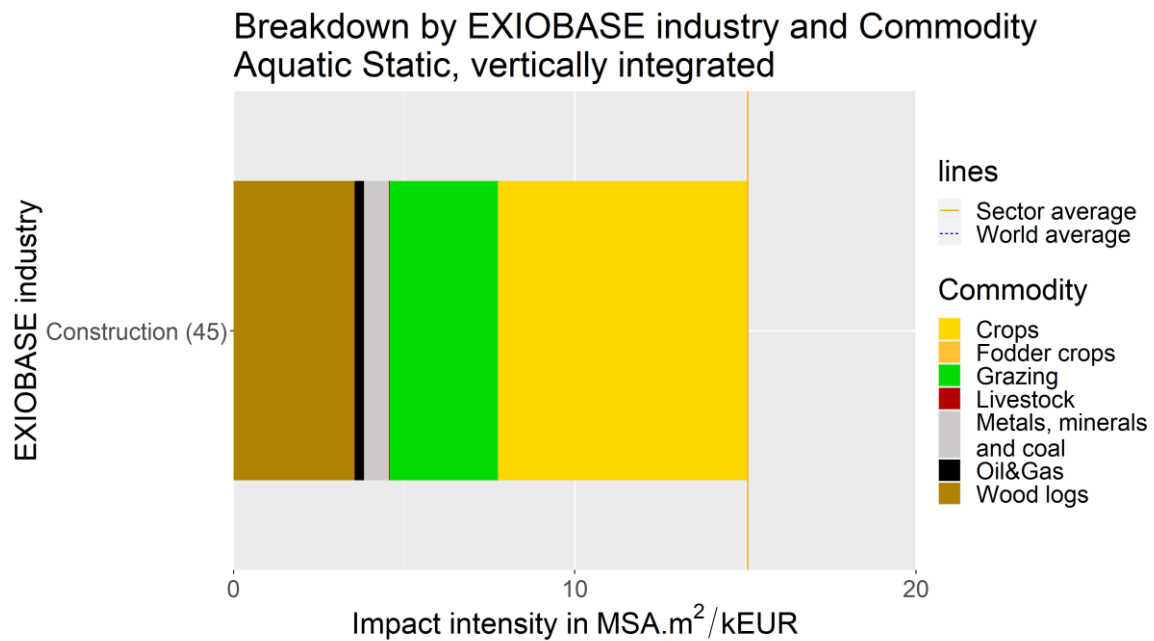
Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 21: Breakdown by EXIOBASE industry and Scope, terrestrial static, vertically integrated



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

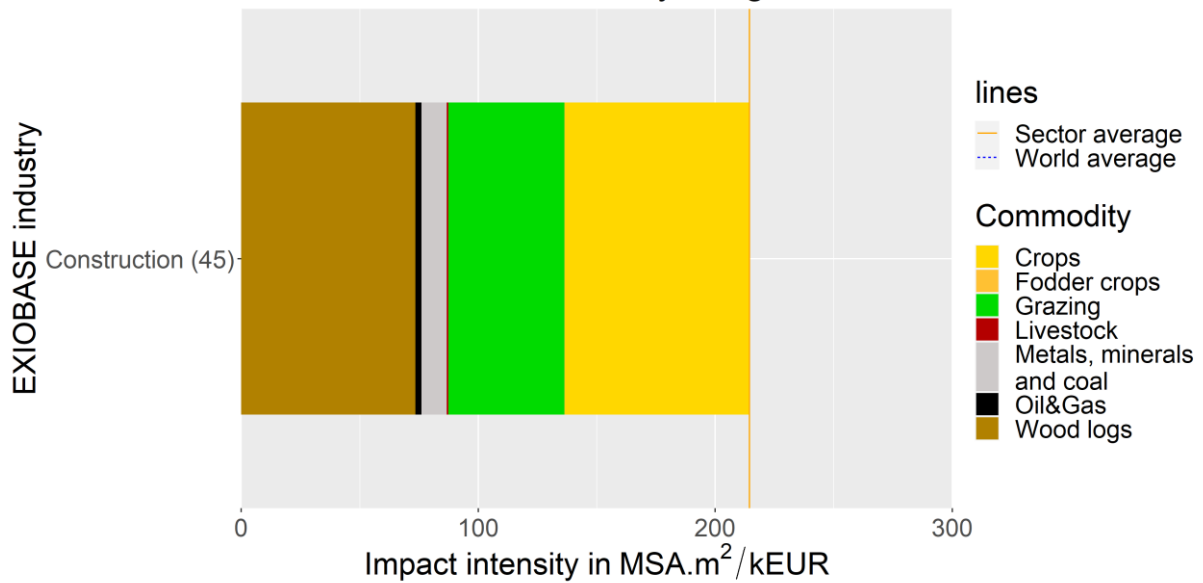
Figure 22: Breakdown by EXIOBASE industry and pressure, terrestrial static, vertically integrated



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

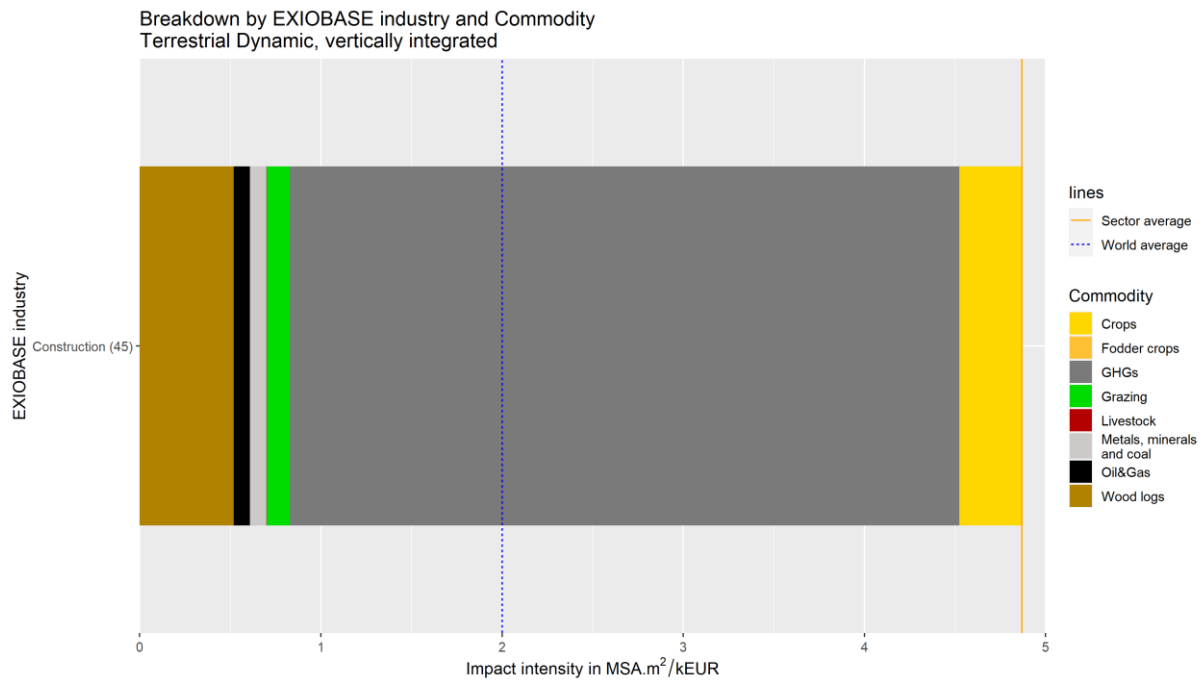
Figure 23: Breakdown by EXIOBASE industry and commodity, terrestrial dynamic, vertically integrated

Breakdown by EXIOBASE industry and Commodity Terrestrial Static, vertically integrated



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 24: Breakdown by EXIOBASE industry and commodity, terrestrial dynamic, vertically integrated



Source: GBS 1.2.2 computation, Oct 2021, Alexis Costes

Figure 25: Breakdown by EXIOBASE industry and commodity, terrestrial static, vertically integrated

2. Comparison of the impact of bio-based concrete, traditional concrete and clay-based brick

In this section, the biodiversity impacts of the materials used in the sector are assessed to determine the most impactful ones. For this purpose, several materials were selected based on the consumption of raw materials by the CHEB¹² sector, as shown in Figure 27 Part of the material use in new housing and tertiary sector.

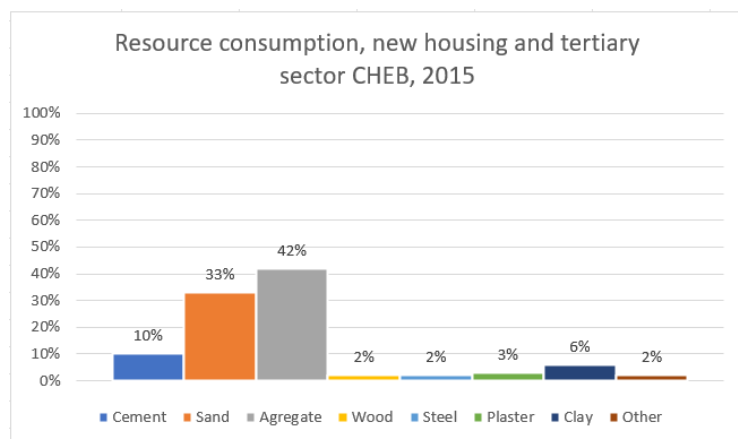


Figure 26 Part of the material use in new housing and tertiary sector

Within the construction sector, cement, sand and gravel are the most consumed raw materials. In addition, they are also the main components of concrete, the most used processed material in the construction sector. For this reason, the following study will focus on 5 structural work materials: three types of concrete based on sand and gravel (traditional concrete, mixed concrete, recycled concrete) made in France, a hemp-concrete made in France and a clay-based material (brick) made in Spain. Table 28 Components and origin of each material studied summarises the main components of each material and their origin. Data was collected from life cycle assessment studies by (Léonard, n.d.; Marcelino-Sadaba et al. 2017; Serres,

Material	Main component	Origin
Traditionnal concrete	Sand and gravel	France
Mixed concrete	Sand and gravel	France
Recycled concrete	Sand and gravel	France
Hemp concrete	Bio-material	France
Clay-based brick	Clay	Spain

Table 22 Components and origin of each material studied

Braymand, and Feugeas 2014).

¹² Commerces de grande distribution, hôtels, enseignement, bureaux (Retail, hotels, education, offices)

To compute and compare the biodiversity impact of each of these materials using the GBS, a functional unit of 1 m³ of material was selected. Thus, life cycle results expressed with a functional unit per ton were converted to m³ using conversion factors presented in Table 23. Due to a lack of data about mixed and recycled concrete weight, we assume that their weight is the same.

Table 23 Mass to volume conversion table for construction materials

Kind of material	1 m ³ of material
Traditional concrete	2,3 tons
Mixed concrete	2,3 tons
Recycled concrete	2,3 tons
Hemp concrete	1,5 tons
Clay based brick	0,330 tons

Other conversions were necessary, such as nutrient emissions which needed to be converted from PO₄³⁻ emission into P_{content}. The following conversion was thus performed:

$$1\text{kg } P_{eq} = MPO_4^{3-} / MP * \text{kg } PO_4^{3-}$$

$$M(P) = 31\text{g/mol} \quad M = \text{Molecular weight}$$

$$M(O) = 16\text{g/mol} \quad PO_4^{3-} = \text{Phosphate ion}$$

$$M(PO_4^{3-}) = (31 + 4*16) \text{g/mol}$$

$$1\text{kg } P_{eq} = 3,07\text{kg } PO_4^{3-}$$

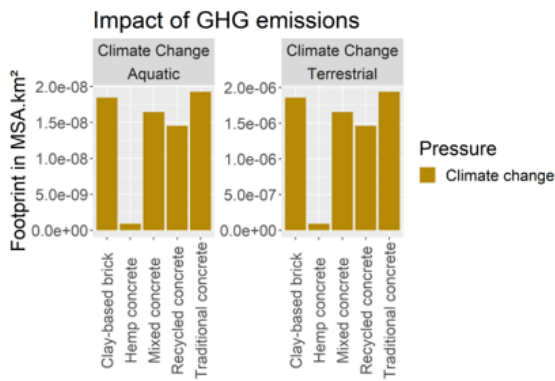
Data are available or partly available for the pressures Climate change, Freshwater eutrophication and Hydrological disturbance due to water use, Ecotoxicity is only available for clay-based brick. However, some of GBS's relevant pressures such as Land use are currently missing in the assessment due to a lack of data. For this reason, the analysis should be taken with caution. Other impact indicators are evaluated in the life cycle assessment used, such as « Photochemical ozone creation », but are currently not covered in the GBS.

The following tables summarize the different pressures covered and the missing data in this analysis. Besides, our assessment doesn't consider the positive impact of the carbon sequestration of hemp concrete.

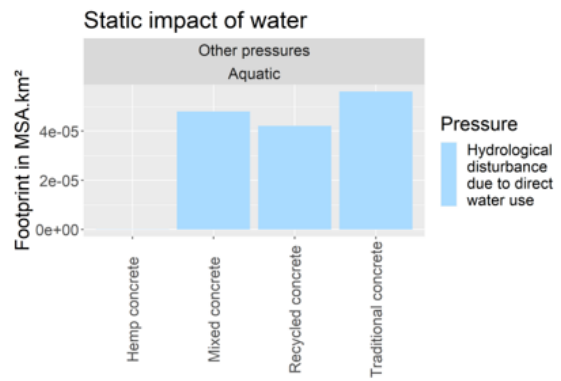
	Climate Change (kg CO ₂ - eq)	Freshwater Eutrophication (kg-P content)	Hydrological disturbance du to water use (m ³)	Ecotoxicity (kg 1,4- dichlorobenzene eq.)	Land Use
Traditional concrete	444	0.071	780	Missing Data	Missing Data
Mixed concrete	379	0.055	667	Missing Data	Missing Data
Recycled concrete	335	0.042	585	Missing Data	Missing Data
Hemp concrete	20.91	0.026	1.80	Missing Data	Missing Data
Clay-based brick	425	0.014	Missing Data	5.37	Missing Data

The following table summarizes the different system boundaries for each material and the different steps of their life cycle. Many steps of life cycle are absent for clay-based brick and Hemp concrete. The case study of (Laidoudi et al. 2015) was focused on embodied energy for bio-based concrete while study of (Marcelino-Sadaba et al. 2017) on clay-based brick used a cradle-to-gate approach which was not the perimeter of traditional concrete, mixed concrete and recycled concrete study. Thus, results should be taken with caution as the impact generated by these steps are not included for all materials.

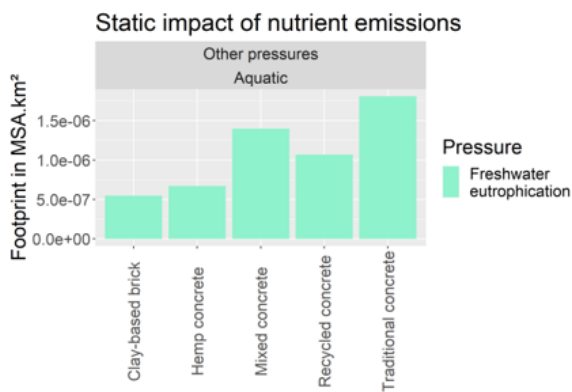
	Resources production	Transport	Transformation	Use	End of life
Traditional concrete	Included	included	included	Included	Included
Mixed concrete	Included	Included	Included	Included	Included
Recycled concrete	Included	Included	Included	Included	Included
Hemp concrete	Included	Included	Included	Not included	Included
Clay-based brick	Included	Included	Included	Not included	Not included



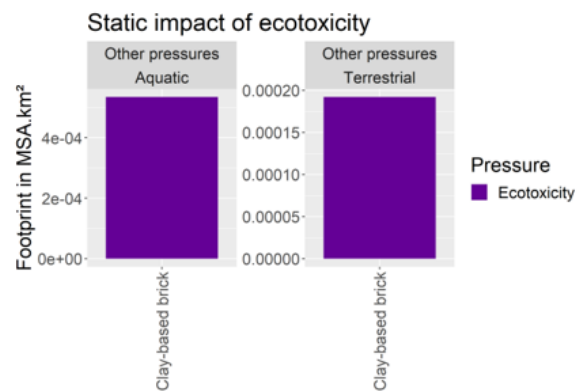
Source: GBS 1.3.1.0 computation, Dec 2021, Camille Breton



Source: GBS 1.3.1.0 computation, Dec 2021, Camille Breton



Source: GBS 1.3.1.0 computation, Jan 2022, Camille Breton



Source: GBS 1.3.1.0 computation, Dec 2021, Camille Breton

Figure 27 GBS results for each construction material

	Climate Change	Hydrological disturbance du to climate change	Freshwater Eutrophication	Hydrological disturbance du to water use	Ecotoxicity	Land Use	Total MSAAppb*
Traditional concrete	1.40E-05	1.80E-06	3.40E-06	1.10E-04	Missing Data	Missing Data	1.30E-04
Mixed concrete	1.30E-05	1.60E-06	2.80E-06	9.40E-05	Missing Data	Missing Data	1.10E-04
Recycled concrete	1.10E-05	1.50E-06	2.20E-06	8.20E-05	Missing Data	Missing Data	9.70E-05
Hemp concrete	6.90E-07	8.80E-08	1.30E-06	2.40E-07	Missing Data	Missing Data	2.30E-06

	Climate Change	Hydrological disturbance du to climate change	Freshwater Eutrophication	Hydrological disturbance du to water use	Ecotoxicity	Land Use	Total MSAppb*
Clay-based brick	1.40E-05	1.70E-06	1.08E-06	Missing Data	1.05E-03	Missing Data	1.10E-03

Figure 9: Aggregated impact in MSAppb* of concretes and brick measured per m³ of material

Among the different impact drivers, Hemp concrete is the less impactful material with excellent performance in climate change, almost ten time less impact due to this pressure compared to the other materials. Clay-based brick in opposition generates the highest impact on biodiversity among the five materials studied. However, the Ecotoxicity results are subject to more uncertainties in the GBS and may not reflect reality. This pressure is also not accounted for the other materials. This data put aside, traditional concrete has the highest impact among all materials studied due to higher Hydrological Disturbance due to water use and Climate change impacts.

3. The sector’s Scope 1 impact on land use

Due to an underestimated result of the Scope 1 impact of land use from EXIOBASE data, the following analysis aims to adjust the Land use Scope 1 impacts by covering part of the missing data of the construction sector from a database of artificial soil corresponding to the construction sector.

To assess the impact of Scope 1 of the construction sector, Eurostat data will be used as input data ('Base de Données - Utilisation / Occupation Des Sols - Eurostat' n.d.). The database used provides the land use data of the construction sector in Europe and is named (lan_use_oww).

Some of the available data are unnecessary or out of perimeter; to ensure that the selected data corresponds to the perimeter of our research, it is necessary to define it.

The LUCAS technical reference document is the reference classification document for the land use class in this database. It provides an overview of the different categories of land use attributed to Europe and what they include. The classification is presented by the letter U and three digits referring to an economic activity of NACE rev 2. The following classification is an extract of the technical reference document LUCAS ('LUCAS2018-C3-Classification.Pdf' n.d.) and provides a characterization of economic activity U330 which was used in the present study.

Land Use classification (LUCAS SU LU)
<p><u>U330 Construction.</u></p> <p>Areas used for construction whatever the degree of completion (NACE F, except agricultural activities under F43.12)</p>

This section includes general construction and specialized construction activities for buildings and civil engineering works. It includes new work, repair, additions and alterations, the erection of prefabricated buildings or structures on the site and construction of a temporary nature. Thus, the construction of entire dwellings, office buildings, stores and other public and utility buildings, farm buildings etc., or the construction of civil engineering works such as motorways, streets, bridges, tunnels, railways, airfields, harbours and other water projects, irrigation systems, sewerage systems, industrial facilities, pipelines and electric lines, sports facilities etc.

This class includes:

- Construction of buildings
- Civil engineering
- Specialised construction activities (e.g. demolition)

This class excludes:

- Field construction related to agriculture (e.g. agricultural land terracing, drainage, preparing rice paddies etc.)

After having selected the type of data according to the definitions of the LUCAS document, the databases must be filtered to select only the data corresponding to our research perimeter. An explanation of the manipulations performed for this table will follow.

The database (lan_use_owv) presents several kinds of Land Use data in Europe. However, the table does not present by default the classes concerned by the present study. To reproduce the database obtained for this study a filter from the "GEO" tab was used to remove the detail of the data by region and keep only the total data per country. Moreover, in the "Land use" tab, only the "LUD5" data linked with the label "construction" and corresponding to the present research perimeter was kept. Finally, the unit of measurement was changed to a square kilometer unit to be used by GBS with the tab "Unit of measure".

After having filtered the database and entered data from Eurostat as "urban area" data in the GBS (areas that are more than 80% built-up), the impact of the construction sector was calculated. The following graph (Figure 28 Static impact of European construction in MSA.km²) represents the static impact in 2018 of construction in Europe according to "U330 construction" from the LUCAS classification and linked with

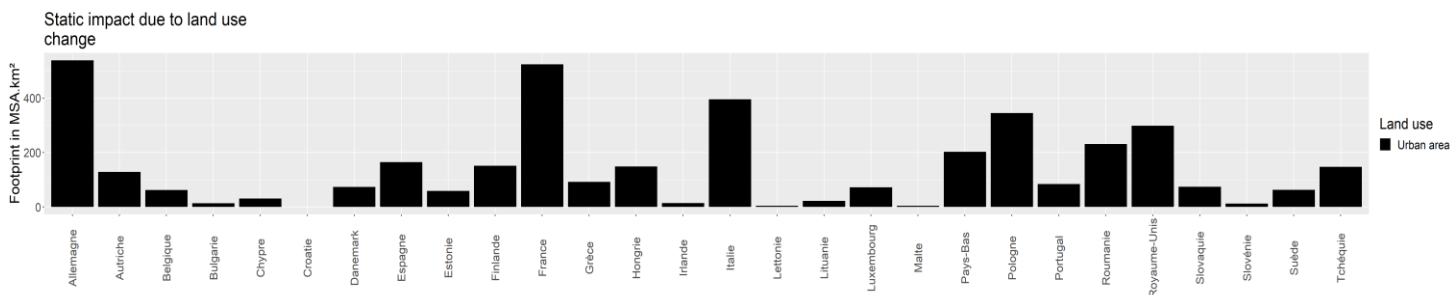


Figure 28 Static impact of European construction in MSA.km²

Source: GBS 1.3.0 computation, Jan 2022, Camille Breton

Section F of NACE rev 2 entitled "Section F – Construction".

From the data entered, the GBS calculated a static impact of the European Union of 3947.6 MSA.km², an area almost roughly equivalent to twice the country of Luxembourg, for a total of 4123 km² occupied by the construction sector. The result is strongly contrasted and often correlated with the size of the country due to a contribution of more than 50 % by five major contributing countries (Germany, France, Italy, Poland and the United Kingdom) and several others whose cumulated impact is very low (Croatia, Bulgaria, Ireland, Latvia, Malta and Slovenia) with a cumulative impact of less than 2 %.

To determine the impact of construction worldwide and due to a lack of global data, the assumption is made that the proportion of areas linked to the construction sector in Europe among the total continent area is the same across the world .

The impact in MSA.km² of Europe will be added to the MSA.km² impact of the world excluding European union. The following computation is made to estimate the area linked to the construction in the world without Europe:

$$A_{U330 \text{ world without Europe}} = \frac{A_{U330 \text{ Europe}}}{A_{\text{Europe}}} \times (A_{\text{World}} - A_{\text{Europe}})$$

Where the variables are:

- $A_{U330 \text{ world without Europe}}$: area linked to the construction sector (U330) worldwide except for Europe
- $A_{U330 \text{ Europe}}$: area linked to the construction sector (U330) in Europe (European Union), which is 4123 km² In 2018
- A_{Europe} : European Union surface which is 4 233 000 km²
- A_{World} : World surface which is 148 000 000 km²

The area linked to the construction sector worldwide except for Europe is computed as below:

$$\frac{4\ 123}{4\ 233\ 000} \times (148\ 000\ 000 - 4\ 233\ 000) = 140\ 031\ \text{km}^2$$

World surface occupied by “U330 construction” excluding European union is estimated to be 140 031 km².

From this data, the land use footprint (in MSA.km²) of the construction sector in the world excluding the European Union was computed. The static footprint of the construction sector in the World excluding the European Union is 130 000 MSA.km².

Therefore, the resulting land use Scope 1 static footprint caused by the construction sector worldwide is 133 947.6 MSA.km² which is equivalent to the surface of Greece. However, this impact must be calculated. The calculated impact assumed that the ratio of areas linked to the construction sector over the whole continent is constant across the world, so this data should be taken with caution as it may not perfectly reflect reality, but it does provide an estimate of the global impact. Moreover, the dynamic impact is currently missing and under computation, which means that the evolution of this footprint (notably the land artificialization) is not presented, although the data on land use in km² by the construction sector was increasing from 2015 to 2018. Finally, it is important to remember that the results obtained represent the impacts during the construction work process and does not cover the buildings’ operation and other ulterior life cycle processes.

C. EU GREEN TAXONOMY GUIDELINES

1. Conditions for making a substantial contribution to the EU Green Taxonomy environmental objectives

The EU Green taxonomy classifies environmentally sustainable activities within the economy. The basis for this taxonomy was published in June 2020, in particular establishing six environmental objectives:

1. Climate change mitigation
2. Climate change adaptation
3. The sustainable use and protection of water and marine resources
4. The transition to a circular economy
5. Pollution prevention and control
6. The protection and restoration of biodiversity and ecosystems

To determine a list of sustainable activities, technical screening criteria for each of these objectives are needed. In June 2021, criteria for the first two objectives were adopted in a first delegated act. (European Commission 2021)

In August 2021, the Platform on Sustainable Finance (PSF) provided draft technical screening criteria to prepare the second draft delegated act, which should be adopted in the first half of 2022. The Construction sector should refer to these criteria for qualitative analysis of its biodiversity impact.

According to Figure 29, the PSF has identified the following priority activities to tackle for the sector and provided conditions for making a substantial contribution to 4 environmental objectives (in column).

ST7 Construction and buildings + ICT + Emergency Services							
Economic Activities	NACE codes	Mitigation	Adaptation	Water	Circular economy	Pollution	Biodiversity
Construction	F						X
Construction of buildings	F41				X		
Civil engineering	F42		X		X		
Implementation of nature based solutions for flood risk prevention and protection for both inland and coastal waters	F42.91			X			
Construction of flood risk prevention and protection infrastructure for inland and coastal floods	F42.91			X			

Figure 29. Extract of (European Commission 2021): activities and environmental objectives prioritised for the Construction sector

Extracts on the criteria described in the draft are given below (Platform on sustainable finance: Technical working group 2021b; 2021a).

“Construction of new buildings and major renovation of buildings” (F41) sector making a substantial contribution to the protection and restoration of biodiversity and ecosystems

A substantial contribution to biodiversity is considered to have been made when **both criteria A and B** are met:

A

A biodiversity strategy or biodiversity management plan for the site has been produced by a suitably qualified ecologist that respects the mitigation hierarchy³⁹⁹ and addresses, as a minimum:

1. Measures taken to protect any species found on the site that are classified by the European and IUCN Red Lists⁴⁰⁰ as Vulnerable, Endangered or Critically Endangered, including, where appropriate; scheme redesign, relocation of works, changes to work methods or timing, monitoring of species and habitat during and after works and any other measures deemed necessary by the suitably qualified ecologist.
2. An ex-ante assessment of the proposed design measures confirming that these will deliver biodiversity net gain, including a gain in number of native species. The implementation must also be confirmed by an ex-post assessment of the site.
3. Measures to mitigate impacts during the construction phase including phasing or timing of construction works to avoid destruction of active nests or disruption of breeding activities of native species and the attenuation of noise and vibration.
4. A plan for ongoing maintenance of green and biodiversity infrastructure included in the development.
5. Consideration for how the development contributes to the aims and objectives of relevant local, national, regional and international strategies for biodiversity and green infrastructure, including connecting the site to urban green infrastructure networks or corridors, where these exist.

And all green infrastructure features have been designed and installed in line with appropriate best practice guidance (examples are listed in footnotes 429 and 431 below).

B

-At least 60% of the external horizontal surface area (excluding surface area that is required for renewable energy sources in order to comply with mandatory local requirements), is dedicated to natural habitat or biotopes (eg green roofs⁴⁰¹)

-At least 80% of all exposed horizontal surfaces on the site (including roofs⁴⁰²) are permeable to water (including open water surfaces).

-Provision has been made of additional biodiversity infrastructure such as artificial, building-integrated nesting boxes for bats and birds and free-standing or building-integrated insect habitats ('insect hotels'). As a minimum, one such feature must be provided per residential unit⁴⁰³ or per 100m² of site for non-residential development.

Compliance may also be demonstrated through the application of a locally applicable Green Space Factor (GSF) ⁴⁰⁴ method and the appropriate locally defined thresholds for the type of development, provided these are not lower in overall ambition than the above thresholds.

Where not already included in the local Green Space Factor (GSF) method, provision must also be made of additional biodiversity infrastructure such as artificial, building-integrated or free-standing nesting boxes for bats and birds and insect habitats ('insect hotels'). As a minimum, one such feature must be provided per residential unit⁴⁰⁵ or per 100m² of site for non-residential development.

“Construction of new buildings and major renovation of buildings” (F41) making a substantial contribution to the transition to a circular economy

The activity complies with the following criteria:

1. At least 90 % (by weight) of the non-hazardous construction waste* (excluding naturally occurring material referred to in category 17 05 04 in the European List of Waste established by Commission Decision 2000/532/EC⁴⁷⁹) generated on the construction site is prepared for re-use or recycling.

2. A life cycle assessment³⁹⁰ of the entire building or of the renovation works has been calculated according to Level(s) and EN 15978, covering each stage in the life cycle and the results are disclosed to investors and clients on demand.
 3. Construction designs and techniques support circularity and in particular demonstrate how they are designed to be more resource efficient, adaptable, flexible and easy to dismantle to enable reuse and recycling. This should be demonstrated with reference to Level(s) indicators 2.3391 (design for adaptability) and 2.4392 (design for deconstruction) at Level 2, in accordance with ISO 20887:2020, EN 15643, and EN 16309.
 4. The asset contains at least 30% (by weight) of recycled content, re-used content, re-manufactured content and/or by-products
 - provided that this is in accordance with technical standards and;
 - provided that the CO2 emissions generated through the production process and the transportation of the recycled or re-used material are not higher than the CO2 emissions generated through the production process and the transportation of virgin material.**
 5. The design promotes material and resource efficiency by following relevant national or international standards³⁹³ or best practice design guidance on material efficiency.
 6. Components and materials used in the construction do not contain asbestos nor substances of very high concern as identified on the basis of the list of substances subject to authorisation set out in Annex XIV to Regulation (EC) No 1907/2006 of the European Parliament and of the Council unless authorised or exempted for the specific use through the appropriate processes in REACH.
 7. Digital tools that support preserving and extending service life and future adaptation and reuse have been deployed to produce, as a minimum:
 - Detailed material specification records as part of a building information model / digital twin or in a separate schedule or material passport, covering at least the structural elements, facades and HVAC equipment.
 - A maintenance schedule including a technical description of the building and its systems and a schedule for future maintenance
- For buildings with floor area above 5000m², an as-built computer model (digital twin)
- All of the above should be held at the site or by the building owner and evidence disclosed to clients and investors on demand.
- *Construction waste is the waste generated through the construction process, excluding excavation and demolition waste.*
- ** The calculation is based on FprEN 17472 or equivalent.*

“Civil engineering” (F42) making a substantial contribution to the transition to a circular economy

1. At least 90 % (by weight) of the non-hazardous construction waste* (excluding naturally occurring material referred to in category 17 05 04 in the European List of Waste established by Commission Decision 2000/532/EC479) generated on the construction site is prepared for re-use or recycling.
2. Construction designs and techniques support circularity and in particular demonstrate how they are designed to be more resource efficient, adaptable, flexible and easy to dismantle to enable reuse and

recycling. This can be demonstrated with reference to ISO 20887:2020 “Sustainability in buildings and civil engineering works — Design for disassembly and adaptability — Principles, requirements and guidance” or equivalent.

3. The asset contains at least 30% (by weight) of recycled content, re-used content, re-manufactured content and/or by-products
 - provided that this is in accordance with technical standards and;
 - provided that the CO₂ emissions generated through the production process and the transportation of the recycled or re-used material are not higher than the CO₂ emissions generated through the production process and the transportation of virgin material.**

4. Electronic tools are used to describe the characteristics of the built asset, including the materials and components used, for the purpose of future maintenance, recovery and reuse. The information is stored in a digital logbook or equivalent and is made available to the owner of the asset.

5. Bridges, tunnels, dikes and sluices are equipped with monitoring functions to predict maintenance needs such as in-built predictive maintenance.

*Construction waste is the waste generated through the construction process, excluding excavation and demolition waste.

** The calculation is based on FprEN 17472 or equivalent.

Focus on “Maintenance of roads and motorways” (F42) to a circular economy

The activity complies with the following criteria:

1. The maintenance operation is mainly dedicated to pavement management and is linked to the following main elements of the road:

- base course and/or
- binder course and/or
- surface course.

2. Where main road elements are demolished, 100% (by weight) of the non-hazardous waste (excluding naturally occurring material referred to in category 17 05 04 in the European List of Waste established by Commission Decision 2000/532/EC479) is prepared for re-use and recycling.

3. Where renewed, the sum of the newly installed road elements contains at least 30% by weight of recycled content, re-used content and/or by-products
 -provided that this is in accordance with technical standards and;
 -provided that the CO₂ emissions generated through the production process and the transportation of the recycled or re-used material are not higher than the CO₂ emissions generated through the production process and the transportation of virgin material.*

4. Where renewed, the newly installed binder course has a service lifetime no shorter than 20 years.
 Where renewed, the newly installed base course has a service lifetime no shorter than 40 years.

* The calculation is based on FprEN 17472 or equivalent.

Focus on “Maintenance of bridges and tunnels” (F42) to a circular economy

The activity complies with the following criteria:

1. The maintenance operation documents that it leads to an extension of the service life by
 - a) remedying defects in the structure which pose a risk to the asset’s structural health or;
 - b) strengthening the asset’s loadbearing capacity in order to restore or enhance its strength compared to what was deemed necessary during their design.
2. Where generated, at least 90% of the non-hazardous construction and demolition waste (excluding naturally occurring material referred to in category 17 05 04 in the European List of Waste established by Commission Decision 2000/532/EC479) are prepared for re-use or recycling.
3. The sum of the newly installed elements contains at least 30% by weight of recycled content, re-used content and/or by-products
 - provided that this is in accordance with technical standards and;
 - provided that the CO2 emissions generated through the production process and the transportation of the recycled or re-used material are not higher than the CO2 emissions generated through the production process and the transportation of virgin material.*

** *The calculation is based on FprEN 17472 or equivalent.*

“Civil engineering” (F42) making a substantial contribution to the transition to climate change adaptation

The economic activity has implemented physical and non-physical solutions (‘adaptation solutions’) that substantially reduce the most important physical climate risks that are material to that activity.

2 The physical climate risks that are material to the activity have been identified from those listed in Appendix A to Annex II of the first Delegated Act supplementing Regulation (EU) 2020/852 by performing a robust climate risk and vulnerability assessment with the following steps:

- (a) screening of the activity to identify which physical climate risks from the list in Appendix A to Annex II of the Delegated Act may affect the performance of the economic activity during its expected lifetime;
- (b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to Annex II of the Delegated Act, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;
- (c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

- (a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;
- (b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios³⁸² consistent with the expected lifetime of the activity, including, at least, 10 to 30 years climate projections scenarios for major investments.

3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports³⁸³, scientific peer-reviewed publications and open source³⁸⁴ or paying models.

4. The adaptation solutions implemented:

- (a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;
- (b) favour nature-based solutions³⁸⁵ or rely on blue or green infrastructure³⁸⁶ to the extent possible;
- (c) are consistent with local, sectoral, regional or national adaptation plans and strategies;
- (d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;
- (e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

5. In order for an activity to be considered as an enabling activity as referred to in Article 11(1), point (b), of Regulation (EU) 2020/852, the economic operator demonstrates, through an assessment of current and future climate risks, including uncertainty and based on robust data, that the activity provides a technology, product, service, information, or practice, or promotes their uses with one of the following primary objectives:

- (a) increasing the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;
- (b) contributing to adaptation efforts of other people, of nature, of cultural heritage, of assets and of other economic activities.

“Flood risk prevention and protection infrastructure for inland river and coastal floods” (F42.91) sector making a substantial contribution to climate change adaptation

1. The economic activity has implemented physical and non-physical solutions (‘adaptation solutions’) that substantially reduce the most important physical climate risks that are material to that activity.

2 The physical climate risks that are material to the activity have been identified from those listed in Appendix A to Annex II of the first Delegated Act supplementing Regulation (EU) 2020/852 by performing a robust climate risk and vulnerability assessment with the following steps:

- (a) screening of the activity to identify which physical climate risks from the list in Appendix A to Annex II of the Delegated Act may affect the performance of the economic activity during its expected lifetime;
- (b) where the activity is assessed to be at risk from one or more of the physical climate risks listed in Appendix A to Annex II of the Delegated Act, a climate risk and vulnerability assessment to assess the materiality of the physical climate risks on the economic activity;
- (c) an assessment of adaptation solutions that can reduce the identified physical climate risk.

The climate risk and vulnerability assessment is proportionate to the scale of the activity and its expected lifespan, such that:

- (a) for activities with an expected lifespan of less than 10 years, the assessment is performed, at least by using climate projections at the smallest appropriate scale;
- (b) for all other activities, the assessment is performed using the highest available resolution, state-of-the-art climate projections across the existing range of future scenarios⁵⁴⁸ consistent with the expected lifetime of the activity, including, at least, 10 to 30 years climate projections scenarios for major investments.

3. The climate projections and assessment of impacts are based on best practice and available guidance and take into account the state-of-the-art science for vulnerability and risk analysis and related methodologies in line with the most recent Intergovernmental Panel on Climate Change reports⁵⁴⁹, scientific peer-reviewed publications and open source⁵⁵⁰ or paying models.

4. The adaptation solutions implemented:

(a) do not adversely affect the adaptation efforts or the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) favour nature-based solutions⁵⁵¹ or rely on blue or green infrastructure⁵⁵² to the extent possible;

(c) are consistent with local, sectoral, regional or national adaptation plans and strategies;

(d) are monitored and measured against pre-defined indicators and remedial action is considered where those indicators are not met;

(e) where the solution implemented is physical and consists in an activity for which technical screening criteria have been specified in this Annex, the solution complies with the do no significant harm technical screening criteria for that activity.

5. In order for an activity to be considered as an enabling activity as referred to in Article 11(1), point (b), of Regulation (EU) 2020/852, the economic operator demonstrates, through an assessment of current and future climate risks, including uncertainty and based on robust data, that the activity provides a technology, product, service, information, or practice, or promotes their uses with one of the following primary objectives:

(a) increasing the level of resilience to physical climate risks of other people, of nature, of cultural heritage, of assets and of other economic activities;

(b) contributing to adaptation efforts of other people, of nature, of cultural heritage, of assets and of other economic activities.

“Nature based solutions (Nbs) for flood risk prevention and protection for both inland and coastal waters” (F42.91) sector making a substantial contribution to sustainable use and protection for water and marine resources

The activity is eligible to substantially contribute only if it meets the following three criteria:

1. The activity is a quantifiable and/or time bound measure to achieve the objectives for flood risk reduction in accordance with a Flood Risk Management Plan (FRMP) coordinated at river basin scale and developed under the Floods Directive. For countries outside the EU the activity is identified as a flood risk reduction measure either in an Integrated Water Resources Management (IWRM) plan at river basin scale or in an Integrated Coastal Zone Management (ICZM) plan along a coast. These plans pursue the objectives for the management of flood risks to reduce adverse consequences where applicable for human health, the environment, cultural heritage and economic activity.

2. The activity demonstrates specific ecosystem co-benefits which contribute to achieving good water status in accordance with WFD⁵⁶³ and nature restoration targets defined in the EU 2030 Biodiversity Strategy (which will be further refined under the proposal on the EU nature restoration regulation⁵⁶⁴ expected by the end of 2021). Each Member State develops ecosystem action plan with clear and binding targets and timelines and definition of criteria either on restoration or conservation which is operationalized at regional or local level. The involvement of local stakeholders from the outset in the planning and design phases is required to ensure the full delivery of multiple benefits and the successful implementation of the activity. The restoration action plan is based on the principles outlined by IUCN

Global Standard for NbS⁵⁶⁵. For countries outside EU, National Biodiversity Strategies and Action Plans⁵⁶⁶ are the equivalent reference documents for developing ecosystem restoration action plans.

3. A monitoring programme is in place to evaluate the effectiveness of an NbS scheme to improving the status of the affected water body and changing climate conditions allowing for flexibility meaning the adaptive management approach. The programme is required to be periodically reviewed by an ad-hoc committee composed of sector experts (including ecologists) and the relevant regional or local managing authorities following the cyclical approach of the River Basin Management Plans and the Flood Risk Management Plans. For countries outside EU where there are no RBMPs or FRMPs equivalent documents in place, the programme is periodically reviewed at intervals not exceeding 10 years. The programme adheres to and aligns with the prevailing legal and regulatory provisions, being clear on where legal responsibilities and liabilities lie. The programme actively engages local communities and other affected stakeholders.

“Demolition or wrecking of buildings and other structures” (F43.1.1) sector making a substantial contribution to a circular economy

1. The demolition is carried out in accordance with the checklist of the EU Demolition and Construction Waste Protocol or an equivalent at national level.
2. At least 90 % (by weight) of the non-hazardous demolition waste (excluding naturally occurring material referred to in category 17 05 04 in the European List of Waste established by Commission Decision 2000/532/EC479) is prepared for re-use or recycled.

2. Additional DNSH Guidelines

The main Do No Significant Harm criteria for the sector (EU Technical Expert Group on Sustainable Finance 2020a) are provided in the factsheet. Additional criteria which did not fit within the factsheet are listed below (EU Technical Expert Group on Sustainable Finance 2020b).

To prevent damage of vulnerable ecosystems activities should ensure that:

The new construction is not built on protected natural areas, such as land designated as Natura 2000, UNESCO World Heritage and Key Biodiversity Areas (KBAs), or equivalent outside the EU as defined by UNESCO and / or the International Union for Conservation of Nature (IUCN).

The new construction is not built on arable or greenfield land of recognized high biodiversity value and land that serves as habitat of endangered species (flora and fauna) listed on the European Red List and / or the IUCN Red List.

For renovation project covering more than 1000 m² of floor area and all new construction projects at least 80% of all timber products used in the renovation/ construction for structures, cladding and finishes must have been either recycled/reused or sourced from sustainably managed forests as certified by third-party certification audits performed by accredited certification bodies, e.g. FSC/PEFC standards or equivalent.

Infrastructure for low carbon transport on land and water should have completed an Environmental Impact Assessment (EIA), in accordance with EU Directives on Environmental Impact Assessment (2014/52/EU) and Strategic Environmental Assessment (2001/42/EC) or other equivalent national provisions.

Use the assessments to, at the very least, identify, evaluate, and mitigate any potential negative impacts of the designated activities, projects, or assets on ecosystems and its biodiversity and it should be assessed and conducted in compliance with the provisions of the EU Habitats and Birds Directives.

Invasive plants are appearing very often along transport infrastructure and are sometimes even spread due to transport infrastructure, which might negatively impact natural ecosystems (e.g. natural fauna). Care should be taken not to spread any invasive plants through proper maintenance.

Wildlife collisions are prevented and that solutions are applied for the detection and avoidance of potential traps that may cause the unnecessary death of animals.

Mitigation options exist and different types of measures can be beneficial for wildlife, such as:

- Wildlife warning systems combined with heat sensors can reduce the number of collisions.
- Fences along areas with high strike risk.
- Viaducts, tunnels, overpasses and bridges, etc.
- Warning signals that are triggered by approaching traffic, particularly in areas of high strike risk.

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4 Glossary

All definitions can be found in the document “How to conduct a Biodiversity Footprint Assessment with the Global Biodiversity Score” (CDC Biodiversité, 2019)

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6 Additional tables and figures

Table 24- Factsheet names per EXIOBASE industries

EXIOBASE_industry	EXIOBASE_industry_group	Factsheet
Cultivation of paddy rice	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of wheat	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of cereal grains nec	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of vegetables, fruit, nuts	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of oil seeds	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of sugarcane, sugar beet	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of plant-based fibers	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cultivation of crops nec	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Cattle farming	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Pigs farming	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Poultry farming	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Meat animals nec	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Animal products nec	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Raw milk	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food

Wool, silk-worm cocoons	Crop and animal production, hunting and related service activities	Agriculture and Agri-Food
Forestry, logging and related service activities	Forestry and logging	Raw materials extraction
Mining of coal and lignite; extraction of peat	Mining of coal and lignite	Raw materials extraction
Extraction of crude petroleum and services related to crude oil extraction, excluding surveying	Extraction of crude petroleum and natural gas	Raw materials extraction
Extraction of natural gas and services related to natural gas extraction, excluding surveying	Extraction of crude petroleum and natural gas	Raw materials extraction
Extraction, liquefaction, and regasification of other petroleum and gaseous materials	Extraction of crude petroleum and natural gas	Raw materials extraction
Mining of uranium and thorium ores	Mining of metal ores	Raw materials extraction
Mining of iron ores	Mining of metal ores	Raw materials extraction
Mining of copper ores and concentrates	Mining of metal ores	Raw materials extraction
Mining of nickel ores and concentrates	Mining of metal ores	Raw materials extraction
Mining of aluminium ores and concentrates	Mining of metal ores	Raw materials extraction
Mining of precious metal ores and concentrates	Mining of metal ores	Raw materials extraction
Mining of lead, zinc and tin ores and concentrates	Mining of metal ores	Raw materials extraction
Mining of other non-ferrous metal ores and concentrates	Mining of metal ores	Raw materials extraction
Quarrying of stone	Other mining and quarrying	Raw materials extraction
Quarrying of sand and clay	Other mining and quarrying	Raw materials extraction
Mining of chemical and fertilizer minerals, production of salt, other mining and quarrying n.e.c.	Other mining and quarrying	Raw materials extraction
Processing of meat cattle	Manufacture of food products	Agriculture and Agri-Food
Processing of meat pigs	Manufacture of food products	Agriculture and Agri-Food
Processing of meat poultry	Manufacture of food products	Agriculture and Agri-Food
Production of meat products nec	Manufacture of food products	Agriculture and Agri-Food
Processing vegetable oils and fats	Manufacture of food products	Agriculture and Agri-Food
Processing of dairy products	Manufacture of food products	Agriculture and Agri-Food
Processed rice	Manufacture of food products	Agriculture and Agri-Food
Sugar refining	Manufacture of food products	Agriculture and Agri-Food
Processing of Food products nec	Manufacture of food products	Agriculture and Agri-Food
Manufacture of beverages	Manufacture of beverages	Agriculture and Agri-Food
Manufacture of fish products	Manufacture of food products	Agriculture and Agri-Food
Manufacture of tobacco products	Manufacture of tobacco products	Manufacturing industry
Manufacture of textiles	Manufacture of textiles	Manufacturing industry
Manufacture of wearing apparel; dressing and dyeing of fur	Manufacture of wearing apparel	Manufacturing industry
Tanning and dressing of leather; manufacture of luggage, handbags, saddlery, harness and footwear	Manufacture of leather and related products	Manufacturing industry

Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Manufacturing industry
Re-processing of secondary wood material into new wood material	Manufacture of wood and of products of wood and cork, except furniture; manufacture of articles of straw and plaiting materials	Processing
Pulp	Manufacture of paper and paper products	Processing
Re-processing of secondary paper into new pulp	Manufacture of paper and paper products	Processing
Paper	Manufacture of paper and paper products	Manufacturing industry
Publishing, printing and reproduction of recorded media	Printing and reproduction of recorded media	Manufacturing industry
Manufacture of coke oven products	Manufacture of coke and refined petroleum products	Manufacturing industry
Petroleum Refinery	Manufacture of coke and refined petroleum products	Manufacturing industry
Processing of nuclear fuel	Electricity, gas, steam and air conditioning supply	Processing
Plastics, basic	Manufacture of chemicals and chemical products	Chemicals industry
Re-processing of secondary plastic into new plastic	Manufacture of coke and refined petroleum products	Processing
N-fertiliser	Manufacture of chemicals and chemical products	Chemicals industry
P- and other fertiliser	Manufacture of chemicals and chemical products	Chemicals industry
Chemicals nec	Manufacture of chemicals and chemical products	Chemicals industry
Manufacture of rubber and plastic products	Manufacture of rubber and plastic products	Manufacturing industry
Manufacture of glass and glass products	Manufacture of other non-metallic mineral products	Manufacturing industry
Re-processing of secondary glass into new glass	Manufacture of other non-metallic mineral products	Processing
Manufacture of ceramic goods	Manufacture of other non-metallic mineral products	Manufacturing industry
Manufacture of bricks, tiles and construction products, in baked clay	Manufacture of other non-metallic mineral products	Manufacturing industry
Manufacture of cement, lime and plaster	Manufacture of other non-metallic mineral products	Manufacturing industry
Re-processing of ash into clinker	Manufacture of other non-metallic mineral products	Processing
Manufacture of other non-metallic mineral products n.e.c.	Manufacture of other non-metallic mineral products	Manufacturing industry
Manufacture of basic iron and steel and of ferro-alloys and first products thereof	Manufacture of basic metals	Manufacturing industry
Re-processing of secondary steel into new steel	Manufacture of basic metals	Processing

Precious metals production	Manufacture of basic metals	Manufacturing industry
Re-processing of secondary precious metals into new precious metals	Manufacture of basic metals	Processing
Aluminium production	Manufacture of basic metals	Manufacturing industry
Re-processing of secondary aluminium into new aluminium	Manufacture of basic metals	Processing
Lead, zinc and tin production	Manufacture of basic metals	Processing
Re-processing of secondary lead into new lead	Manufacture of basic metals	Processing
Copper production	Manufacture of basic metals	Processing
Re-processing of secondary copper into new copper	Manufacture of basic metals	Processing
Other non-ferrous metal production	Manufacture of basic metals	Manufacturing industry
Re-processing of secondary other non-ferrous metals into new other non-ferrous metals	Manufacture of basic metals	Processing
Casting of metals	Manufacture of basic metals	Manufacturing industry
Manufacture of fabricated metal products, except machinery and equipment	Manufacture of fabricated metal products, except machinery and equipment	Manufacturing industry
Manufacture of machinery and equipment n.e.c.	Manufacture of machinery and equipment n.e.c.	Manufacturing industry
Manufacture of office machinery and computers	Manufacture of computer, electronic and optical products	Manufacturing industry
Manufacture of electrical machinery and apparatus n.e.c.	Manufacture of electrical equipment	Electrical and electronic equipment
Manufacture of radio, television and communication equipment and apparatus	Manufacture of electrical equipment	Manufacturing industry
Manufacture of medical, precision and optical instruments, watches and clocks	Manufacture of computer, electronic and optical products	Manufacturing industry
Manufacture of motor vehicles, trailers and semi-trailers	Manufacture of motor vehicles, trailers and semi-trailers	Manufacturing industry
Manufacture of other transport equipment	Manufacture of other transport equipment	Manufacturing industry
Manufacture of furniture; manufacturing n.e.c.	Manufacture of furniture	Manufacturing industry
Recycling of waste and scrap	Waste collection, treatment and disposal activities; materials recovery	Processing
Recycling of bottles by direct reuse	Waste collection, treatment and disposal activities; materials recovery	Processing
Production of electricity by coal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by gas	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by nuclear	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by hydro	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by wind	Electricity, gas, steam and air conditioning supply	Energy

Production of electricity by petroleum and other oil derivatives	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by biomass and waste	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by solar photovoltaic	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by solar thermal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by tide, wave, ocean	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity by Geothermal	Electricity, gas, steam and air conditioning supply	Energy
Production of electricity nec	Electricity, gas, steam and air conditioning supply	Energy
Transmission of electricity	Electricity, gas, steam and air conditioning supply	Energy
Distribution and trade of electricity	Electricity, gas, steam and air conditioning supply	Energy
Manufacture of gas; distribution of gaseous fuels through mains	Electricity, gas, steam and air conditioning supply	Energy
Steam and hot water supply	Electricity, gas, steam and air conditioning supply	Energy
Collection, purification and distribution of water	Water collection, treatment and supply	Non financial services and other activities
Construction	Construction	Construction
Re-processing of secondary construction material into aggregates	Waste collection, treatment and disposal activities; materials recovery	Processing
Sale, maintenance, repair of motor vehicles, motor vehicles parts, motorcycles, motor cycles parts and accessories	Wholesale and retail trade and repair of motor vehicles and motorcycles	Non financial services and other activities
Retail sale of automotive fuel	Wholesale and retail trade and repair of motor vehicles and motorcycles	Retail
Wholesale trade and commission trade, except of motor vehicles and motorcycles	Wholesale trade, except of motor vehicles and motorcycles	Retail
Retail trade, except of motor vehicles and motorcycles; repair of personal and household goods	Retail trade, except of motor vehicles and motorcycles	Retail
Hotels and restaurants	Accommodation and food service activities	Non financial services and other activities
Transport via railways	Land transport and transport via pipelines	Transport
Other land transport	Land transport and transport via pipelines	Transport
Transport via pipelines	Land transport and transport via pipelines	Transport
Sea and coastal water transport	Water transport	Transport
Inland water transport	Water transport	Transport
Air transport	Air transport	Transport
Supporting and auxiliary transport activities; activities of travel agencies	Travel agency, tour operator and other reservation service and related activities	Non financial services and other activities

Post and telecommunications	Post and telecommunications	Non financial services and other activities
Financial intermediation, except insurance and pension funding	Financial service activities, except insurance and pension funding	Financial services
Insurance and pension funding, except compulsory social security	Insurance, reinsurance and pension funding, except compulsory social security	Financial services
Activities auxiliary to financial intermediation	Activities auxiliary to financial services and insurance activities	Financial services
Real estate activities	Real estate activities	Non financial services and other activities
Renting of machinery and equipment without operator and of personal and household goods	Other personal service activities	Non financial services and other activities
Computer and related activities	Computer and related activities	Non financial services and other activities
Research and development	Scientific research and development	Non financial services and other activities
Other business activities	Other business activities	Non financial services and other activities
Public administration and defence; compulsory social security	Public administration and defence; compulsory social security	Non financial services and other activities
Education	Education	Non financial services and other activities
Health and social work	Human health and social work activities	Non financial services and other activities
Incineration of waste: Food	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Paper	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Plastic	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Metals and Inert materials	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Textiles	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Wood	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Incineration of waste: Oil/Hazardous waste	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Biogasification of food waste, incl. land application	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Biogasification of paper, incl. land application	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Biogasification of sewage sludge, incl. land application	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector

Composting of food waste, incl. land application	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Composting of paper and wood, incl. land application	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Waste water treatment, food	Water collection, treatment and supply	Waste and waste management sector
Waste water treatment, other	Water collection, treatment and supply	Waste and waste management sector
Landfill of waste: Food	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Landfill of waste: Paper	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Landfill of waste: Plastic	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Landfill of waste: Inert/metal/hazardous	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Landfill of waste: Textiles	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Landfill of waste: Wood	Waste collection, treatment and disposal activities; materials recovery	Waste and waste management sector
Activities of membership organisation n.e.c. (91)	Activities of membership organisation n.e.c.	Non financial services and other activities
Recreational, cultural and sporting activities (92)	Arts, entertainment and recreation	Non financial services and other activities
Other service activities (93)	Other service activities	Non financial services and other activities
Private households with employed persons (95)	Activities of households as employers of domestic personnel	Non financial services and other activities
Extra-territorial organizations and bodies	Activities of extraterritorial organisations and bodies	Non financial services and other activities

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