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Pathways to a liveable planet as resource use spikes

Annex II: Country Profiles

International Resource Panel

Global Resources Outlook 2024

Disclaimer

Production: Qian Zhang

Global Resources Outlook
2024

Bend the trend

Pathways to a liveable planet as resource use spikes

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Introduction and rationale

The country factsheets were developed with support from Philip Nuss, Renato Marra Campanale, and Veronique van Hoof through the European Topic Centre on Circular Economy and Resource Use (ETC CE), a consortium working with the European Environment Agency (EEA) under a 2022-2026 partnership agreement.

While the Global Resources Outlook 2024 (GRO 2024) discusses material resource use and its environmental impacts on the global and regional scale, data at country level underpins the analyses in Chapters 2 and 3. This Annex presents country profiles based on this country level data, covering data on material flows (Chapter 2) and environmental impacts (Chapter 3) of resource use for a set of four countries. The objective of these country profiles is to illustrate that the data and assessments presented in the report can also be applied at national level.

To develop the case studies, country experts were asked to use the underlying country-level data as a basis to describe and interpret the trends and patterns observed, reproducing some of the figures of the report at the national level. For material flows (linked to Chapter 2), they are based on the International Resource Panel's (IRP) material flow database, which in some cases may differ from national-level statistics.

Environmental impact data (linked to Chapter 3) comes from the dataset generated ad hoc for this edition of the GRO, available at this data viewer: https://public.tableau.com/app/profile/livia.cabernard. The viewer provides data on the environmental impacts of the extraction and processing of material resources as well as their downstream use (>160 sectors and several provisioning services). In addition, the tool provides data on the international trade relations to discuss the role of displacing impacts through trade of material resources.

The patterns and trends are described, as well as the type of additional information and remarks provided by experts, differ across the different country examples. The case studies have not been peer reviewed or formally approved by the International Resource Panel. They represent the views of the Case Study Authors alone.

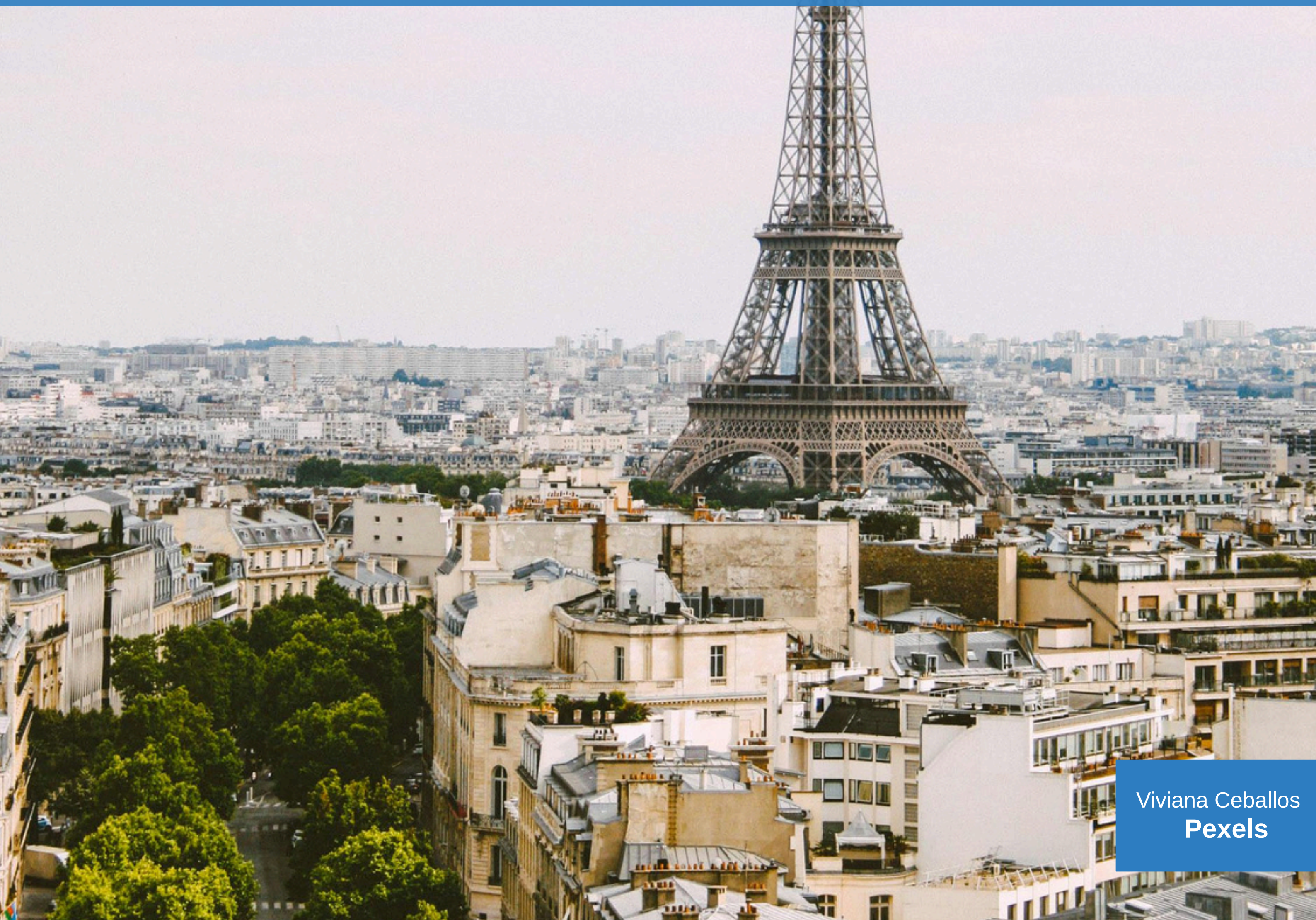
Country Profiles

International Resource Panel

Global Resources Outlook 2024

Country Profile: France

Lise Colard (Commissariat Général au Développement Durable)



Viviana Ceballos
Pexels

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Resource use, environmental impacts, and examples of effective policies for France

01 Country Profile: France

1. Domestic extraction, domestic material consumption and material footprint

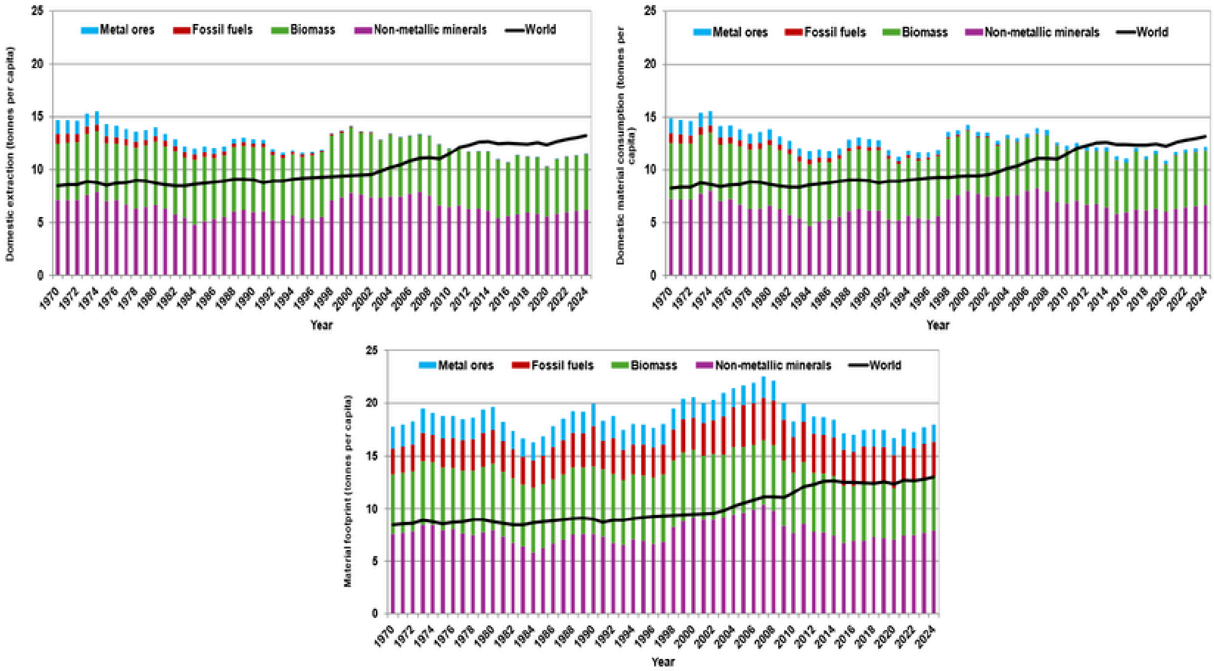


Figure 1: **Domestic extraction, domestic material consumption, and material footprint per capita in *France*** [1]

- Domestic extraction of non-metallic minerals (sand, gravel, slate, etc.) constitute more than half of the total of France domestic extraction, followed closely by biomass. Domestic extraction of fossil fuel and metal ores have been decreasing since the 1970s with the goal to reduce environmental impacts[2] and costs. While domestic consumption for those materials has been decreasing since the 1970s, France depends greatly on imports for fossil fuels and metal ores. This dependence is especially evident when looking at the material footprint[3], since those materials demand a lot of resources for extraction.

- Since 1970, French domestic material consumption per capita has declined, with some variation over the year linked to global crisis. It has fallen sharply since the financial crisis of 2008, reflecting the more moderate growth of the construction sector in particular. The decline in domestic fossil fuel consumption also contributed – albeit to a lesser extent – to the reduction in material consumption.

- France's domestic material consumption of mostly non-metallic minerals and biomass has altered its landscapes, increasing the risk exposure to a wide range of natural phenomena: floods, terrestrial and meteorological hazards, etc. Climate change is likely to exacerbate most of these risks.

- Imports of raw materials have doubled between 1970 and 2008. After a great decline in 2009 linked to the decline of economic activity, import have regained their normal level before declining again in 2020. Exports are mainly made up of biomass (33%) and it is the only material category where exports are greater than imports.

1. Note that data provided in the UNEP IRP MFA database might vary from national- and EU-statistics due to different accounting and modeling approaches used (see technical annex).
2. https://www.statistiques.developpement-durable.gouv.fr/les-sites-dextraction-de-matieres-minerales-et-energetiques-en-france-pres-de-3-000-carrieres-123?rubrique=395&dossier=1028249
3. https://www.statistiques.developpement-durable.gouv.fr/lempreinte-matieres-de-la-france-en-2021-un-indicateur-revelant-notre-consommation-reelle-de?rubrique=395&dossier=1028249

- The **material footprint** is a more comprehensive indicator than domestic material consumption for measuring how much pressure is exerted by France's domestic demand on material flows. On top of the flows extracted at domestic level and direct imports, the material footprint also includes the materials mobilized outside French borders to produce and transport all imported products (consumption of fuels and ores in particular). Taking these indirect material flows into account, the material footprint is higher than domestic material consumption mainly due to the need for imports of fossil fuels and metals and the associated indirect extraction taking place in other countries.

2. Environmental impacts

Resource-related impacts:
This section focuses on the environmental consequences and socio-economic benefits related to raw materials extraction and processing (including the upstream supply chain, such as electricity generation and transport, and downstream use and disposal of materials, fuels, fibres, and food (see chapter 3 in the GRO 2024)). Resource-related impacts include impacts of growing and harvesting biomass, extracting metallic and non-metallic minerals and fossil fuels, and processing of materials, fuels, and food. Impacts of households include private mobility and heating (for climate impacts), while the remaining economy includes all other activities (e.g., manufacturing of products, energy production, construction, transport, services, etc.). The matching of economic sectors to raw material types and the remaining economy is documented in Cabernard et al. (2019), with a few deviations of the GRO 2024 highlighted in the GRO Annex 2).

Provisioning systems:
Provisioning systems were defined on the level of end-sectors and products. For example, the use of a private car or public mobility would be associated with the provisioning system "mobility", whereas transport of materials to a building site would be counted within the provisioning system "built environment" (GRO 2024). The use of provisioning systems allows to view impacts by the service they provide to society.

2.1 The contribution of raw materials extraction and processing to environmental impacts

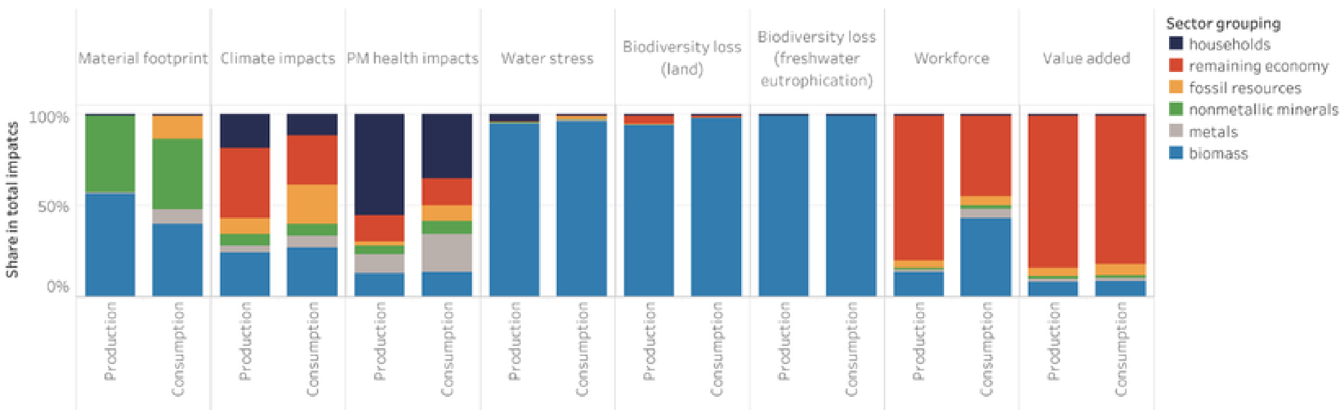


Figure 2: ***Relative contribution of different types of resources (extraction and processing), the remaining economy (downstream chain of resource extraction and resource processing) and households to global environmental and socioeconomic impacts for the year 2022. Data for France***

4. https://www.statistiques.developpement-durable.gouv.fr/chiffres-cles-des-risques-naturels-edition-2023?rubrique=43&dossier=200

· The impacts of biomass production and harvesting are the primary drivers of water stress, land-related biodiversity loss, and freshwater eutrophication. Chemical pollution poses a threat to drinking water production, human health and biodiversity, and is widely monitored in France's rivers and lakes. Since 2000, an improvement has been observed for some nitrogen and phosphorus compounds implicated in the surface waters asphyxiation process. On the contrary, pesticides and other hazardous substances continue to exercise high accumulations of toxic pressures over vast territories and in all categories of watercourse[5].

· Half of France territory is covered by agricultural soil, while a little less than 10% are artificial soil[6].

· While non-metallic minerals represent the largest share of material extraction and footprint from both production and global consumption perspectives, the majority of climate change impacts related to materials arise from the extraction and processing of biomass and fossil resources.

2.1 Decoupling analysis over time

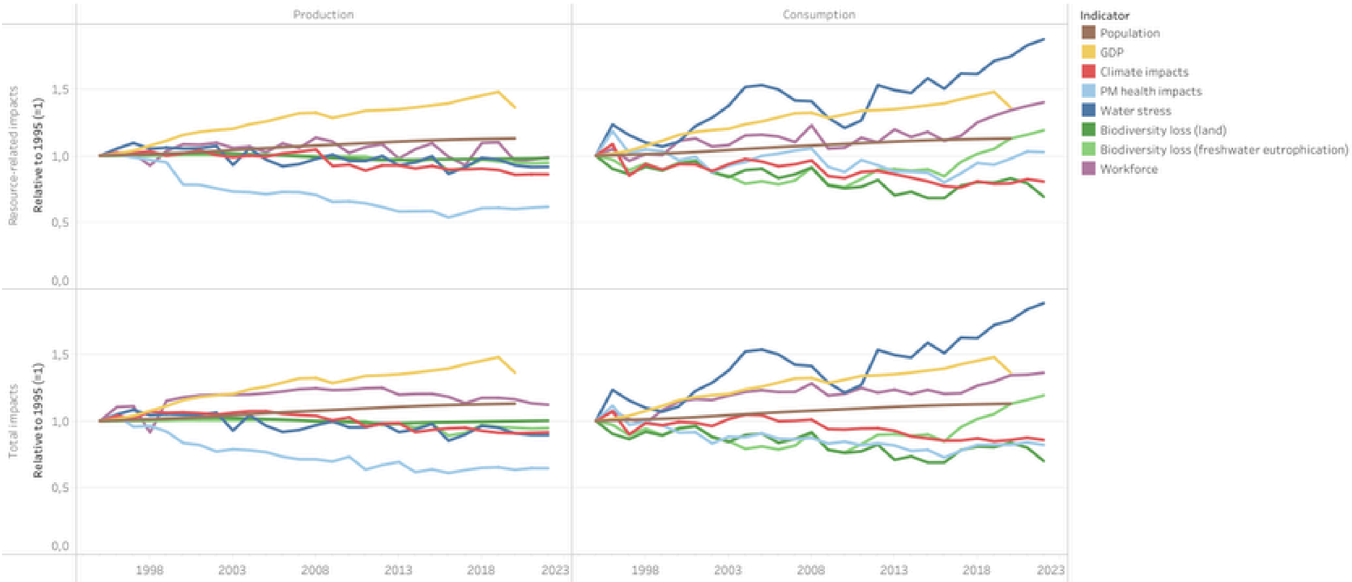


***Figure 3:* Temporal development of environmental impacts and socio-economic indicators from 1995 to 2022, from a production (left) and consumption perspective. Top figures: from resource extraction and processing up to "ready-to-be-used" materials, food or fuels (as in GRO 2019). Bottom figures: total worldwide impacts (following new scope displayed in Figure 3.1). Data for France**

- Resource-related impacts for production have globally decreased for all sectors. On the other hand, resource-related impacts for consumption have increased for water stress from 1995, and for freshwater eutrophication and PM health since 2015.
- France has increased its expenditure on soil and water protection and decontamination between 2000 and 2021, rising from 730 million € to 2,397 million €[7].

5 https://www.statistiques.developpement-durable.gouv.fr/la-pollution-chimique-des-cours-deau-et-des-plans-deau-en-france-de-2000-2020?rubrique=44&dossier=1028186
6 https://www.statistiques.developpement-durable.gouv.fr/bilan-environnemental-de-la-france-edition-2023-0?rubrique=41&dossier=176
7 https://www.statistiques.developpement-durable.gouv.fr/la-depense-de-protection-et-de-depollution-des-sols-et-des-eaux-en-2021?rubrique=44&dossier=1028186

- During the 2010 decade, sales of plant protection products, more commonly referred to as "phytosanitary products", remained at high levels, before beginning to decline in the early 2020s. However, sales of active substances not used in organic farming or biocontrol have fallen (-19% between 2009-2011 and 2020-2022), as have sales of molecules classified as being of greatest concern. The proportion of active substances classified as carcinogenic, mutagenic and reprotoxic (CMR) has fallen from 33% to 15% between 2009 and 2022[8].

- GDP grew faster than environmental impacts from a production perspective: there was a decoupling.

2.3 Temporal evolution by raw materials group

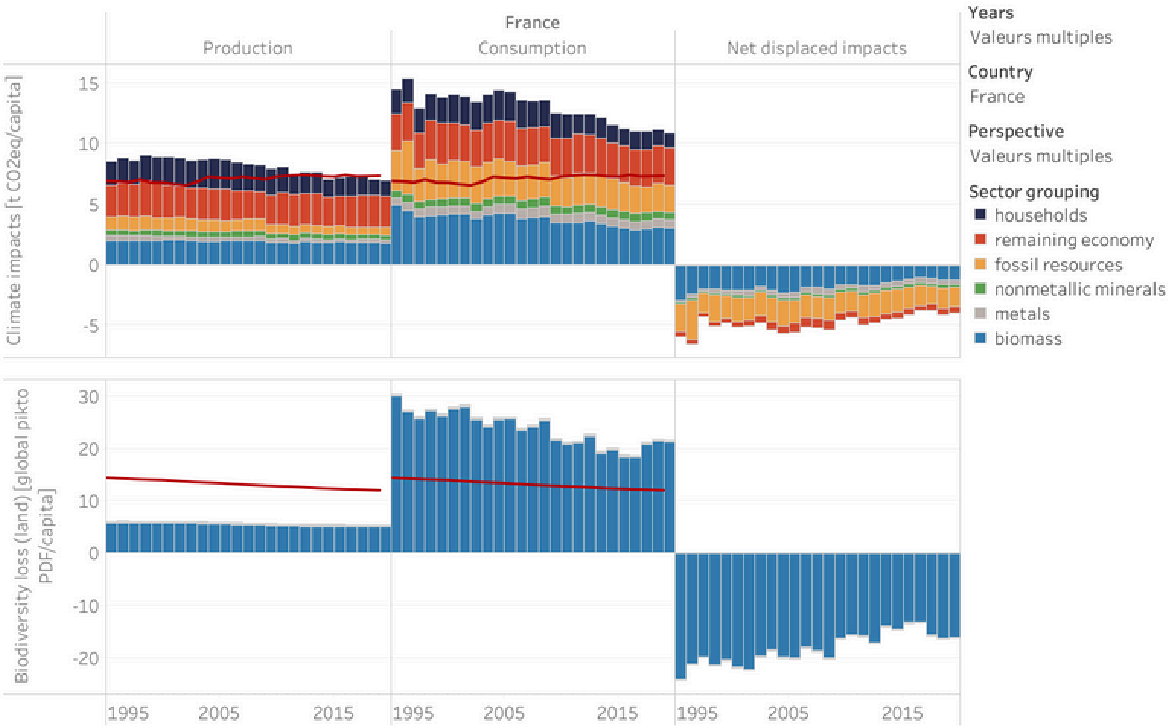


Figure 4: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by material resource group (cultivation, extraction and processing) and downstream use (remaining economy and households). Moving averages over five years used for land occupation and change. Left: Production perspective. Middle: Consumption perspective (footprints). Right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere). The red lines show the global per-capita average values. Data for France***

Above: aggregated impacts; below: per capital impacts with global per-capita average values indicated by the red line; right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere).

- Per capita impacts of resource use on climate change and biodiversity loss decrease from 1995 to 2022. France has negative net displaced impacts, meaning that France's consumption depends on goods and services that are imported and therefore cause environmental impacts in the producing countries (outside of France's border).

8 https://www.statistiques.developpement-durable.gouv.fr/etat-des-lieux-des-ventes-et-des-achats-de-produits-phytosanitaires-en-france-en-2022?rubrique=33&dossier=1028217

- Biodiversity loss is primarily linked to biomass extraction and processing, whereas climate impacts arise not only from extraction and processing of both biomass and fossil resources, but also from the use of these resources within the economy.
- France largely shifts biodiversity loss to other countries due to its imports of biomass (such as tropical products like coffee, cocoa, palm oil, etc.)[9] similar to other European countries (see the right bottom graph). Impacts on biodiversity loss as a result of France´s consumption is almost twice the world average.

2.4 Provisioning systems of food, energy, mobility and the built environment are the main contributors to environmental impacts

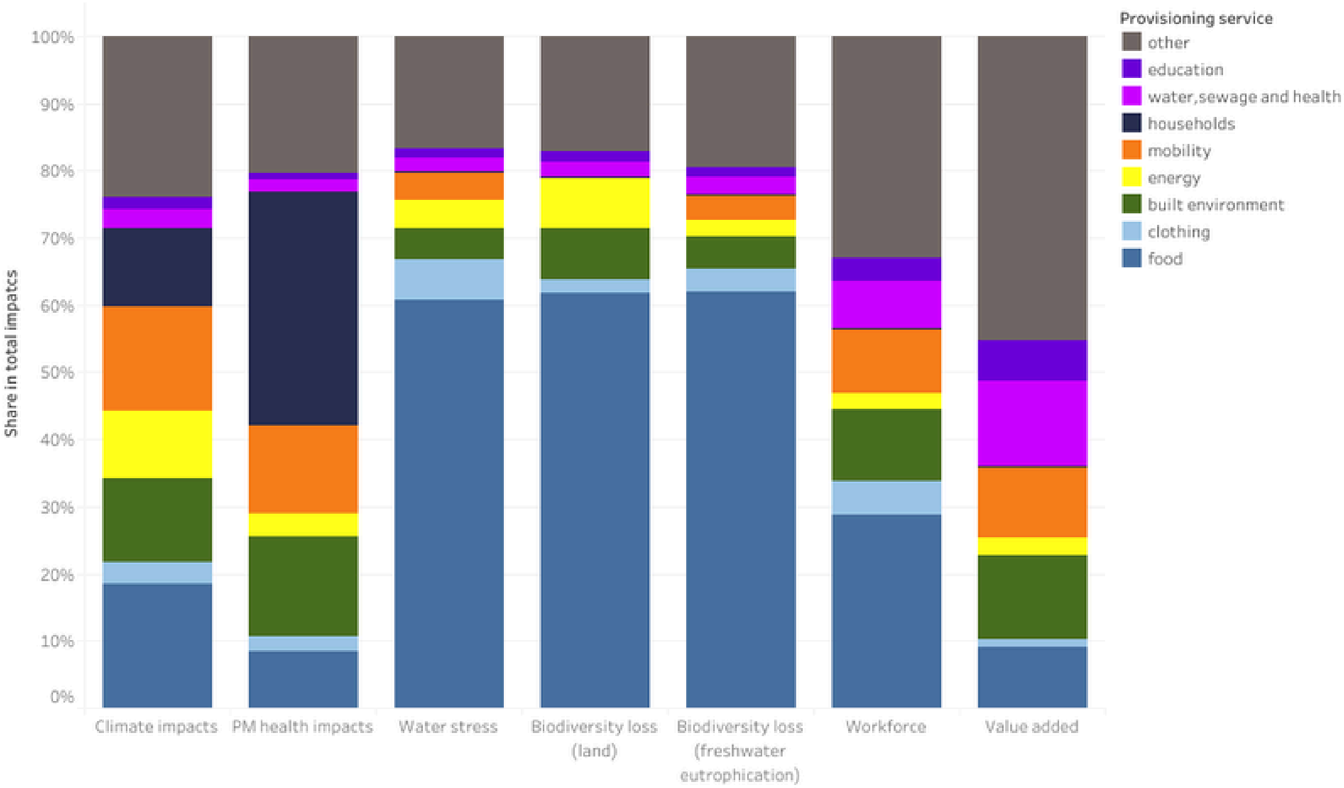


Figure 5: ***Relative contribution of different types of provisioning systems to global environmental and socioeconomic impacts for the year 2022. *Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). Data for France***

- Water stress, land biodiversity loss and freshwater eutrophication are all mostly impacted by the production of food (62%), whereas food has a very limited impact on PM health and value added.

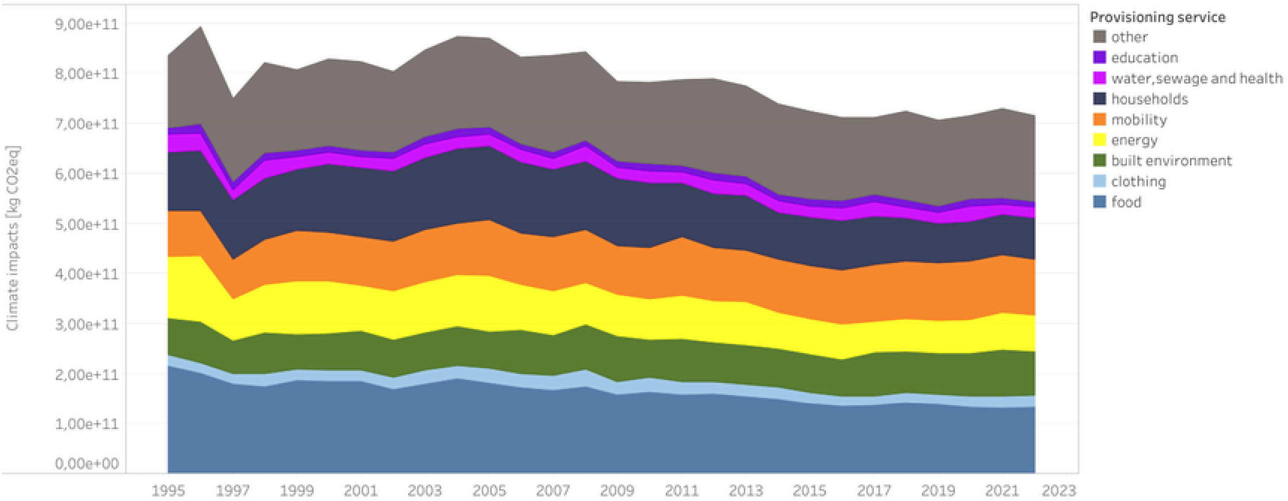
- In 2022, mobility remains the largest source of GHGs. The food and agricultural sector, the main emitter of methane (CH4) through livestock and nitrous oxide (N2O) through fertilizer use, is second in terms of total GHG emissions[10]. The French emit less CO2 than their European neighbors: this difference can be explained by the fact that the energy mix in France contains less carbon in the production and residential sectors. Regarding transport, the French emissions are close to average[11].

9 https://www.statistiques.developpement-durable.gouv.fr/importations-francaises-de-matieres-premieres-visees-par-la-strategie-nationale-de-lutte-contre-la
10 https://www.statistiques.developpement-durable.gouv.fr/emissions-de-gaz-effet-de-serre-et-empreinte-carbone-en-2022-syntheses-des-connaissances-en-2023?rubrique=28&dossier=1274
11 https://www.statistiques.developpement-durable.gouv.fr/les-francais-emettent-moins-de-co2-que-leurs-voisins-europeens-0?rubrique=28&dossier=1274

- Particulate matter (PM) health impacts come mostly from households. On top of that, PM inputs due to dust transport from the Sahara Desert in the West Indies and French Guiana, and forests fires in mainland France in summer 2022, caused increases in particulate matter with a diameter of 10 µm or less (PM10) concentrations and local pollution episodes[12].

- In 2021, arable crops (excluding forage maize) covered 43% of the utilized agricultural area (UAA), with one-third sown in spring. While plowing aerates the soil and enhances fertilization, it affects soil structure and biodiversity, accelerates carbon depletion, and increases nitrogen leaching[13].

2.5 Evolution of environmental impacts by provisioning system over time



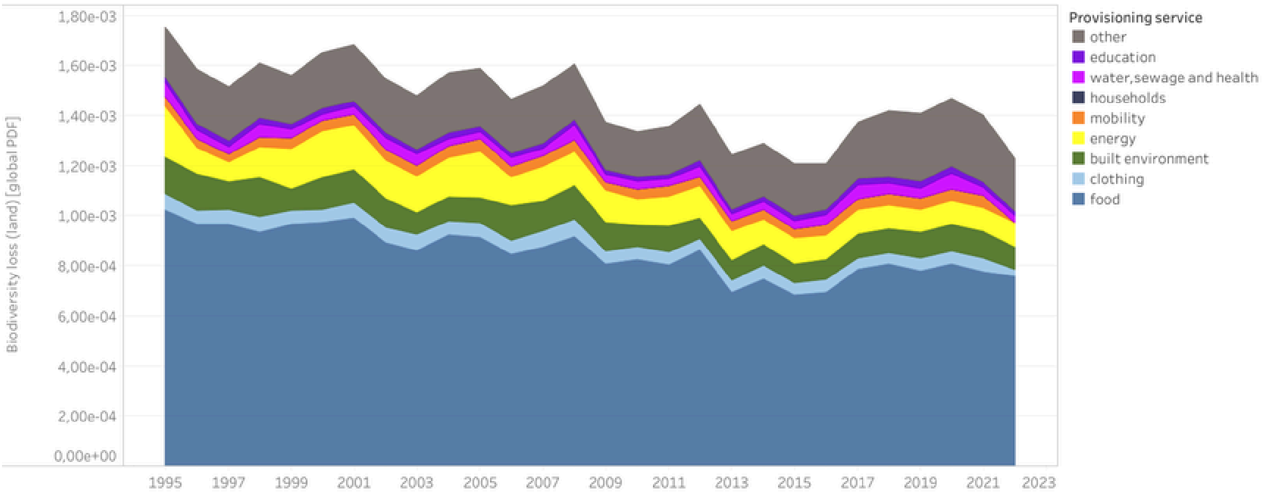


Figure 6: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by provisioning system. Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). The red lines show the global per-capita average values. Data for France***

- Overall, climate impacts have decreased by 14% since 1995. The most significant decline comes from the built environment sector (-22%), closely followed by mobility (-21%). The most polluting sector, after "other," is food production, accounting for 19% of climate impacts in 2022. Over the period 1995-2022, the climate impacts of food production decreased by 38%, placing it third in terms of emissions reductions, after energy (+41%) and water, sewage, and health (+43%).

12 https://www.statistiques.developpement-durable.gouv.fr/bilan-de-la-qualite-de-lair-exterieur-en-france-en-2022?rubrique=32&dossier=204
13 https://www.statistiques.developpement-durable.gouv.fr/les-sols-en-france-synthese-des-connaissances-en-2023?rubrique=&dossier=222

- Overall, land-related biodiversity loss has decreased by 30% since 1995. The production of food accounts for more than half of the impacts, which has decreased by 26% since 1995. Biodiversity loss associated with mobility was small compared to other provisioning systems that demand more biomass such as food.

2.6 Per-capita environmental impacts against wellbeing trajectories

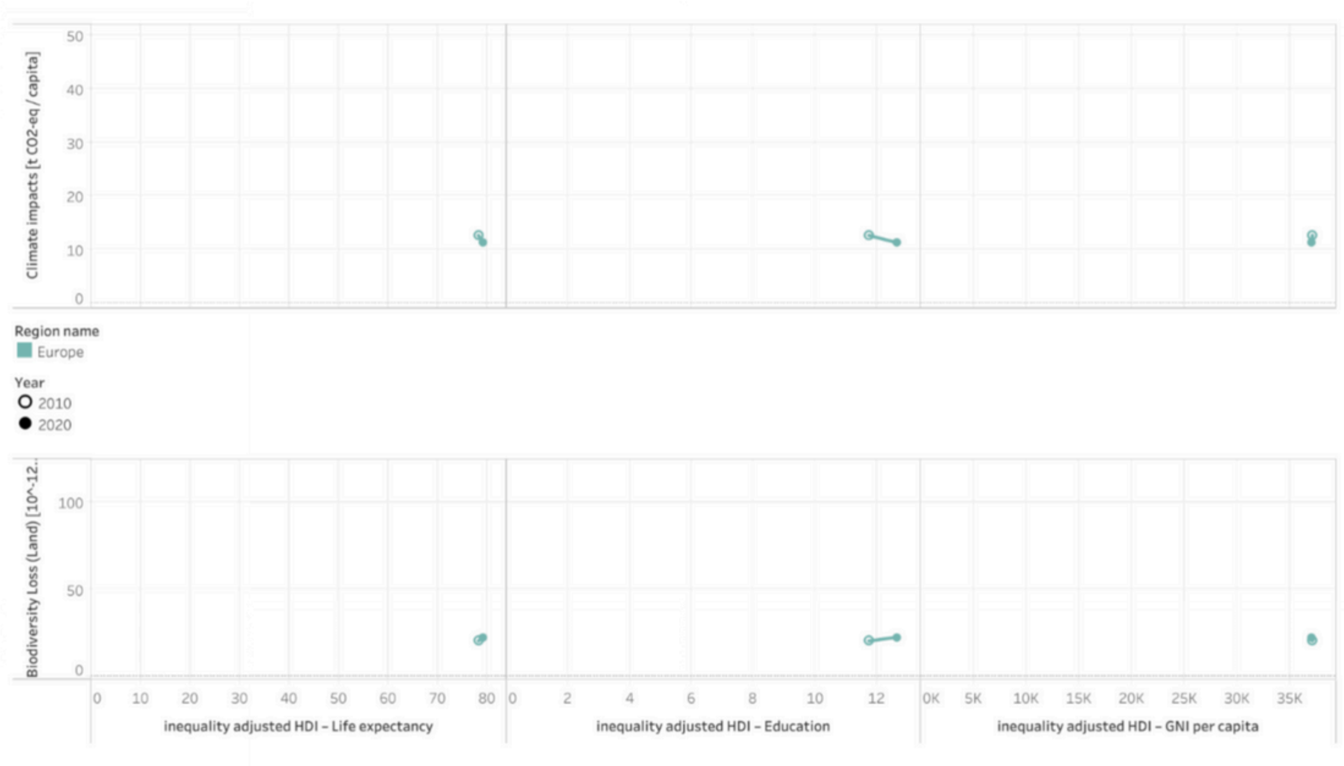


Figure 7: ***Per-capita impacts (consumption perspective) against wellbeing trajectory from 2010 to 2020 (each pair of dots represents one country; colors mark the region).***

- In France, life expectancy at birth is one of the highest of the European Union for woman[14]. It progressed from 78,1 to 79,0 from 2010 to 2020 for the entire population.
- Education gained one point between 2010 and 2020, while reducing its impact on climate change, but there was a slight increase on the impact on land-related biodiversity loss.
- France’s inequality adjusted human development index did not progress during this period.

2.7 Final remarks

- The Earth is facing environmental challenges, often grouped under the concept of planetary boundaries, defined by scientists to assess the overall health of the planet. France, among the countries committed to the 2030 Agenda, is confronted with these boundaries and must take significant measures to mitigate negative impacts. The choices and decisions of local territories play a crucial role in managing these planetary boundaries. The concept of planetary boundaries aims to define a "safe operating space for humanity" based on the evolution of nine complex, interconnected environmental issues: climate change,

14 https://www.insee.fr/fr/statistiques/3676610?sommaire=3696937

biodiversity loss, biogeochemical flows (Phosphorus and Nitrogen cycles), land-system change, freshwater use, ocean acidification, stratospheric ozone depletion, atmospheric aerosols loading, introduction of novel entities into the biosphere. In France, provisions to regulate the release of novel entities have been adopted under the precautionary principle enshrined in Article 5 of the Constitutional Charter for the Environment. The 2020 anti-waste law for a circular economy provides for the end of single-use plastic packaging on the market by 2040, as well as targets for reduction, reuse or re-employment, and recycling. At international level, France is strongly behind the proposed international treaty against plastic pollution[15].

- France has set the goal of achieving 'zero net land artificialization' by 2050, with an intermediate objective of halving the consumption of natural, agricultural, and forested areas during the decade 2021-2031, compared to the previous decade 2011-2021.
- The extraction of raw materials that are vital to the manufacturing of consumer goods generates high environmental and climatic costs. According to the circular economy principle, secondary raw materials (SRM) help preserve resources by taking the place of virgin materials and hence reducing the dependence of France and, more generally, of the European Union, on such materials. France is Europe’s biggest net exporter in terms of quantities[16].

3. Additional remarks on material flows and environmental impacts

Additional information on resource use in France can be found in Matières mobilisées par l’économie française with a set of articles on the use of resources in the French economy (domestic extraction, material footprint, etc). This articles are written by the French ministry of environment using its own database, compiled by following the methodology proposed by Eurostat for Material Flows and resource productivity. The data differs from the IRP database due to different methodologies, but the interpretations and evolutions are the same.

4. Glossary and technical annex (based on the IRP reports and website)

Consumption perspective: The consumption perspective allocates the use of natural resources or the related impacts throughout the supply chain to the region where these resources, incorporated in various commodities, are finally consumed by industries, governments and households. It equals the domestic impacts plus impacts of imports minus impacts of exports.

Decoupling: Decoupling is when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling).

Domestic extraction (DE): Direct, gross physical extraction of materials within a country’s territory (production perspective).

Domestic material consumption (DMC): Amount of materials directly used by an economy (DMC = DE + Material Imports – Material Exports).

Material resources: metals, non-metallic minerals, biomass, and fossils.

Material footprint (MF): A nation’s MF fully accounts for material extraction in other countries used for local consumption in the nation of interest (consumption perspective).

15 https://www.statistiques.developpement-durable.gouv.fr/edition-numerique/la-france-face-aux-neuf-limites-planetaires/en/synthesis
16 https://www.statistiques.developpement-durable.gouv.fr/indicateurs-cles-pour-le-suivi-de-leconomie-circulaire-edition-2021?rubrique=395&dossier=1028251

Material-related impacts: Environmental impacts and socio-economic benefits (value added, workforce) related to the extraction and processing of material resources (including the upstream supply chain, such as electricity generation and transport).

Production perspective: The production perspective allocates the use of natural resources or the impacts related to

Methodological notes:

- Material flows data: The MFA data come from the UNEP IRP MFA database (https://www.resourcepanel.org/global-material-flows-database) which covers the period 1970-2024, for more than 200 countries and regions. The database reports extraction and direct trade of raw materials, indirect trade flows (including material footprints), as well as intensities derived from these material measures. Note that due to underlying model and data sources used, results might differ from national- and EU-level material flows data provided, e.g., by Eurostat. A detailed technical annex of the IRP database is available at: https://resourcepanel.org/sites/default/files/technical_annex_for_global_material_flows_database_-_vers_30_aug22.pdf

- Environmental impacts: The analysis is based on data from Exiobase v3.8, complemented with trade data from Eora, and production data from FAOSTAT and British Geological Survey (Minerals UK). Further methodological details can be found in the GRO 2024 (https://www.resourcepanel.org/reports/global-resources-outlook-2024). The matching of economic sectors to the four raw materials types, remaining economy, and households is documented in Cabernard et al. (2019) (https://doi.org/10.1016/j.scitotenv.2019.04.434), with a few deviations (see Annex 2 of the GRO 2024).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International Resource Panel

Global Resources Outlook 2024

Country Profile: Italy

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Gonzalo Mendiola
Pexels

Contents

Resource use, environmental impacts, and examples of effective policies for Italy

Contents

01 Country Profile: Italy

1. Domestic extraction, domestic material consumption and material footprint

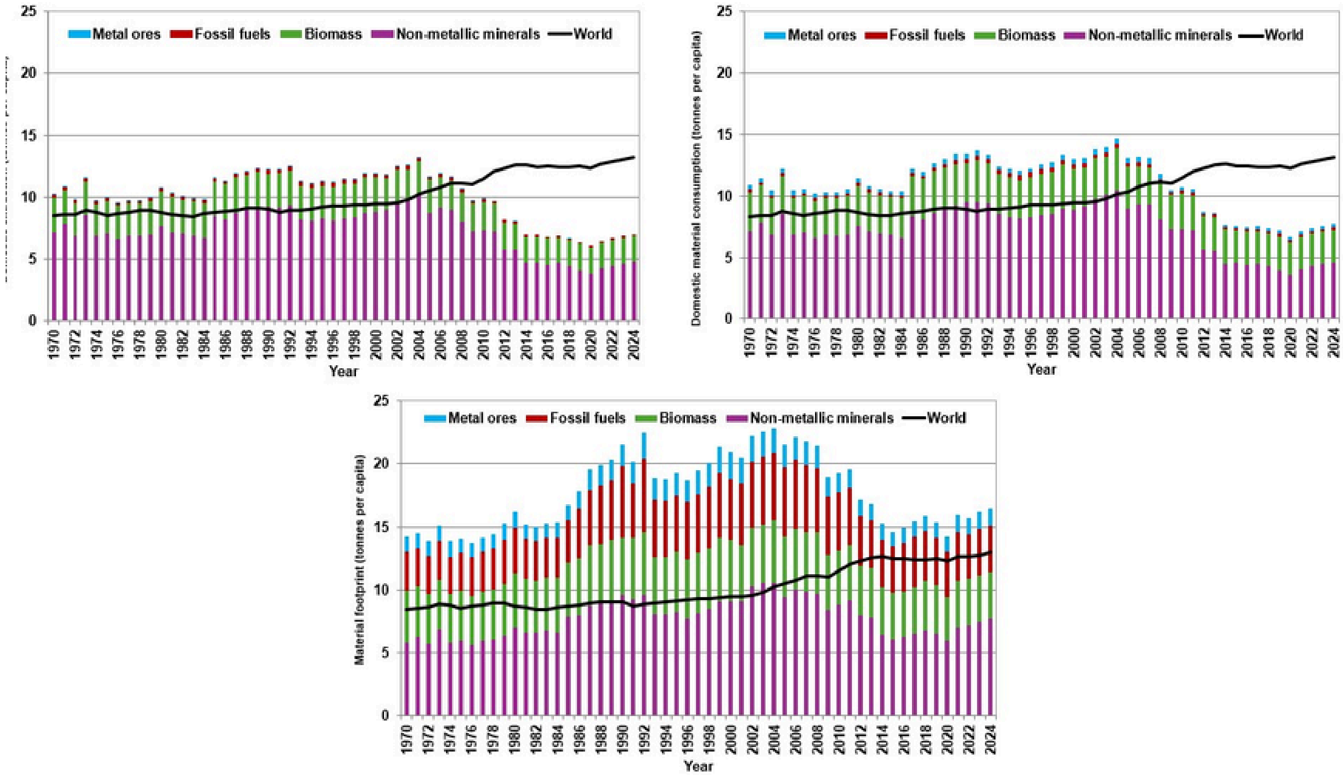

Figure 1: ***Domestic extraction (DE), domestic material consumption (DMC), and material footprint per capita in Italy[1].***

- Since 1970, the three Italian material-related headline indicators have shown two periods of growth: up to the 1992 monetary crisis and up to 2004. The 2007-2008 global financial and economic crisis and its aftermath resulted in a pronounced dip, followed by relatively stable and lower levels of DE, DMC and material footprint. Indeed, between 2014 and 2024 DE and DMC levels are lower on average than 2004 by a factor of around 0.5, and material footprint level by a factor of 0.7.

- Non-metallic minerals are the main driver of these developments. This material category feeds the manufacture of chemicals and, above all, constructions. The output of the latter industry has been accumulating in the Italian socioeconomic system's buildings, infrastructure, and machinery. In addition, these human-made material stocks have changed the Italian landscape, not last increasing the risk exposure to landslides and floods as well as the loss of ecosystem services[2].

- The physical trade balance in DMC and material footprint have grown significantly from the early Eighties to the 2007-2008 global financial crisis. Net imports reveal a strong dependency from the rest of the world on fossil fuels and metal ores as well as an increasing dependency on biomass. Physical imports and exports point out the international role of Italy in terms of resource use as manufacturer of goods from raw materials for exports and for domestic use.

1 Note that data provided in the UNEP IRP MFA database might vary from national- and EU-statistics due to different accounting and modeling approaches used (see technical annex).
2 Istat (2021) Economia e ambiente: una lettura integrata

- The shares in the Italian throughput of imported and exported materials (the latter at a lower level) have increased over the years. The life-cycle perspective of the material footprint, which includes indirect material flows (i.e., the shift elsewhere of the ecological burden[3]), explains the higher level at which the material footprint is found compared to DMC. Looking at the material footprint highlights the worldwide demand for resources triggered by consumption and investment by households, government and businesses in Italy. The material footprint has not decoupled from the global average of material extraction[4].

2. Environmental impacts

Resource-related impacts:
This section focuses on the environmental consequences and socio-economic benefits related to raw materials extraction and processing (including the upstream supply chain, such as electricity generation and transport, and downstream use and disposal of materials, fuels, fibres, and food (see chapter 3 in the GRO 2024)). **Resource-related impacts** includes impacts of growing and harvesting biomass, extracting metallic and non-metallic minerals and fossil fuels, and processing of materials, fuels, and food. Impacts of **households** includes private mobility and heating (for climate impacts), while the **remaining economy** includes all other activities (e.g., manufacturing of products, energy production, construction, transport, services, etc.). The matching of economic sectors to raw material types and the remaining economy is documented in Cabernard et al. (2019), with a few deviations of the GRO 2024 highlighted in the GRO Annex 2).

Provisioning systems:
Provisioning systems were defined on the level of end-sectors and products. For example, the use of a private car or public mobility would be associated with the provisioning system "mobility", whereas transport of materials to a building site would be counted within the provisioning system "built environment" (GRO 2024). The use of provisioning systems allows to view impacts by the service they provide to society.

2.1 The contribution of raw materials extraction and processing to environmental impacts

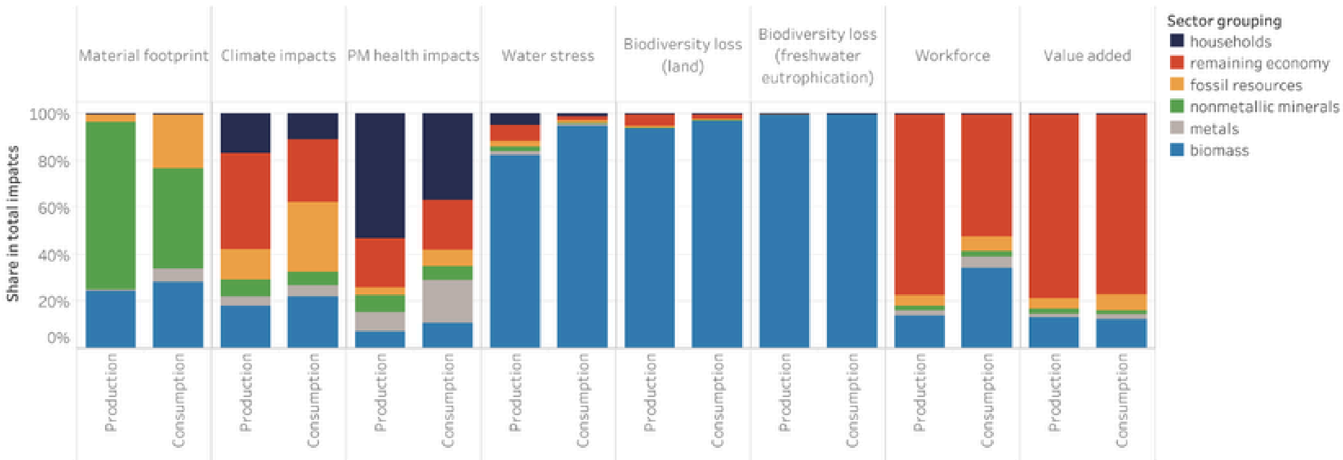

Figure 2: ***Relative contribution of different types of resources (extraction and processing), the remaining economy (downstream chain of resource extraction and resource processing) and households to global environmental and socioeconomic impacts for the year 2022. Data for Italy.***

3 Femia A., Marra Campanale R. (2012): Air emissions and displacement of production. A case study for Italy, 1995-2007, in Hybrid economic-environmental accounts
4 Femia A., Marra Campanale R. (2013): An Environmentally Ineffective Way to Increase Resource Productivity, in Resources 2013, 2(4)

- Although non-metallic minerals account for the highest fraction in material extraction both in the production and (global) consumption perspective, the majority of material-related climate change impacts stems from the extraction and processing of biomass and fossil resources.

- A large part of PM health impacts is due to direct emissions released by households' combustion of fuels for private mobility and heating/cooling purposes, and to the downstream industries that use resources after extraction and processing such as manufacturing of products and energy production (remaining economy).

- Impacts of growing and harvesting biomass – e.g., cultivation of vegetables and fruit, cattle farming – are responsible almost entirely for water stress and biodiversity.

- Work input and economic benefit occur prevalently in the downstream chain of resource extraction and resource processing (remaining economy) for producing goods and services.

2.2 Decoupling analysis over time

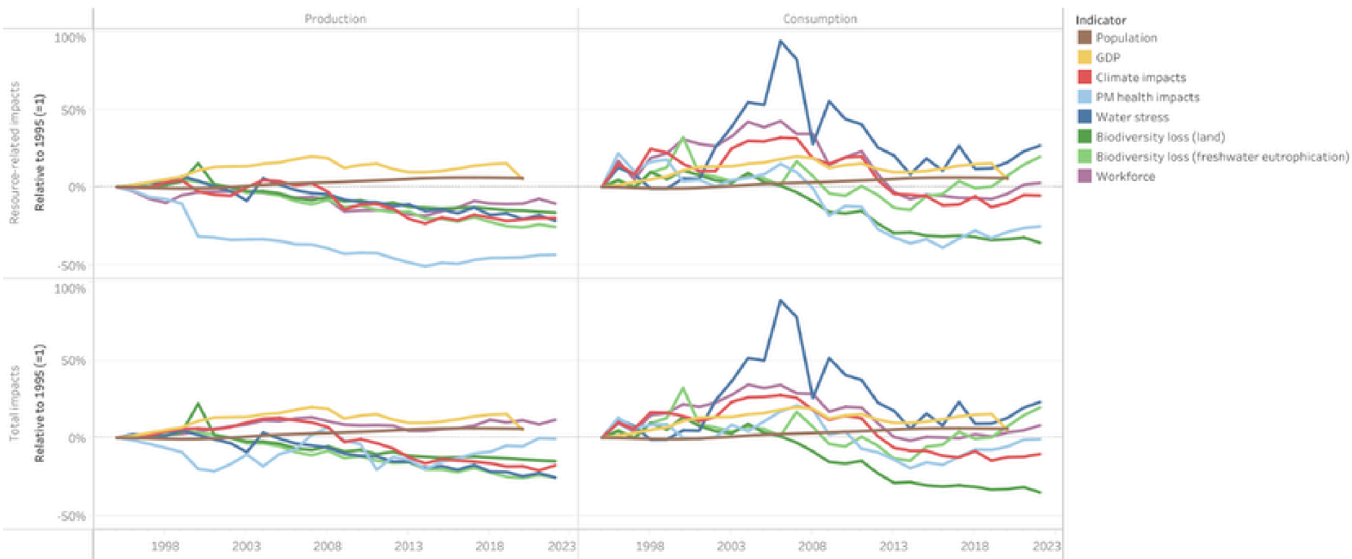

Figure 3: ***Temporal development of environmental impacts and socio-economic indicators from 1995 to 2022, from a production (left) and consumption perspective. Top figures: from resource extraction and processing up to "ready-to-be-used" materials, food or fuels (as in GRO 2019). Bottom figures: total worldwide impacts (following new scope displayed in Figure 3.1). Data for Italy.***

- Between 1995 and the 2020 there was no absolute decoupling of economic activity from any environmental impacts in Italy, due to a not sustained recovery from the 2007-2008 global financial and economic crisis and to a considerably larger fall in GDP in 2020 than in 2009 as the initial impact of the COVID-19 pandemic was felt. This weak development of the economic activity, along with the relatively stable levels of resource use described in section 1, resulted in a relative decoupling of GDP from resource-related impacts.

- In general, if the consumption perspective is adopted impacts show less favourable developments than in the production perspective due to pressures that occur throughout the global production chains.

2.3 Temporal evolution by raw materials group

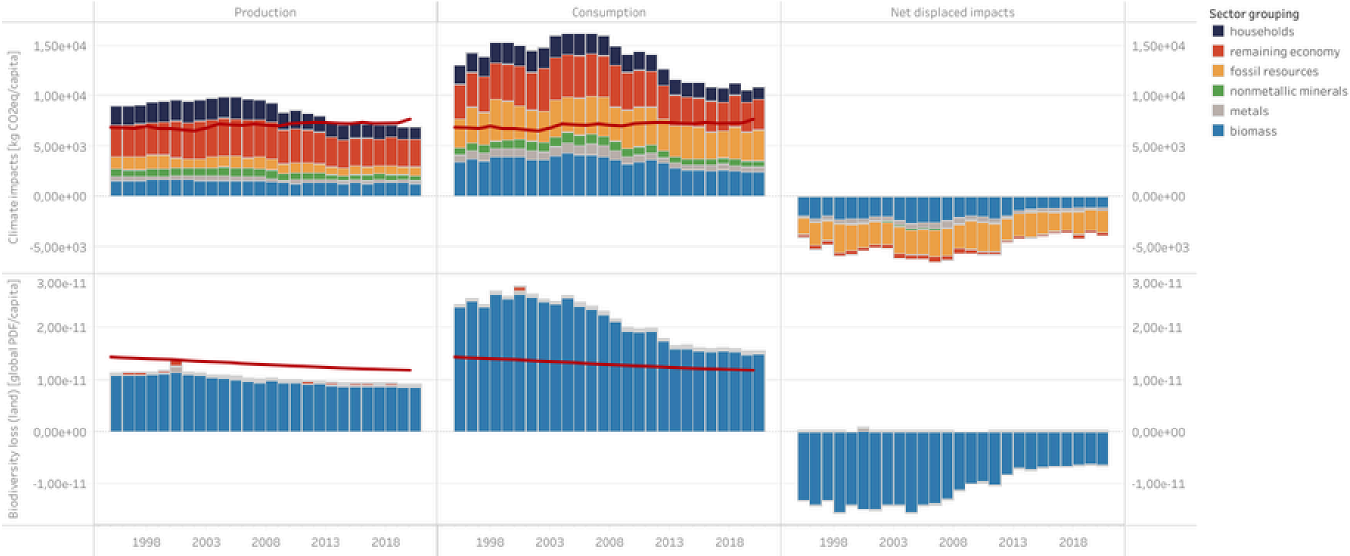

Figure 4: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by material resource group (cultivation, extraction and processing) and downstream use (remaining economy and households). Moving averages over five years used for land occupation and change. Left: Production perspective. Middle: Consumption perspective (footprints). Right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere). The red lines show the global per-capita average values. Data for Italy.***

- Per capita impacts of resource use on climate change and biodiversity loss decreased from 1995 to 2022. However, impacts are allocated differently along value chains.
- While biodiversity loss occurs almost exclusively during the upstream biomass extraction and processing, climate impacts derive from both the upstream extraction and processing of biomass and fossil resources, and the downstream use of resources in the economy after extraction and processing of resources.
- Due to its economy’s import dependency on raw materials, Italy – like other high-income countries – is a net importer of natural resources. Italy’s resource debt towards the rest of the world causes environmental impacts worldwide.
- Italy displaces biodiversity loss and climate impacts to other countries mostly as a result of biomass and fossil resources needs for final products used within the country and for goods and services exported to other economies.

2.4 Relative contributions of the provisioning systems to environmental impacts

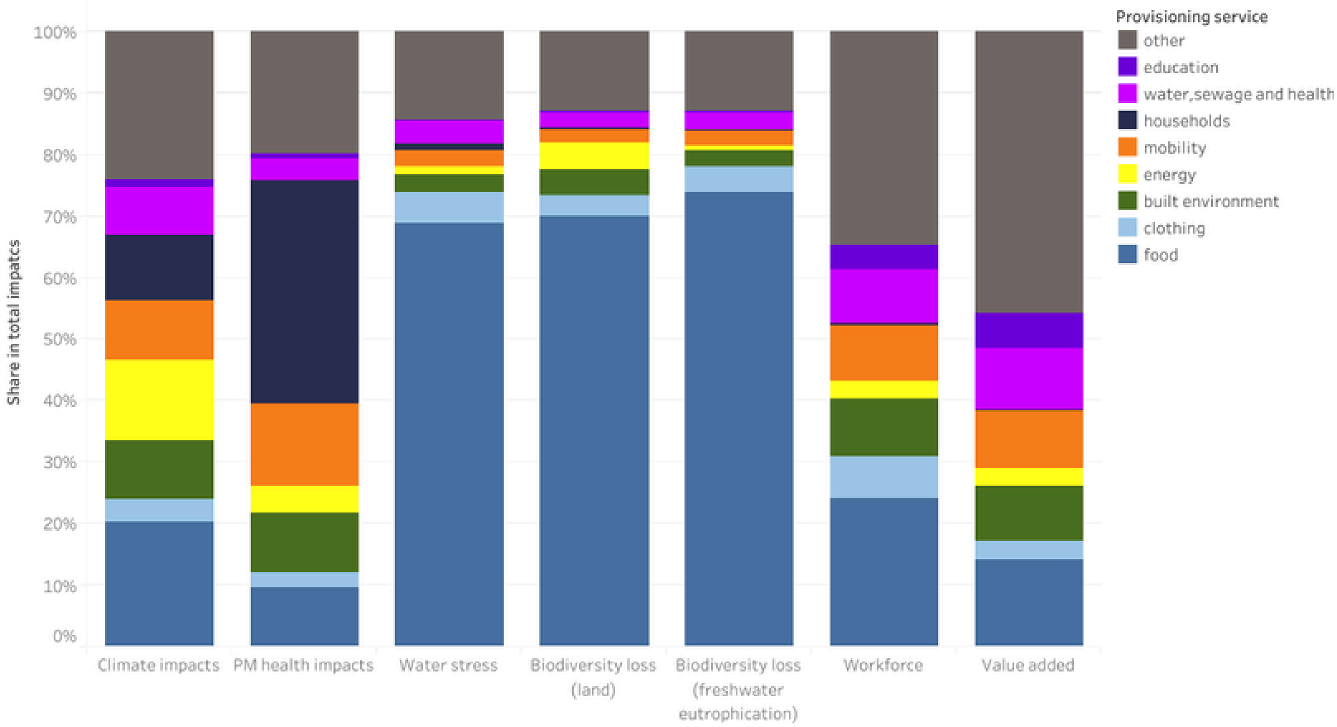

Figure 5: ***Relative contribution of different types of provisioning systems to global environmental and socioeconomic impacts for the year 2022. *Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). Data for Italy.***

- According to the responsibility of the final user approach ("consumption perspective"), the resource-related pressures and impacts are referred to the vertically integrated industries, i.e., to the sets of all the production activities that are directly and indirectly necessary to obtain final products[5].

- In 2022, goods and services that everyone requires for serving basic needs, such as housing, eating and mobility cause almost evenly climate and PM health impacts. More than two thirds of impacts on water stress and biodiversity losses stem only from the global food production chains.

- There are limits to how much of the use of these products can be reduced. Italy may focus on how these needs can be provided with a lower production-chain-wide use of natural resources.

5 Pasinetti L. (1973): The notion of vertical integration in economic analysis, in Metroeconomica, XXV: 1-29.

2.5 Evolution of environmental impacts by provisioning systems over time

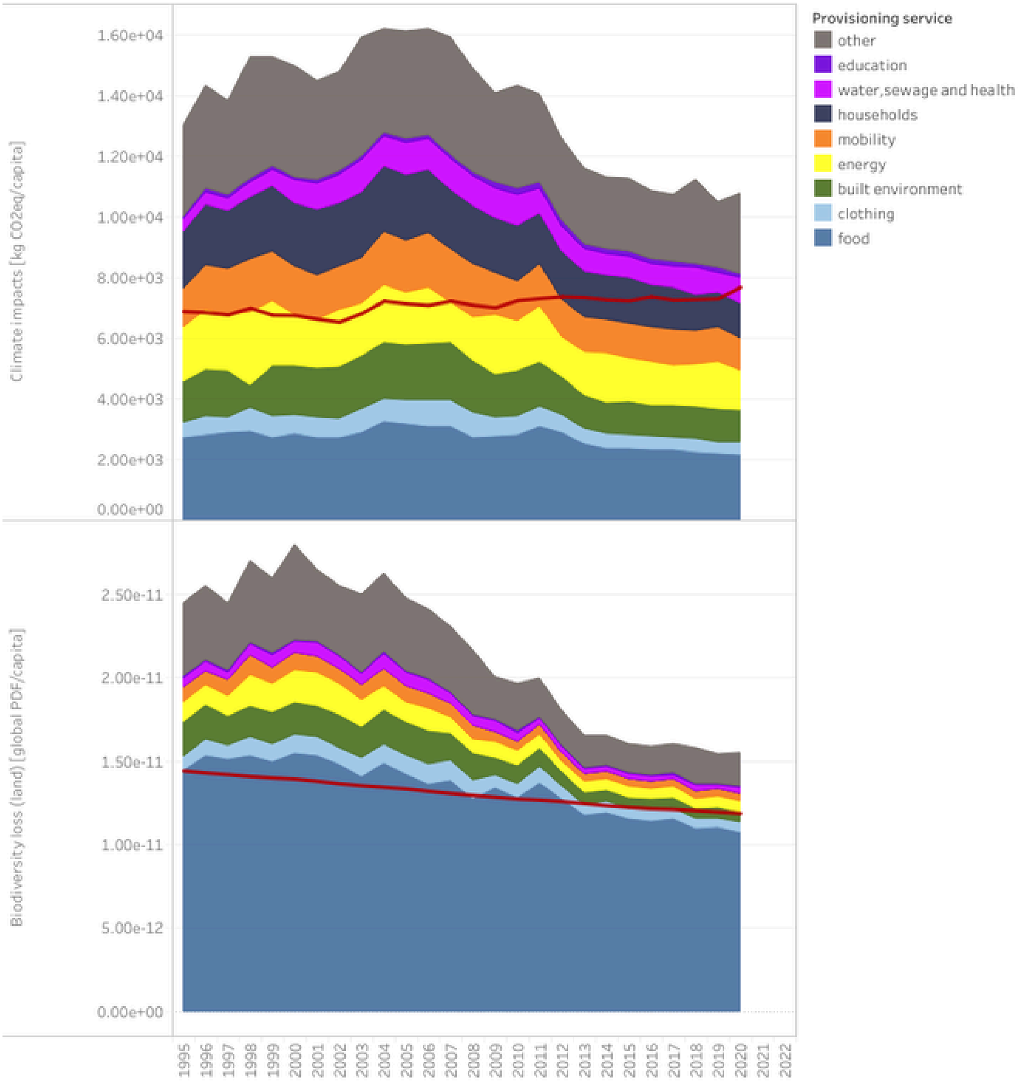

Figure 6: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by provisioning system. Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). The red lines show the global per-capita average values. Data for Italy.***

- Italian per--capita impacts of resource use on climate and land-related biodiversity loss decreased from 1995 to 2022 and are above the worldwide impact averages in the period.
- Despite the different levels of total climate and biodiversity loss impacts from 1995 to 2022, the contributions of the provisioning systems to these impacts have remained rather stable in the period.
- This evolution suggests a decrease of impacts as a result of the resource use reduction rather than the effect of determined action in governance along value chains to identify the most relevant stages for improved resource efficiency.

2.6 Per-capita environmental impacts against wellbeing trajectories

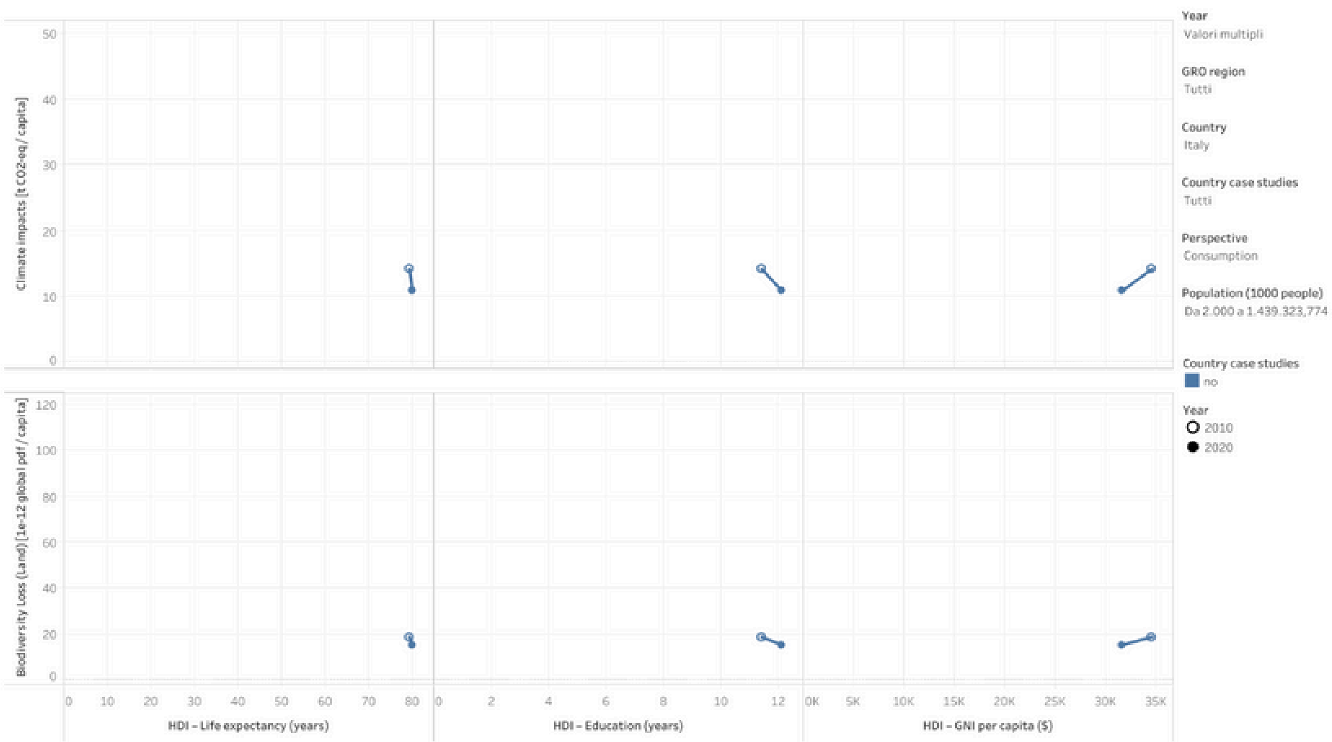

Figure 7: ***Per-capita impacts (consumption perspective) against wellbeing trajectory from 2010 to 2020.***

- Italy shows a downward development of climate and land-related biodiversity loss impacts from 2010 to 2020.
- At the same time, only life expectancy and education improve among wellbeing indicators. Gross national income per capita drops by some 10% in the period.
- Life expectancy and education evolutions are aligned to comparable European countries such as France and Germany, while the development of gross national income per capita varies differently within these three countries.

3. Additional remarks on material flows and environmental impacts

Additional information on resource use in Italy can be found in the description of the physical dimension of the Italian economy from 1951 to 2008[6] and in Ambiente e territorio. Strumenti e metodi per un'analisi del consumo di risorse e degli ecosistemi released by the Italian National Institute of Statistics (Istat) in February 2024.

Within the European Statistical System, Istat produces economy-wide material flow accounts[7] which belong to the international system of environmental economic accounting (SEEA-Central Framework) and are one of the physical modules of Eurostat's programme on European environmental economic accounts.

6 Femia A., Marra Campanale R., Vignani D. (2011): The description of the physical dimension of the economy in historical perspective - material flows. Italy 1951 -2008, in Statistics in the 150 years from Italian Unification. SIS 2011 Statistical Conference, Bologna, 8 – 10 June 2011.
7 https://esploradati.istat.it/databrowser/#/it/dw/categories/IT1,DATAWAREHOUSE,1.0/UP_ACC_AMBIEN/UP_DCCN_FLUMAT

4. Examples of effective policies

The Circular Economy Strategy[8] (June 2022). The Strategy includes overall targets on:
- the growth of secondary markets for raw materials to replace traditional raw materials;

- strengthening of the principle of Extended Producer Responsibility;

- taxation on raw material extraction;

- strengthening the upstream circularity actions (eco-design, extension of product life, reparability and reuse, etc.);

- developing and disseminating methods and models for assessing the life cycle of products and waste management systems and their overall environmental effects;

- improving the traceability of waste streams;

- developing CE skills and education in the public and private sectors to promote the employment of young people and women.

The **Catalogue of environmentally harmful subsidies and environmentally favourable subsidies**[9]. The Catalogue aims to identify, analyse, and evaluate fiscal erosion, tax expenditures, as well as existing tax breaks and incentives. The knowledge of environmentally relevant subsidies is key in designing ambitious and efficient environmental and economic policies, including CE.

Sovereign Green Bonds[10]: Through the issue of the Sovereign Green Bonds since 2021, Italy has financed public expenditure intended to contribute to the achievement of environmental objectives of the EU's Sustainable Finance Taxonomy within which the transition to a circular economy.

8 https://www.mase.gov.it/sites/default/files/archivio/allegati/PNRR/SEC_21.06.22.pdf (in Italian).
9 The 2022 edition is available at (in Italian): https://www.mase.gov.it/pagina/catalogo-dei-sussidi-ambientalmente-dannosi-e-dei-sussidi-ambientalmente-favorevoli
10 https://www.dt.mef.gov.it/en/debito_pubblico/titoli_di_stato/quali_sono_titoli/btp_green/

5. Glossary and technical annex (based on the IRP reports and website)

Consumption perspective: The consumption perspective allocates the use of natural resources or the related impacts throughout the supply chain to the region where these resources, incorporated in various commodities, are finally consumed by industries, governments and households. It equals the domestic impacts plus impacts of imports minus impacts of exports.

Decoupling: Decoupling is when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling).

Domestic extraction (DE): Direct, gross physical extraction of materials within a country's territory (production perspective).

Domestic material consumption (DMC): Amount of materials directly used by an economy (DMC = DE + Material Imports – Material Exports).

Material resources: metals, non-metallic minerals, biomass, and fossils.

Material footprint (MF): A nation's MF fully accounts for material extraction in other countries used for local consumption in the nation of interest (consumption perspective).

Material-related impacts: Environmental impacts and socio-economic benefits (value added, workforce) related to the extraction and processing of material resources (including the upstream supply chain, such as electricity generation and transport).

Production perspective: The production perspective allocates the use of natural resources or the impacts related to

Methodological notes:

Material flows data: The MFA data come from the UNEP IRP MFA database (https://www.resourcepanel.org/global-material-flows-database) which covers the period 1970-2024, for more than 200 countries and regions. The database reports extraction and direct trade of raw materials, indirect trade flows (including material footprints), as well as intensities derived from these material measures. Note that due to underlying model and data sources used, results might differ from national- and EU-level material flows data provided, e.g., by Eurostat. A detailed technical annex of the IRP database is available at:
https://resourcepanel.org/sites/default/files/technical_annex_for_global_material_flows_database_-_vers_30_aug22.pdf

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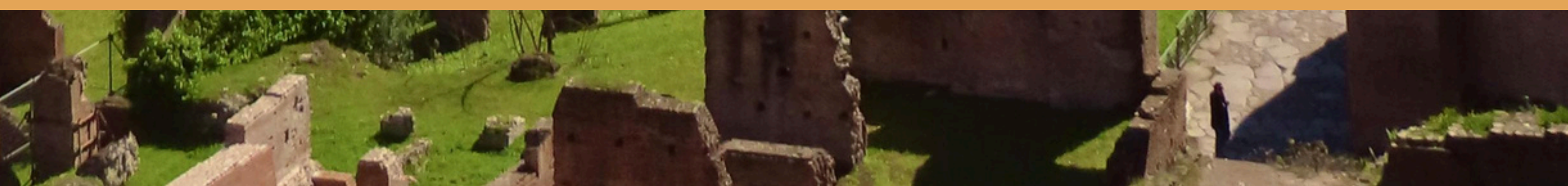
Justine Lauzon
Pexels



International Resource Panel

Global Resources Outlook 2024

Country Profile: Portugal

Regina Vilão and Tomás Albergaria (Departamento de Estratégia e Análise Económica)

Julie Aagaard
Pexels

Contents

01 Country Profile: Portugal

1. Domestic extraction, domestic material consumption and material footprint

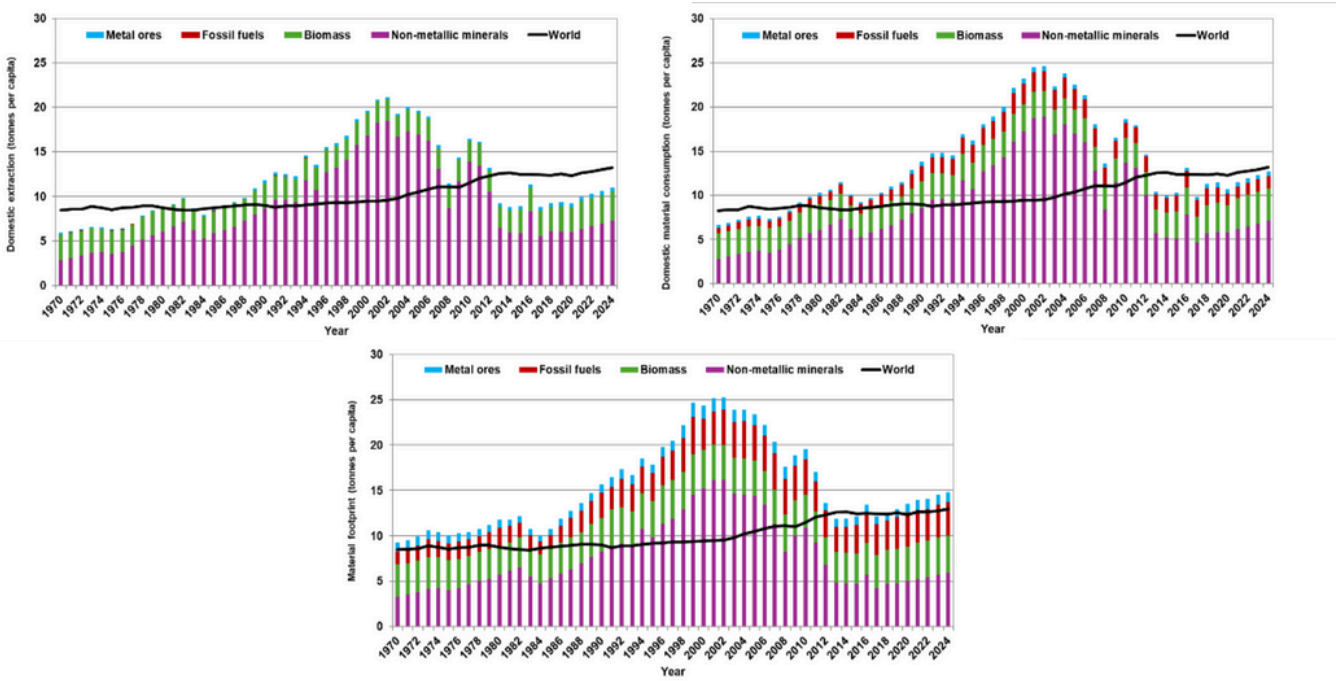


Figure 1: ***Domestic extraction, domestic material consumption, and material footprint per capita in [Portugal]*** [1]

- Portuguese domestic extraction has always been targeted almost entirely to non-metallic minerals and biomass. Metal ores represent a minor share in all the extracted materials (below 8%). Since 1994, the year that the last coal mine was closed (Pejão Mine), Portugal stopped extracting fossil fuels becoming more dependent on the import of such materials.

- Since 1970 and until the beginning of this century, Portugal increased fourfold its domestic extraction, mostly due to the extraction of non-metallic minerals, that feeds the production of chemicals and the construction sector. Following this, Portugal registered three decreasing periods:

  - in the beginning of the century, due to the implementation of austerity measures that caused a reduction of investments and an economic downturn,
  - in 2008, because of the global financial and economic crisis, leading the domestic extraction to levels of the 1980´s, and
  - in 2020, due to the COVID-19 pandemic.

- In the following years, a moderate increase in domestic extraction was registered, in line with the world average.

- The domestic material consumption and the material footprint trends reveal a strong dependency on the rest of the world, especially in relation to fossil fuels.

1 Note that data provided in the UNEP IRP MFA database might vary from national- and EU-statistics due to different accounting and modeling approaches used (see technical annex).

- The life cycle perspective of the material footprint, which includes the indirect material flows, i.e. the amount of material extracted from nature, both inside and outside Portugal, to manufacture or provide the goods and services consumed inland, explains the higher level of material footprint when compared to the domestic material consumption.

- These trends differ from that observed for the world average, where, for all material-related headline indicators, a slight and consistent increase was observed.

2. Environmental impacts

Resource-related impacts:
This section focuses on the environmental consequences and socio-economic benefits related to raw materials extraction and processing (including the upstream supply chain, such as electricity generation and transport, and downstream use and disposal of materials, fuels, fibres, and food (see chapter 3 in the GRO 2024)). **Resource-related impacts** include impacts of growing and harvesting biomass, extracting metallic and non-metallic minerals and fossil fuels, and processing of materials, fuels, and food. Impacts of **households** include private mobility and heating (for climate impacts), while the **remaining economy** includes all other activities (e.g., manufacturing of products, energy production, construction, transport, services, etc.). The matching of economic sectors to raw material types and the remaining economy is documented in Cabernard et al. (2019), with a few deviations of the GRO 2024 highlighted in the GRO Annex 2).

Provisioning systems:
Provisioning systems were defined on the level of end-sectors and products. For example, the use of a private car or public mobility would be associated with the provisioning system “mobility”, whereas transport of materials to a building site would be counted within the provisioning system “built environment” (GRO 2024). The use of provisioning systems allows to view impacts by the service they provide to society.

2.1 The contribution of raw materials extraction and processing to environmental impacts

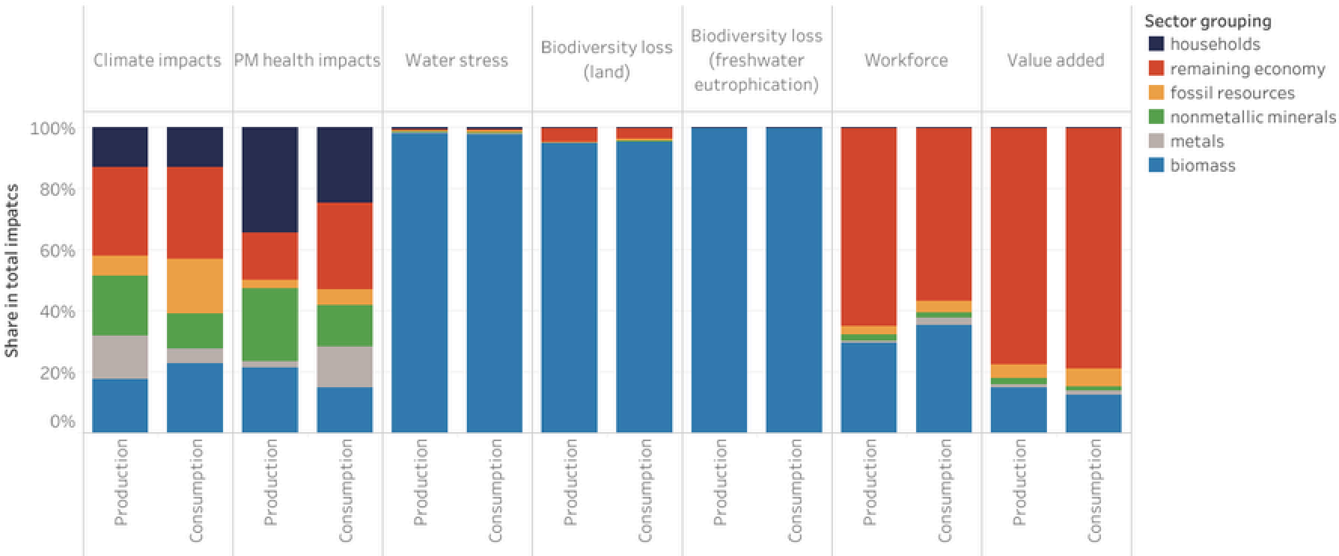


Figure 2: ***Relative contribution of different types of resources (extraction and processing), the remaining economy (downstream chain of resource extraction and resource processing) and households to global environmental and socioeconomic impacts for the year 2022. Data for [Portugal]***

- Despite being the most extracted material, the production and consumption of non-metallic minerals have insignificant impacts on water, biodiversity loss, work force and value added (below 2.2%). However, the impact on climate change and on the particulate matter (PM) health is more relevant (ranging between 11 and 24%).

- The extraction, processing and consumption of resources (biomass, metals, non-metallic minerals and fossil fuels) contributed to near 60% of the climate impacts.

- Outdoor PM related health impacts were mainly caused by households (mostly due to private mobility) and the "*remaining economy*" (that includes construction and transport), the sum exceeding 50%, for both perspectives. It should also be underlined that the extraction and processing of non-metallic minerals contributed nearly 24% to PM health impact in the production perspective.

- Water stress and biodiversity loss (land-related and freshwater eutrophication-related) impacts were mainly caused by biomass, for both the production and consumption perspectives.

- The "*remaining economy*" contributed the major share to workforce (65 and 57% for the production and consumption perspective, respectively) and to value added (nearly 80%).

2.2 Decoupling analysis over time

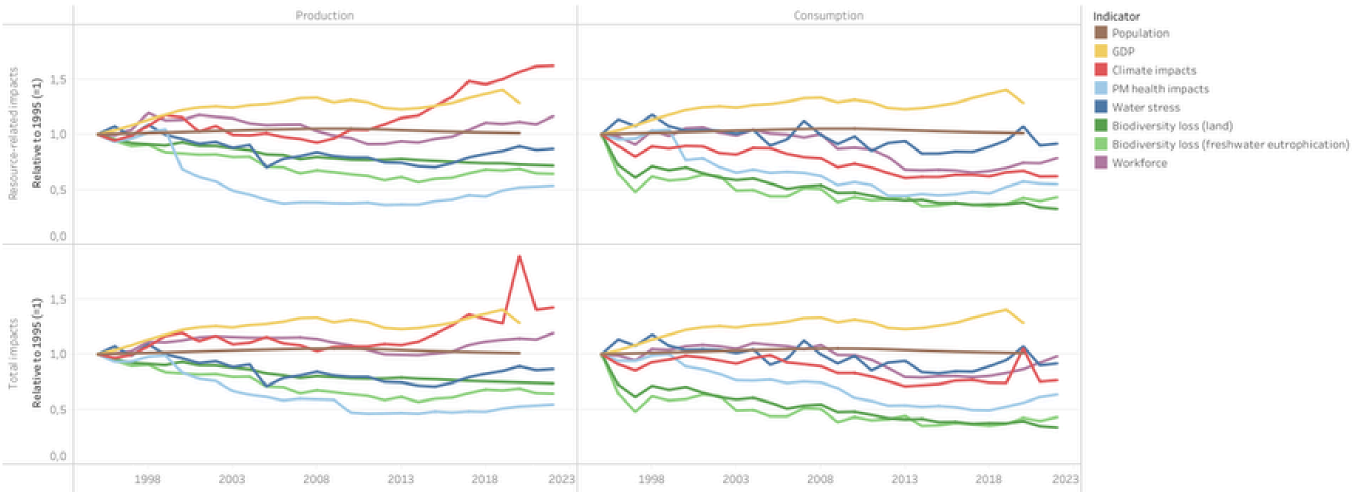


***Figure 3:** Temporal development of environmental impacts and socio-economic indicators from 1995 to 2022, from a production (left) and consumption perspective. Top figures: from resource extraction and processing up to "ready-to-be-used" materials, food or fuels (as in GRO 2019). Bottom figures: total worldwide impacts (following new scope displayed in Figure 3.1). Data for [Portugal]. Note that climate impacts are nowcasted from 2020 onwards which may lead to larger uncertainties in the data.*

- The Portuguese population slowly increased until 2010 and then slowly decreased, reaching, in 2020, the value achieved in 1998. The GDP increased until 2008 (halted by the financial crisis in 2007) and afterwards presented some fluctuations.

- Climate change impacts decreased in the consumption perspective however it increased in the production perspective. This occurred for the resource related impacts as well as for total impacts.

- (PM) health impacts, water stress and biodiversity loss (land-related and freshwater eutrophication-related) decreased in both the production and consumption perspectives, and for resource related and total impacts. This decrease is stronger in the production than in the consumption perspective.

- The workforce impact shows a fluctuating trend, with a general decreasing tendency in the consumption perspective, while in the production perspective it oscillated around the value of 1.

- Considering the increase of the GDP and the reduction (significant in some cases) of several impacts, it can be assumed that Portugal accomplished a relative decoupling of economic activity from environmental impacts.

2.3 Temporal evolution by raw materials group

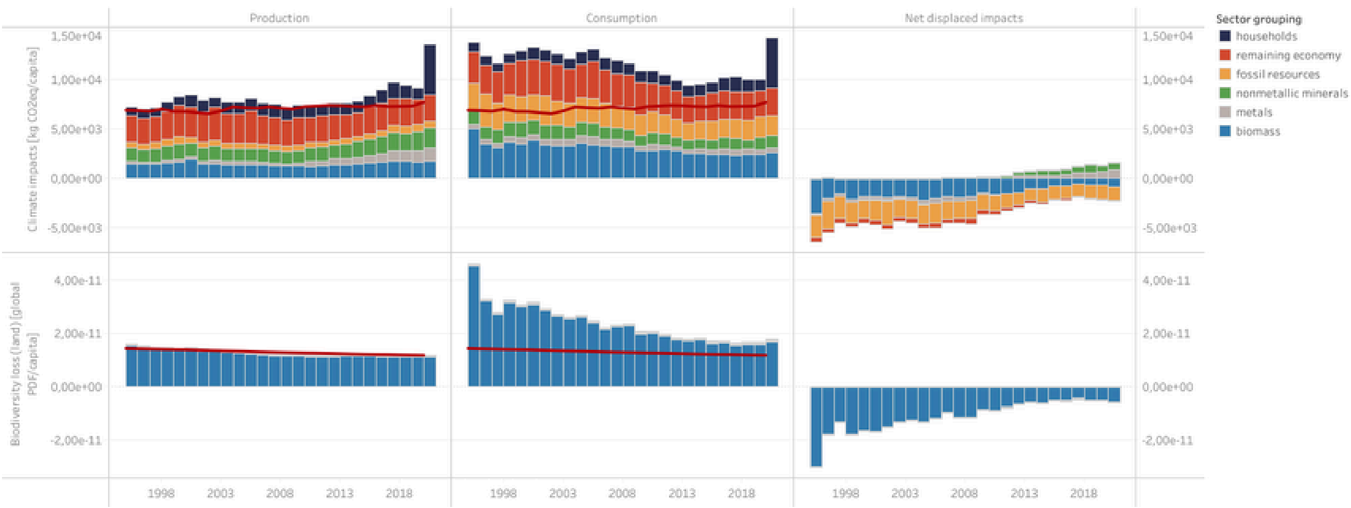


Figure 4: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by material resource group (cultivation, extraction and processing) and downstream use (remaining economy and households). Moving averages over five years used for land occupation and change. Left: Production perspective. Middle: Consumption perspective (footprints). Right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere). The red lines show the global per-capita average values. Data for [Portugal]. Note that climate impacts are nowcasted from 2020 onwards which may lead to larger uncertainties in the data.***

Above: aggregated impacts; below: per capital impacts with global per-capita average values indicated by the red line; right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere).

- Considering the production perspective, the impacts on climate change of resource use and their downstream use in the economy have been oscillating throughout the years (1995-2019) with a slight growth trend, while on the consumption perspective, a consistent decrease was observed until 2019.

- The biodiversity loss impact has decreased, in a smooth way for the production perspective and in a steeper way for the consumption perspective. This loss is almost entirely due to the cultivation, extraction and processing of biomass.

- The impact of biomass use on biodiversity is displaced to other countries due to the imported material used in Portugal and the exported material and goods exported to other economies.
- Regarding climate change impacts, on the one hand, Portugal emits greenhouse gas emissions for exporting metals and non-metallic minerals. On the other hand, imports of fossils and biomass-based products cause greenhouse gas emissions in other countries.
- The Portuguese figures, for the production perspective, are similar to those observed for the worldwide average. For the consumption perspective the values are higher, but converging to the worldwide average, more clearly in the biodiversity loss.

2.4 Provisioning systems of food, energy, mobility and the built environment are the main contributors to environmental impacts

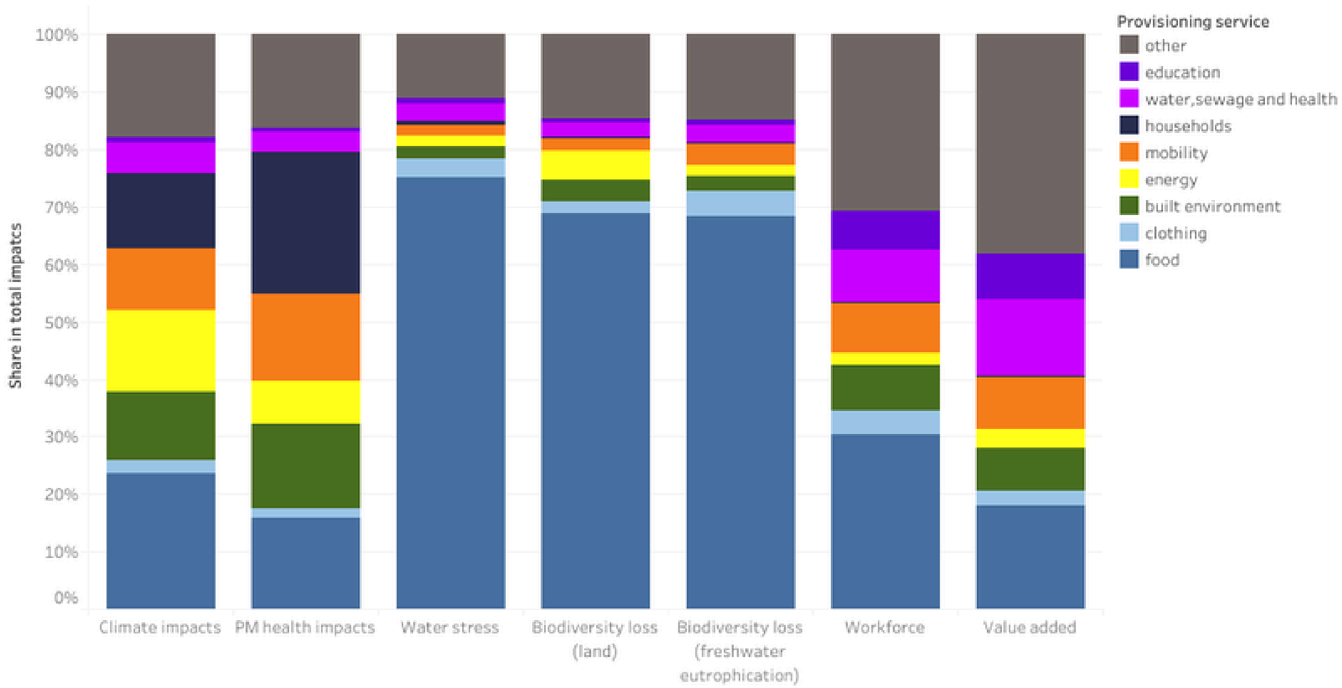


Figure 5: ***Relative contribution of different types of provisioning systems to global environmental and socioeconomic impacts for the year 2022. *Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). Data for [Portugal]***

- As for other European countries, the relative impacts of the different types of provisioning systems on climate change are similar. The same is observed for PM health impacts, in which household consumption stands out having a strong contribution (near one third of the total).
- In Portugal, more than 68% of impacts on water stress and biodiversity losses (land-related and freshwater eutrophication-related) originate from the food provision systems.
- Other services, that include public services, social security, furniture, consumer electronics or recreation, are the main contributors of the impacts on the workforce and value added.

2.5 Evolution of environmental impacts by provisioning system over time

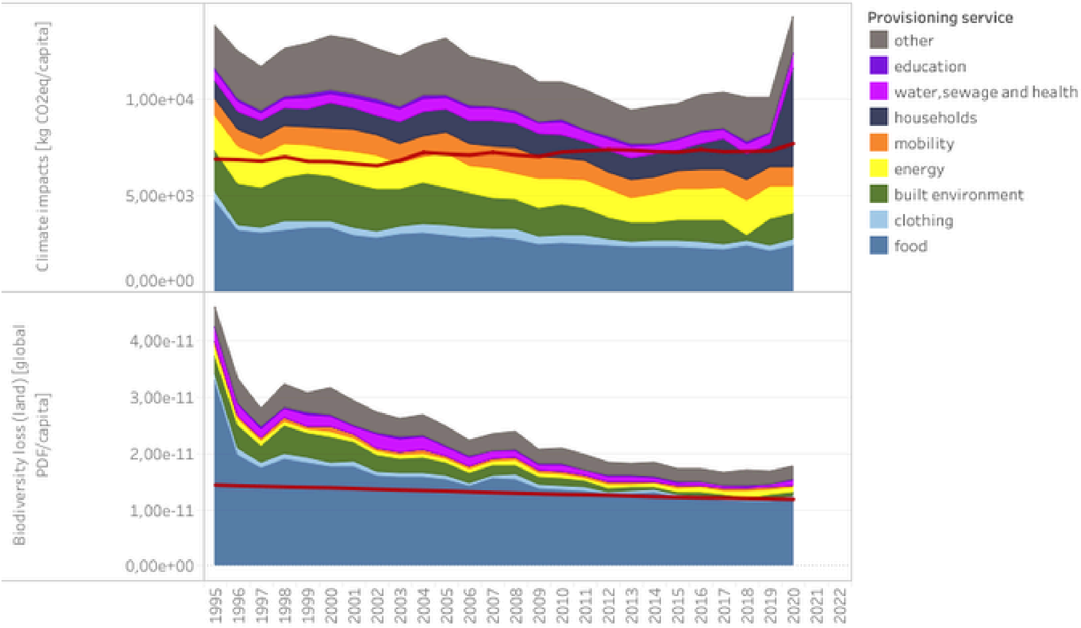


Figure 6: ***Time series of climate change (top) and land-related biodiversity loss (bottom) split by provisioning system. Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). The red lines show the global per-capita average values. Data for [Portugal]. Note that climate impacts are nowcasted from 2020 onwards which may lead to larger uncertainties in the data.***

- The overall impact of the provisioning systems on climate change and on biodiversity loss has been generally decreasing over the years, more inconsistent in the former and more steeply in the latter, always above the worldwide impact averages.
- Food, built environment, energy and others are the main provisioning services that contribute to climate change impacts while for the biodiversity loss, food services are clearly the most relevant.

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2.6 Per-capita environmental impacts against wellbeing trajectories

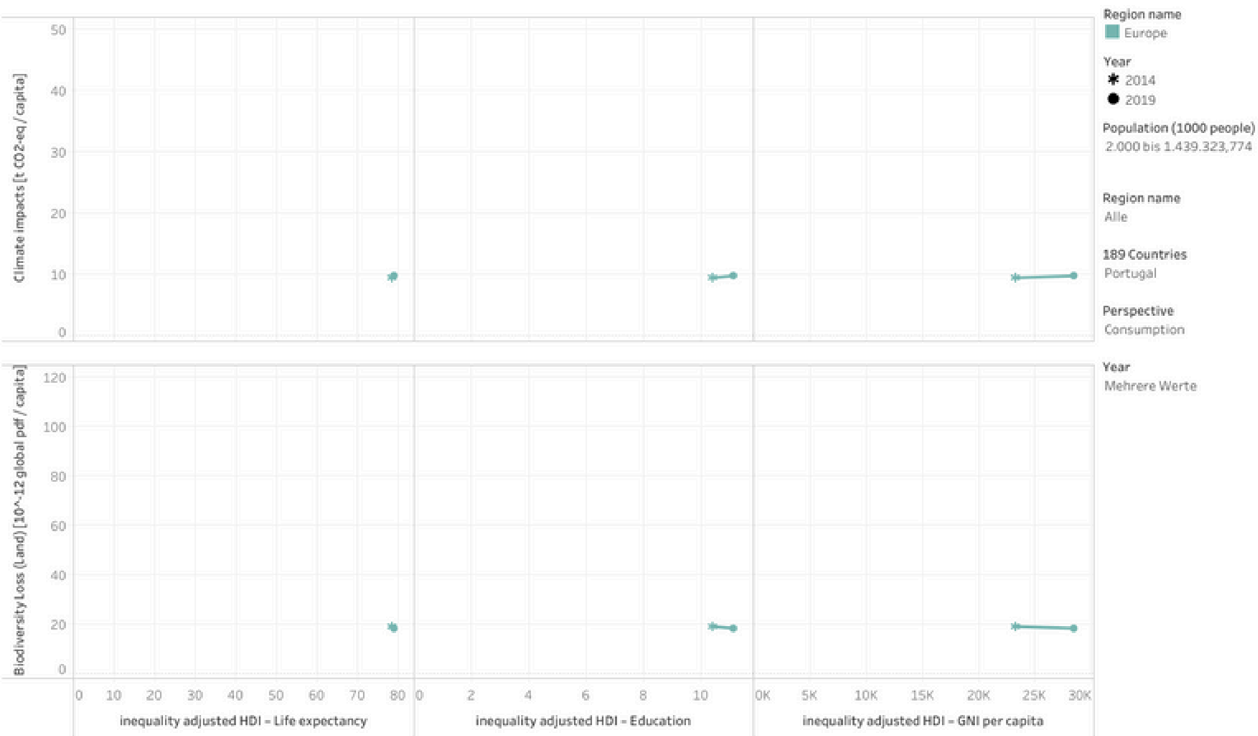

Figure 7. ***Per-capita impacts (consumption perspective) against wellbeing trajectory from 2010 to 2020 (each pair of dots represents one country; colors mark the region).***

- Portugal shows a small increase in climate impacts from 2014 to 2019. Biodiversity impacts decrease slightly over this time period.
- At the same time, HDI education and gross national income per capita (GNI) increase.
- Life expectancy stays roughly constant during the 2014-2020 time period.
- Portugal data is aligned with other similar European countries, such as Spain and Italy.

2.7 Final remarks

- In the last five years, Portugal has increased the domestic extraction (20%) and consumption (16%). The material footprint also increased, but at a lower extent (6%), in line with the worldwide average. Non-metallic minerals are the main contributors for these three indicators.
- Biomass is the resource that creates more environmental impacts, namely in water stress and biodiversity loss, while the “remaining economy” is the process that have the most impact on the environment.
- Attending to the increase of the GDP and the reduction of the global environmental impacts, it can be concluded that Portugal accomplished a relative decoupling of economic activity from the environmental impacts.

- ·The use of resources and the most important processing activities have more environmental impacts in other countries than those occurring in Portugal.

- Considering all the environmental impacts evaluated, the provision of food is the most relevant service. Attending to the climate change and biodiversity loss impacts, both have been decreasing but at different rates, being the latter more consistent and at a higher extend.

- Regarding the per-capita environmental impacts against wellbeing, Portugal is in line with other European countries, such as Spain and Italy.

3. Additional remarks on material flows and environmental impacts

The Portuguese Statistical Institute, Statistics Portugal, publishes data and information on the material flow account as part of the system of environmental economic accounting. The Statistics Portugal publishes annual information bulletins[2] that include data regarding domestic material consumption, domestic extraction, material trade balance or resource productivity. It also provides full updated data packages for a wide range of material flow indicators[3].

4. Examples of effective policies

Name: Circular Economy Action Plan 2024-2030 (PAEC 2030)

Description: PAEC 2030 aims at implementing both an economic and social development model which is regenerative, efficient, productive and inclusive. PAEC 2030 assumes three levels of action:

- macro – transversal to all sectors and regions (divided into seven dimensions: i) policy instruments, ii) funding, iii) education, training and awareness raising, iv) technology, research and innovation, v) circularity in organizations, vi) partnership, and vii) life cycle);
- meso – targeted at priority sectors (Agri-food, Construction, Distribution and Retail, Electric and Electronic, Plastics, Tourism, and Textile and Clothing), and
- micro – to stimulate strategies at regional / local level. The Plan will be monitored by a selected and appropriate set of indicators aligned with those foreseen in the EU's revised monitoring framework for the circular economy.
-

Results: Expected to be adopted in the second half of 2024.
Reference:

Name: National Energy and Climate Plan 2021-2030 (PNEC 2030)

Description: PNEC 2030 is the main instrument of the national energy and climate policy for the next decade towards a carbon neutral future. It defines ambitious targets for the 2030 horizon and sets out the appropriate policies and measures, in line with the guidelines and goals established in the Roadmap for Carbon Neutrality 2050, regarding the reduction of greenhouse gas (GHG) emissions, use of renewable energies, energy efficiency and interconnections.
PNEC 2030 is a pioneer and innovative instrument that translates a convergent and articulated approach to achieve the vision established for Portugal, which is, promoting the decarbonisation of the economy and the energy transition, aiming at carbon neutrality in 2050.

Results: Under implementation.
Reference:
National Energy and Climate Plan 2021-2030, in Portuguese.

2 Available at (in Portuguese): https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=ine_destaques&DESTAQUEStipo=ea&DESTAQUEScoleccao=108018572&DESTAQUEStema=55557&selTab=tab0
3 Available at (in Portuguese): https://www.ine.pt/xportal/xmain?xpid=INE&xpgid=cn_quadros&boui=391699537

Name: National Waste Management Plan 2030 (PNGR 2030)

Description: PNGR 2030, based on the guiding principles of waste management, is a planning instrument for waste policy, at macro-level, that focuses on changing the current paradigm in terms of waste. It aims at advocating waste prevention in order to protect, preserve and improve the quality of the environment and protect human health and ensuring that the management of waste that cannot be prevented is carried out through sustainable material management, ensuring the efficient use of natural resources, promoting the principles of circular economy, reinforcing the use of renewable energy and increasing energy efficiency.

Results: Under implementation.
Reference:
National Waste Management Plan 2030, in Portuguese.

Name: The Strategic Plan for Municipal Waste 2030 (PERSU 2030)

Description: PERSU 2030 focuses on the prevention of waste production and on the separate collection, paying particular attention to new fractions: textile waste, hazardous waste and bio-waste. It also promotes the use of materials resulting from waste treatment. It includes several important actions regarding waste prevention and management, such as, among others: the establishment of performance parameters aiming to develop product sustainability indices, such as circularity, reparability or recyclability indices; the promotion of reuse; the provision of incentives to reintroduce the recyclables fractions recovered from municipal waste (plastic, paper...) in the production cycle; and the application of the polluter pays principle and the waste hierarchy, through the differentiation of tariff systems depending on production and destinations.

Results: Under implementation.
Reference:
Strategic Plan for Municipal Waste 2030, in Portuguese.

Name: The Strategic Plan for Non-Municipal Waste 2030 (PERNU 2030)

Description: PERNU 2030 is the new reference instrument for non-municipal waste policy in Portugal, replacing the specific sectoral plans (i.e. Strategic Plan for Industrial Waste or Strategic Plan for Hospital Waste) and addressing both the remaining uncovered sectors and the specific flows that may be associated with them. It includes actions such as, the promotion of a centralized platform for waste, by-products and other secondary raw materials, contributing to administrative, legislative and regulatory simplification, in order to facilitate circular processes.

Results: Under implementation.
Reference:
Strategic Plan for Non-Municipal Waste 2030, in Portuguese.

5. Glossary and technical annex (based on the IRP reports and website)

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International
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Global Resources Outlook 2024

Country Profile: Sweden

by Daniel Berlin (Swedish Environmental Protection Agency)

Damir K .ballos
Pexels

Contents

01 Country Profile: Sweden

1. Domestic extraction, domestic material consumption and material footprint

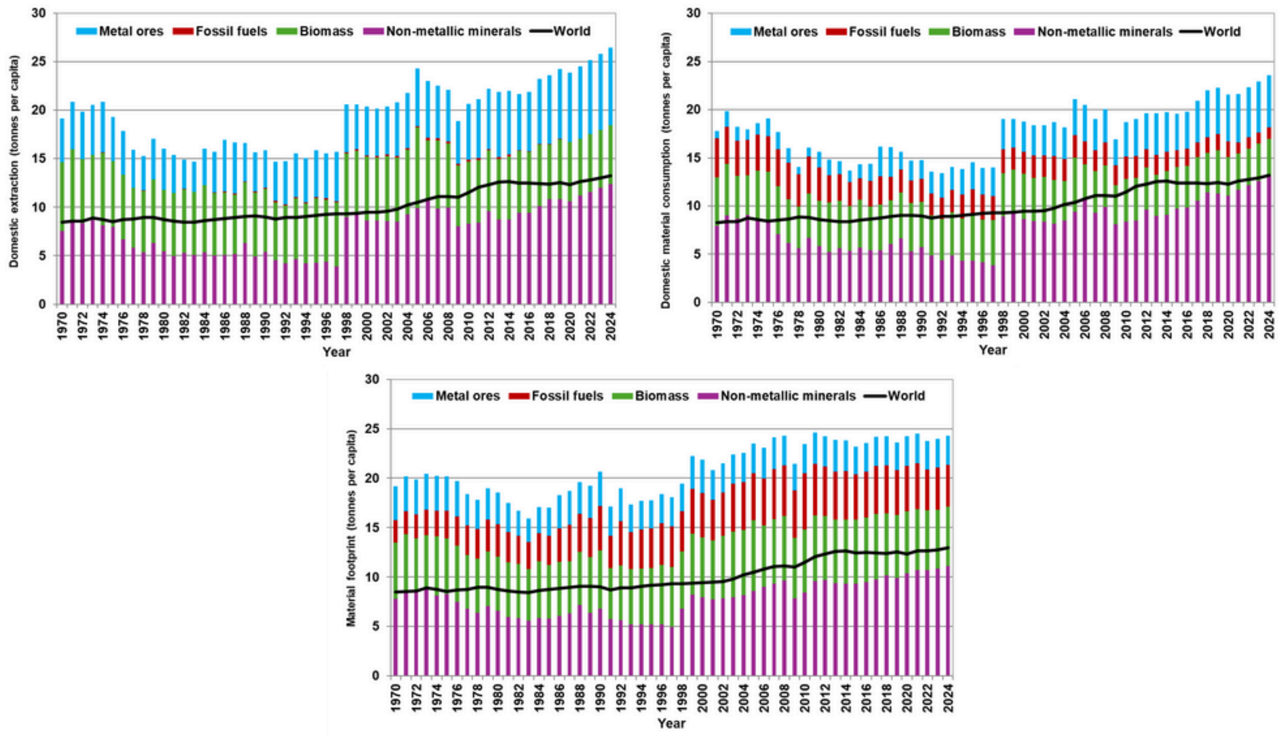


Figure 1: Domestic extraction, domestic material consumption, and material footprint per capita in Sweden[1]

- Material resources form the foundation of Sweden's economy. In 2024, extraction in Sweden amounts to around 280 million tons. Non-metallic minerals, including sand and gravel, account for nearly half of the total extraction. Metal ores, such as iron and copper ores, constitute 30%, while biomass, including timber, makes up 23%. Since 1970, biomass extraction has consistently remained at approximately 60 million tons per year. Meanwhile, all other types of extraction have experienced an annual growth rate of 2% from 1970 to 2024. In other words, the yearly extracted volume of fossil fuels, metal ores, and non-metallic minerals has doubled during this period.

- On average, Swedes extract and consume approximately twice as much per capita as the global average. This trend has persisted since 1970 and remains true in 2024. During this period, Swedish material consumption per capita has fluctuated between 151% and 237% of the world average. In 2024, both Swedish and global material consumption reached a peak of 23.6 tons per capita and 13.2 tons per capita, respectively.

- In Sweden, more biomass, metal ores, and non-metallic minerals are extracted domestically than globally to meet Swedish consumption (on a per-capita basis). However, the situation is different for fossil fuels, where Sweden heavily relies on the rest of the world. From 1970 to 2024, Sweden had minimal fossil fuel extraction. Meanwhile, domestic fossil fuel consumption decreased from 4.0 tons per capita in 1970 to 1.2 tons per capita, while the fossil fuel footprint increased from 2.2 tons per capita in 1970 to 4.2 tons per capita in 2024. This shift reflects a move from consuming fossil fuels within Sweden in 1970 to relying on fossil fuels consumed elsewhere to meet Swedish demand in 2024. However, it is worth noting that the fossil fuel footprint has significantly decreased since its peak in 2010 (5.7 tons per capita).

1 Note that data provided in the UNEP IRP MFA database might vary from national and EU statistics due to different accounting and modeling approaches used (see technical annex). The observed jump in the time series for non-metallic minerals extraction from 1997 to 1998 is due to a methodological adjustment in the IRP MFA database. For construction-dominant non-metallic minerals like sand and gravel, where official data is incomplete or unavailable, estimates are used and compared with reported data, with the larger value being adopted. In some Nordic countries, data reported by BGS starting in 1998 is significantly higher than prior estimates, resulting in the observed discontinuity.

- National MFA statistics for Sweden[2] highlight the following: From 1970 to 2024, Sweden consistently maintained a significant annual trade surplus in biomass and metal ores. In 2024, the country exported 30.7 million tons of biomass, mainly categorized as "products mainly from biomass" and "wood", while importing 13.4 million tons of biomass, predominantly wood. Similarly, 30.7 million tons of metal ores, chiefly iron, were exported, and 4.3 million tons of metal ores, primarily classified as "products mainly from metals" and "iron", were imported.

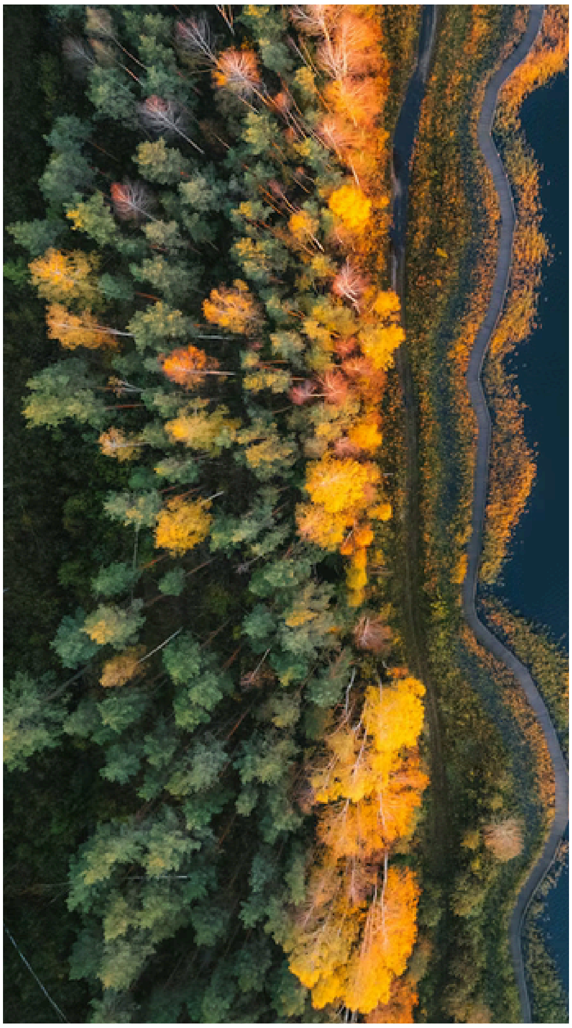
- Sweden has faced a trade deficit in non-metallic minerals almost every year between 1970 and 2024, with a few exceptions around 1997. In 2024, the nation exported 3.4 million tons of non-metallic minerals, mainly sand and gravel, and imported 6.9 million tons of non-metallic minerals, largely falling under the categories of "chemical and fertilizer minerals", "limestone and gypsum", "sand and gravel", and "products mainly from non-metallic minerals".

- Throughout the period from 1970 to 2024, Sweden's annual trade deficit in fossil fuels remained substantial. In 2024, the country exported 1.5 million tons of fossil fuels, primarily categorized as "crude oil, condensate, and natural gas liquids", while importing 23.0 million tons of fossil fuels, mainly under the categories of "crude oil, condensate, and natural gas liquids" and "products primarily from fossil energy products".

2. Environmental impacts

Resource-related impacts:
This section focuses on the environmental consequences and socio-economic benefits related to raw materials extraction and processing (including the upstream supply chain, such as electricity generation and transport, and downstream use and disposal of materials, fuels, fibres, and food (see chapter 3 in the GRO 2024)). **Resource-related impacts** include impacts of growing and harvesting biomass, extracting metallic and non-metallic minerals and fossil fuels, and processing of materials, fuels, and food. Impacts of **households** include private mobility and heating (for climate impacts), while the **remaining economy** includes all other activities (e.g., manufacturing of products, energy production, construction, transport, services, etc.). The matching of economic sectors to raw material types and the remaining economy is documented in Cabernard et al. (2019), with a few deviations of the GRO 2024 highlighted in the GRO Annex 2).

Provisioning systems:
Provisioning systems were defined on the level of end-sectors and products. For example, the use of a private car or public mobility would be associated with the provisioning system "mobility", whereas transport of materials to a building site would be counted within the provisioning system "built environment" (GRO 2024). The use of provisioning systems allows to view impacts by the service they provide to society.



© unsplash

2 Material flows by material categories. Year 1998 - 2022. PxWeb (scb.se)

2.1 The contribution of raw materials extraction and processing to environmental impacts

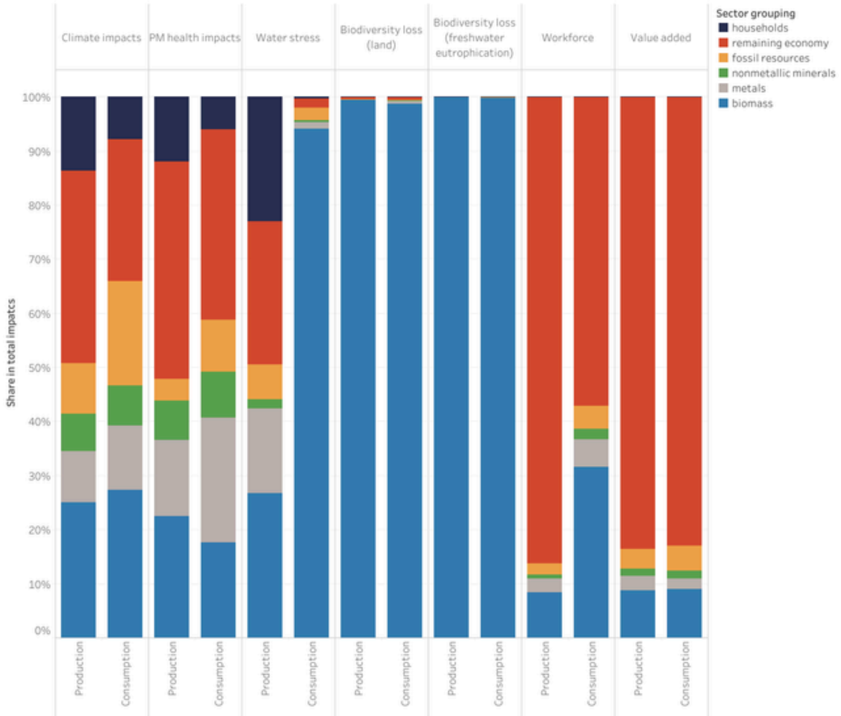


Figure 2: Relative contribution of different types of resources (extraction and processing), the remaining economy (downstream chain of resource extraction and resource processing) and households to global environmental and socioeconomic impacts for the year 2022. Data for Sweden.

- The extraction and processing of material resources contribute to just over half of the climate impacts from production, while consumption accounts for approximately two-thirds of these impacts. For health-related effects due to particulate matter, production contributes slightly below 50%, whereas consumption is responsible for 60% of the impact.

- Growing and harvesting biomass contributes to over 98% of all biodiversity loss, affecting both freshwater ecosystems and terrestrial habitats. From a consumption perspective, biomass cultivation and harvesting also account for more than 94% of water stress.

- Policies aimed at reducing resource use, enhancing resource efficiency and transitioning to a circular economy are crucial for mitigating climate change and other environmental impacts.

- Although material resources form the foundation of Sweden's economy, the extraction and processing of these resources contribute to less than 20% of added value. The downstream chain adds more value and employs a larger share of the Swedish workforce. Notably, industrial machinery, electronics and telecommunications, and road vehicles are particularly important commodity groups[3].

3 Trade in goods and services (scb.se)

2.2 Decoupling analysis over time

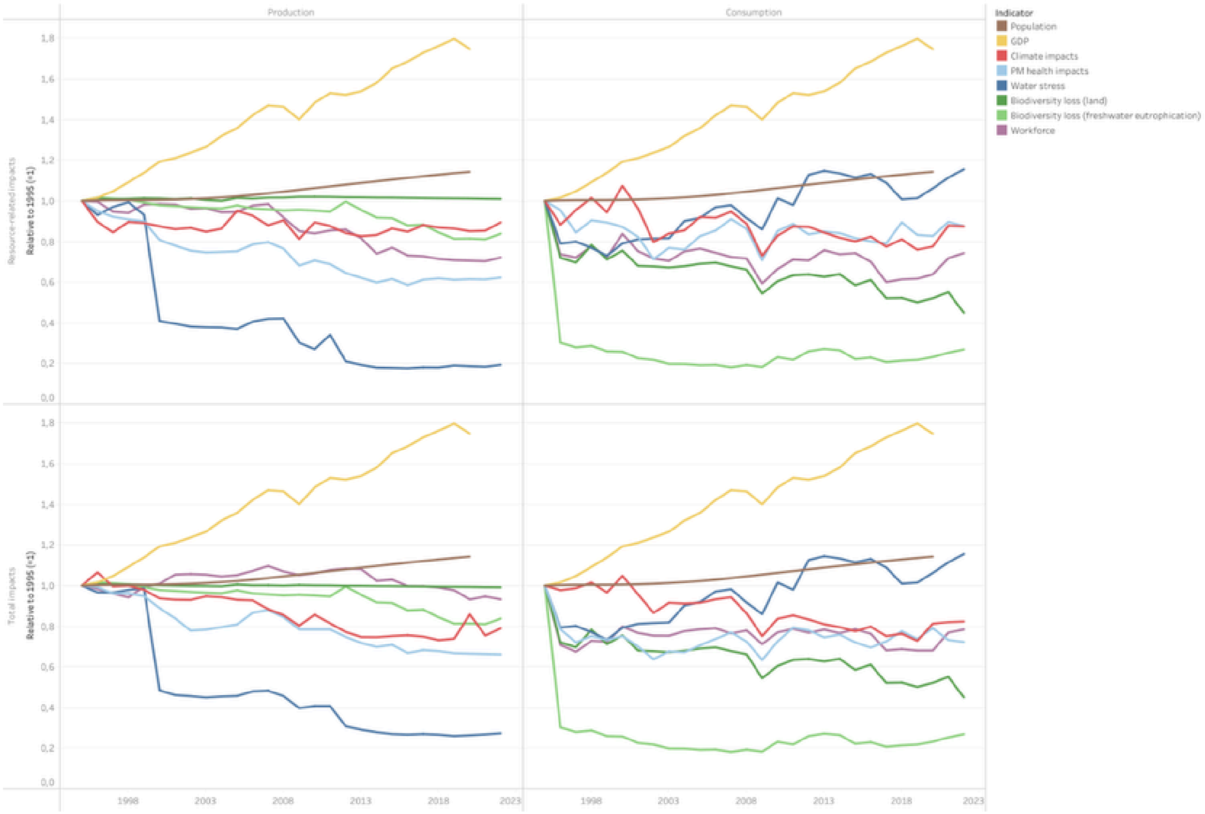
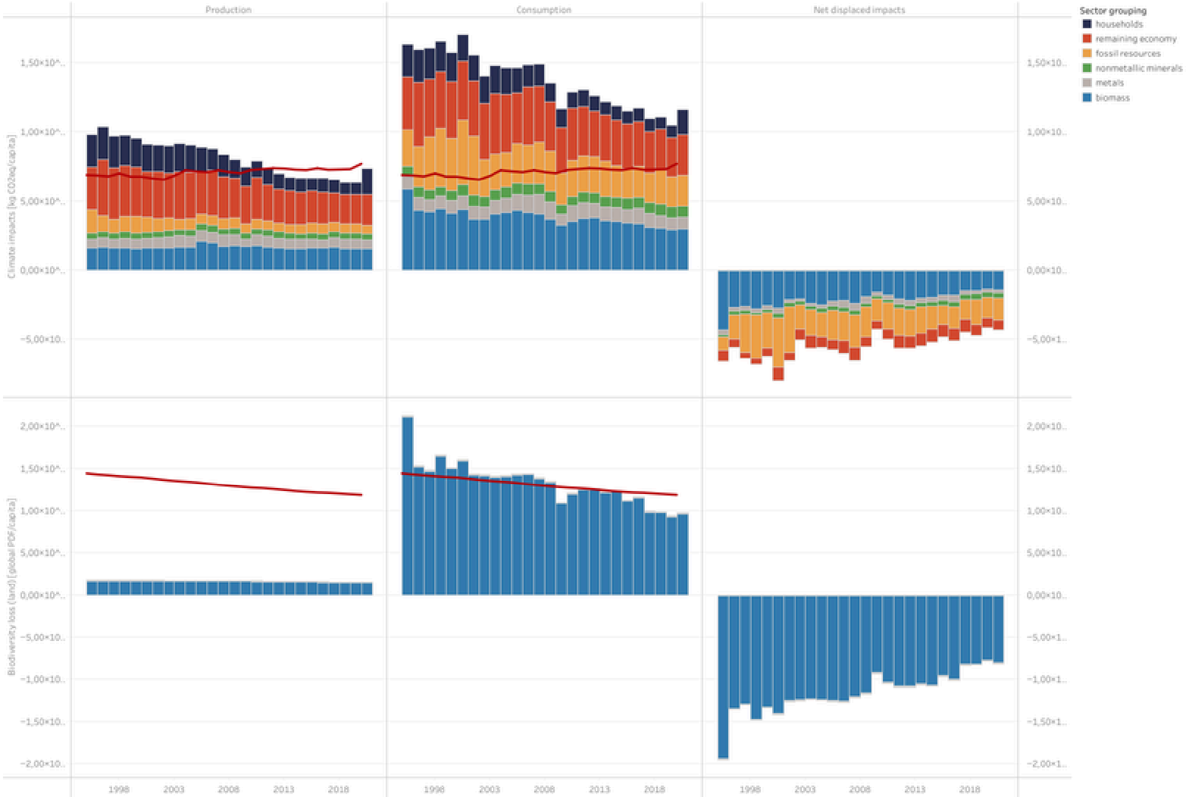


Figure 3: Temporal development of environmental impacts and socio-economic indicators from 1995 to 2022, from a production (left) and consumption perspective. Top figures: from resource extraction and processing up to "ready-to-be-used" materials, food or fuels (as in GRO 2019). Bottom figures: total worldwide impacts (following new scope displayed in Figure 3.1). Data for Sweden.

- Between 1995 and 2020, Sweden's gross domestic product (GDP) increased by 75%, while the population grew by 14%.
- During this period, climate impacts from production and consumption decreased by 21% and 18%, respectively. Until 2018-2019, Sweden achieved absolute decoupling – reducing climate impact in absolute terms even as GDP increased. However, recent trends show that both climate impacts have risen at a similar or higher rate than GDP, indicating relative or no decoupling. This poses a challenge for Sweden's ability to meet climate targets. Sweden aims to achieve net-zero greenhouse gas emissions by 2045 as part of its long-term strategy[4].
- Since 1995, water stress caused by production decreased by 73%. However, water stress from consumption increased by 16% during the same period.
- Since 1995, production-related biodiversity loss on land has remained stable. Freshwater eutrophication resulting from production followed a similar trend until 2012 but has since decreased by 16% compared to the 1995 level. In contrast, consumption-related freshwater eutrophication has remained stable since 1996 . Additionally, biodiversity loss on land has consistently decreased year by year, reaching 55% lower than the 1995 level in 2022.

4 Sweden's Climate Act and Climate Policy Framework (naturvardsverket.se)

2.3 Temporal evolution by raw materials group



Time series of climate change (top) and land-related biodiversity loss (bottom) split by material resource group (cultivation, extraction and processing) and downstream use (remaining economy and households). Moving averages over five years used for land occupation and change. Left: Production perspective. Middle: Consumption perspective (footprints). Right: net trade impacts (positive values indicate that impacts occur in these locations for producing exported goods, negative values indicate that goods are imported to these regions causing impacts and value added elsewhere). The red lines show the global per-capita average values. Data for Sweden.

- Between 1995 and 2020, per capita climate impacts have decreased from both production and consumption perspectives, as well as along the entire value chain. While per capita climate impacts from production have remained below the global average in recent years, those from consumption have significantly exceeded the global average.

- In the timeframe of 1995 to 2020, biomass cultivation, extraction, and processing in the early stages of the value chain were the main causes of biodiversity loss on land. Throughout this period, biodiversity loss per capita remained well below the global average. From a consumption perspective, it is only in recent years that this impact has decreased below the global average.

- Although material resources are the backbone of Sweden’s economy, negative net trade impacts indicate that cultivation, extraction, and processing add more value outside Sweden than within its borders. In fact, most of the climate impacts and biodiversity loss on land also occur outside Sweden.

2.4 Provisioning systems of food, energy, mobility and the built environment are the main contributors to environmental impacts

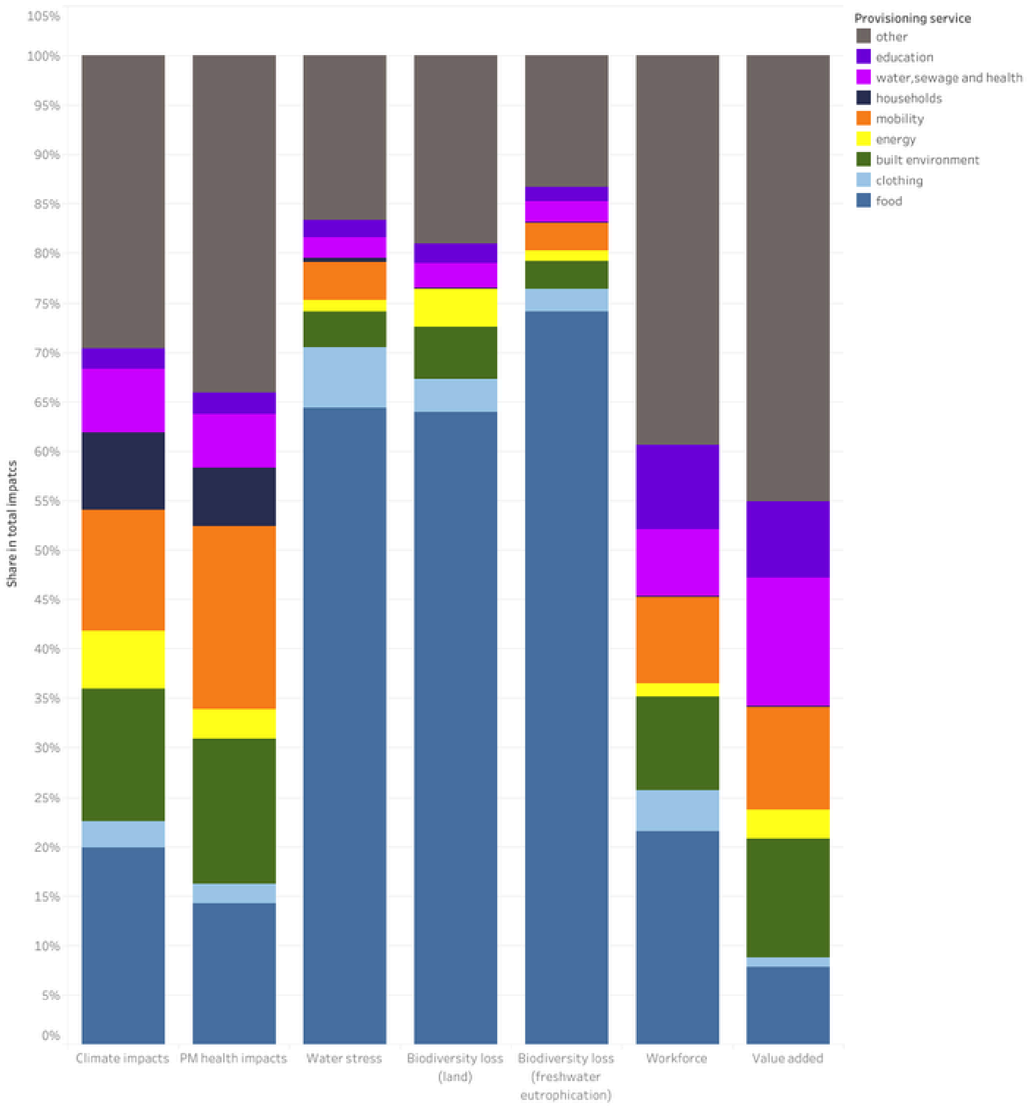


Figure 5: Relative contribution of different types of provisioning systems to global environmental and socioeconomic impacts for the year 2022. *Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). Data for Sweden.

- The four most impactful provisioning systems globally – built environment, energy, food, and mobility – are also the most significant in Sweden. Together, they contribute to the larger share of each type of environmental impact.

- Fossil Free Sweden was launched by the Swedish government in anticipation of the UN climate conference in Paris in 2015. This initiative spans all four of the most impactful provisioning systems. It is managed by an office led by a national coordinator, aiming to build a competitive, fossil-free, industrial sector. To date, Fossil Free Sweden has assisted 22 business sectors in developing roadmaps for fossil-free competitiveness, encompassing both commitments and political proposals[5].

- Nearly two-thirds of water stress and biodiversity loss are attributed to the food value chain. Global data reflects similar trends for this provisioning system.

5 https://fossilfrittsverige.se/en/start-english/

- Recognizing food as a priority area, Sweden has set two key milestone targets. The first aims to increase the proportion of food reaching consumers by 2025. The second target is to reduce food waste by 20% per capita between 2020 and 2025[6]. Additionally, Sweden has a long-term food strategy to establish competitive food value chains that align with the country's environmental quality objectives by 2030[7].

2.5 Evolution of environmental impacts by provisioning system over time

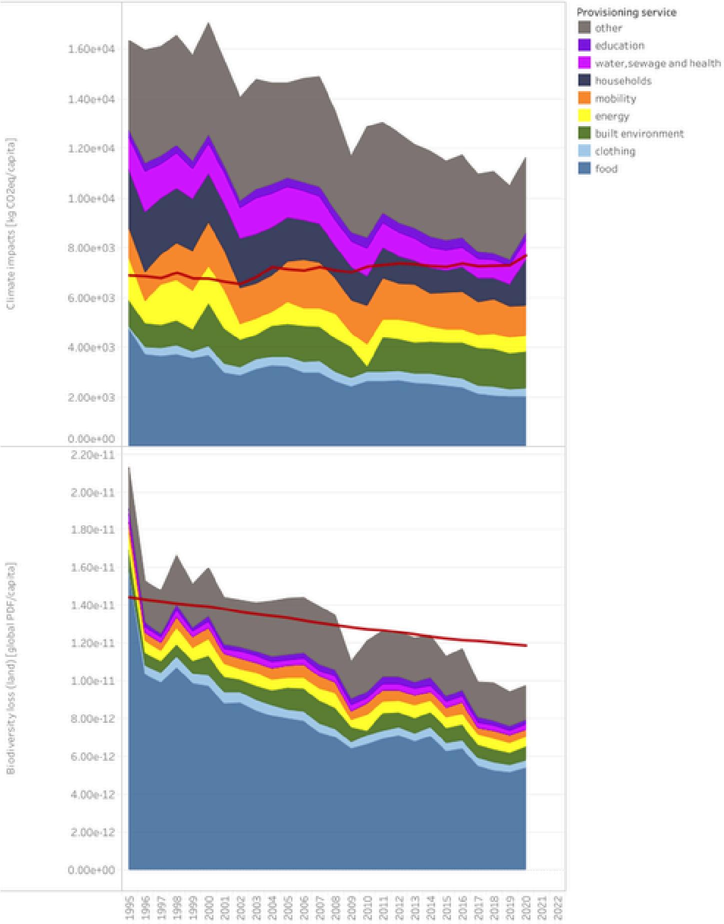


Figure 6: Time series of climate change (top) and land-related biodiversity loss (bottom) split by provisioning system. Household consumption includes emissions from mobility&energy (adding to the separately shown impacts of these provisioning systems). The red lines show the global per-capita average values. Data for Sweden.

- Sweden's per capita climate impact decreased by 30% between 1995 and 2020. Significant reductions in climate impacts from the energy (-58% per capita) and food (-64% per capita) provisioning systems have contributed significantly to this trend. However, increases in climate impacts from the built environment (+44% per capita) and mobility (+3% per capita) provisioning systems have counteracted these improvements.

- Despite improvements, Sweden's per capita climate impact remains significantly above the global average. At 11.6 tons of CO2 equivalent per capita, Sweden's climate impact is 51% higher than the global average in 2024.

6 Swedish environmental objectives (naturvardsverket.se)
7 En livsmedelsstrategi för jobb och hållbar tillväxt i hela landet (regeringen.se)

- Throughout the period from 1995 to 2020, the majority of biodiversity loss was attributed to the food provisioning system. However, significant improvements were made, and by 2020, per capita biodiversity loss was only one-third of what it was in 1995. Comparatively, Sweden's per capita biodiversity loss on land decreased by 54% during this period.

2.6 Per-capita environmental impacts against wellbeing trajectories

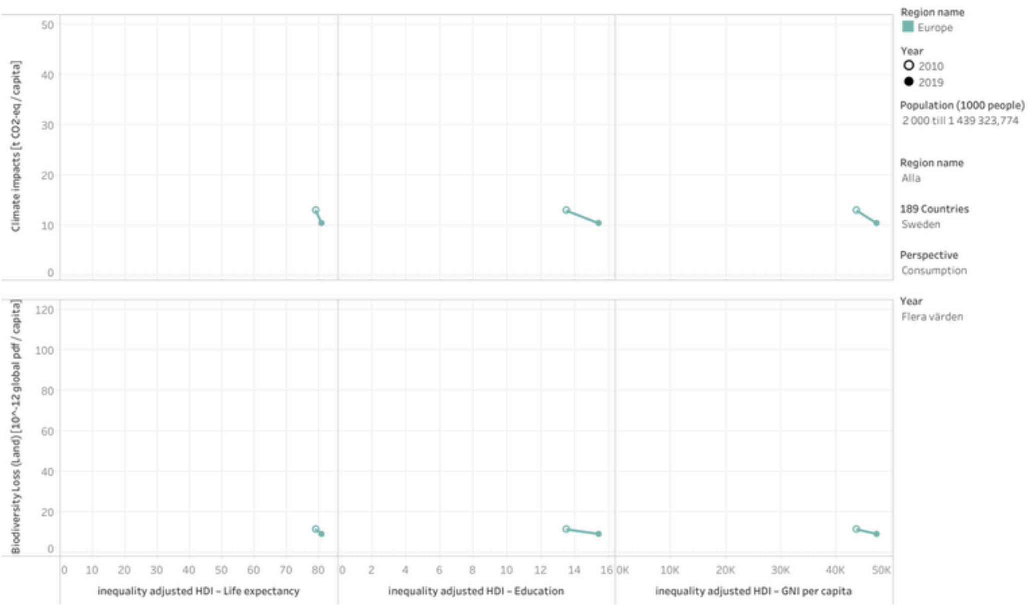


Figure 7. Per-capita impacts (consumption perspective) against wellbeing trajectory from 2010 to 2020 (each pair of dots represents one country; colors mark the region).

- Between 2010 and 2019, Sweden reduced its per capita environmental impacts while achieving improvements across all well-being measures. Specifically, per capita climate impacts, biodiversity loss on land, life expectancy, education, and gross national income all saw positive changes during this period.

- Sweden's development trends are similar to those of neighboring countries – Denmark, Finland, and Norway. However, Sweden's per capita climate impact was notably lower than that of these countries in both 2010 and 2019. In terms of well-being indicators, Norway's gross national income per capita stands out as exceptionally high in comparison.

3. Additional remarks on material flows and environmental impacts

For more information on natural resource use in Sweden, refer to Statistics Sweden[8]. They publish data on material flow accounts as part of the environmental economic accounting system, which is included in their circular economy statistics[9].

In 2022, the Circle Economy Foundation's Circularity Gap Reporting Initiative, in collaboration with the Research Institutes of Sweden and RE:Source, released "The Circularity Gap Report: Sweden." This report assesses the state of the Swedish economy and identifies key strategies for transitioning to a circular economy[10].

8 https://www.scb.se/en/finding-statistics/statistics-by-subject-area/environment/
9 Cirkulär ekonomi (scb.se)
10 The Circularity Gap Report: Sweden (circularity-gap.world)

4. Examples of effective policies

Name:
The Circular Economy Delegation[11]

Description:
The Circular Economy Delegation acts as an advisory body to the Swedish government, aiming to facilitate and drive the business sector's transition to a circular economy. The Delegation comprises a chairperson, a vice chairperson, and ten members representing various industries related to the circular economy, including recycling, waste management, construction, forestry, and finance. The government has tasked the Circular Economy Delegation with the following objectives:
· Supporting the business sector's shift towards a circular economy.
· Identifying barriers hindering this transition.
· Highlighting and communicating the opportunities that a circular economy presents for businesses.

Results:
The Circular Economy Delegation advises the Swedish government to focus on three key areas:
· Informing businesses about the economic benefits of transitioning to a circular economy.
· Facilitating cooperation among stakeholders to enhance understanding of conditions for a circular economy.
· Clarifying the importance of political decision-making concerning circular business models.

Reference: https://www.delegationcirkularekonomi.se/om-oss/

5. Glossary and technical annex (based on the IRP reports and website)

Consumption perspective: The consumption perspective allocates the use of natural resources or the related impacts throughout the supply chain to the region where these resources, incorporated in various commodities, are finally consumed by industries, governments and households. It equals the domestic impacts plus impacts of imports minus impacts of exports.

Decoupling: Decoupling is when resource use or some environmental pressure either grows at a slower rate than the economic activity that is causing it (relative decoupling) or declines while the economic activity continues to grow (absolute decoupling).

Domestic extraction (DE): Direct, gross physical extraction of materials within a country's territory (production perspective).

Domestic material consumption (DMC): Amount of materials directly used by an economy (DMC = DE + Material Imports – Material Exports).

Material resources: metals, non-metallic minerals, biomass, and fossils.

Material footprint (MF): A nation's MF fully accounts for material extraction in other countries used for local consumption in the nation of interest (consumption perspective).

Material-related impacts: Environmental impacts and socio-economic benefits (value added, workforce) related to the extraction and processing of material resources (including the upstream supply chain, such as electricity generation and transport).

Production perspective: The production perspective allocates the use of natural resources or the impacts related to

11 https://www.delegationcirkularekonomi.se/om-oss/

Methodological notes:

Material flows data: The MFA data come from the UNEP IRP MFA database (https://www.resourcepanel.org/global-material-flows-database) which covers the period 1970-2024, for more than 200 countries and regions. The database reports extraction and direct trade of raw materials, indirect trade flows (including material footprints), as well as intensities derived from these material measures. Note that due to underlying model and data sources used, results might differ from national- and EU-level material flows data provided, e.g., by Eurostat. A detailed technical annex of the IRP database is available at: https://resourcepanel.org/sites/default/files/technical_annex_for_global_material_flows_database_-_vers_30_aug22.pdf

Environmental impacts: The analysis is based on data from Exiobase v3.8, complemented with trade data from Eora, and production data from FAOSTAT and British Geological Survey (Minerals UK). Further methodological details can be found in the GRO 2024 (https://www.resourcepanel.org/reports/global-resources-outlook-2024). The matching of economic sectors to the four raw materials types, remaining economy, and households is documented in Cabernard et al. (2019) (https://doi.org/10.1016/j.scitotenv.2019.04.434), with a few deviations (see Annex 2 of the GRO 2024).

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