Natural Resource Use in the Group of 20

Status, trends, and solutions

UN environment programme

International Resource Panel

About the International Resource Panel

The International Resource Panel (IRP), a global scientific panel hosted by the United Nations Environment Programme, was created in 2007 to contribute to a better understanding of sustainable development from a natural resources perspective. It provides science-based policy options on how to decouple economic growth from environmental degradation while enhancing human well-being. With more than 20 scientific publications, the work of the Panel has shed light on growing environmental challenges related to natural resources, their socio-economic implications and potential new pathways towards their sustainable management.

About the factsheets

This collection of factsheets from the International Resource Panel (IRP), was prepared in cooperation with the Ministry of Environment of Japan and the Institute for Global Environmental Strategies (IGES), as a contribution to the G20 Resource Efficiency Dialogue 2019 in Japan. The document is based on research completed by the IRP for the report "Global Resources Outlook 2019: Natural Resources for the Future We Want".

Acknowledgements

The data analysis and text for the G20 was prepared by Livia Cabernard, Stephan Pfister Stefanie Hellweg (ETH Zurich), and Maria Jose Baptista (UNEP) with inputs from Victor Valido (UNEP), Yingying Lu and Heinz Schandl (CSIRO). The layout and infographics were designed by Yi-Ann Chen with support from Qinhan Zhu on figure layout. Icons used on the cover and individual factsheets are from Freepik.

NATURAL RESOURCE USE IN THE GROUP OF 20

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Contents

GLOSSARY

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 intensity (MI): Indicates efficiency of material use (MI = DMC / GDP).

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).

Net traded materials/impacts: Difference between material-related impacts from a production and consumption perspective. In the case of environmental impacts, a positive value means that the material-related impacts from exports are greater than the impacts from imports (and vice-versa: environmental impacts with negative values mean that the material-related impacts from imports are greater than the impacts from exports).

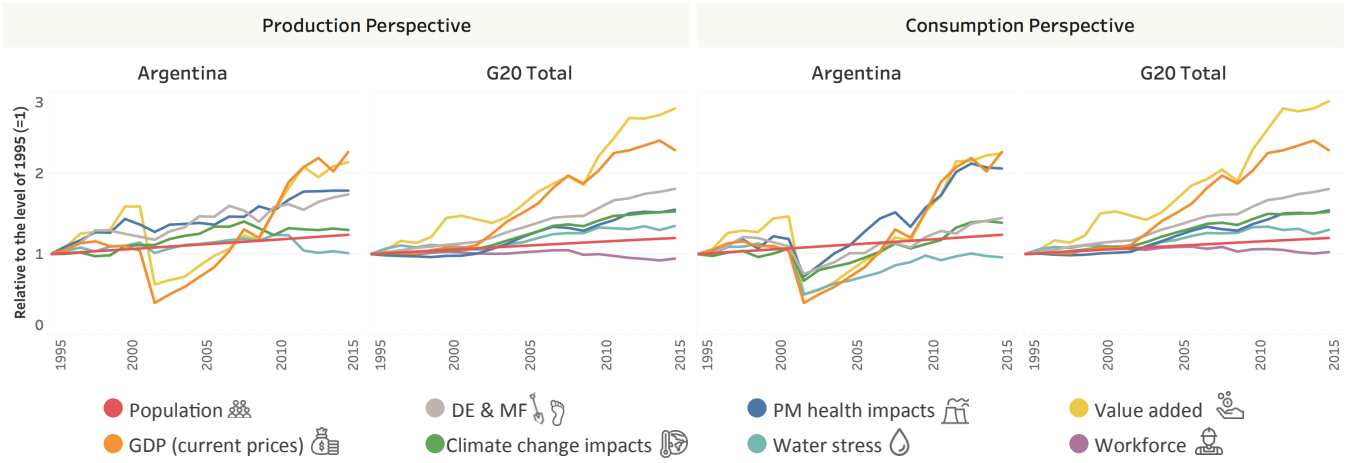
Production perspective: The production perspective allocates the use of natural resources or the impacts related to natural resource extraction and processing to the location where they physically occur.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Argentina

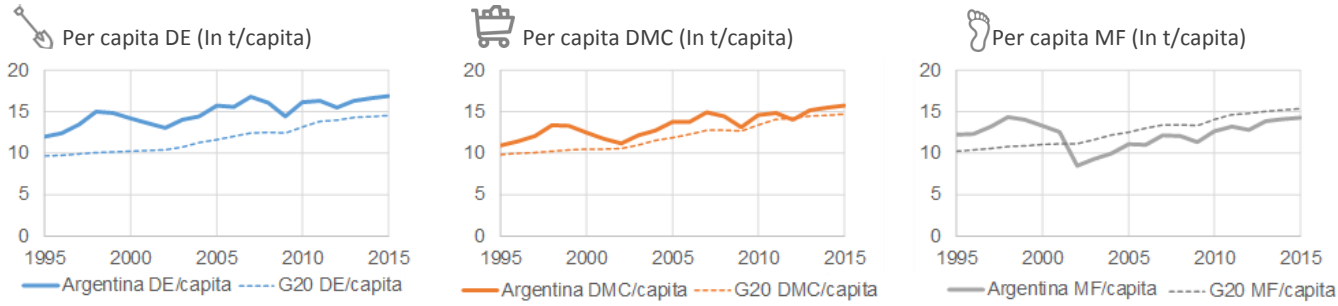
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Argentina and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase 3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Argentina and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **24%** and GDP **doubled** (with a significant recession in-between).

Domestic extraction, domestic material consumption and material footprint slightly increased and matched the G20 average in evolution and magnitude.

Domestic extraction was **17** tonnes per capita and material footprint was **14** tonnes per capita.

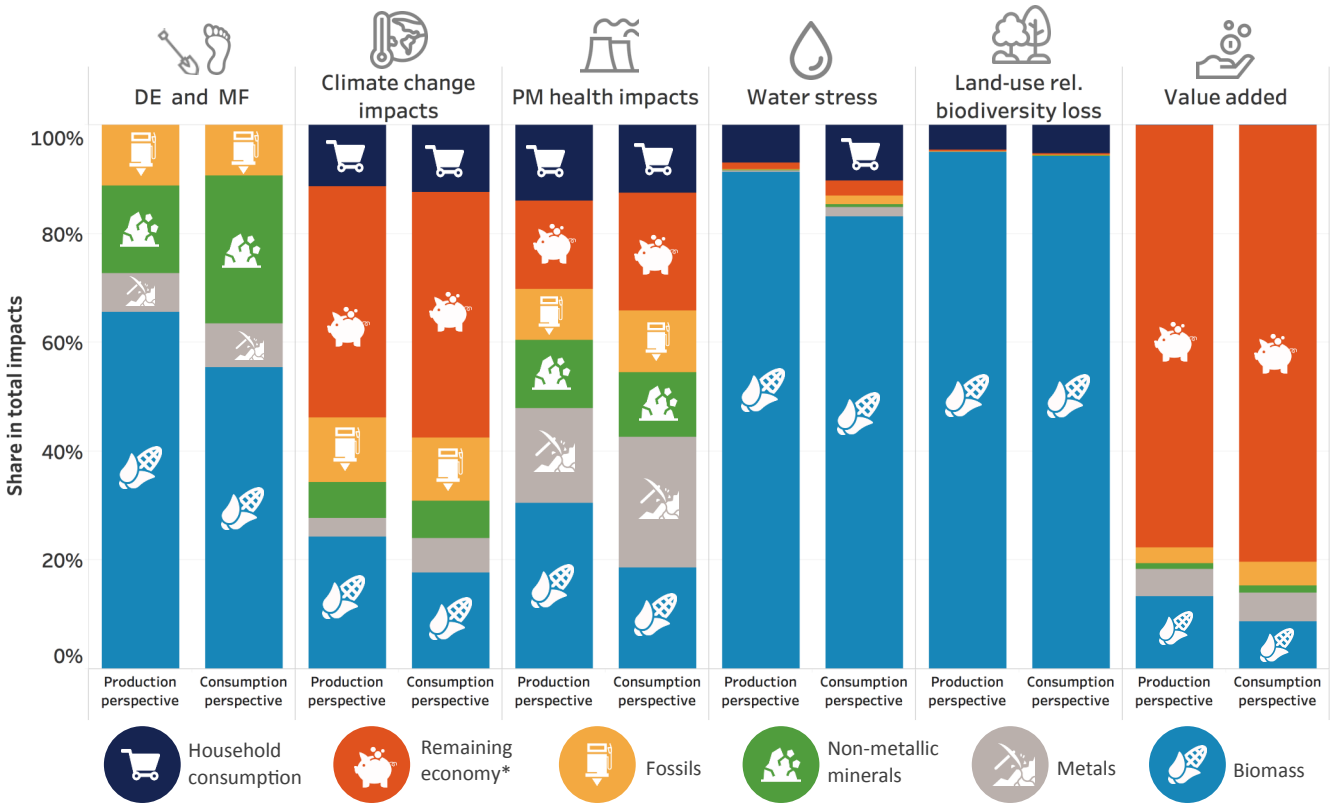
Material related environmental impacts decoupled from GDP.

Per-capita climate change impacts related to material extraction and processing increased only slightly.

Particulate matter related health impacts showed the same development as GDP from a consumption perspective.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Argentina (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, OECD, Pfister et al. 2011, Chaudhary et al. 2016, Cabernard et al. 2019

Unlike G20 average, biomass dominated domestic extraction amounts and material footprint.

The extraction and processing of natural resources accounted for more than 40% of Argentina's total climate change impacts from both a production and a consumption perspective (the G20 average was approximately 50% from both perspectives).

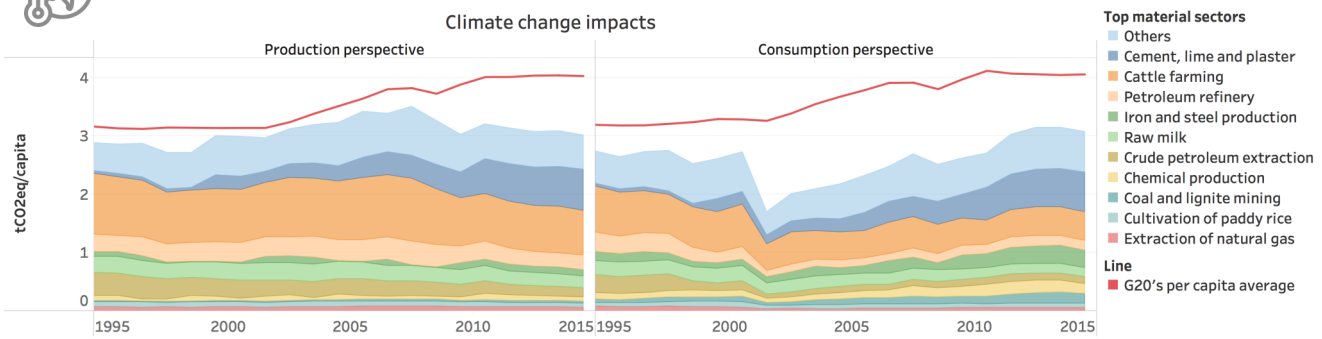
Resource extraction and processing caused more than 60% of outdoor particulate matter health impacts, much higher than G20 average.

Water stress and land use-related biodiversity impacts were caused mainly by biomass production (same as other G20 countries).

The material sector contributed to about 20% of value added, which is similar to G20 average.

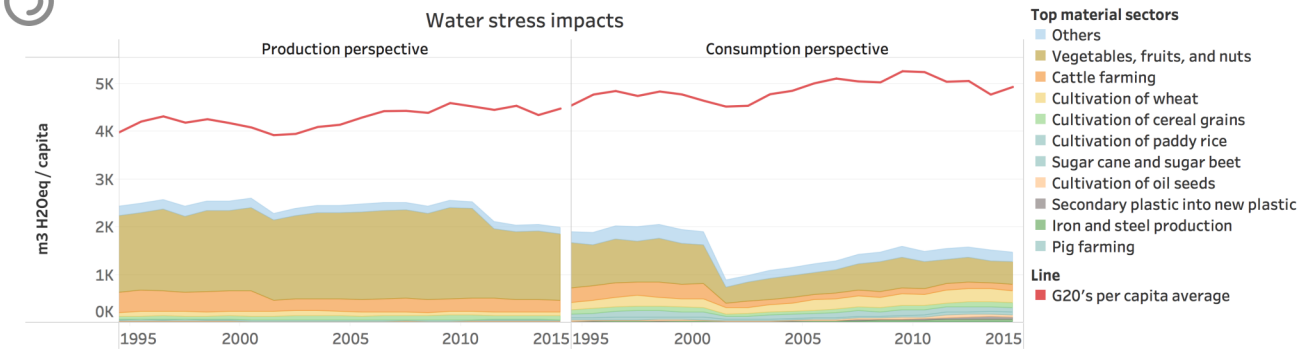
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Argentina (1995-2015)*



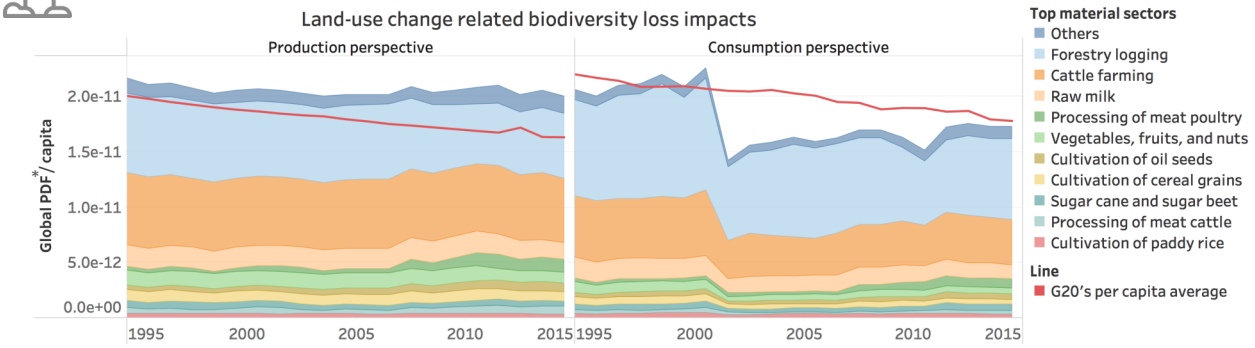
*Data after 2011 was nowcasted.
Source: Exiobase v3.4, Eora 26, FAOSTAT, Cabernard et al 2019

Figure 5: Water stress from agricultural crop and material sectors in Argentina (1995-2015)*



*Data after 2011 was nowcasted.
Source: Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Argentina (1995-2015)*

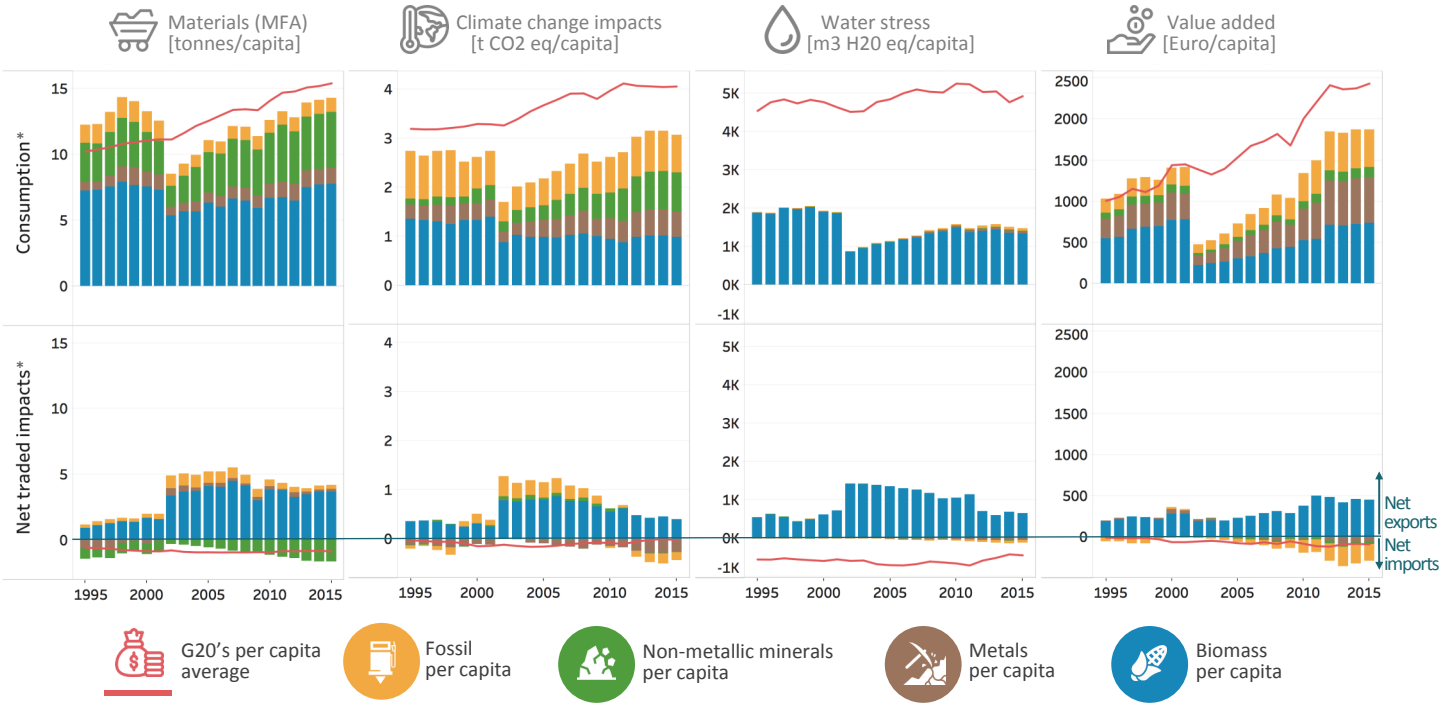


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: Exiobase v3.4, Eora 26, FAO, OECD, Pfister et al. 2011, Chaudhary et al. 2016, Cabernard et al 2019

- From a production perspective, material-related climate change impacts were mainly caused by cattle farming, cement production, and petroleum refinery (together they represented 50% of material related climate impacts).
- From a consumption perspective, cattle farming and petroleum refinery mattered less due to exports of beef and petroleum. The iron and steel as well as the coal mining sectors caused an important share of material-related climate change impacts due to imports.
- Material related climate-change impacts were more than 25% lower than G20 average from both a production and consumption perspective.
- Argentina has water-scarce regions, but overall water stress impacts are lower than the G20 average.
- Water stress was dominated by the production of vegetables, fruits, and nuts (mostly for export).
- Land use related biodiversity loss was more than 20% higher than the G20 average from a production perspective. From a consumption perspective, the impact was close to the G20 average. Forestry, beef and dairy production were main causes, from both perspectives.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Argentina (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in Argentina.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

Argentina is a net exporter of biomass, metals and fossils, but a net importer of non-metallic minerals.

More climate change, water stress and land use related biodiversity impacts were caused by biomass exports (particularly beef) than for biomass imports.

More climate change, water stress and land use related biodiversity impacts were caused by imports of metals and fossils than by exports.

Future trends and potential Decoupling

Ambitious resource efficiency and circular economy policies could decrease material related environmental impacts.

Argentina harbors valuable ecosystems and further efforts for biodiversity protection could achieve large ecological benefits.

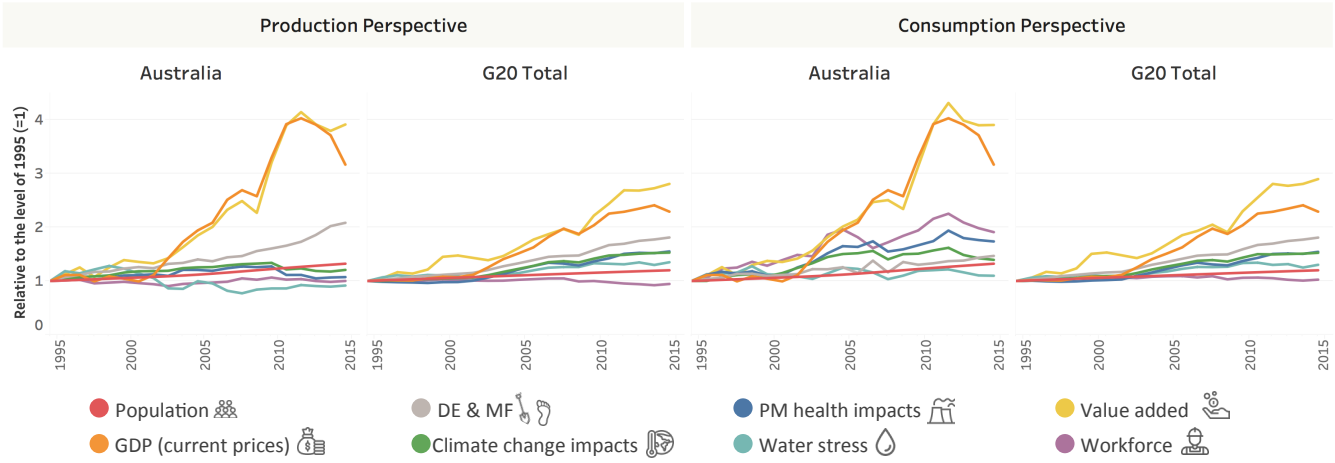
The energy mix relies on primarily on fossil fuels. Increasing the share of renewable energies and making use of the large potential, particular for solar based technologies, could lower the impacts of fossil mining and greenhouse gas emissions during the use phase.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Australia

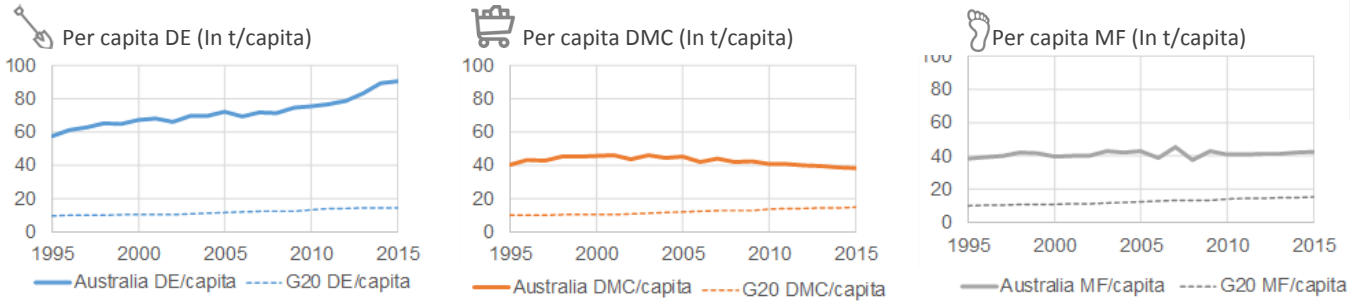
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Australia and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Australia and in the G20 (1995-2015)



Source: IRP database

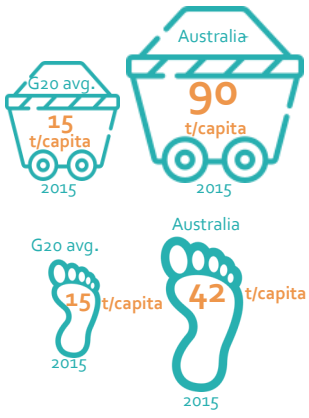
From 1995 to 2015

Population grew by **32%** and GDP grew by a factor of **3**.

Domestic extraction increased by **50%** and remained at **90** tonnes per capita (G20 average was 15 tonnes per capita in 2015)

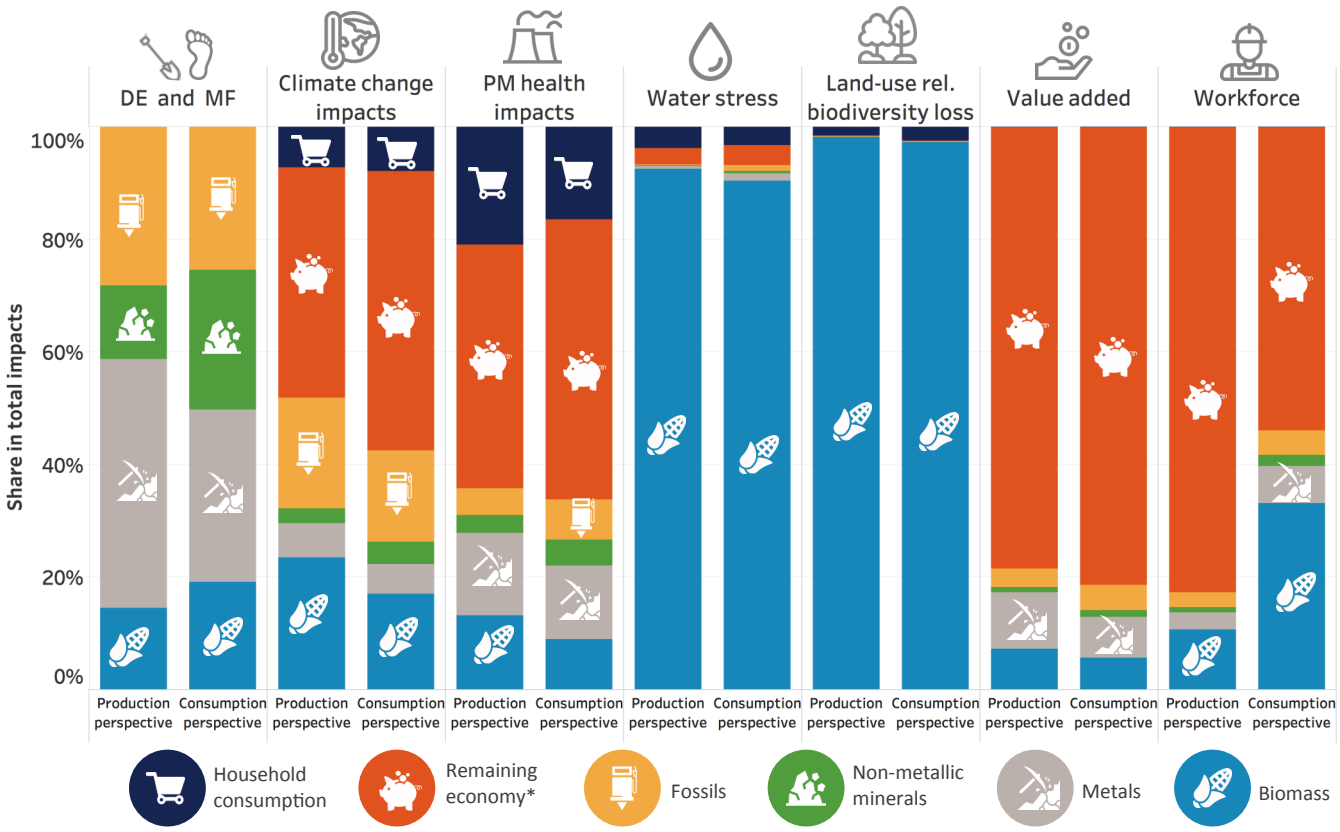
Material footprint remained stable at **42** tonnes per capita (G20 average was 15 tonnes per capita in 2015).

From a consumption perspective, Australia experienced relative decoupling of material footprint and all environmental impacts from GDP. However, climate change impacts were particularly elevated and remained almost **3** times higher than the G20 average.



Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Australia (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Unlike the G20 average, metals dominated the share of domestic extraction amounts and material footprint, but contributed only a minor share to environmental impacts.

From a production perspective, the extraction and processing of natural resources accounted for approximately 50% of total climate change impacts (similar to the G20 average).

From a consumption perspective, materials caused more than 40% of climate change impacts (below G20 average of 50%).

In line with other G20 countries, Australia's water stress and land use-related biodiversity impacts were caused mainly by biomass production from both the production and consumption perspectives.

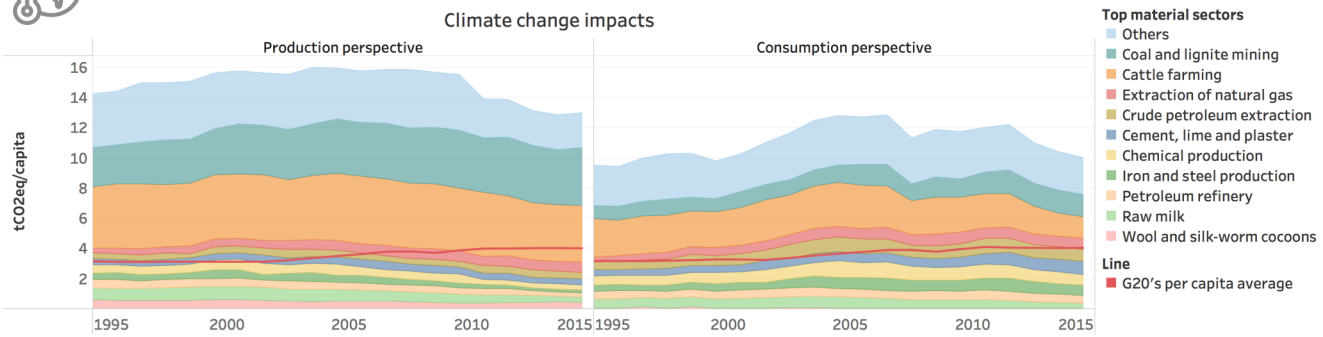
Resource extraction and processing caused one third of outdoor particulate matter related health impacts.

The material sector contributed to a minor share of value added as well as domestic jobs (both around 20%), and relied on low-income workforce in agriculture outside of Australia for food imports.

The share of impacts related to material extraction and processing was similar from a production and consumption perspective for all indicators but climate change and workforce.

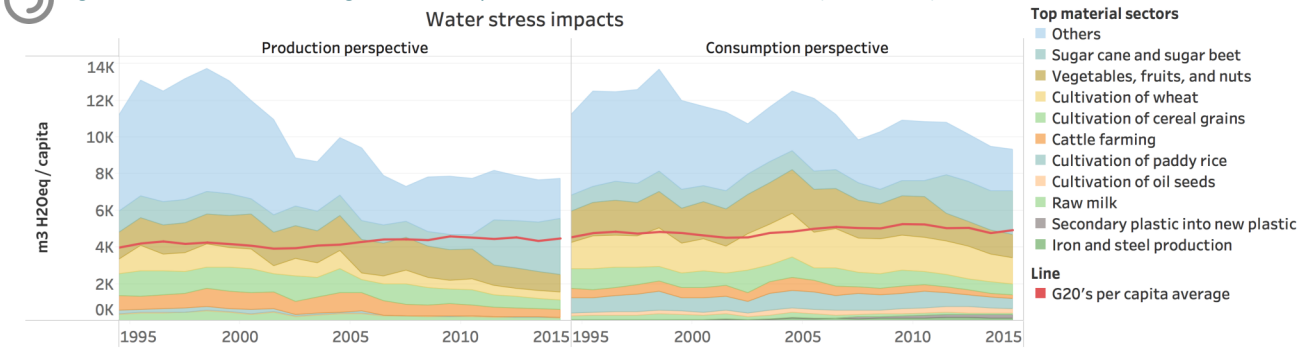
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Australia (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Australia (1995-2015)*



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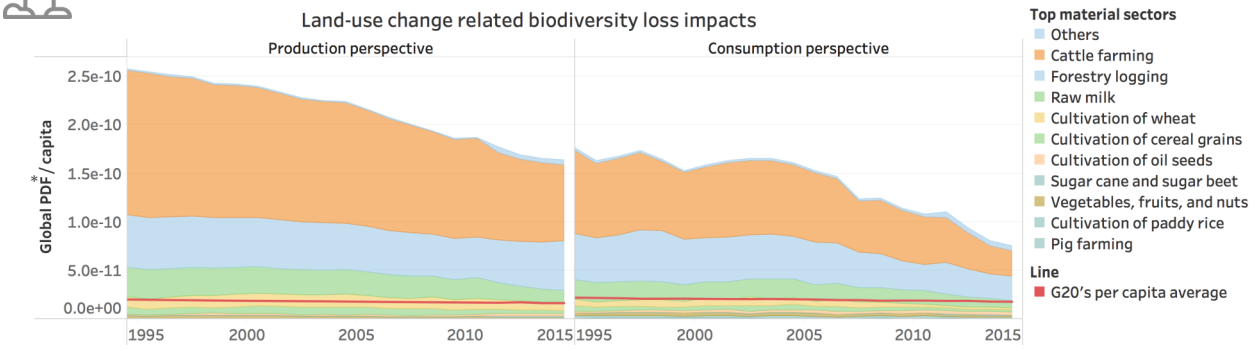
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Australia (1995-2015)*

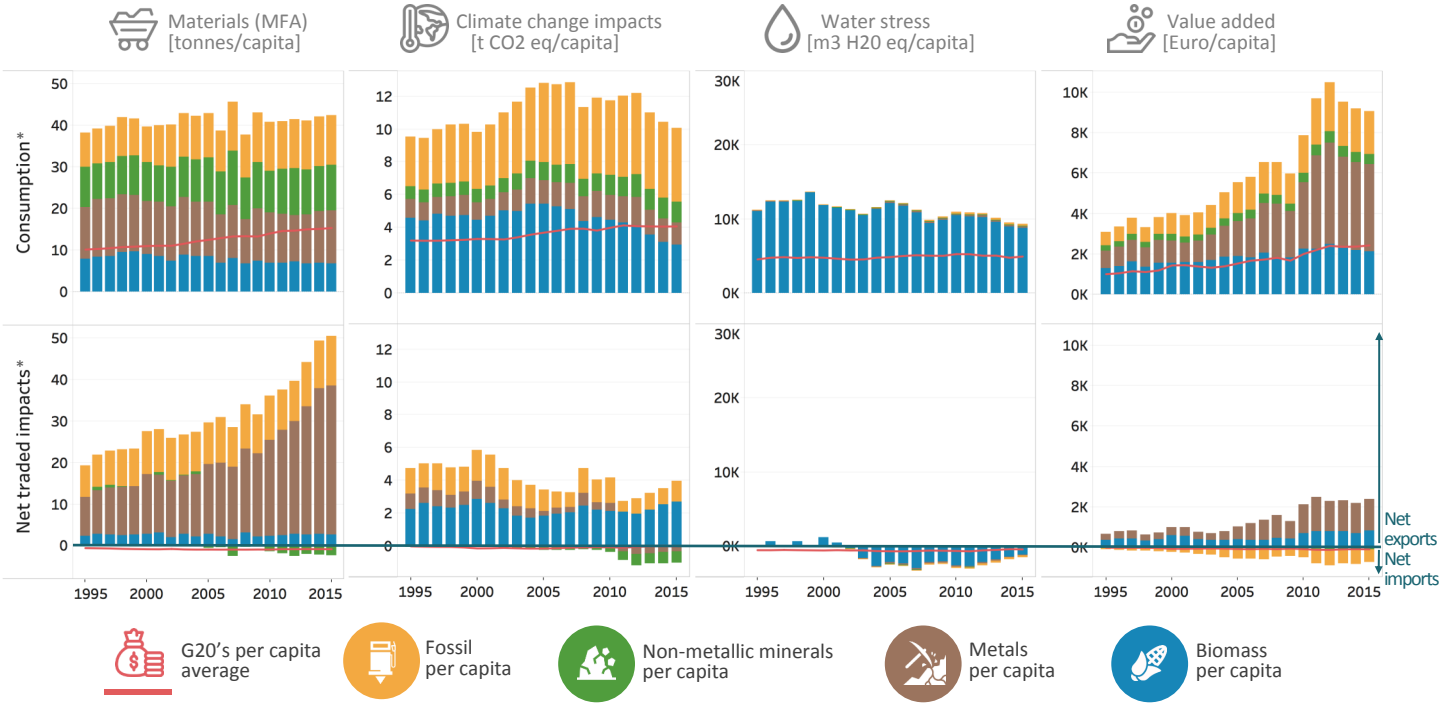


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- From a production perspective, material-related climate change impacts were mainly caused by coal and lignite mining and cattle farming (each more than 25% of these impacts).
- Material-related climate change impacts remained much higher than the G20 average.
- Most materials with large climate change impacts (beef, other food products and petroleum) were directly consumed by households especially for food, mobility and heating.
- The construction sector used the largest share of climate-intensive materials.
- From a production perspective, water stress within the Australian territory remained high. This is due to arid climate in large areas, and irrigation requirements of crops, mainly sugar, vegetables, fruits, nuts, wheat and cereals.
- From a consumption perspective, water stress is twice as high as the G20 average. It is dominated by the local production of crops (sugar, vegetables, fruits, nuts, wheat and cereals) and by imported wheat and rice.
- From a production perspective, per-capita land use-related biodiversity loss is eight times higher than the G20 average, mostly caused by cattle farming and forestry.
- From a consumption perspective, land use-related biodiversity loss was roughly 4 times higher than the G20 average due to extensive local cattle farming and forestry.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Australia (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Australia.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Australia was a large net exporter of metals and fossil resources, and a moderate net exporter of biomass. Furthermore, since 2006, Australia is a net importer of small amounts of non-metallic minerals.

More climate change impacts were caused by fossil and biomass exports than by fossil and biomass imports.

More climate change impacts were caused by imports of non-metallic minerals and metals than by exports of non-metallic minerals and metals (the latter since 2011).

Since 2002, more water stress impacts were caused by food imports (e.g. wheat) than by biomass exports (mainly sugar and meat).

For all biomass and metals, net value added was higher inside Australia than outside. It was the opposite for fossils.

Future trends and potential Decoupling

Scenarios developed by the IRP forecast an increase of GDP by more than a factor of 2.5 and a population growth of more than 60% until 2060.

If ambitious resource efficiency policies are introduced, Australia could see an absolute decoupling of domestic material extraction and domestic material consumption from GDP until 2060.

Material footprint and all environmental impacts per capita remained much higher than the G20 average. Reducing consumption of impactful resources like coal (particularly electricity), petroleum (particularly for mobility) and beef, and switching to more efficient and less impactful alternatives would make a difference.

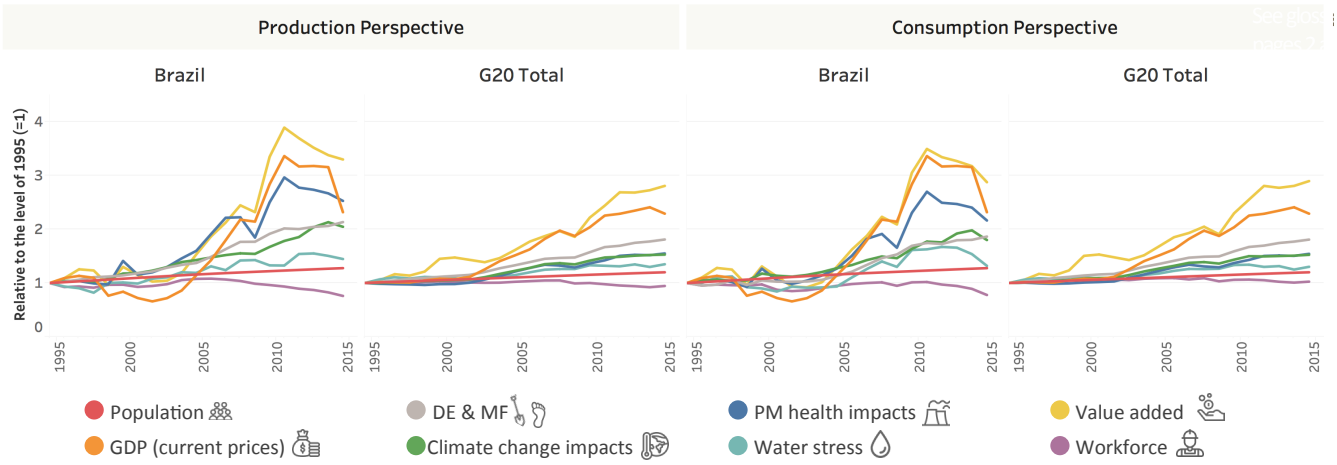
Designing material and energy efficient buildings could help decrease material related impacts in the construction sector.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Brazil

STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Brazil and in the G20 (1995-2015)*



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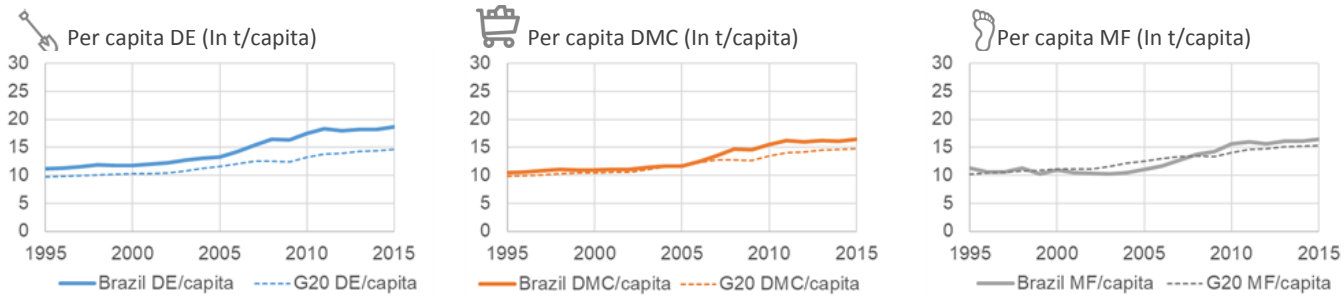


Source: IRP database

From 1995 to 2015

Population grew by **28%** and GDP more than doubled (with recessions at the beginning and end of the period).

Domestic extraction, domestic material consumption and material footprint slightly increased, similar to the G20 average.

By 2015, domestic extraction reached 19 tonnes per capita, while domestic material consumption and material footprint each reached 16 tonnes per capita (G20 average was 15 tonnes per capita for all three indicators).

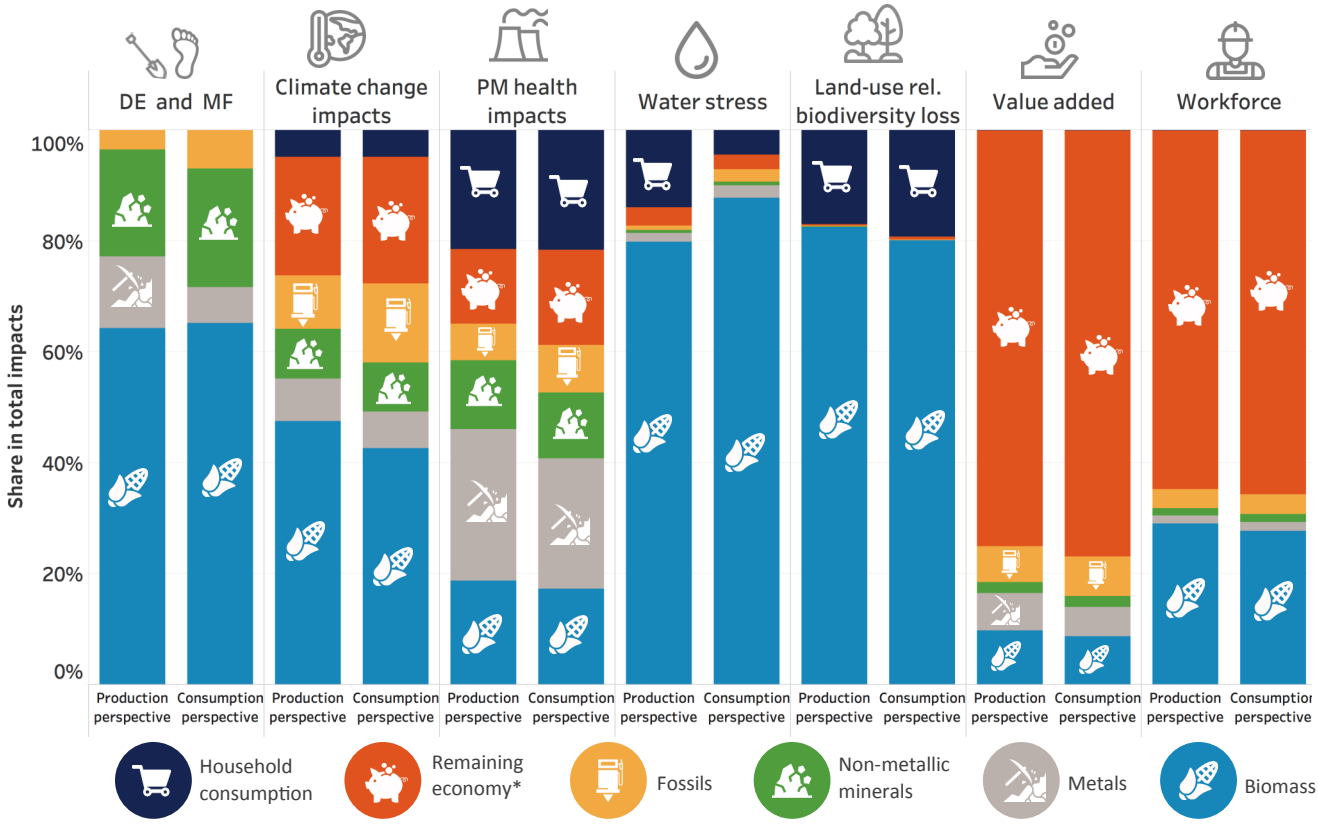
19 t/capita **16** t/capita **16** t/capita

Material-related environmental impacts decoupled relatively from GDP, except for particulate matter related health effects.

From both a production and consumption perspective, climate change impacts related to material extraction and processing increased and were slightly higher than the G20 average.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Brazil (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Unlike G20 average, biomass production dominated domestic extraction amounts and material footprint, followed by non-metallic minerals.

From a production and consumption perspective, the extraction and processing of natural resources accounted for more than 70% of Brazil's total climate change impacts (the G20 average is approximately 50% from both perspectives). More than 40% of these impacts come from the biomass sector (the G20 average is less than 20%).

Outdoor particulate matter related health impacts were mainly caused by the extraction and processing of natural resources (more than 60% from the production and consumption perspectives).

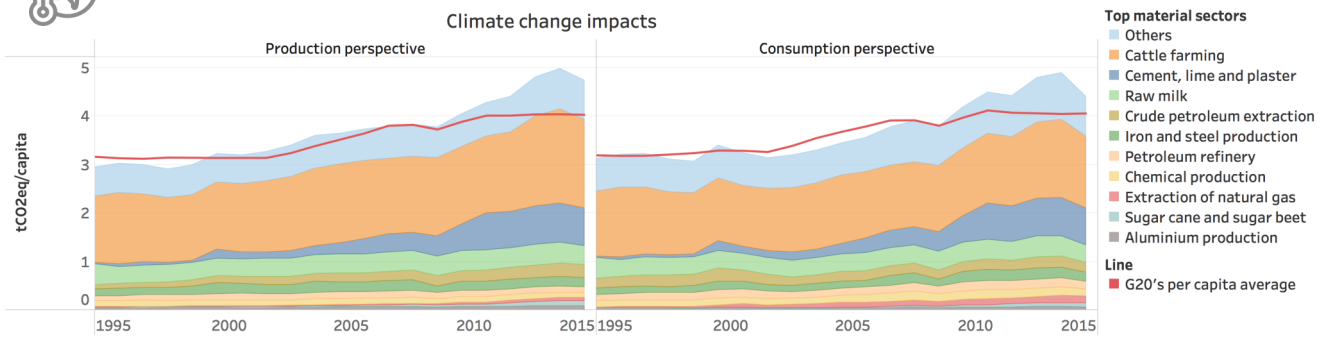
In line with other G20 countries, water stress and land-use related biodiversity impacts were caused mainly by biomass production.

From a production and consumption perspective, the material sector contributed to around 20% of value added, which is similar to the G20 average.

One third of the workforce is employed in material related sectors (mainly biomass production).

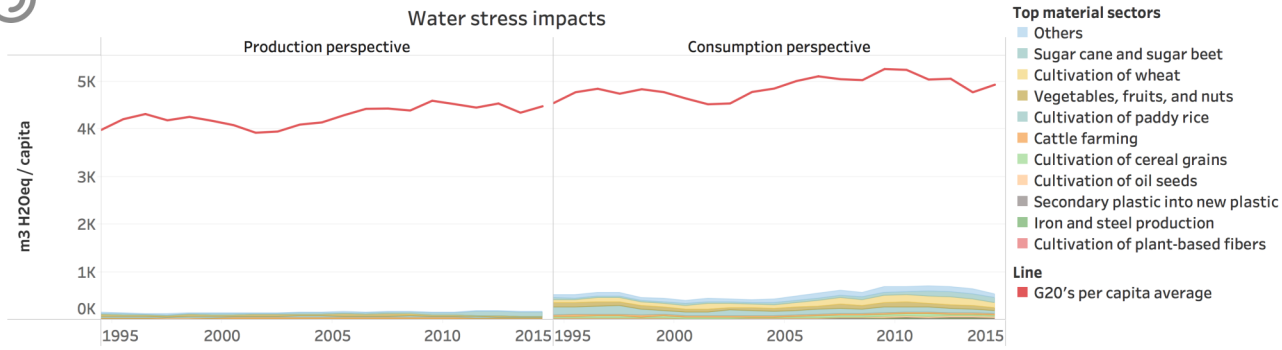
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Brazil (1995-2015)*



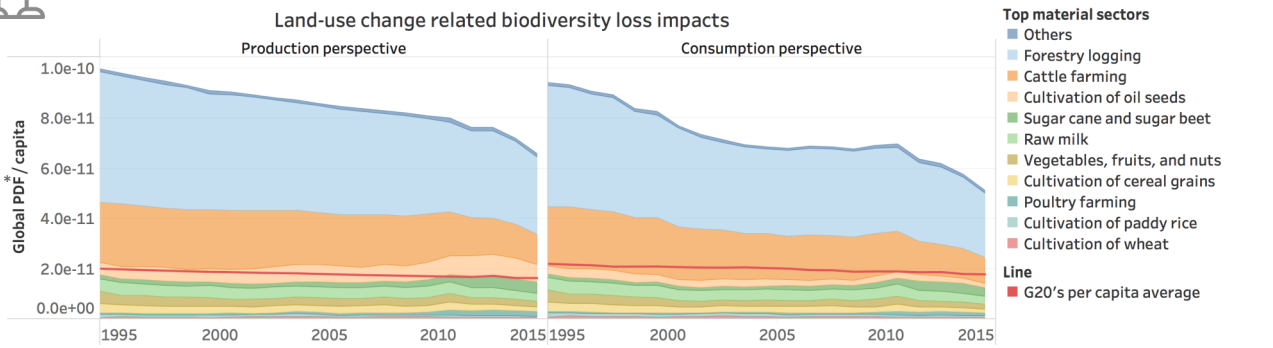
*Data after 2011 was nowcasted. Climate change impacts from deforestation were not included.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Brazil (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Brazil (1995-2015)*

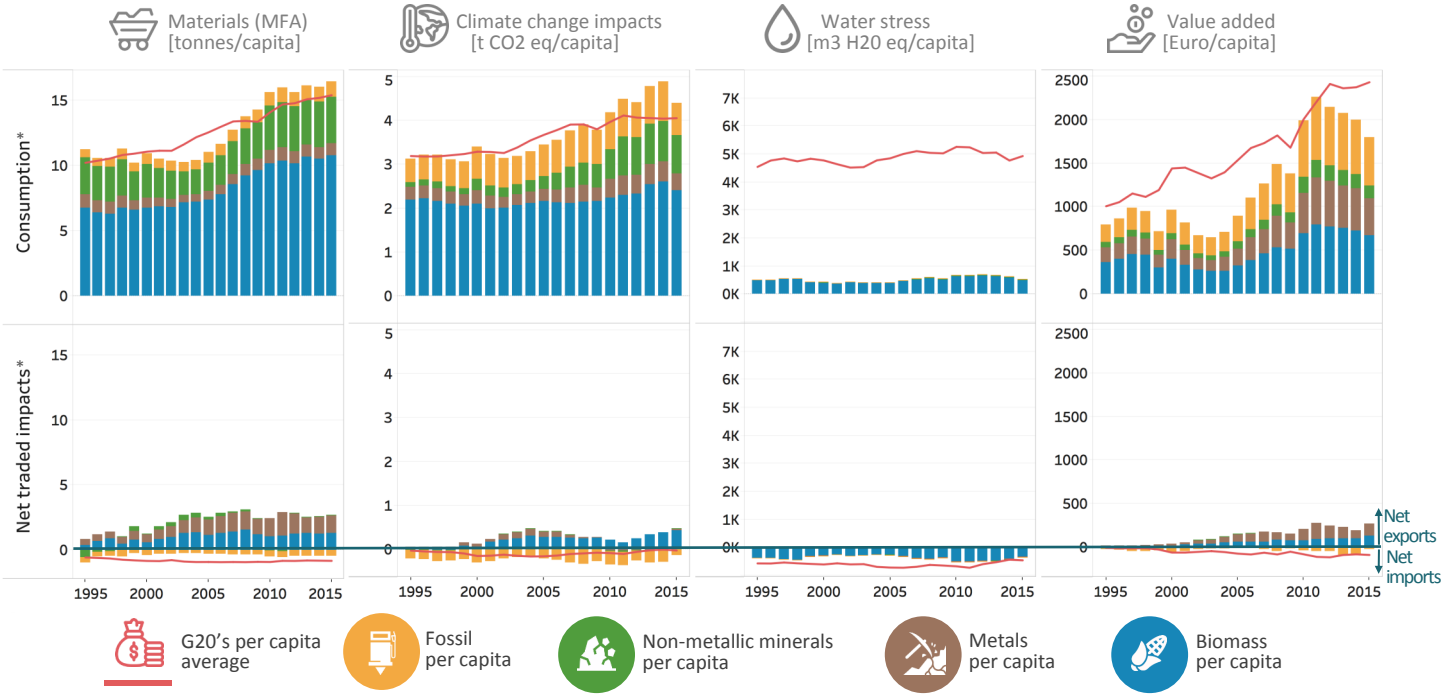


*Data after 2011 was nowcasted. Only biodiversity impacts of deforestation registered as land used for cropland or pasture were accounted for.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- From a production and consumption perspective, material-related climate change impacts were mainly caused by cattle farming, followed by cement, milk production, petroleum extraction, and steel production. Climate change impacts from land use change (e.g. deforestation) were not included in this analysis.
- Material-related climate change impacts were higher than the G20 average, by about 20% from a production perspective and 10% from a consumption perspective. This difference is due to emissions from cattle farming (i.e. beef exports).
- Most materials with large climate impacts (beef, dairy and petroleum products) are directly consumed by households.
- The construction sector is the major industrial end-user of climate-intensive materials (18% of total material-related impacts).
- While Brazil has abundant water resources, some regions suffer from water scarcity. Compared to the G20 average, water stress impacts in Brazil are negligible (from both perspectives).
- From a production perspective, land-use related biodiversity loss was almost four times higher than the G20 average.
- From a consumption perspective, land-use related biodiversity loss was three times higher than the G20 average. Forestry, contributed to almost half of these impacts, followed by beef, oil seeds and sugar production. Note that land use change impacts (deforestation) were assessed here only when there was a new registered use for the deforested area (e.g. cropland). As a consequence, biodiversity loss in Fig. 6 is underestimated.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Brazil (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Brazil.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase 3.4, Cabernard et al. 2019

- Brazil is a net exporter of all material types, except for fossils. Net traded amounts of materials were low compared to consumption, except for metals.
- More climate change impacts are caused by material exports than by material imports, except for fossils. Biomass is the main source of net impacts.
- More water stress is caused by imports than exports due to imports of biomass from water-scarce countries.
- For all material types but fossils, material trade created net value added within Brazil.

Future trends and potential Decoupling

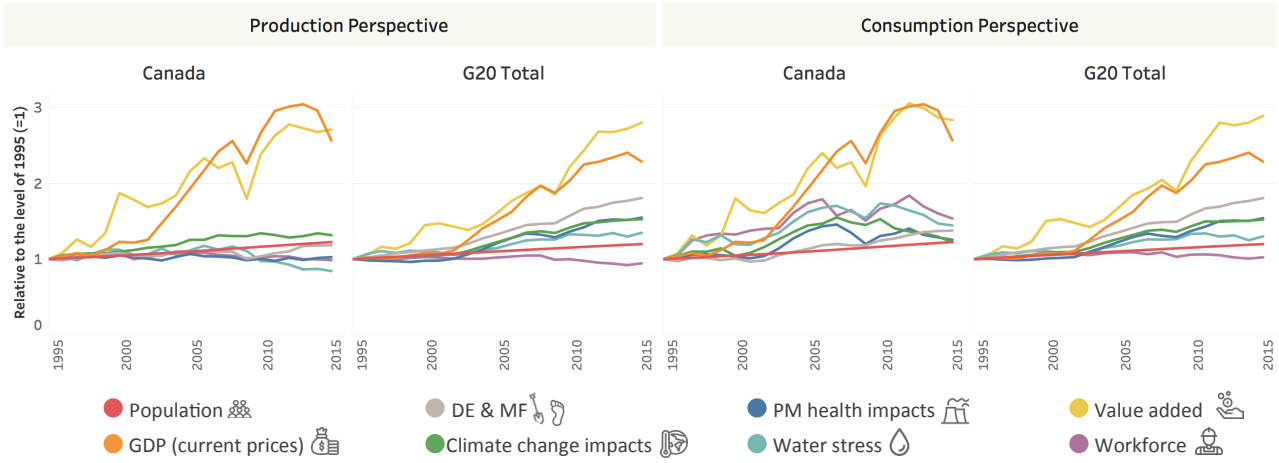
- Scenarios developed by the IRP forecast an increase of GDP by a factor between 2.7 and 3.7 and a population growth of between 3% and 13% until 2060.
- If ambitious resource efficiency policies are introduced, Brazil could achieve a relative decoupling of domestic material extraction and domestic material consumption from GDP until 2060.
- Overall, domestic extraction and domestic material consumption are projected to increase by about 40% and 30%, respectively, in the resource efficiency scenario.
- Brazil suffers from particulate matter pollution from resource extraction and processing, especially related to metal exports (mainly iron and steel). Improving emission control in material sectors is important.
- A large build-up of infrastructure is anticipated in the next decades. This could result in enhanced resource demands and environmental impacts from steel and cement production. Material efficient urban design is therefore crucial.
- Forest protection policies in Brazil significantly slowed down deforestation of the Amazon rainforest in the last 10 years but rates have started to rise again. Improved management and protection of this unique ecosystem is critical to lower environmental impacts

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Canada

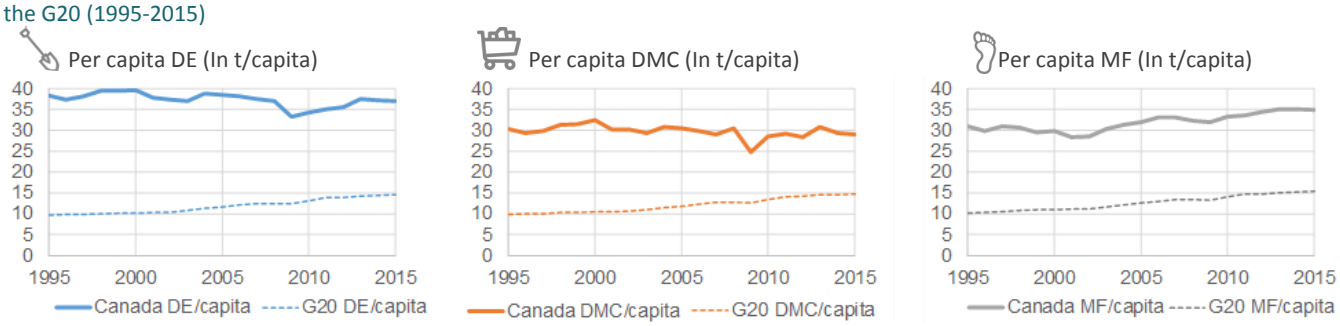
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Canada and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction (DE), domestic material consumption (DMC), and material footprint (MF) per capita in Canada and in the G20 (1995-2015)



Source: IRP database

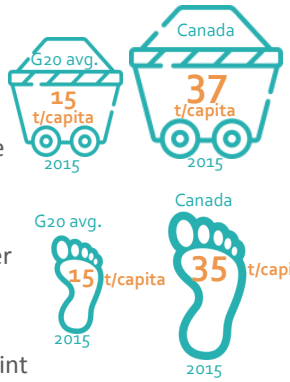
From 1995 to 2015

Population grew by **23%** and GDP grew by a factor of **2.5**

Domestic extraction remained rather stable at **37** tonnes per capita (G20 average was 15 tonnes/capita in 2015).

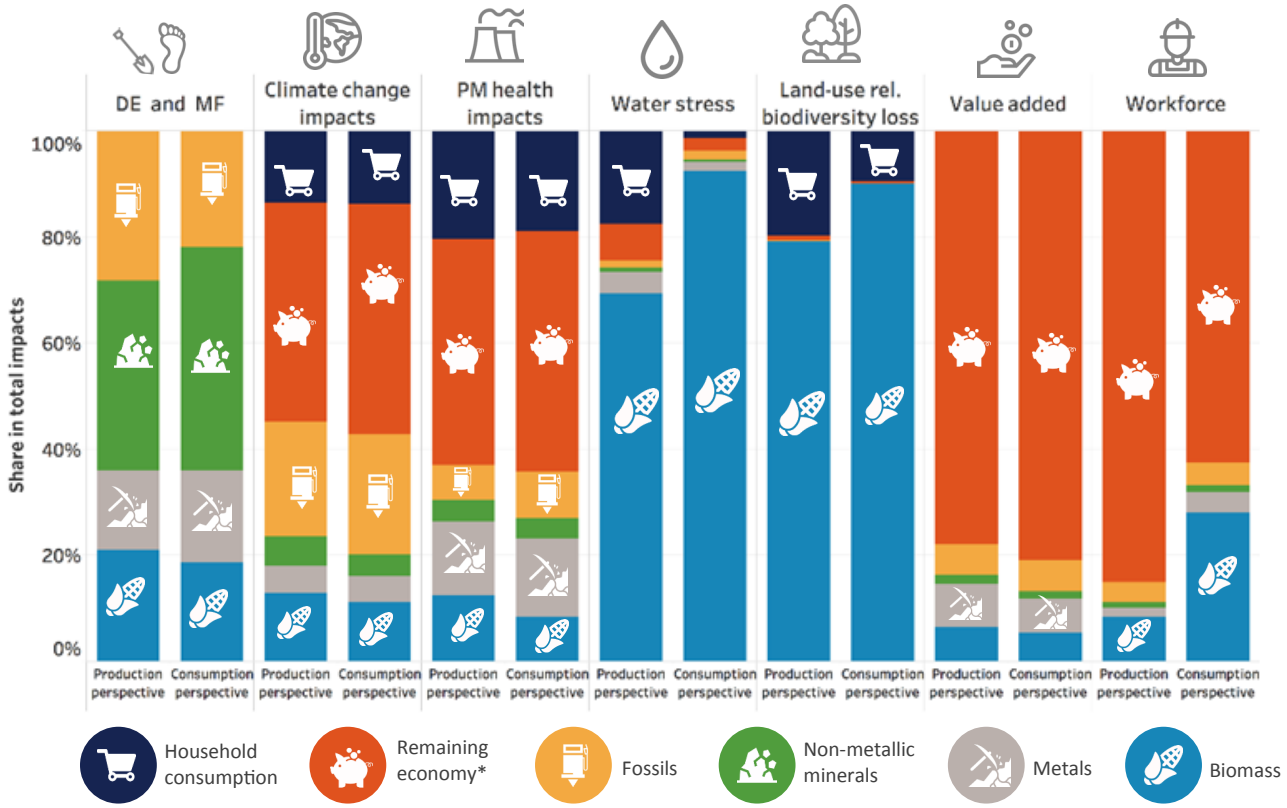
Material footprint increased from **31** tonnes per capita in 1995 to **35** tonnes per capita (G20 average was 15 tonnes per capita in 2015).

From a consumption perspective, there was a relative decoupling of material footprint and all environmental impacts from economic growth. However, climate change impacts were more than double the G20 average.



Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Canada (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

In line with G20 average, non-metallic minerals like sand and gravel dominated the share of domestic extraction amounts and material footprint, but contributed to only a minor share of environmental impacts.

The extraction and processing of natural resources accounted for more than 40% of Canada's total climate change impacts from both a production and consumption perspective (the G20 average was approximately 50% from both perspectives).

In line with other G20 countries, Canada's water stress and land use-related biodiversity impacts were caused mainly by biomass production from a consumption perspective.

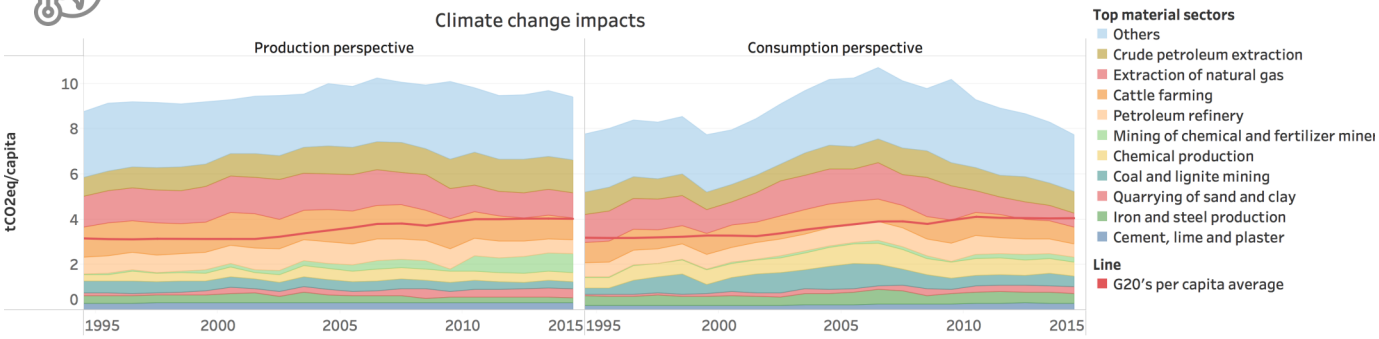
Resource extraction and processing caused almost 40% of outdoor particulate matter related health impacts.

The material sector contributed to a minor share of value added as well as domestic jobs (both around 20%), and relied on low-income workforce in agriculture outside of Canada for food imports.

In general, for all indicators but water stress and workforce, the share related to material extraction and processing from a consumption perspective was comparable to the share related to material extraction and processing from a production perspective.

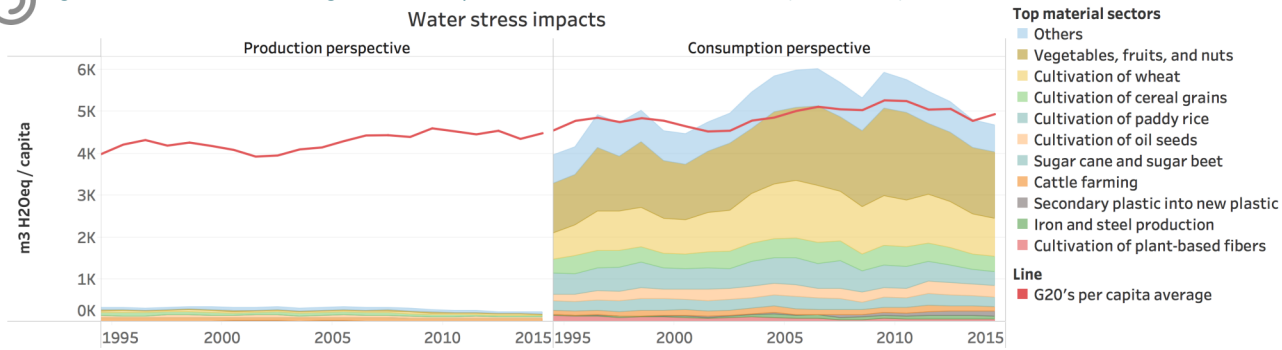
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Canada (1995-2015)*



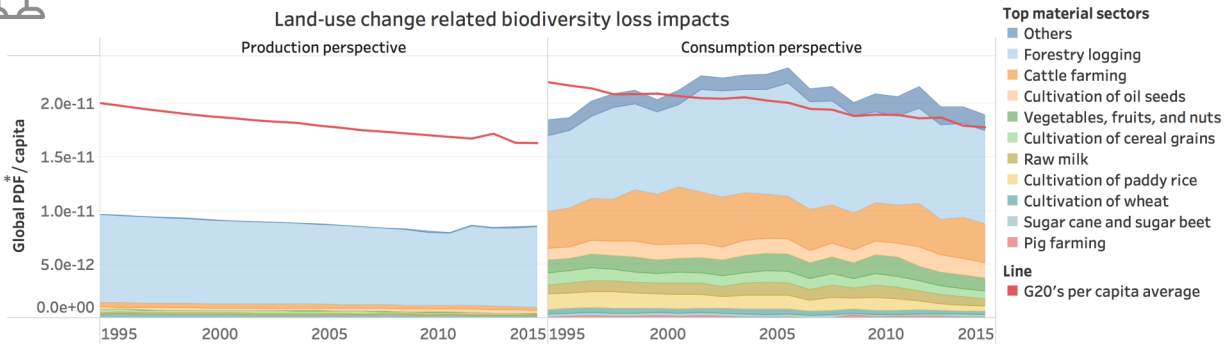
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Canada (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Canada (1995-2015)*

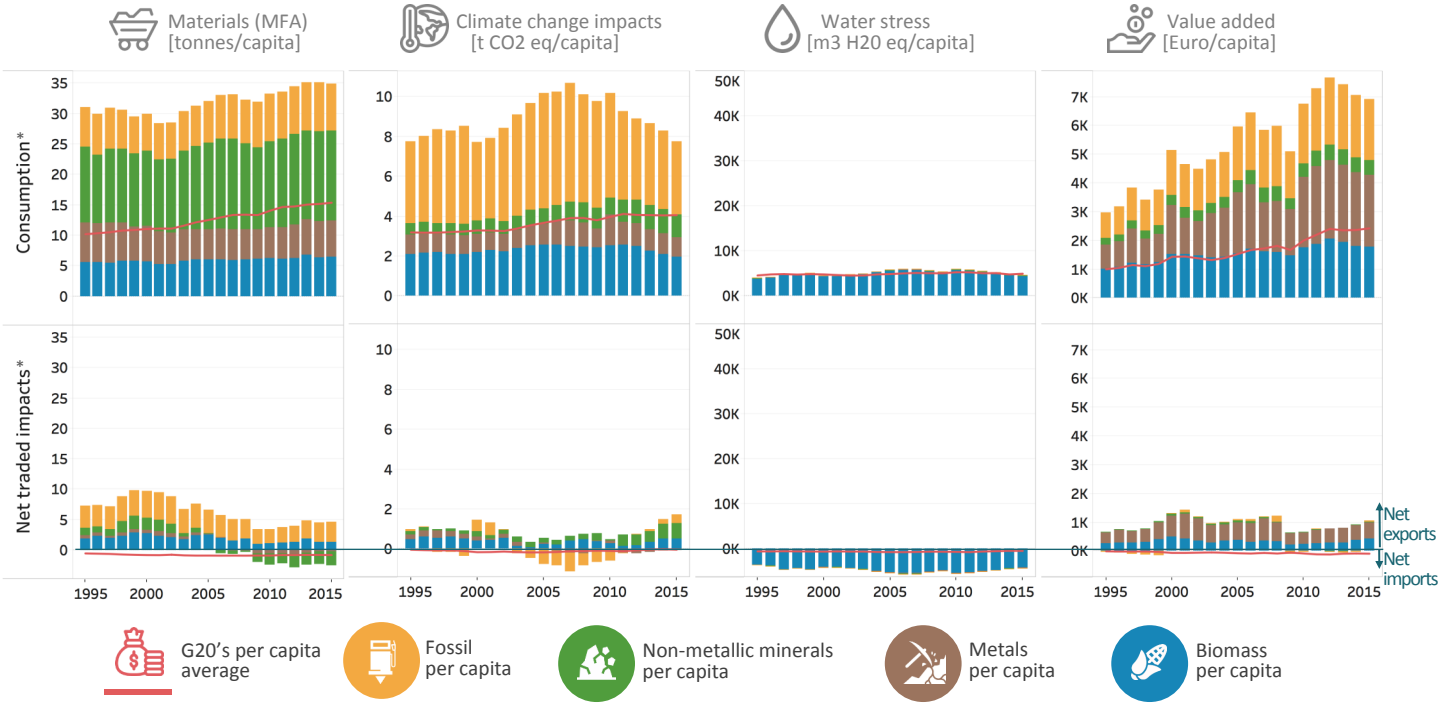


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts in Canada were mainly caused by the extraction and refinery of petroleum, the extraction of natural gas, cattle farming, and mining of chemical and fertilizer minerals.
- Climate change impacts remained much higher than the G20 average (double for both perspectives in 2015).
- Materials with large climate impacts (petroleum, natural gas and beef) were mostly consumed by households, especially for mobility, heating and food.
- The construction and motor vehicle manufacturing sectors were the largest industrial users of climate-intensive materials.
- From a production perspective, there was almost no water stress within Canadian territory. This was due to low irrigation requirements and sufficient availability of renewable water sources to cover internal demand.
- From a consumption perspective, water stress levels were comparable to the G20 average. These were caused mainly by agricultural activities related to imports of vegetables, fruits, nuts, and wheat.
- From a production perspective, land use-related biodiversity loss was lower than the G20 average, mainly caused by forestry activities. However, from a consumption perspective, land use-related biodiversity loss was comparable to the G20 average due to imports of beef, oil seeds, vegetables, fruits and nuts from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Canada (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Canada.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Canada has been a net exporter of biomass and fossil resources and a net importer of minerals since 2006.
- More climate change impacts were caused by exports of biomass and non-metallic minerals than by imports. The trade balance for fossils and metals fluctuated over the years.
- Food imports caused higher water stress impacts in the countries of origin than biomass exports from Canada (mainly wood).
- For all material types, net value added was higher inside Canada than outside.

Future trends and potential Decoupling

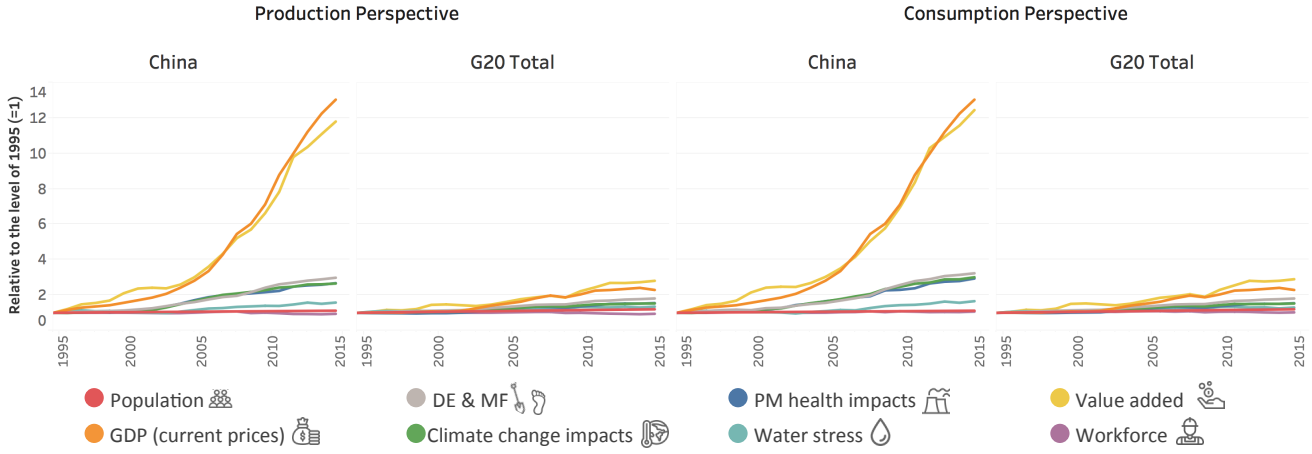
- Scenarios developed by the IRP forecast an increase of GDP by more than a factor of 2 and a population growth of more than 40% until 2060.
- If ambitious resource efficiency policies are introduced, Canada could see absolute decoupling of domestic material extraction and domestic material consumption from GDP until 2060.
- Material footprint and all environmental impacts per capita remained higher than the G20 average. Reducing the consumption of impactful resources like petroleum (particularly for mobility) and beef could help lower these impacts. Furthermore, material related impacts could be reduced with the design of material-efficient infrastructure and fossil fuels (natural gas) by constructing energy-efficient buildings.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | China

STATUS AND TRENDS OF NATURAL RESOURCE USE

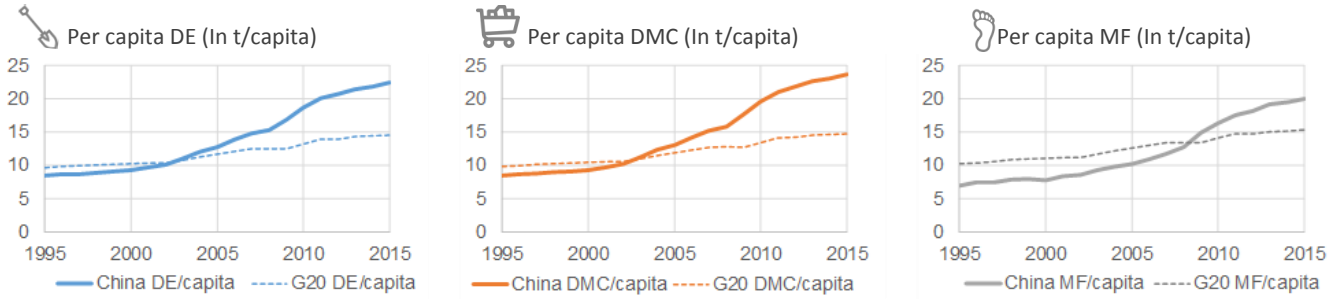
Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in China and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in China and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

GDP multiplied **thirteenfold**, while population increased only slightly.

In 2015, more than 1/3 of global resource extraction and 45% of total resource extraction in the G20 took place in China .

Material footprint, climate change and particulate matter (PM) health impacts related to resource extraction and processing **tripled** and are now higher than G20 average.

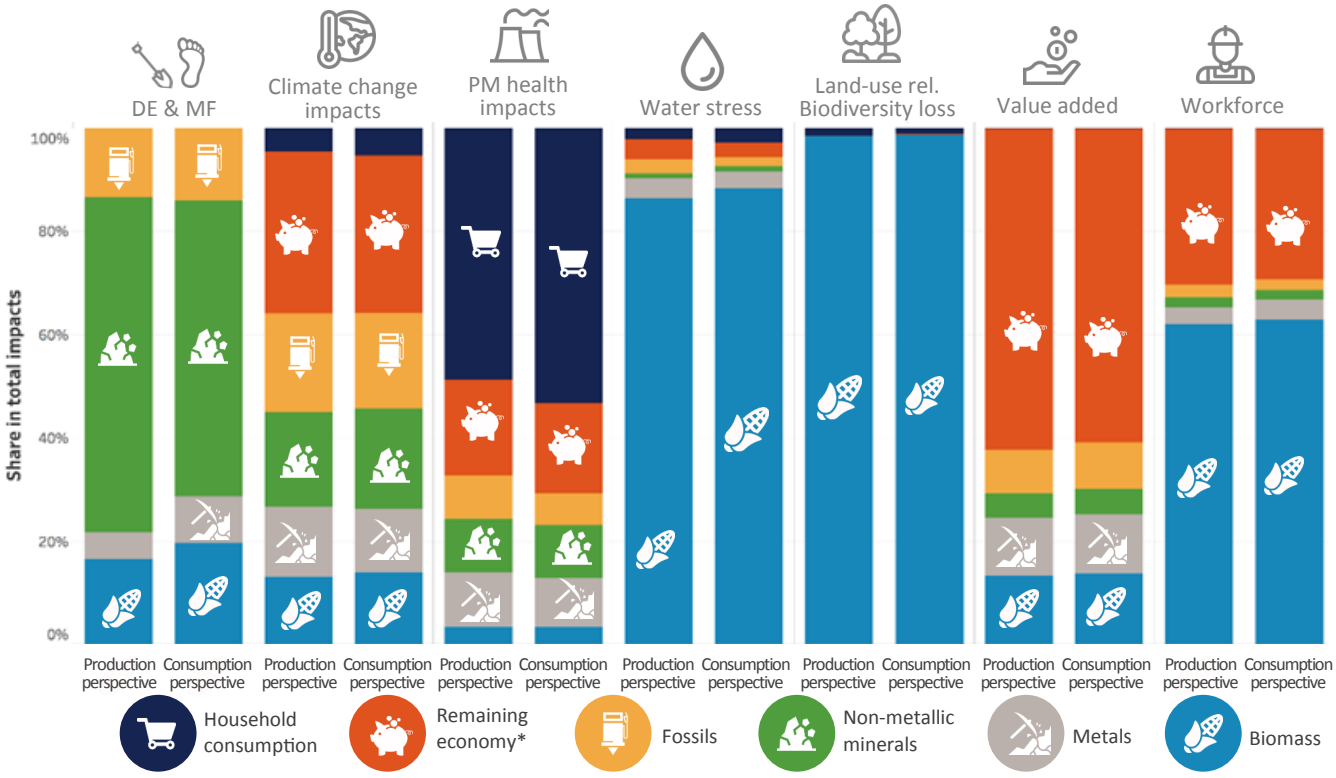
Water stress grew by **50%**

China experienced a **strong relative decoupling** of both material use and impacts from national GDP.

Material intensity and environmental impact intensity (Impacts/GDP) significantly improved.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in China (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated domestic extraction and material footprint (higher than the G20 average), but played a comparably minor role for environmental impacts.

Resource extraction and especially material processing contributed to approximately 65% of total climate change impacts in China. This was due mostly to large build-up of infrastructure as an emerging economy.

In line with other G20 countries, water and land use-related biodiversity impacts were caused mainly by biomass production.

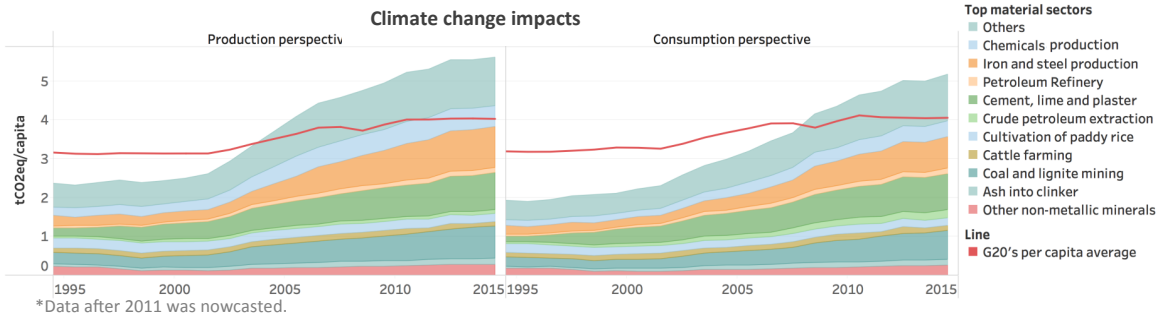
Outdoor PM related health impacts came mainly from household activities (e.g. heating and cooking) and industrial resource use (e.g. coal electricity).

More than one third of economic value added was created through resource extraction and processing in China. This is larger than the G20 average.

Resource extraction and processing provided 70% of all jobs in China, which were mainly low-income agriculture jobs.

Key Sectors and Resources

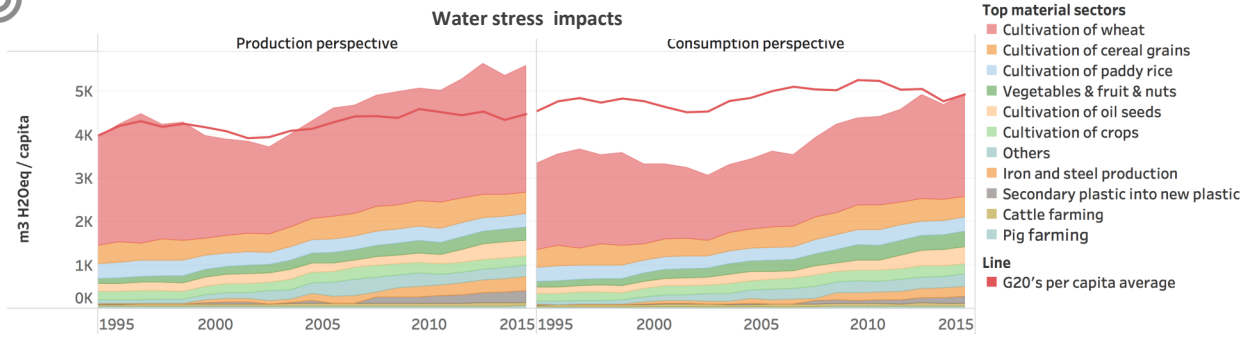
Figure 4: Climate change impacts from material sectors in China (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

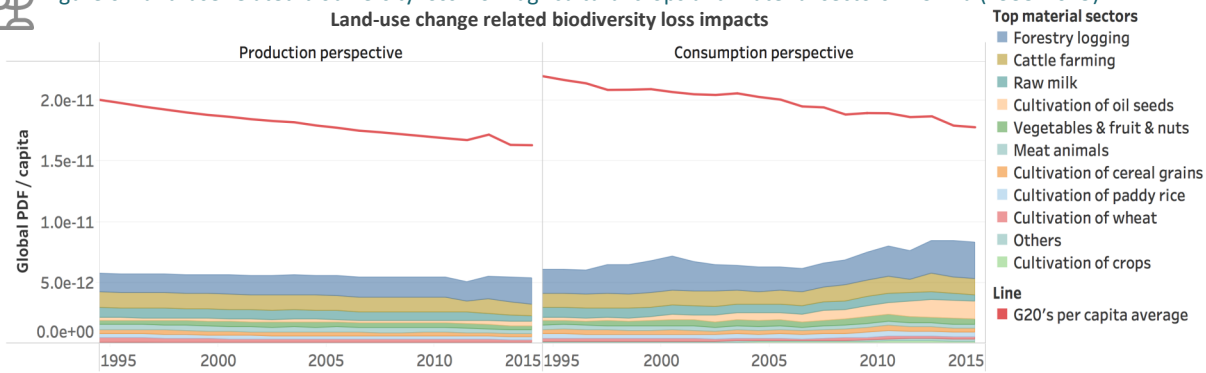
Figure 5: Water stress from agricultural crop and material sectors in China (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in China (1995-2015)*



*Data after 2011 was nowcasted.

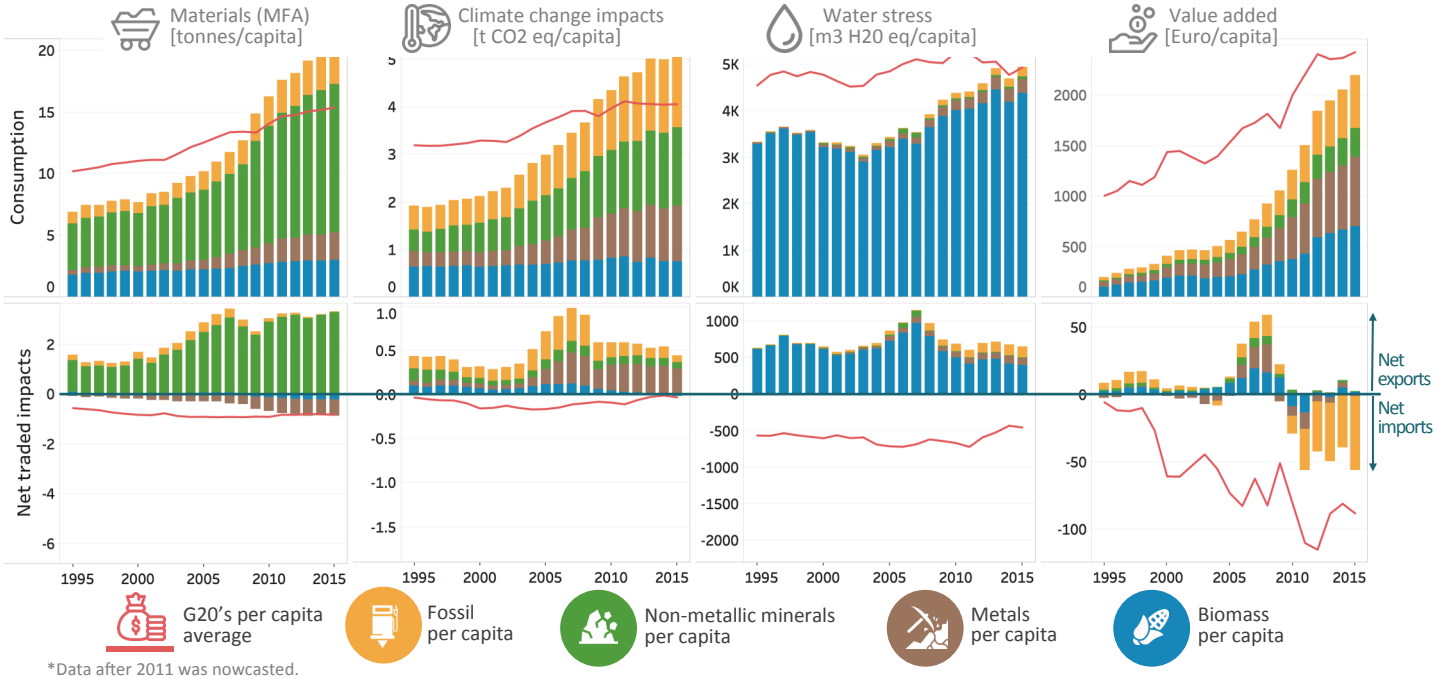
**PDF:* Potentially disappeared fraction of species

Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- In the past 15 years, build-up of infrastructure has led to major increases in climate change impacts from construction materials, particularly cement and steel.
- China has become the world's top steel and cement producer. It contributed to more than half of global greenhouse gas emissions emitted by these sectors in 2015.
- Other important material sectors include the chemical industry and mining of coal and lignite, which have grown threefold in the last two decades to produce electricity for China's growing economy.
- Water stress impacts in China are mostly produced by agricultural activities due to irrigation for wheat, cereal, paddy rice and oil seed production.
- Water stress impacts significantly increased between 1995 and 2015 due to the cultivation of oil seeds, wheat and cereals for meat production. It also increased due to the cultivation of vegetables, fruits, and nuts, and the production of iron and steel.
- Water stress impacts are higher from a production perspective due to wheat exports.
- Overall, biodiversity loss impacts in China remained below the G20 average.
- Forestry and cattle farming are the main sources of land-use related biodiversity loss.
- Impacts from the production of cereals and oil seeds increased between 1995 to 2015 from a consumption perspective, due to imports from regions with high rates of biodiversity loss.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in China (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in China.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

China is a net exporter of non-metallic minerals, which dominate material exports. However, the picture is different for other resource categories.

In 1995 more fossils and biomass were exported than imported. By 2015, this situation was reversed for biomass and evened for fossils.

Climate change impacts caused by metal exports were larger than climate change impacts caused by metal imports. This is due to the energy and water intensity of metal processing taking place in China (i.e. production of steel). Impacts of imported ores are relatively low.

After 2010, value added was generated by China's domestic material production more than by its material consumption. This is mainly attributed to imports of fossils (mostly crude petroleum).

Future trends and potential Decoupling

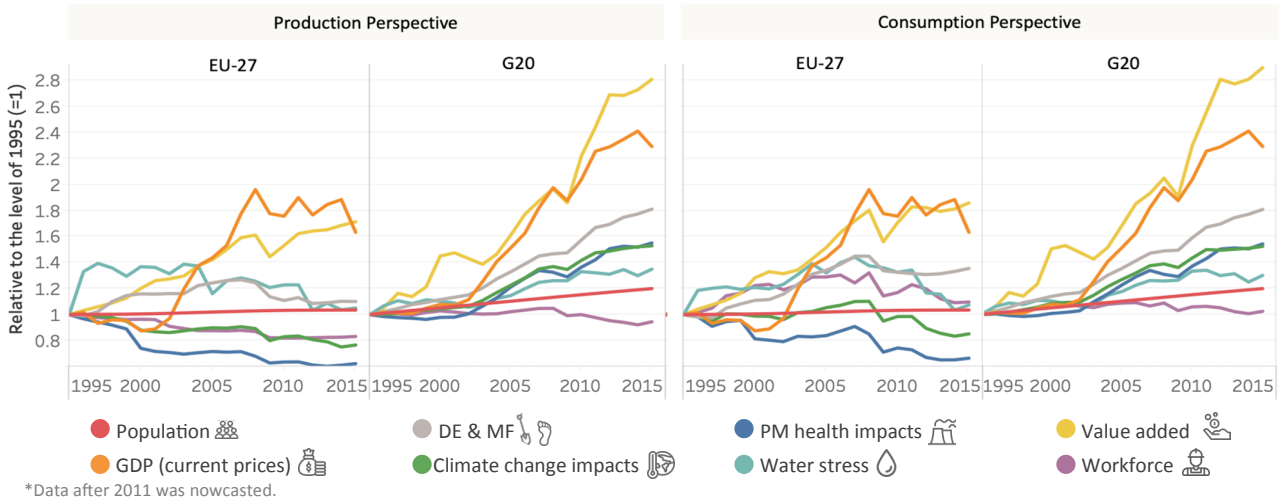
- Scenarios developed by the IRP forecast an increase of GDP for China by a factor of ~4 and for DE and DMC an increase lower than a factor of 2 by 2060. This means relative material decoupling will happen.
- If ambitious resource efficiency policies are introduced, China could even see an absolute decoupling of material extraction after 2040.
- Material productivity has largely improved in the last decades in China. The continuation of this positive trend could have a large effect globally on the decrease of environmental impacts.
- Several types of environmental impacts have decoupled relatively from material extraction in China. Opportunities for further improvement exist, especially in the coal-based electricity sector, which is responsible for 23% of the supply chain climate impacts.
- A large share of material-related environmental impacts was caused by the build-up of infrastructure. Material-efficient urban design and circular economy solutions could help lower these impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | European Union (EU-27)

STATUS AND TRENDS OF NATURAL RESOURCE USE

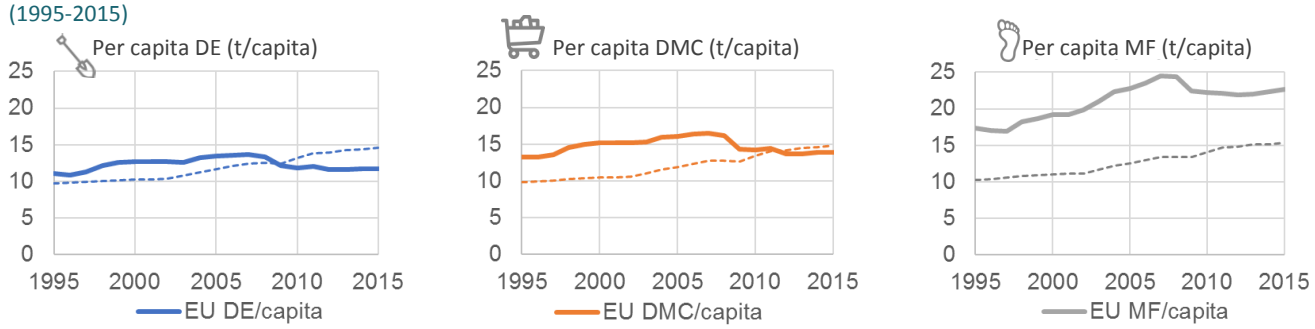
Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in the European Union and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in the European Union and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population increased only slightly (**5%**), while GDP **doubled** until the start of the financial crisis in 2007 (Figure 1). Afterwards, GDP declined slightly with some fluctuations.

The EU's per capita DE and DMC remained constant and fell below G20 average (Figure 2). In contrast, per capita MF increased (**+30%**) and remained **50%** above the G20 average. This increase is attributed to doubling of the net material imports (Figure 7).

Despite the increasing material footprint, material-related climate change and particulate matter (PM) health impacts decreased in both perspectives (Figure 1). This decrease is stronger in the production than in the consumption perspective. This points to strong environmental policy and technology improvements, particularly for domestically produced materials.

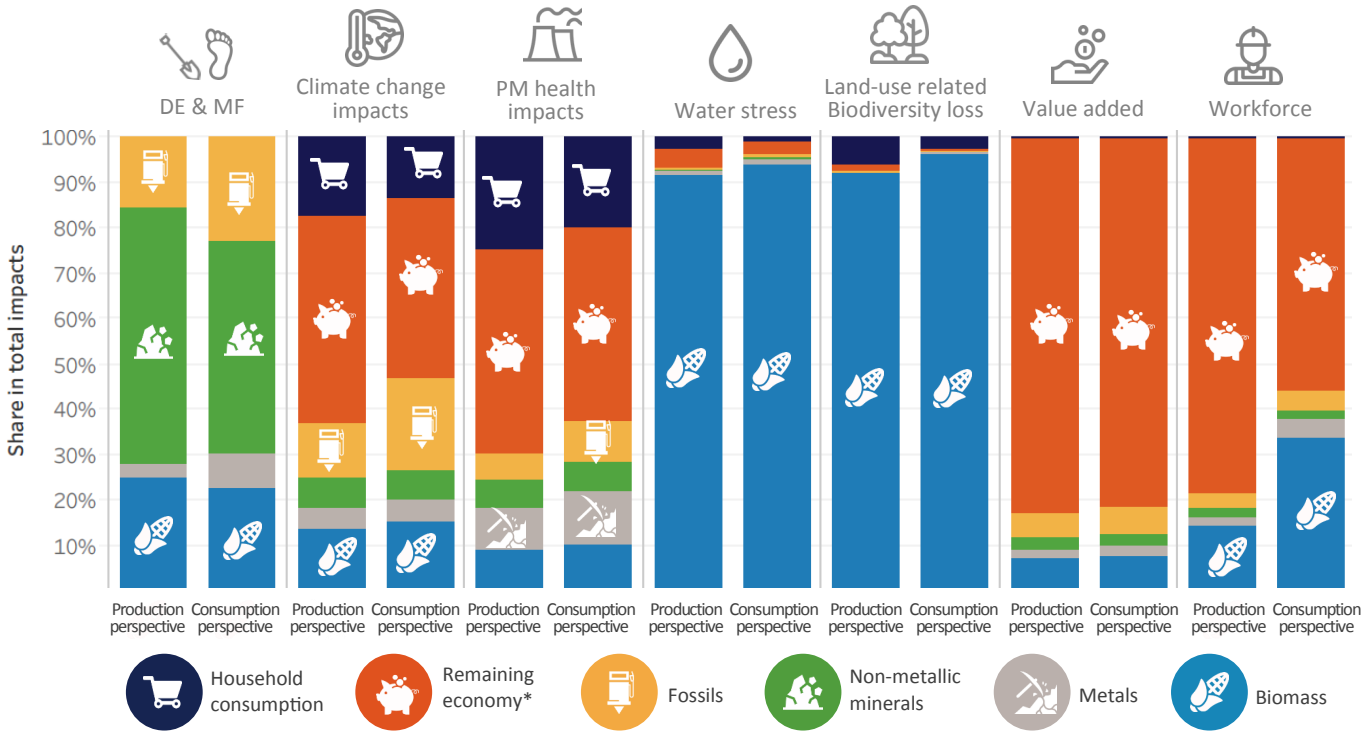
Despite decreasing climate change impacts, material-related per capita climate change footprints remained above the G20 average in the consumption perspective (**+25%** in 2015, Figure 4).

Per capita water stress footprints increased until 2007 (**+40%**), then decreased back to the 1995 level, however continue to remain above the G20 average in the consumption perspective (**+20%** in 2015, Figure 5).

Technology improvements and increased material imports have decreased the fraction of the EU's population working in the material sector (**-20%** , Figure 1). The value added created in the EU's material sector increased by **70%** .

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in the European Union (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals such as sand and gravel dominated the domestic extraction amounts and material footprint (>50%), but were responsible for a minor share of environmental impacts (<7% for all impact categories, Figure 3).

The extraction and processing of resources contributed to almost 40% of domestic climate change impacts and almost half of climate change impacts from a consumption perspective. This was lower than the G20 average in the production perspective, but similar in the consumption perspective (the G20 average was approximately 50% for both perspectives).

75% of material-related climate change impacts were caused by biomass and fossils in the consumption perspective.

Outdoor particulate matter (PM) related health impacts were mainly caused by the remaining economy (>40%) and households (>20%) in both perspectives.

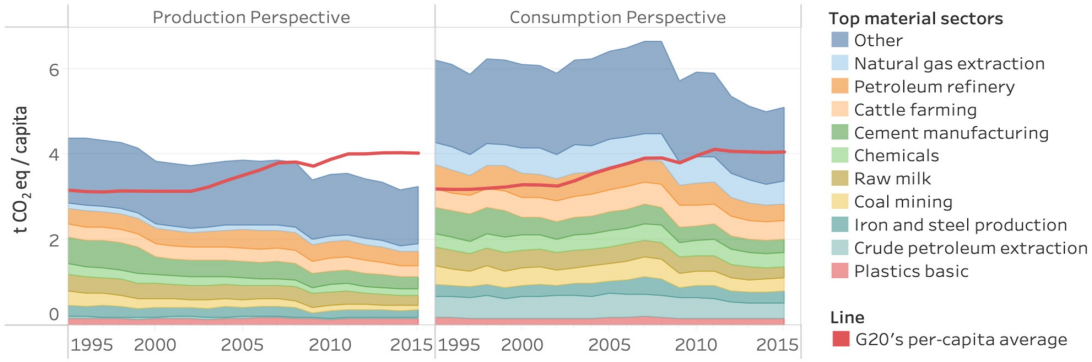
In line with the G20 average, water stress and land use-related biodiversity impacts were caused mainly by biomass production in both perspectives.

The material sector contributed a minor share to value added as well as domestic jobs (both less than 20%), but relied on low-income workforce in the agriculture outside the EU for food imports.

For all indicators, the share related to material extraction and processing was higher from a consumption than from a production perspective, pointing to the reliance on material imports.

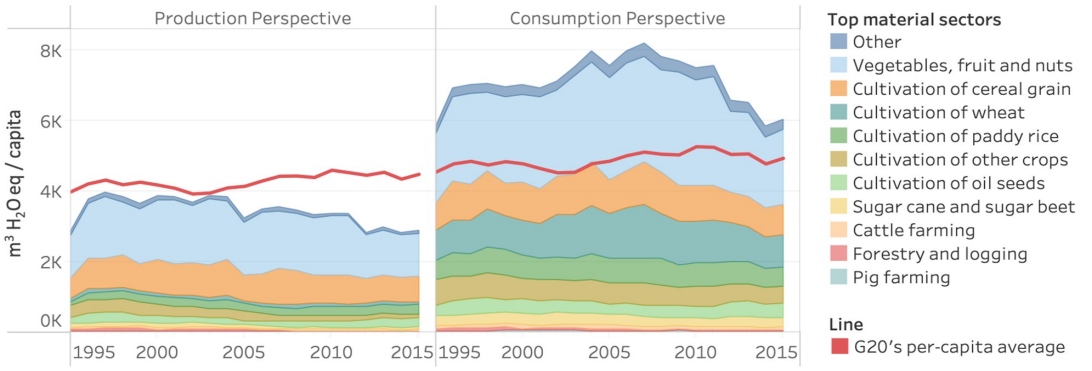
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in the European Union (1995-2015)*



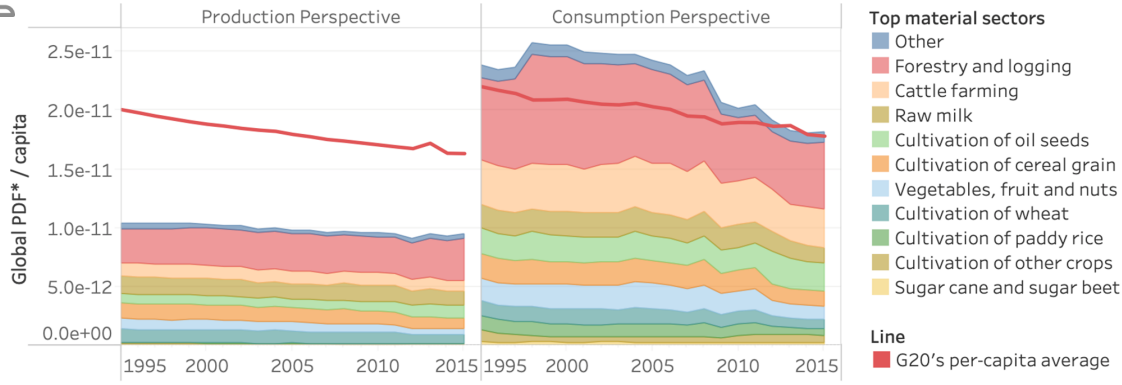
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in the European Union (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in the European Union (1995-2015)*

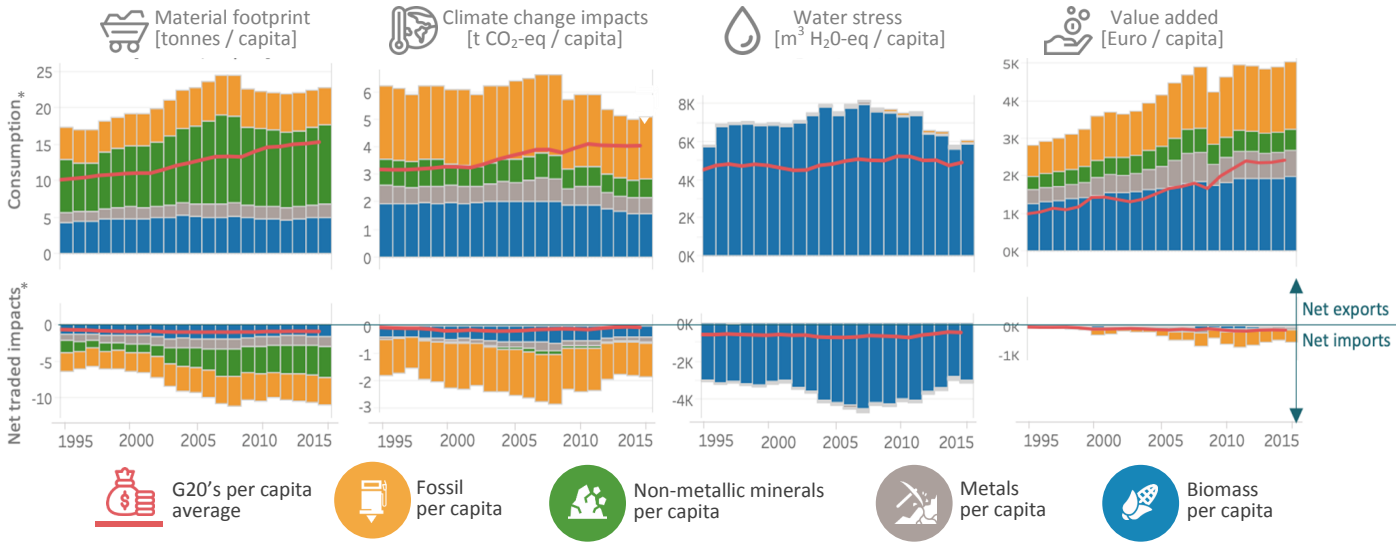


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Half of material-related climate change impacts were caused by petroleum, cement, cattle, natural gas and coal (in both perspectives, Figure 4).
- Material-related climate change impacts were 60% higher in the consumption than in the production perspective in 2015 (Figure 4). This was mainly attributed to the import of petroleum, natural gas, coal, and chemicals.
- The majority of biomass and fossils were directly consumed by households as food, for heating and private transport. Households were responsible for 60% of material-related climate change impacts (Year 2015, data not shown here).
- Minerals mainly ended up in the construction sector, electrics and electronics and the automobile industry. These end-sectors were responsible for 25% of material-related climate change impacts (14% construction, 7% electrics and electronics, 5% automobile industry; Year 2015, data not shown here).
- From a consumption perspective, a third of the water stress impacts were caused by the cultivation of vegetables, fruits and nuts and another 50% by the cultivation of cereals, wheat, paddy rice, oil seeds, sugar cane and other crops (Figure 5).
- Land-use related biodiversity loss was 50% lower than the G20 average in the production perspective, but comparable to the G20 average in the consumption perspective (Figure 6).
- Forestry logging, cattle and raw milk production were responsible for half of land-use related biodiversity loss (Figure 6).
- Water stress and land-use related biodiversity losses were more than twice as high in the consumption than in the production perspective (Figure 5 and 6). This was mainly attributed to imports of vegetables, fruits, nuts, and wheat for water stress and to imports of wood products, cattle meat and oil seeds for land-use related biodiversity loss.
- The consumption of animal products was responsible for 24% of material-related climate change impacts, 15% of water stress, and 40% of land-use related biodiversity loss (Year 2015, data not shown here). For water stress and land-use related biodiversity loss, 65% of these impacts were caused outside the EU due to imports of animal products and fodder crops.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in the European Union (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in the European Union.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

The EU was a net importer of all material types. Accordingly, more environmental impacts were caused outside the EU for material imports than within its borders for material exports.

Half of EU's material footprint came from imported materials (mainly minerals and fossils).

The reliance on trade was highest for fossils. More than 70% of consumed fossils were extracted abroad. Consequently, the majority of climate change impacts related to the extraction and processing of these fossils were caused outside the EU.

Although 65% of consumed biomass was cultivated domestically, the majority of water stress and land-use related biodiversity loss impacts were caused abroad. This was mainly attributed to food and wood imports from regions with significant water scarcity and high ecological value.

Despite the high fraction of environmental impacts caused abroad, the majority (>90%) of the value added related to material production was generated within the EU.

Future trends and potential Decoupling

Per capita impacts remained above or equal the G20 average in the consumption perspective. Depending on the impact category, between 40 and 70% of impacts occur outside the EU. Therefore, responsible sourcing along the entire supply chain (with a special focus on fossils for climate change and agricultural products for water stress and land-use related biodiversity loss), as well as resource efficiency and circular economy strategies are critical to lower these impacts.

A shift from fossil electricity and heat supply to renewable energy production (wind, water, solar, etc) would lower the high climate change impacts from fossil extraction and processing.

Material efficient construction and urban design (e.g. substitution of high-impact materials like cement) can decrease EU's material footprint and related impacts. This includes also resource efficient building restoration (e.g. for better insulation and fuel saving for heating) and offering good public transport systems in and between cities to lower mobility impacts.

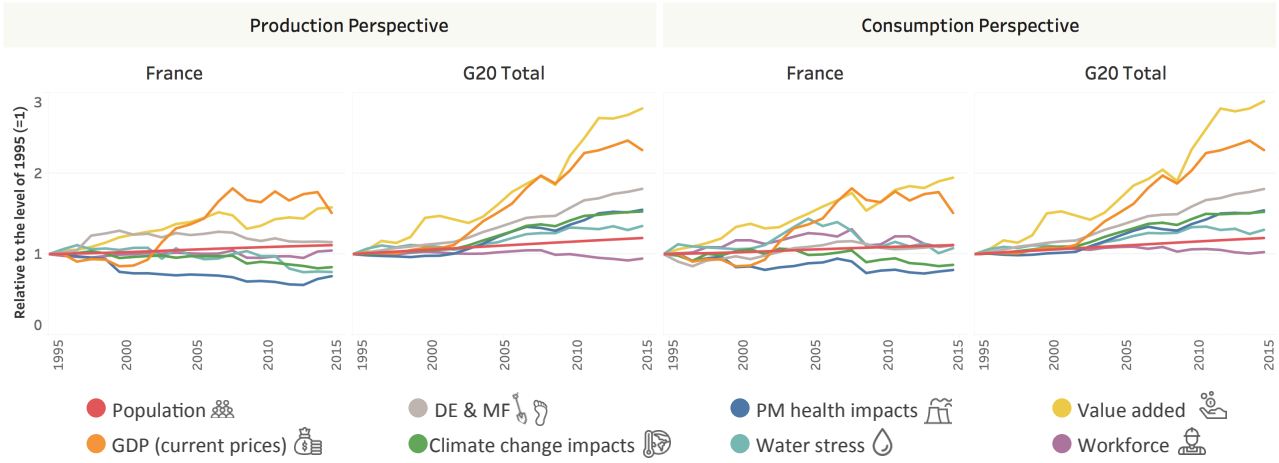
A shift to a sustainable consumer behavior is essential to lower per capita impacts. This includes ecological housing (e.g. appropriate per capita living space), a shift from private fossils-based cars to shared electric vehicles and public transport, reduced consumption of animal products (particularly cattle products) and minimization of food waste.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | France

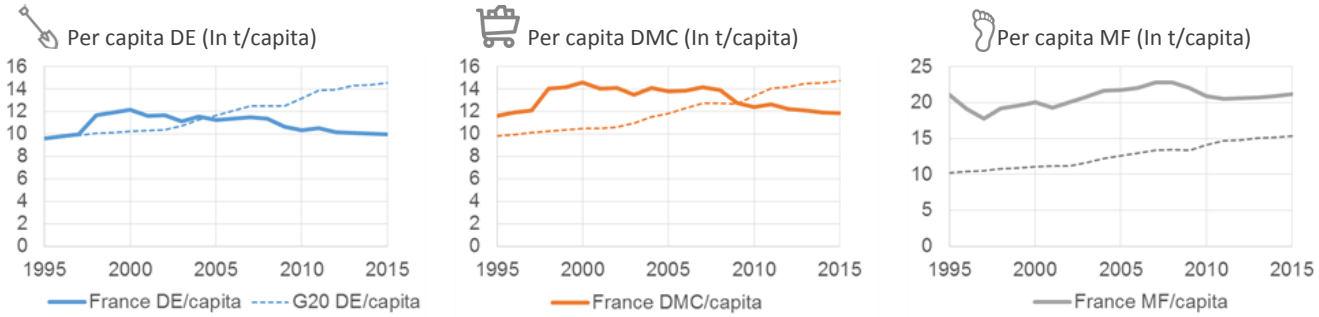
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in France and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in France and in the G20 (1995-2015)

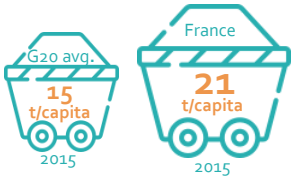


Source: IRP database

From 1995 to 2015

Population increased by **11%** while GDP increased by almost **80%** until the start of the global financial crisis in 2007. GDP remained rather stable afterwards with some fluctuations.

Material footprint remained around **21** tonnes/capita, with a slight intermediate increase until 2007 (G20 average was at 15 tonnes/capita in 2015).



The domestic extraction and domestic consumption of materials slightly decreased after the year 2000 and fell below G20 average.

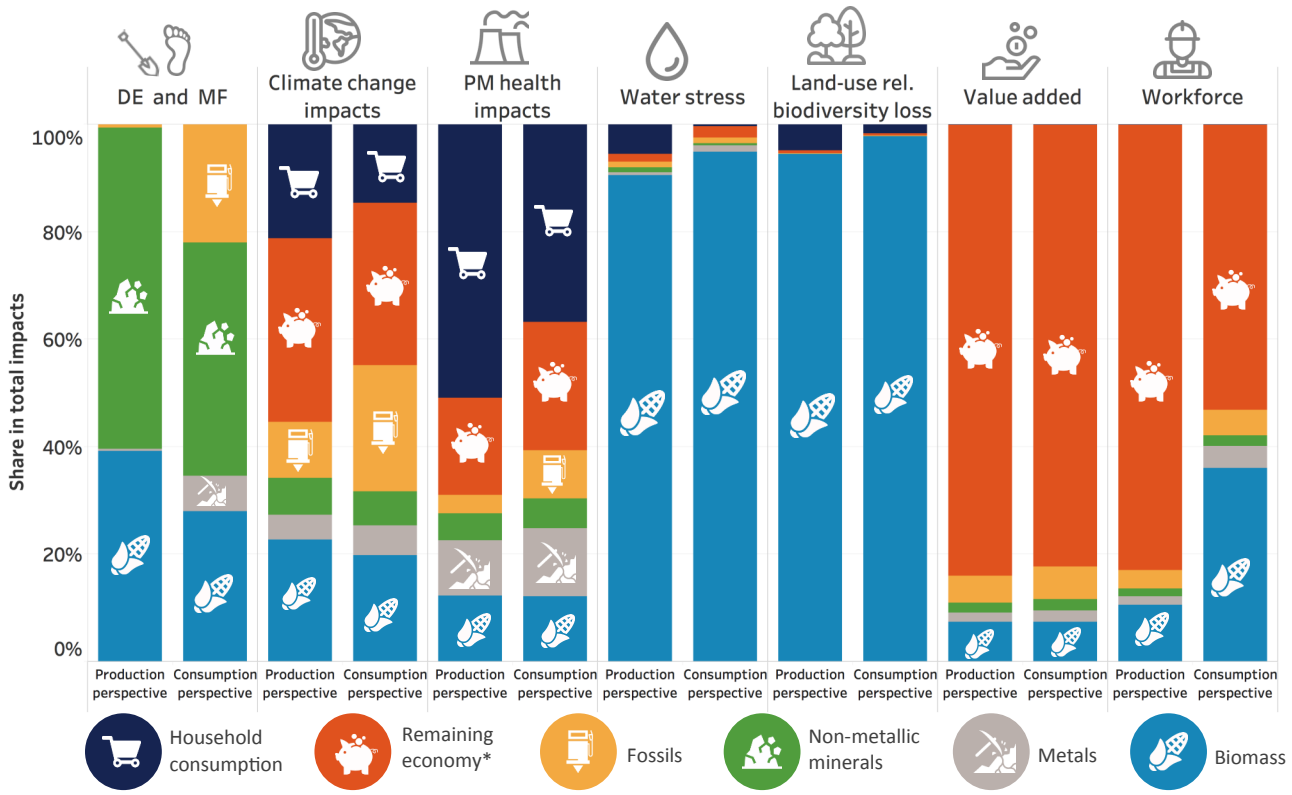
France experienced absolute decoupling of climate change impacts related to material extraction and processing from economic growth. However, material-related climate change impacts remained above G20 average (**>20%** higher than G20 average from a consumption perspective).

Water stress decreased from the production but not from the consumption perspective.

Particulate matter (PM) health impacts related to resource extraction and material processing showed the strongest absolute decoupling from both perspectives.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in France (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated the domestic extraction amounts, but contributed less to material footprint and only caused a minor share of environmental impacts.

Biomass contributed ~40% to domestic extraction. There is nearly no metal and fossils extraction within France (from a production perspective).

The extraction and processing of natural resources accounted for up to 40% of France's total climate change impacts from a production perspective and 50% from a consumption perspective (the G20 average was approximately 50% for both perspectives).

In line with other G20 countries, water stress and land use-related biodiversity impacts were caused mainly by biomass production (consumption perspective).

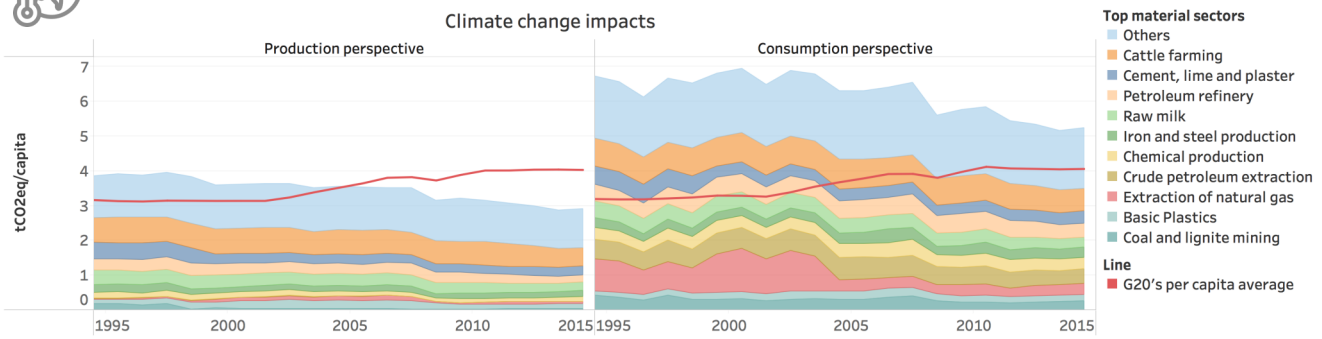
Outdoor particulate matter (PM) related health impacts came mainly from households and the remaining economy.

The material sector contributed a minor share to value added as well as domestic jobs (both less than 20%) but relied on low-income workforce in agriculture outside of France for food imports.

In general, the share related to material extraction and processing was comparable or higher from a consumption perspective than from a production perspective for all indicators.

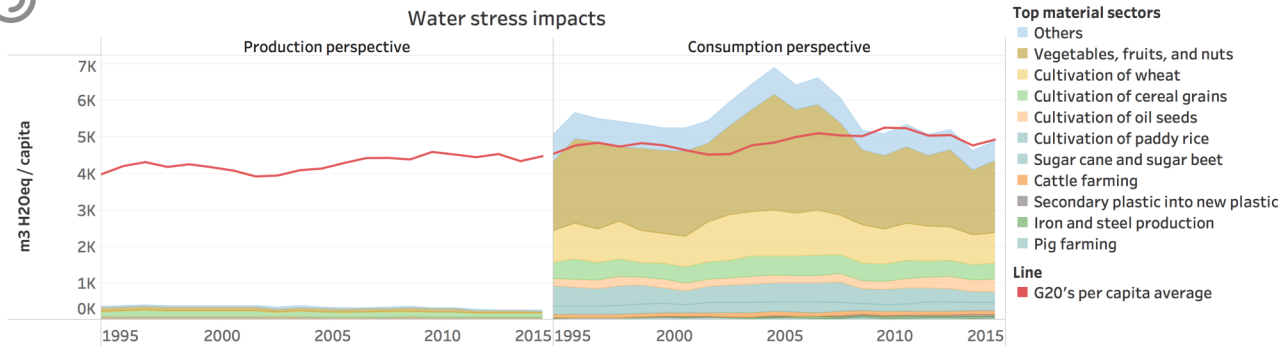
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in France (1995-2015)*



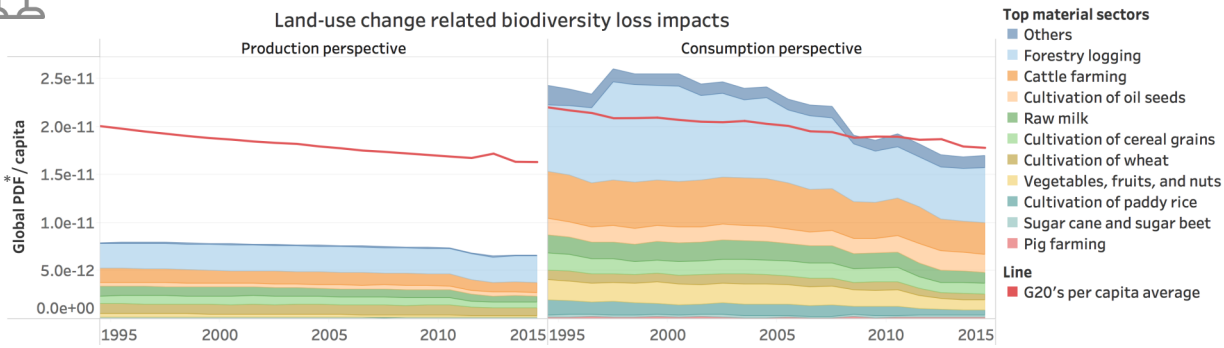
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in France (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in France (1995-2015)*

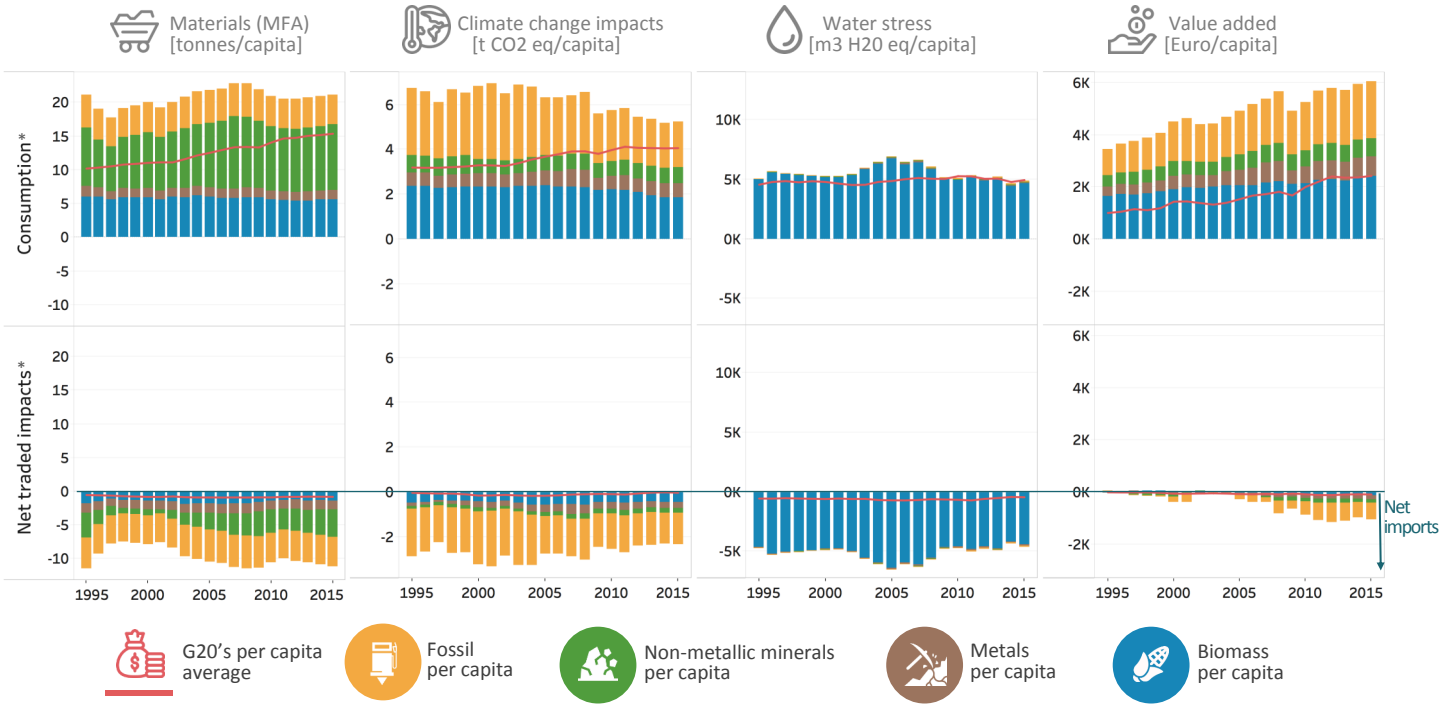


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts within France (production perspective) were particularly caused by cattle and milk production, followed by iron, steel, and cement production as well as petroleum refining.
- From a production perspective, climate change impacts decreased below G20 average. From a consumption perspective, they were more than 20% higher than the G20 average. This is due to imports of goods with large embodied greenhouse gas emissions for domestic consumption, e.g. crude petroleum.
- The construction sector, followed by motor vehicle manufacturing were the largest industrial users of climate-intensive materials.
- Materials with large climate impacts are often directly consumed by households, especially fossil fuels for mobility and heating, and food (particularly beef and dairy).
- From a production perspective, water stress is mainly caused by cereals, but at a very low level.
- Water stress caused abroad for French consumption is dominated by agricultural activities, such as the production of vegetables, fruits, nuts, wheat, other cereals and oil seeds.
- From a production perspective, land use-related biodiversity loss is considerably lower than the G20 average. It is similar to the G20 average from a consumption perspective. Main causes of this biodiversity footprint are imports of wood, beef, and oil seeds from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in France (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in France.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

France is a net importer of all material types (much higher reliance on trade than G20 average). Accordingly, more environmental impacts are caused by material imports than by material exports.

For all material types and particularly fossil fuels, net value added was created outside of France for material imports since the year 2004.

Future trends and potential Decoupling

Scenarios developed by the IRP forecast an increase of GDP by 113% to 141% and a rather small population increase (22%-26%) until 2060.

If ambitious resource efficiency policies are introduced, France could see an absolute decoupling of domestic material extraction and domestic material consumption until 2060.

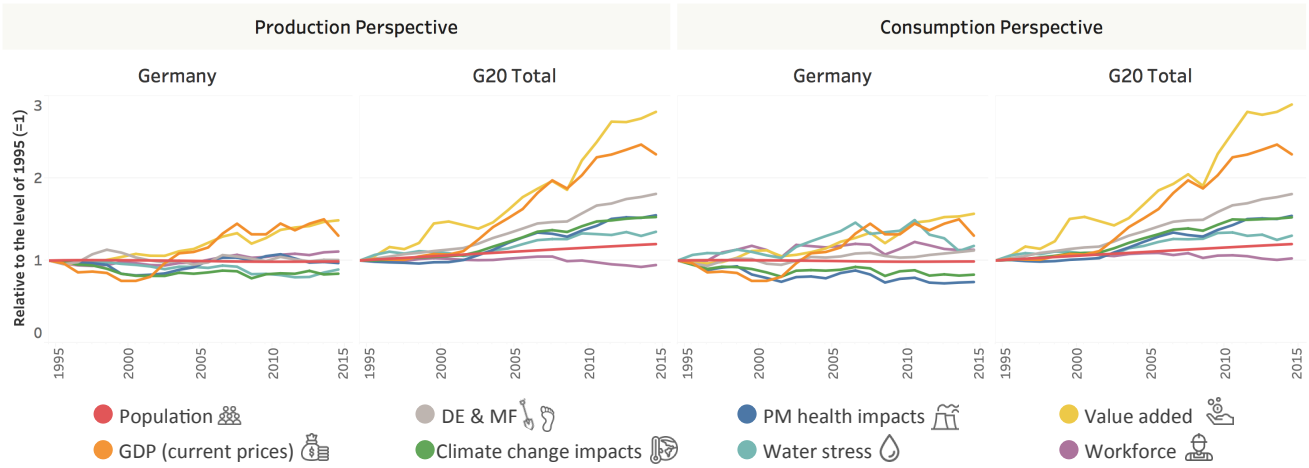
Material-related climate change and water stress impacts have slightly decreased in the past two decades. However, material footprint and all environmental impacts per capita remain above G20 average (consumption perspective). Resource efficiency strategies along the entire supply chain (with a special focus on cattle farming) could help decrease these impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Germany

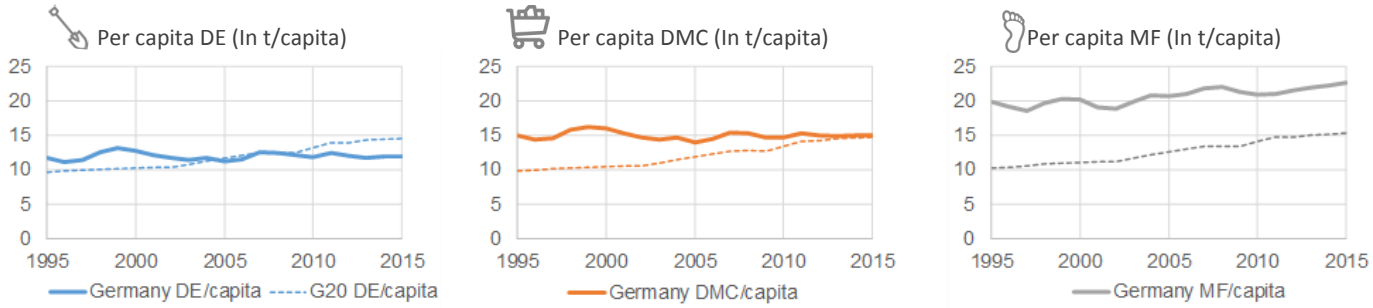
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Germany and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Germany and in the G20 (1995-2015)



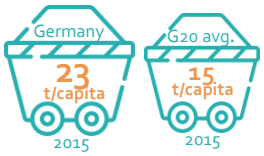
Source: IRP database

From 1995 to 2015

-1%

While population remained stable, the economy underwent a recession in the beginning of this period and recovered afterwards.

Material footprint increased to 23 tonnes/capita (G20 average was at 15 tonnes/capita in 2015). This increase occurred in the supply chain of imported products, while domestic extraction of materials remained constant.

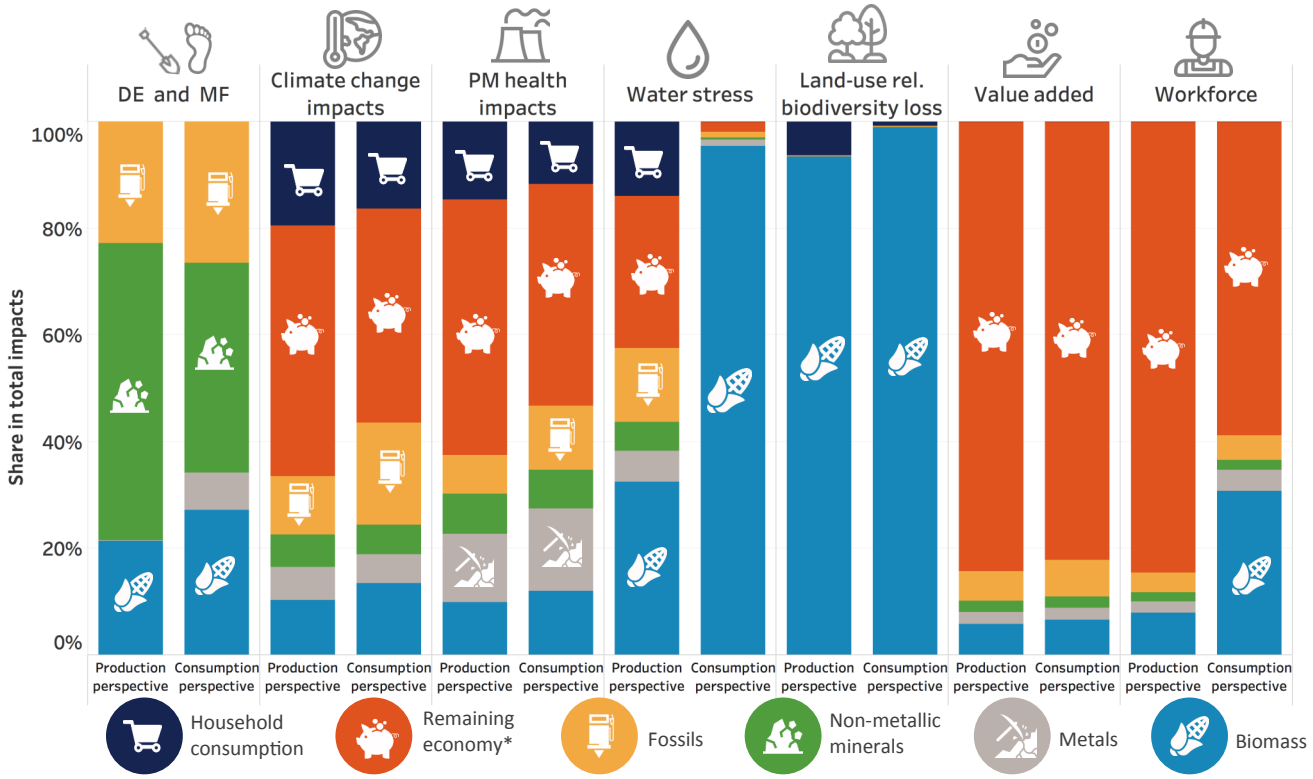


Climate change impacts related to material extraction and processing slightly decreased, but the absolute level of material-related climate change impacts remained high (>50% higher than G20 average from a consumption perspective).

Environmental impacts other than climate change showed a varying pattern between the production and consumption perspectives. Particulate matter health impacts decreased from a consumption perspective. Water stress from food imports increased, while domestic water stress was marginal.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Germany (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated the domestic extraction amounts, but contributed less to the material footprint and only caused a minor share of environmental impacts.

The extraction and processing of natural resources accounted for about 40% of Germany's total climate change impacts (the G20 average was approximately 50%).

Water stress and land use-related biodiversity loss were of minor relevance within the country. Supply chain environmental effects through imported food products were significant and comparable (for land use effects) or even above (for water stress) to the G20 average.

In line with other G20 countries, Germany's water stress and land use-related biodiversity impacts were caused mainly by biomass production (consumption perspective).

Outdoor particulate matter (PM) related health impacts mainly came from the remaining economy (e.g. electricity from coal power and transport).

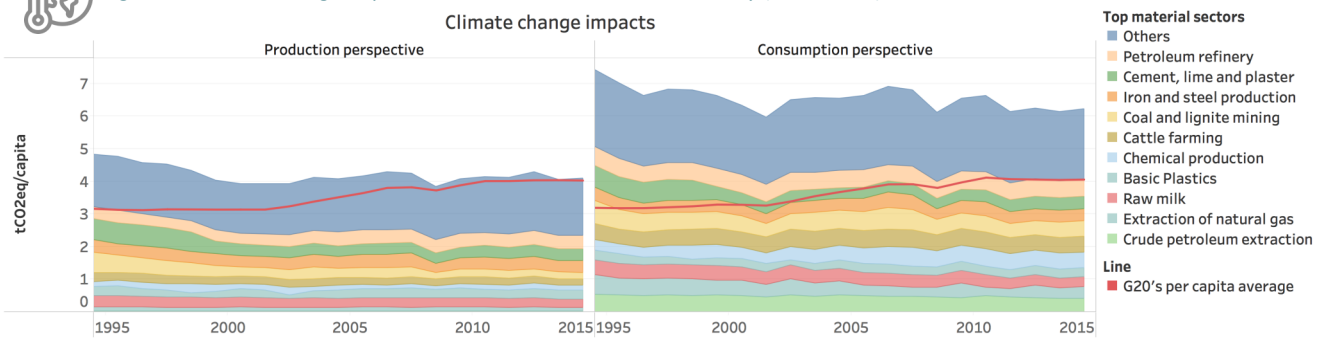
Less than 20% of economic value added was created through resource extraction and processing both in the production and consumption perspective.

The material sector contributed a minor share to value added as well as domestic jobs (both less than 20%) but relied on low-income workforce in agriculture outside of Germany for food imports.

In general, for all indicators the share related to material extraction and processing was higher from a consumption perspective than from a production perspective.

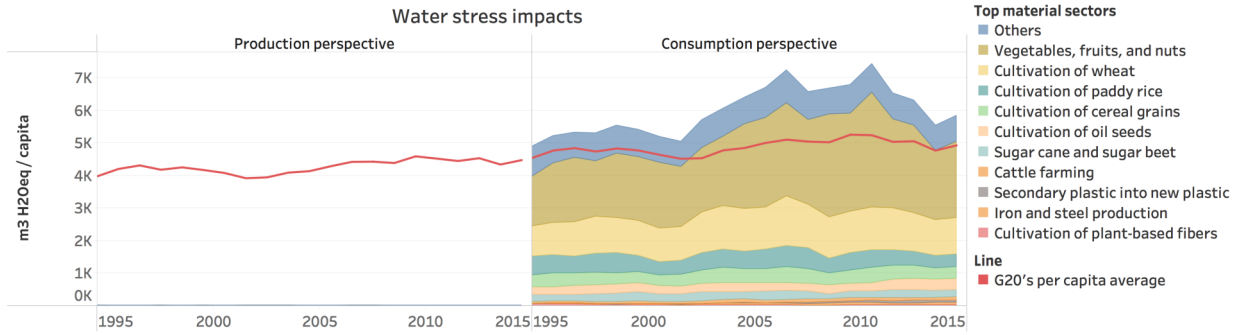
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Germany (1995-2015)*



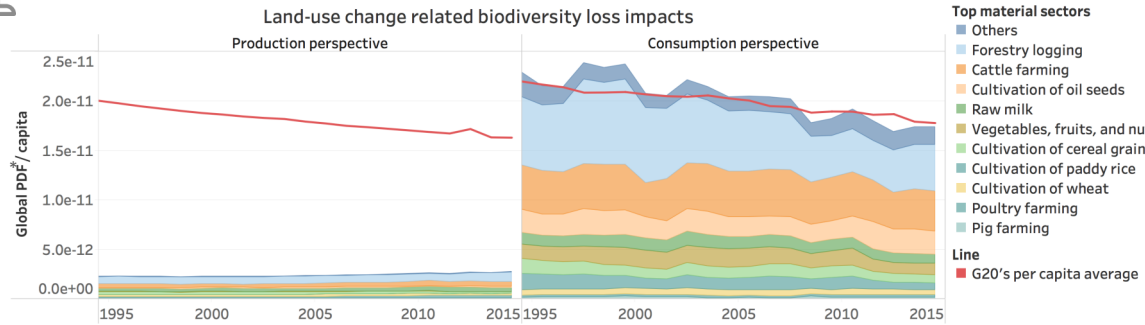
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Germany (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Germany (1995-2015)*

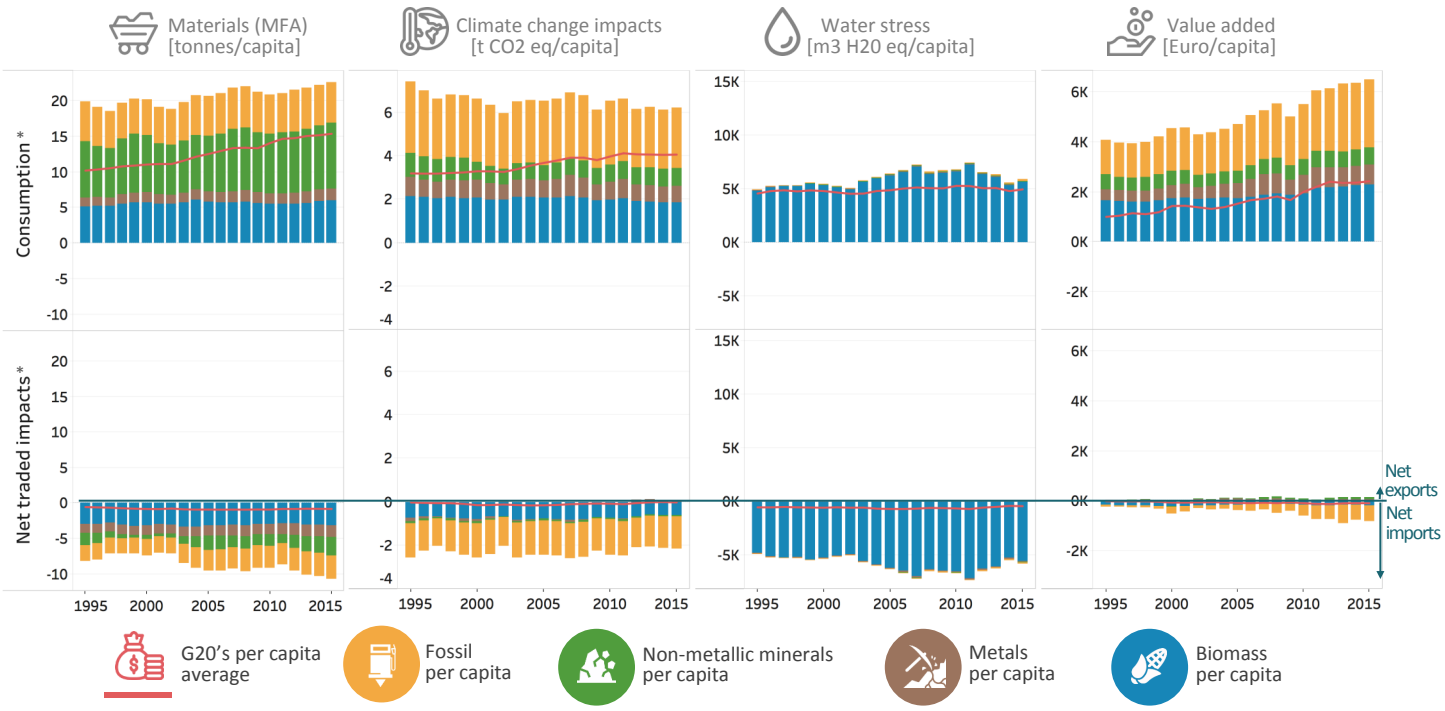


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Most of the material-related climate change impacts are caused by the production of iron and steel, cement manufacturing, petroleum refining, chemical and plastics production, cattle farming and extraction of coal, natural gas, and oil.
- From a production perspective, climate change impacts in Germany were comparable to the G20 average. From a consumption perspective, they were more than 50% higher than the G20 average. This is due to imports with large embodied greenhouse gas emissions for domestic consumption.
- The majority of biomass and fossils are directly consumed by Germany's households for food and heating.
- Minerals play a key role for Germany's automobile industry, electrics and electronics, and construction (data not shown).
- From a production perspective, water stress remains low due to low irrigation requirements and enough renewable water sources to cover demand.
- From a consumption perspective, water stress is larger than the G20 average due to increasing food imports. Water stress caused abroad is dominated by agricultural activities, such as the production of vegetables, fruits, nuts and wheat.
- Land use-related biodiversity loss in Germany is much lower than the G20 average, but comparable to the G20 average from a consumption perspective. Forestry and cattle farming are main causes of this loss through imports of wood and meat from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Germany (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in Germany.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Germany is a net importer of all material types. Accordingly, more environmental impacts are caused outside Germany for material imports than within its borders for material exports.

Value added for metals and non-metallic minerals was higher within Germany than outside. This indicates that rather cheap raw materials are imported, while more expensive products are exported.

Future trends and potential Decoupling

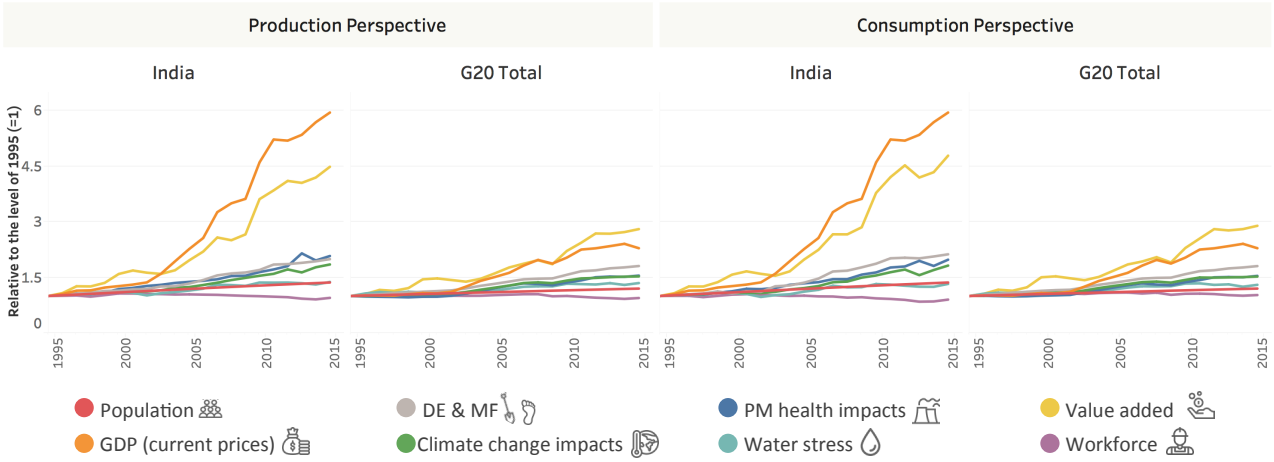
- Scenarios developed by the IRP forecast an increase of GDP for Germany of 65% to 80% and a slight decrease of population of 1% to 6% until 2060.
- If ambitious resource efficiency policies are introduced, Germany could see an absolute decoupling of domestic material extraction and domestic material consumption until 2060.
- Material-related climate change impacts have slightly decreased in the past two decades. However, material footprint and climate change impacts per capita remain high compared to the G20 average. Resource efficiency strategies along the entire supply chain (including responsible sourcing of biomass imports) could help decrease these impacts.
- While Germany has a high share of renewables in their energy mix, the economy still relies heavily on fossils as an energy source. Increasing renewable energies and a soon exit from lignite and coal could help lower the material-related climate change impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | India

STATUS AND TRENDS OF NATURAL RESOURCE USE

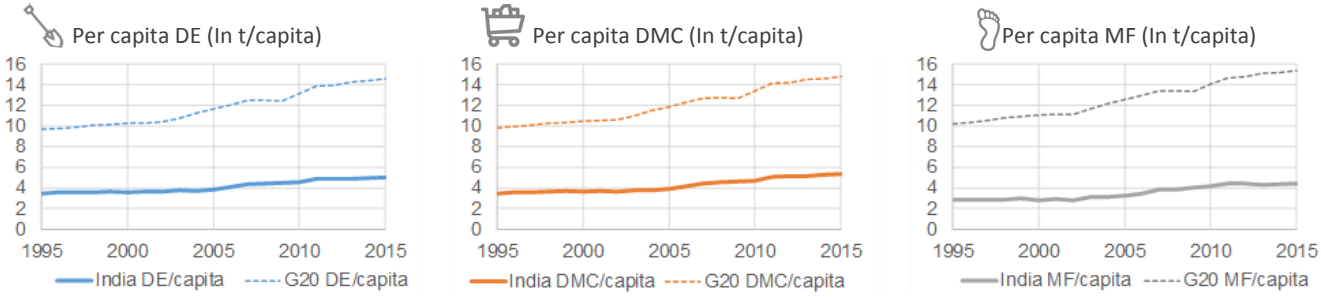
Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in India and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in India and in the G20 (1995-2015)



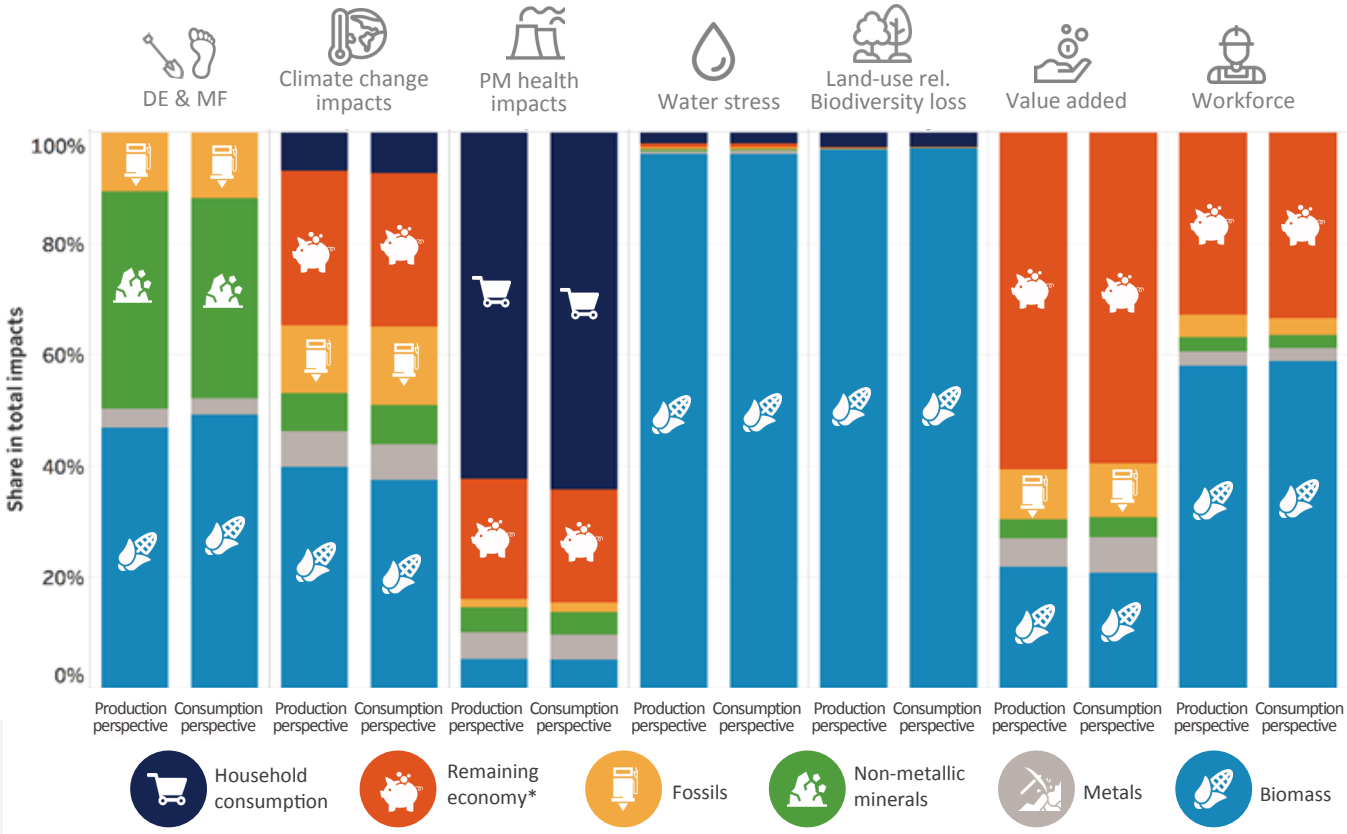
Source: IRP database

From 1995 to 2015

- Population grew by **36%** and GDP multiplied almost **sixfold.**
- Domestic extraction, domestic material consumption and material footprint are similar in trend and magnitude.
- Material footprint increased from **3** tonnes/capita in 1995 to **4.5** tonnes/capita in 2015 (only **30%** of the G20 average of 15 tonnes/capita in 2015). The difference with the G20 average grew over time.
- India experienced a strong relative decoupling of both material use and impacts from national GDP and added value related to material production. However, all material impacts increased on an absolute scale.
- Water stress impacts related to material extraction and processing grew in line with population growth. The absolute level remained above G20 average
- PM related health impacts grew stronger than the G20 average.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in India (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

In contrast to G20 average, biomass dominated the share of domestic extraction amounts and material footprint. Non-metallic minerals only came in second, as India has not yet built up all infrastructure.

The extraction and processing of natural resources accounted for two thirds of India's total climate change impacts from both a production and consumption perspective (the G20 average was approximately 50% from both perspectives).

Outdoor particulate matter (PM) related health impacts mainly came from households (use of solid fuels for cooking).

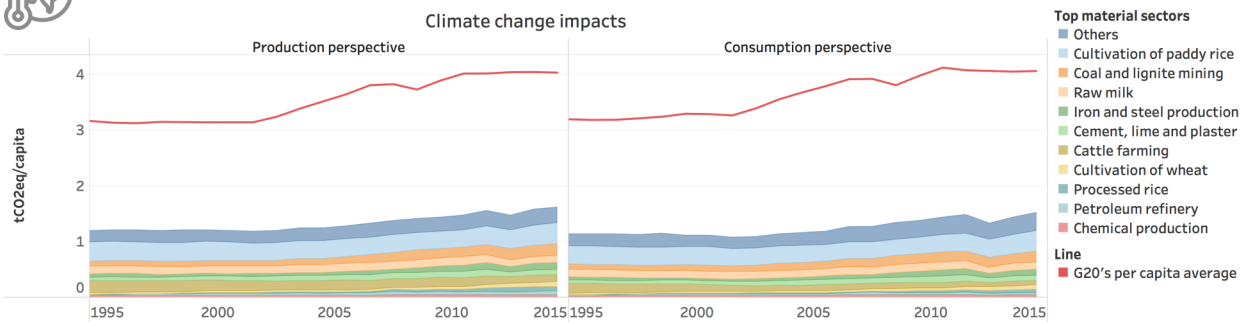
In line with other G20 countries, India's water stress and land use-related biodiversity impacts were caused mainly by biomass production.

The material sector contributed 40% to value added and two thirds of all jobs, mostly low-income workforce in agriculture. This is much higher than G20 average (both less than 20%).

Results for all indicators from both a production and consumption perspective were rather similar.

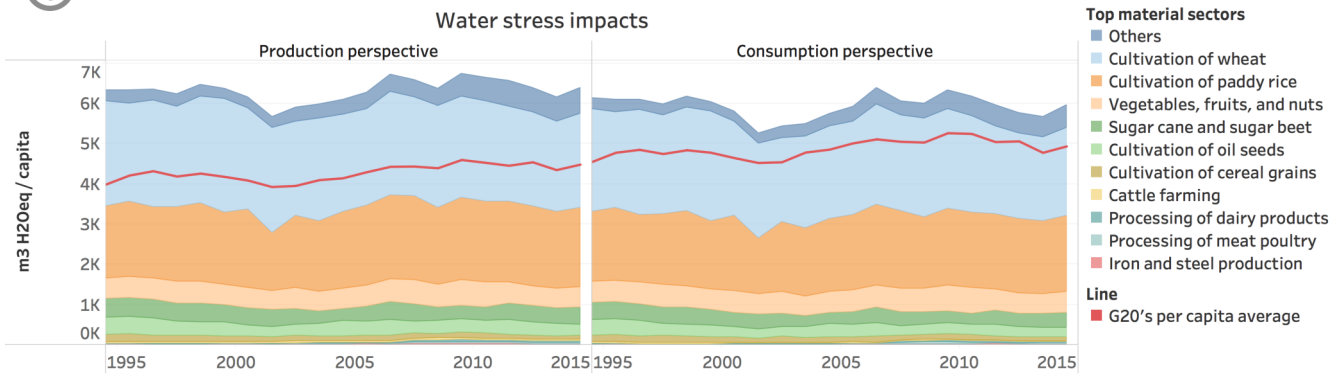
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in India (1995-2015)*



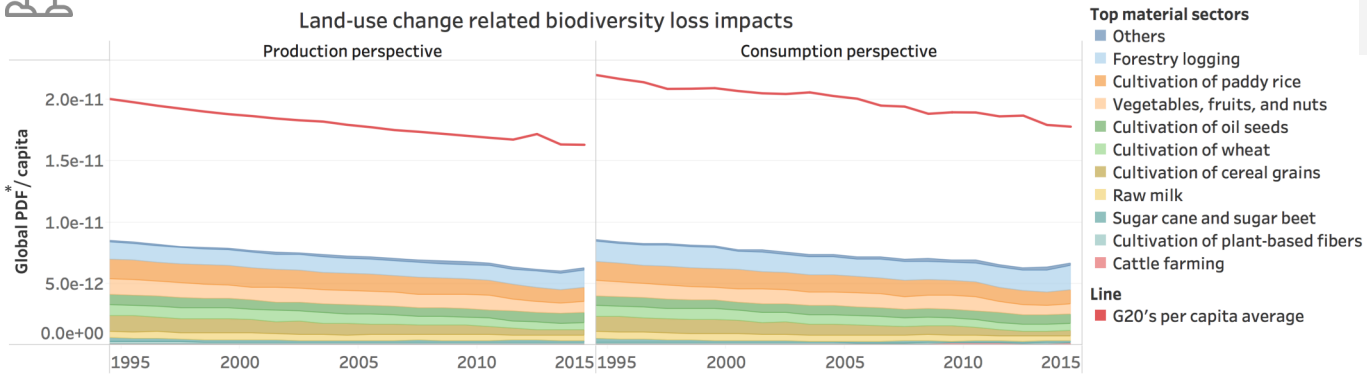
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in India (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in India (1995-2015)*

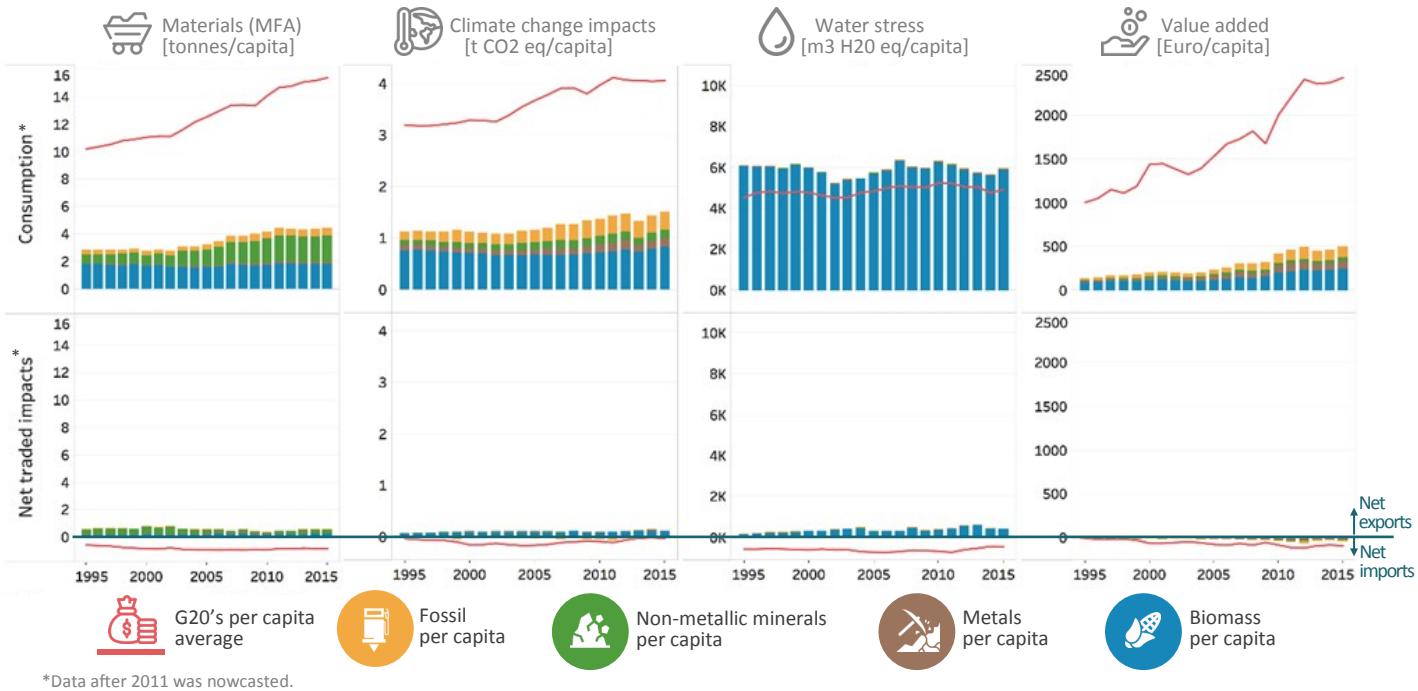


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by paddy rice production, coal mining and milk production.
- Climate change impacts remained 50% lower than G20 average.
- The construction industry used most climate-intensive materials, followed by the leather industry. Paddy rice and milk production caused the highest climate impacts from food consumed directly by households.
- Water stress impacts are significantly higher than the G20 average, due to domestic agriculture in water-scarce regions.
- Water stress is dominated by the production of wheat and paddy rice from both a production and consumption perspective.
- Land use related biodiversity loss is more than 50% lower than G20 average, with a decreasing trend. This loss comes mostly from the forestry sector, followed by paddy rice production (from a consumption and production perspective).

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in India (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in India.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

India's demand for resources is mostly covered by domestic sources.
India is a net exporter of all material types, but traded amounts are relatively low.

Accordingly, more environmental impacts are caused within India for material exports than outside its borders for imports (except for climate change impacts of fossils).

For all material types but biomass, net value added was higher outside of Indian borders. This means that cheap raw materials were exported and more expensive materials were imported.

Future trends and potential Decoupling

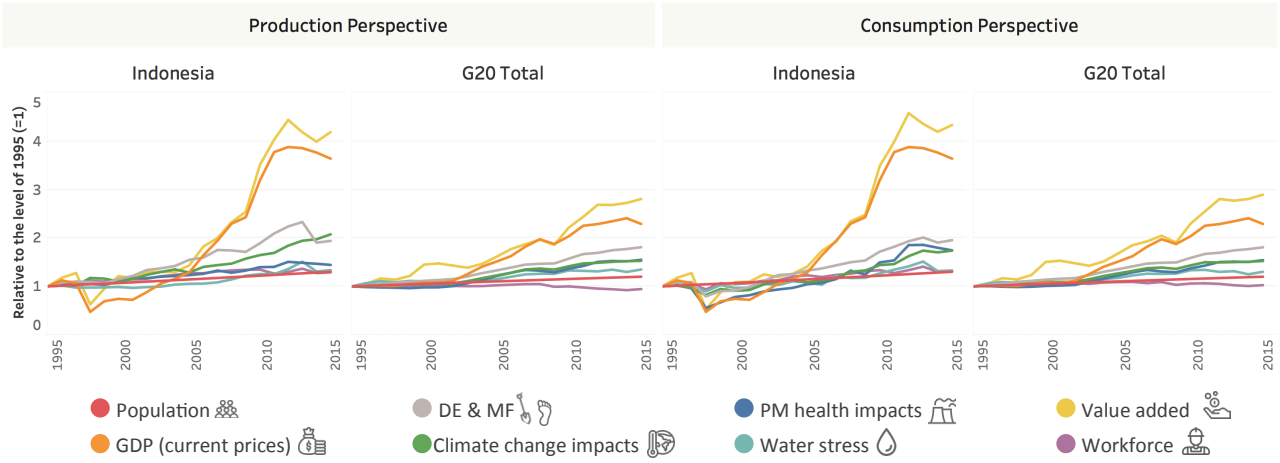
- Scenarios developed by the IRP forecast an increase of GDP by a factor of between 7 and 10 and a population growth of between +19% and +36% until 2060.
- If ambitious resource efficiency policies are introduced, India could see a relative and maybe even absolute decoupling of domestic material extraction and domestic material consumption from GDP until 2060. Overall, DE and DMC are projected to increase by 50% and 70%, respectively, in the best-case scenario.
- India suffers from considerable particulate matter pollution due to resource use. Lowering solid fuel burning in households and improving coal power abatement technologies are essential steps for combating health effects.
- A large build up of infrastructure is anticipated in the next decades. Due to the size of the population, this could result in significant resource demands and environmental impacts. Material efficient urban design is therefore of uttermost importance.
- Several types of environmental impacts have been relatively decoupled from material extraction. Opportunities for further improvement exist, for example in the coal-based electricity sector.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Indonesia

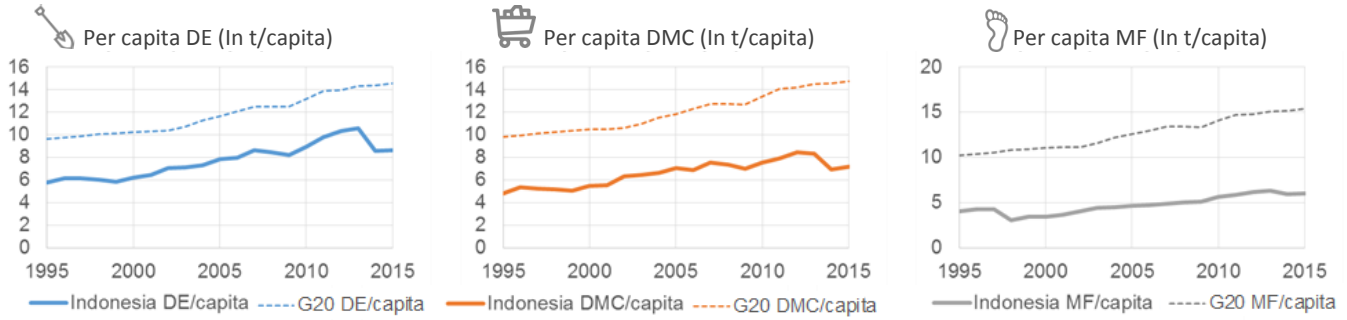
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Indonesia and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Indonesia and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **30%** and GDP multiplied almost **four-fold**.

Domestic extraction per capita and domestic material consumption per capita presented similar trends. Both were higher than material footprint.

Material footprint increased from **4** tonnes per capita in 1995 to **6** tonnes per capita in 2015 (G20 average in 2015 was 15 tonnes per capita). The difference with the G20 average increased over time.

Climate change impacts increased faster than the G20 average.

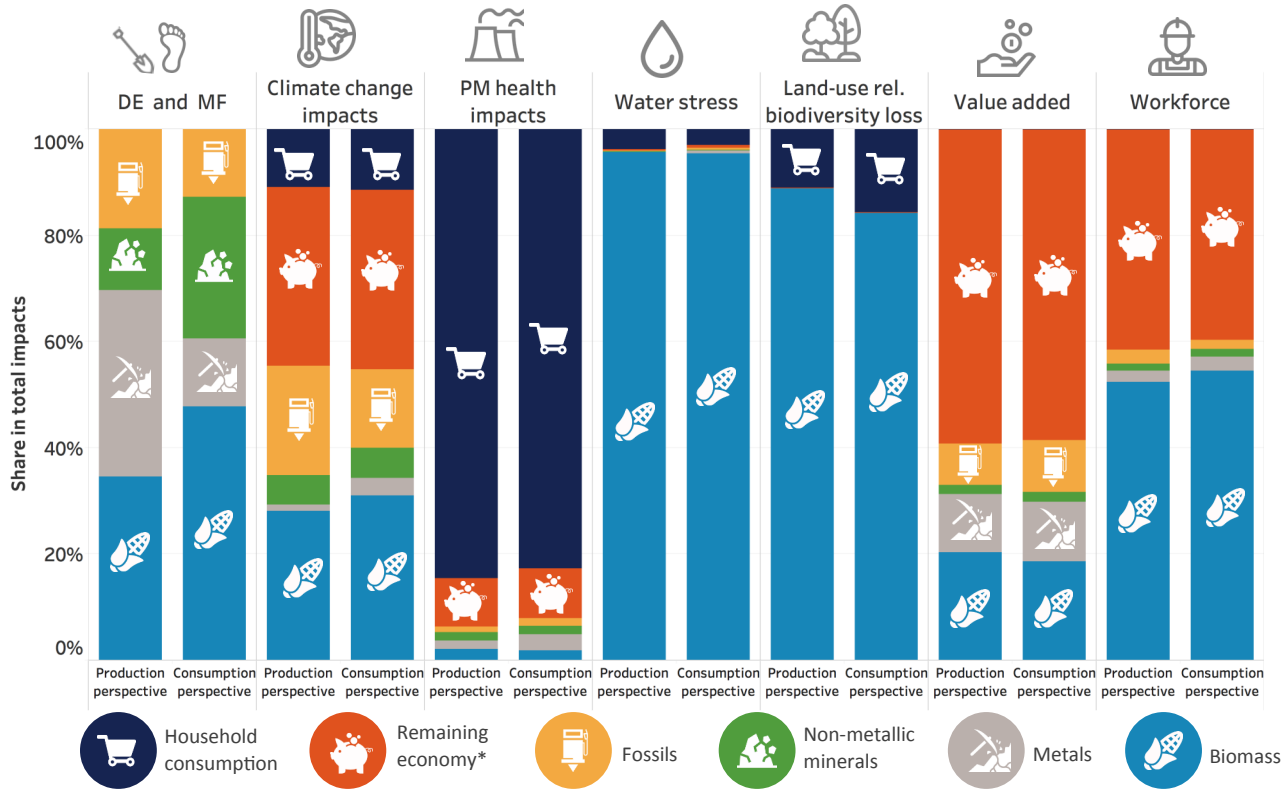
A strong relative decoupling occurred between both material use and impacts and national GDP and added value related to material production.

Water stress impacts related to material extraction and processing slightly increased in line with population growth. Per-capita water stress remained stable and was significantly below the G20 average

Particulate matter related health impacts increased more than the G20 average, from a consumption perspective. These impacts increased less from a production perspective.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Indonesia (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Unlike the G20 average, metal and biomass dominated domestic extraction amounts (they both caused more than a third of total domestic extraction). Almost 50% of the material footprint was caused by biomass.

The extraction and processing of natural resources accounted for more than 50% of total climate change impacts from both a production and consumption perspective (similar to G20 average).

Outdoor particulate matter related health impacts came mostly from households (use of solid fuels for cooking and private mobility).

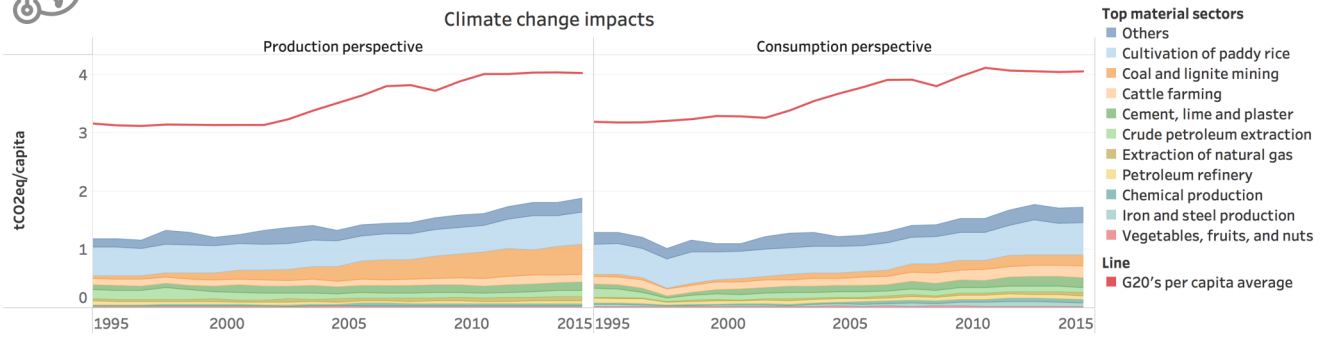
Water stress and land use-related biodiversity impacts were caused mainly by biomass production (similar to G20 average).

The material sector contributed 40% to value added and represented more than 50% of jobs, mostly low-income workforce in agriculture. The G20 average for both of these were less than 20%.

For all impact and socio-economic indicators, the production and consumption perspectives were rather similar.

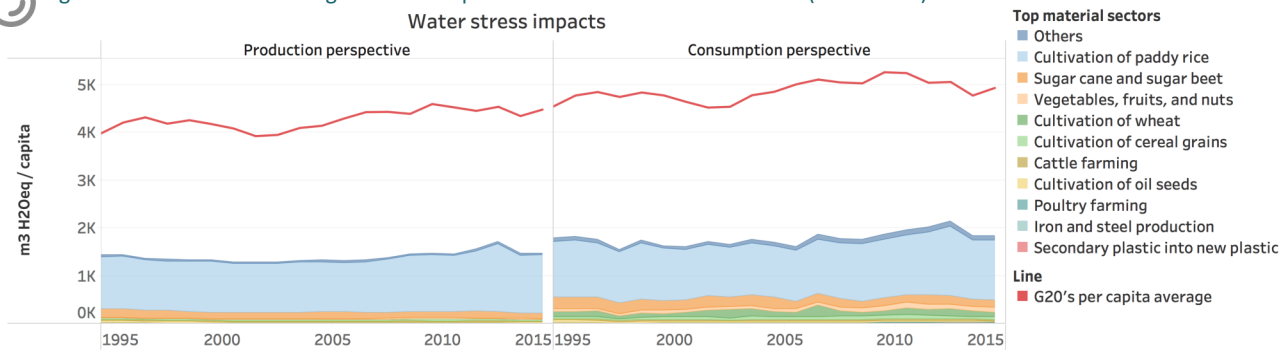
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Indonesia (1995-2015)*



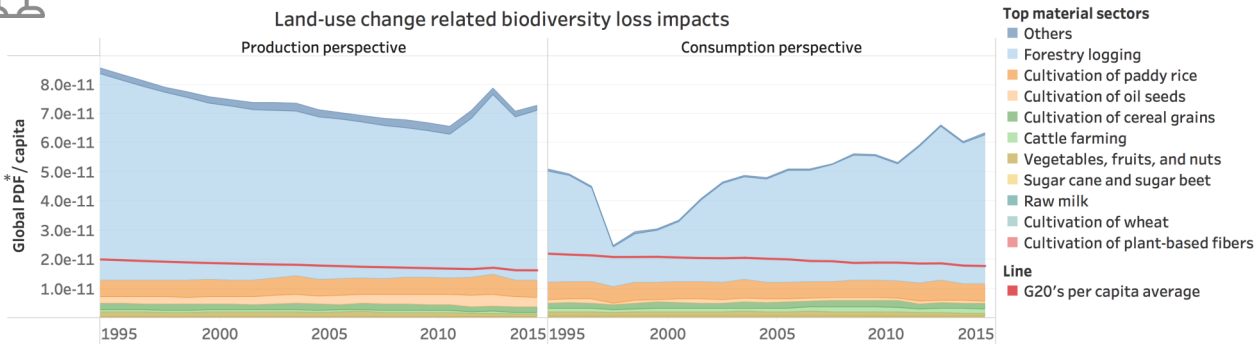
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Indonesia (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Indonesia (1995-2015)*

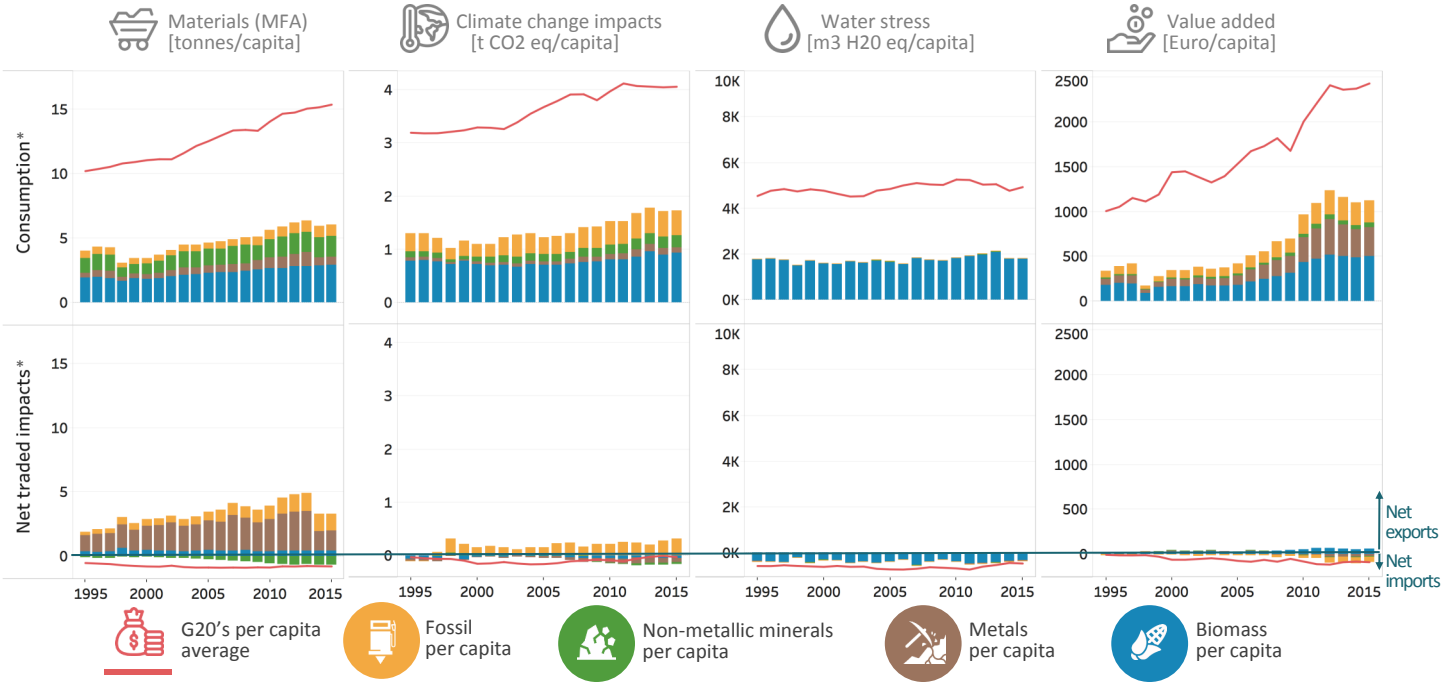


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by paddy rice cultivation and coal mining. Together, they accounted for 50% of said impacts. Coal and lignite mining increased significantly over time.
- Climate change impacts remained 50% lower than G20 average.
- Households directly consumed the most climate-intensive resources (paddy rice). The second largest share of material -related climate impacts were caused by the construction and chemical industries.
- Water stress impacts were significantly lower than the G20 average, and caused almost solely by the cultivation of rice.
- Land use related biodiversity loss is roughly 4 times higher than the G20 average. While it has decreased from a production perspective, it significantly increased from a consumption perspective (more than 3.5 times higher than the G20 average in 2015). The forestry sector caused more than 80% of this loss, followed by paddy rice (consumption and production perspective). Indonesia harbors valuable ecosystems in its territory, explaining the large impact of land use interventions.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Indonesia (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in Indonesia.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Indonesia's demand for resources was mostly covered by domestic sources.

Until 2013, Indonesia was a large net exporter of metals (mainly raw bauxite) and fossils. It was the second largest exporter of coal and it imported crude oil. Furthermore, it was a net importer of non-metallic minerals, with relatively low traded amounts.

More climate change impacts were caused by fossil exports than by fossil imports. However, Indonesia is a net importer of climate change impacts from other materials.

More water stress impacts were caused by imports than by exports, due to relatively small amounts of food imports.

For all material categories but biomass, net value added was higher outside of Indonesia. This means that cheap raw materials are exported and more expensive materials are imported.

Future trends and potential Decoupling

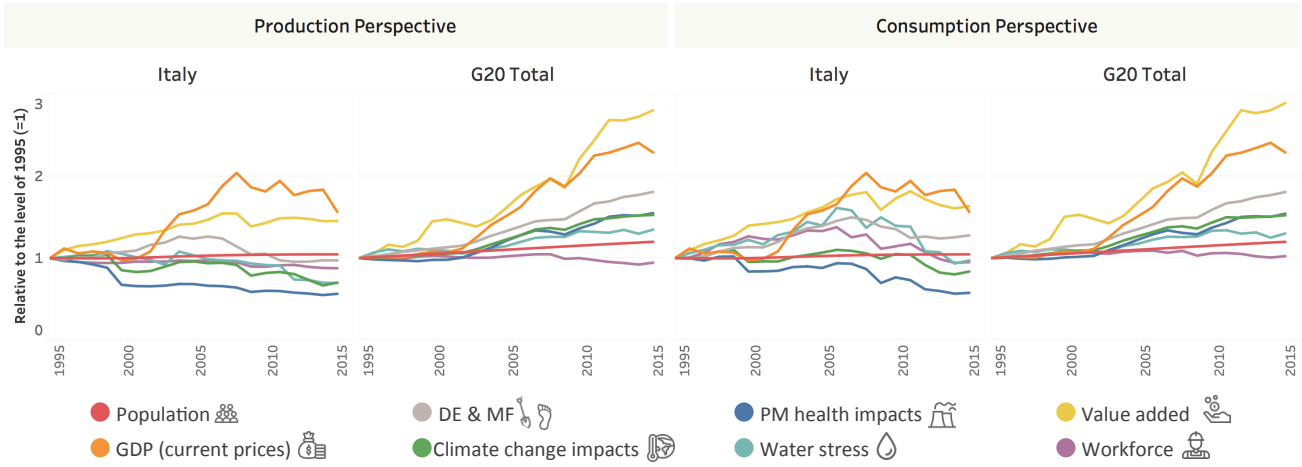
- Scenarios developed by the IRP forecast an increase of GDP by a factor of between 6 and 9 and a population growth of between +4% and +12% until 2060.
- If ambitious resource efficiency policies are introduced, relative decoupling of domestic material extraction and domestic material consumption from GDP until 2060 could occur. Overall, DE and DMC are projected to increase by 74% and 121%, respectively, in the best-case scenario.
- Indonesia suffers largely from particulate matter pollution from material use by households. Lowering solid fuel burning, providing higher fuel quality and generally improving transportation systems can help significantly decrease these impacts.
- A large build-up of infrastructure is anticipated in the next decades. Due to size of the population, this could result in significant resource demands and environmental impacts. Material efficient urban design is, therefore, of strategic importance.
- Several types of environmental impacts have relatively decoupled from material extraction.
- There is great potential to decrease land use related biodiversity loss from forestry through resource efficiency strategies.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Italy

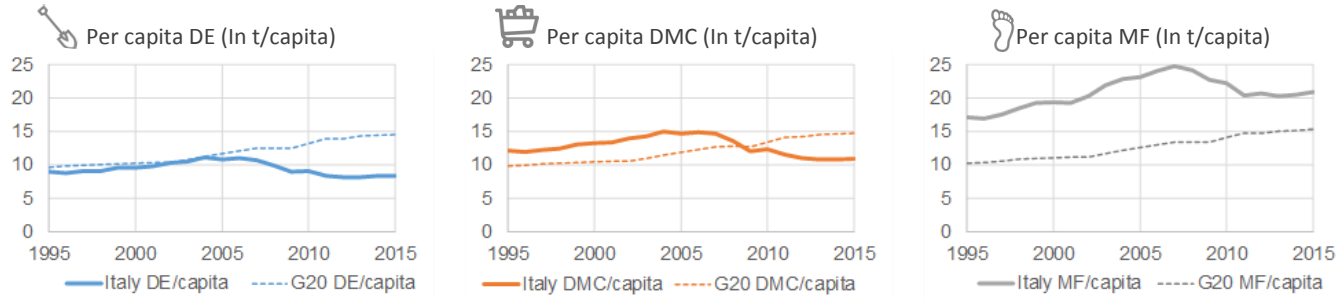
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Italy and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Italy and in the G20 (1995-2015)



Source: IRP database

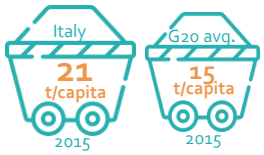
From 1995 to 2015

+5%

While population grew slightly, GDP almost doubled until the global financial crisis and then declined.

Material footprint increased to 21 tonnes/capita (G20 average was at 15 tonnes/capita in 2015).

This increase occurred in the supply chain of imported products, while domestic extraction and domestic consumption of materials slightly decreased and even fell below G20 average.



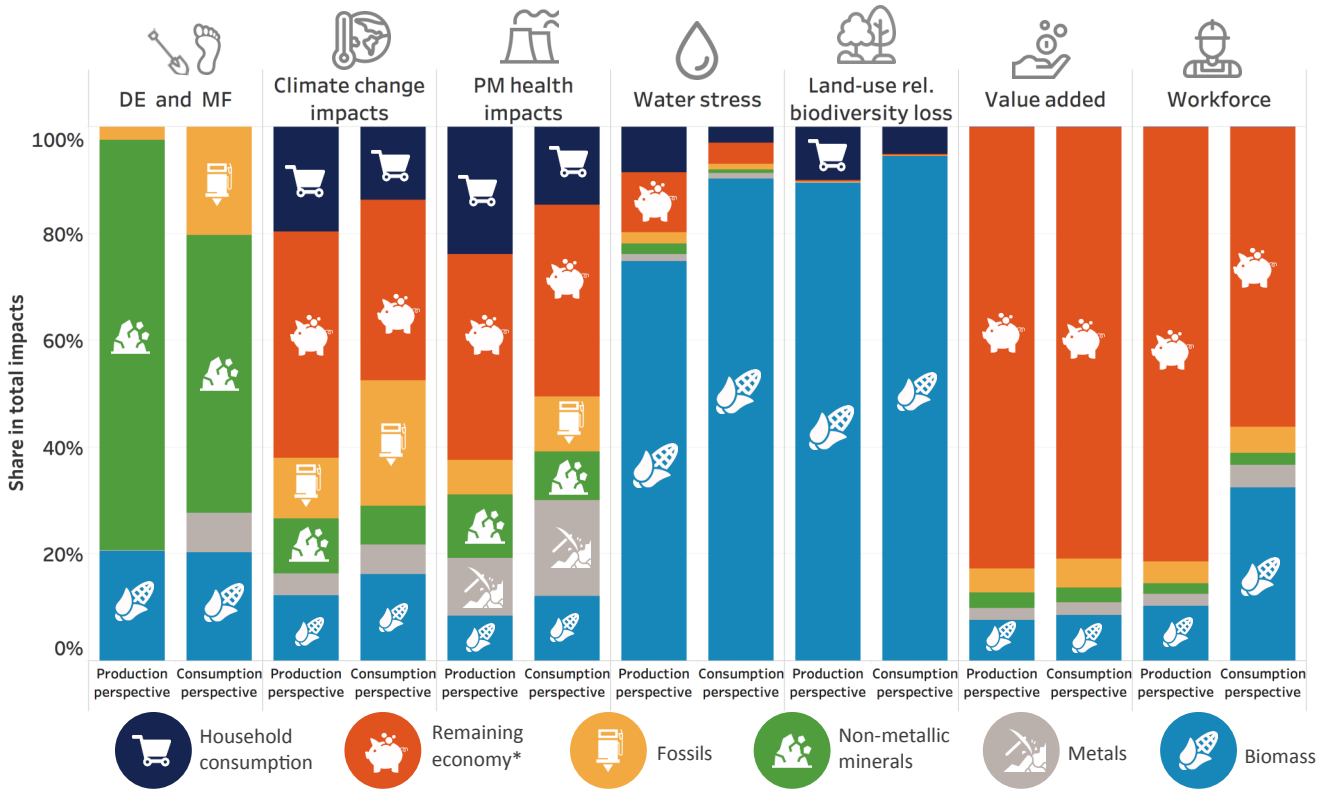
Climate change impacts related to material extraction and processing slightly decreased, but the absolute level of material-related climate change impacts remained above G20 average (>20% higher than G20 average from a consumption perspective).

Water stress decreased from both the production and consumption perspectives.

Particulate matter (PM) health impacts related to resource extraction and material processing showed the strongest absolute decoupling.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Italy (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated domestic extraction amounts, but contributed less to the material footprint and only caused a minor share of environmental impacts. There was nearly no metal extraction and only little fossil extraction (mainly natural gas) within Italy (production perspective), but the contribution of resources to material footprint resembles well G20 average.

The extraction and processing of natural resources accounted for up to 40% of Italy's total climate change impacts from a production perspective and 50% from a consumption perspective (the G20 average was approximately 50% from both perspectives).

In line with other G20 countries, Italy's water stress and land use-related biodiversity impacts were caused mainly by biomass production (consumption perspective).

Outdoor particulate matter (PM) related health impacts mainly came from the remaining economy (e.g. fossil electricity and transport) and households.

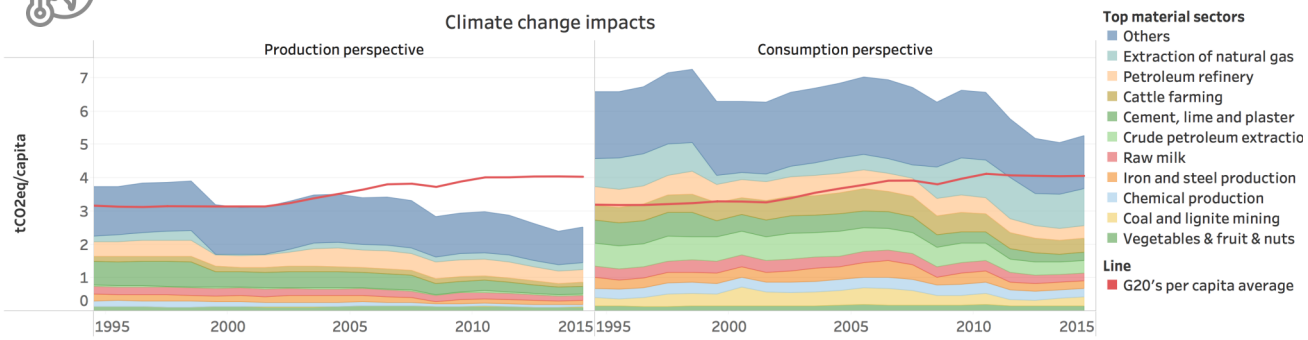
Less than 20% of economic value added was created through resource extraction and processing both from a production and consumption perspectives.

The material sector contributed a minor share to value added as well as domestic jobs (both less than 20%) but relied on low-income workforce in agriculture outside of Italy for food imports.

In general, for all indicators, the share related to material extraction and processing was comparable or higher from a consumption perspective than from a production perspective.

Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Italy (1995-2015)*



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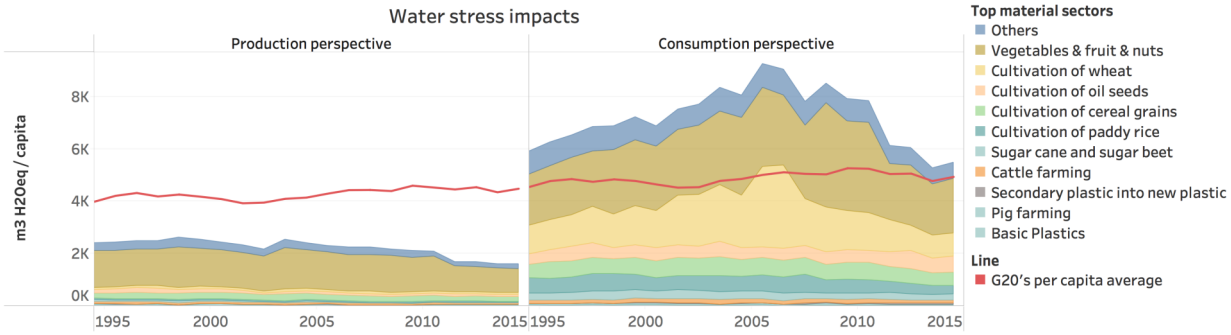
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Italy (1995-2015)*



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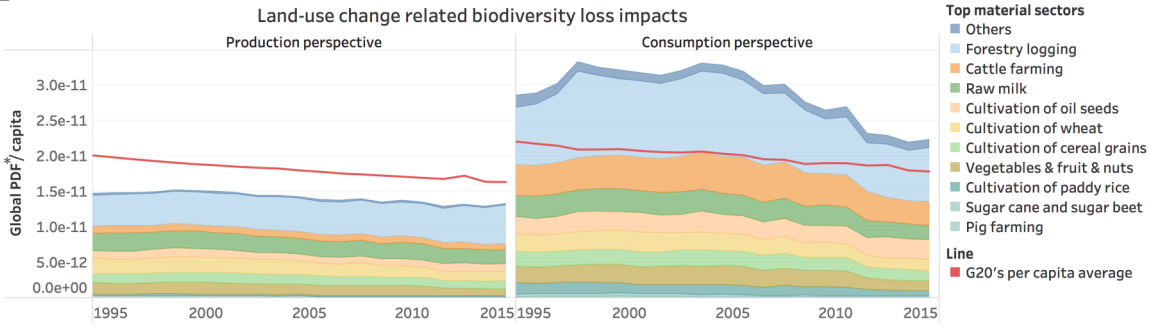
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Italy (1995-2015)*

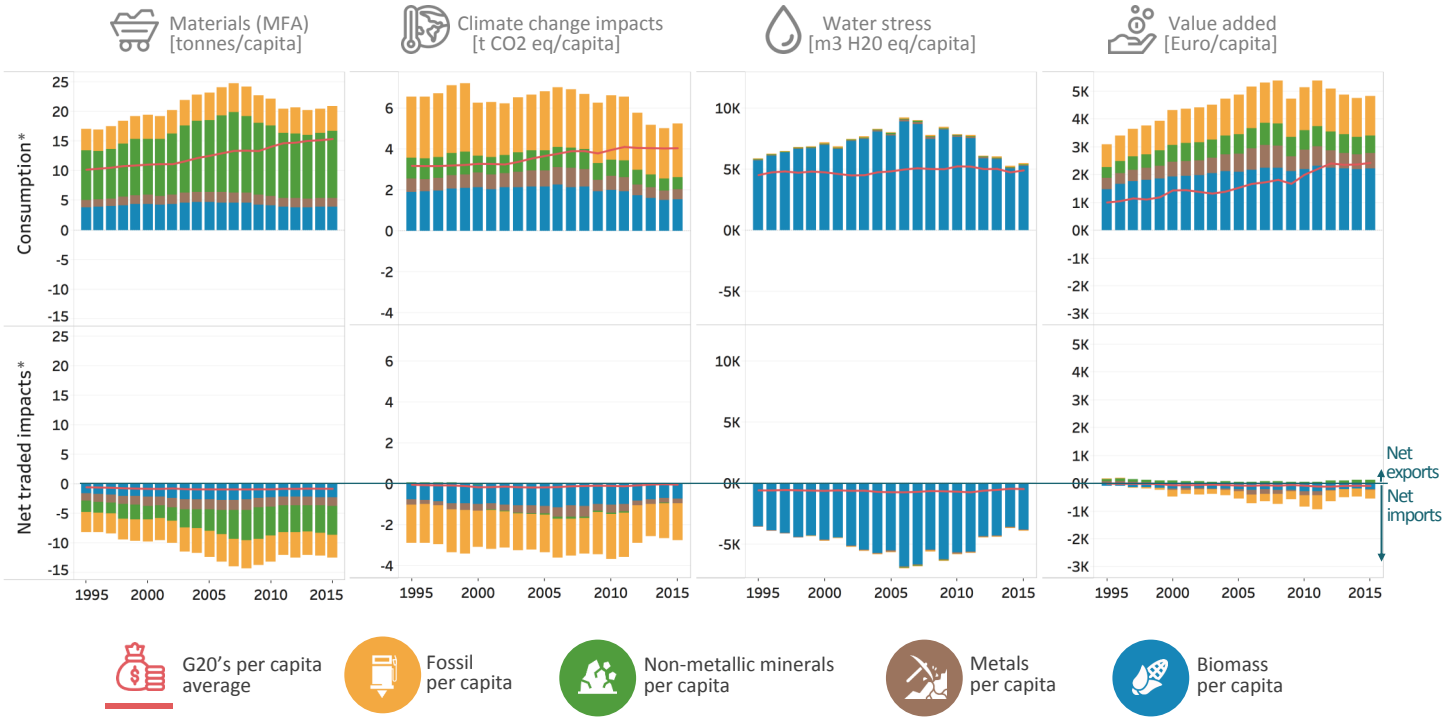


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- More than a third of material-related climate change impacts within Italy (production perspective) were caused by petroleum refining, cement and milk production.
- From a production perspective, climate change impacts decreased below G20 average. From a consumption perspective, climate change impacts were 20% higher than the G20 average. This is due to imports of goods with large embodied greenhouse gas emissions for domestic consumption, e.g. natural gas.
- The majority of biomass and fossils are consumed by Italian households (e.g. for food, mobility and housing).
- Minerals and wood play a key role for Italy's construction, furniture and machinery sectors.
- From a production perspective, water stress is mainly caused by the production of vegetables, fruits, and nuts.
- Water stress caused abroad for Italian consumption is dominated by agricultural activities, such as the production of vegetables, fruits, nuts, wheat, oil seeds, paddy rice and cereals.
- From a production perspective, land use-related biodiversity loss is slightly lower than the G20 average. It is higher than the G20 average from a consumption perspective. Main causes of this biodiversity footprint are imports of wood, beef, milk and oil seeds from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Italy (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Italy.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Italy is a net importer of all material types (with a much higher reliance on trade than the G20 average). Accordingly, more environmental impacts are caused outside of Italy from material imports than within its borders from material exports.

Value added for traded non-metallic minerals was higher within Italy than outside. This indicates that rather cheap raw materials are imported, while more expensive products are exported (e.g. marble products).

For traded fossils, metals and biomass, the net added value created was higher outside of Italy than inside, since the year 2000.

Future trends and potential Decoupling

Scenarios developed by the IRP forecast an increase of GDP of 74% to 97% and a rather constant population rate until 2060.

If ambitious resource efficiency policies are introduced, Italy could see an absolute decoupling of domestic material extraction and domestic material consumption from GDP until 2060.

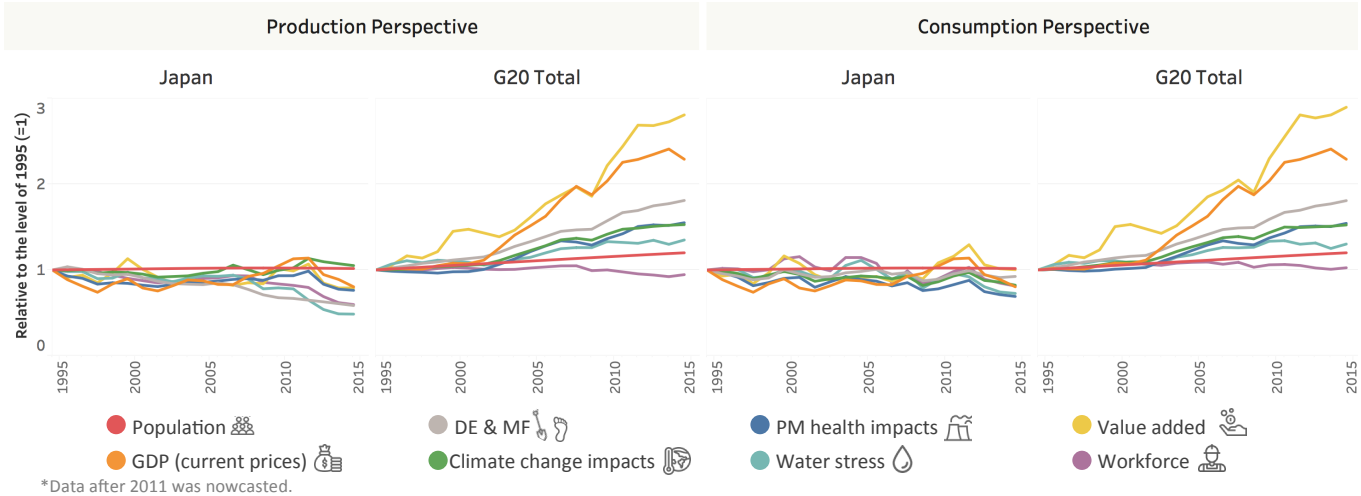
Material-related climate change and water stress impacts have slightly decreased in the past two decades. However, material footprint and all environmental impacts per capita remain above G20 average (consumption perspective). Resource efficiency strategies along the entire supply chain (including responsible sourcing of biomass imports and reduction of reliance on fossil fuels) could help decrease these impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Japan

STATUS AND TRENDS OF NATURAL RESOURCE USE

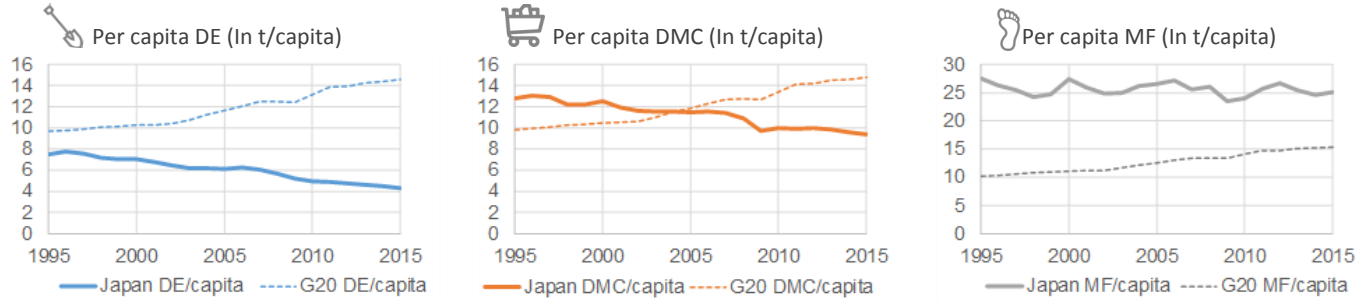
Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Japan and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.

Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Japan and in the G20 (1995-2015)



Source: IRP database

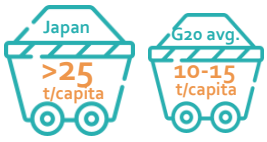
From 1995 to 2015

+2%

While the population only increased slightly, there were two economic recessions and a short recovery period.

Domestic extraction declined by **40%**

Material footprint remained stable and is higher than the G20 average.



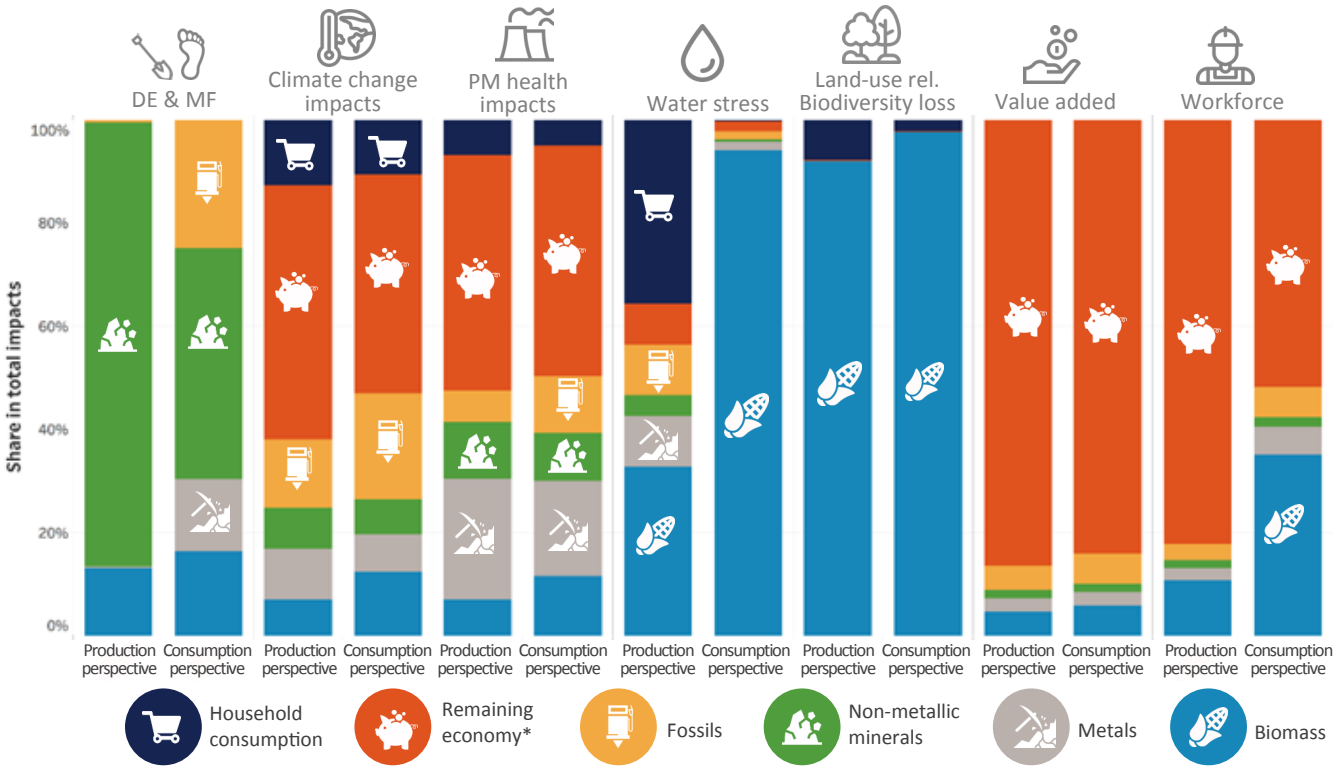
Material-related environmental footprints decreased slightly. There is slight decoupling of particular matter health impacts and water stress from economic growth (different from G20 average trends).

Domestic climate change impacts remained stable.

Per-capita impacts on climate change are **50%** higher than G20 average.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Japan (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated the domestic extraction amounts, but contributed less to material footprint and only caused a minor share of environmental impacts.

Japan sourced almost all fossil and metal resources from other countries.

The extraction and processing of natural resources accounted for about 50% of Japan's total climate change impacts and more than 90% of Japan's impacts on biodiversity loss and water stress (from a consumption perspective), both of which correspond closely to the G20 average.

From a production perspective, the extraction and processing of natural resources accounted for about 40% of total climate change impacts in Japan.

In line with other G20 countries, Japan's water stress and land use-related biodiversity footprints were caused mainly by biomass production (consumption perspective). However, biomass resources contributed to only 33% of the domestic water stress in Japan (production perspective), compared to the G20 average of more than 90%.

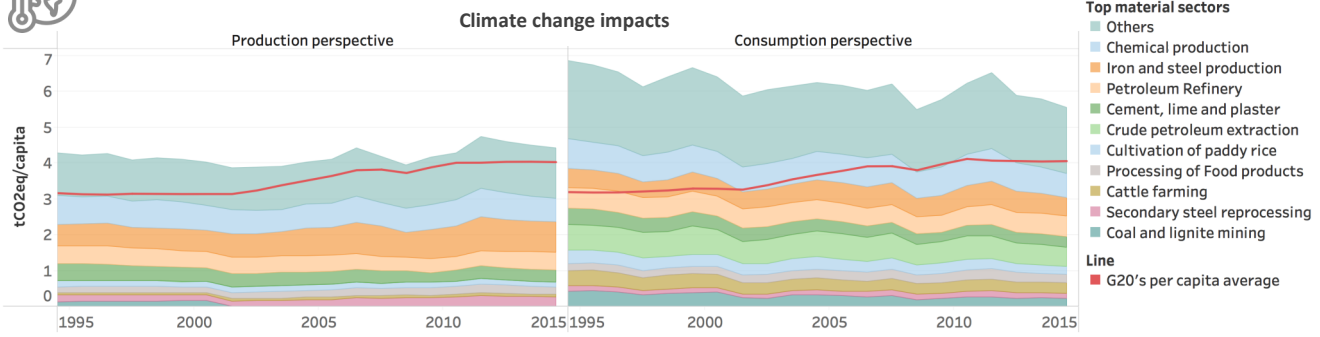
Outdoor PM related health impacts were more heavily influenced by the metal processing industries and less by households compared to the G20 average. This reflects Japan's high economic development, as households do not rely on solid fuels for cooking and heating.

The material sector contributed a minor share to value added as well as domestic jobs (both less than 20%) but relied on low-income workforce in agriculture outside of Japan for food imports.

In general, for all indicators the share related to material extraction and processing was higher in the consumption perspective than in the production perspective.

Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Japan (1995-2015)*



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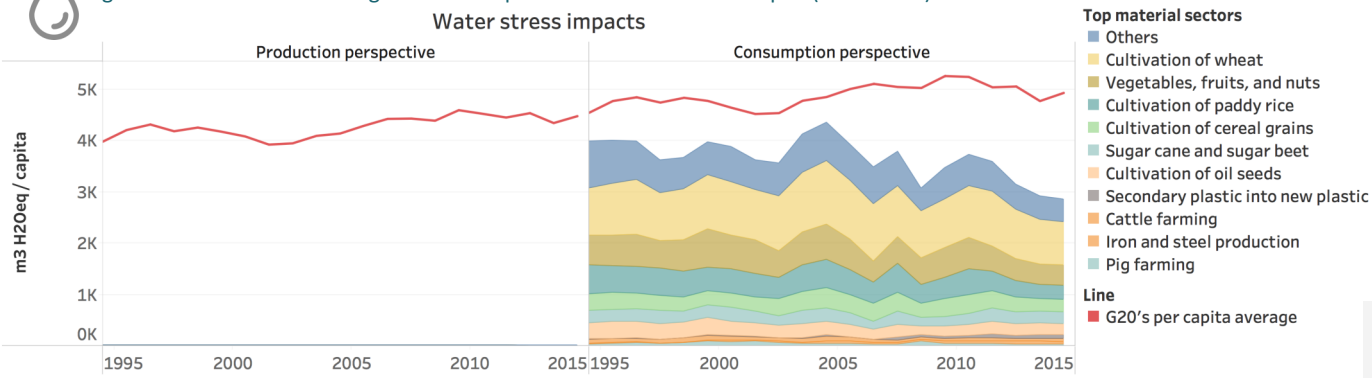
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Japan (1995-2015)*



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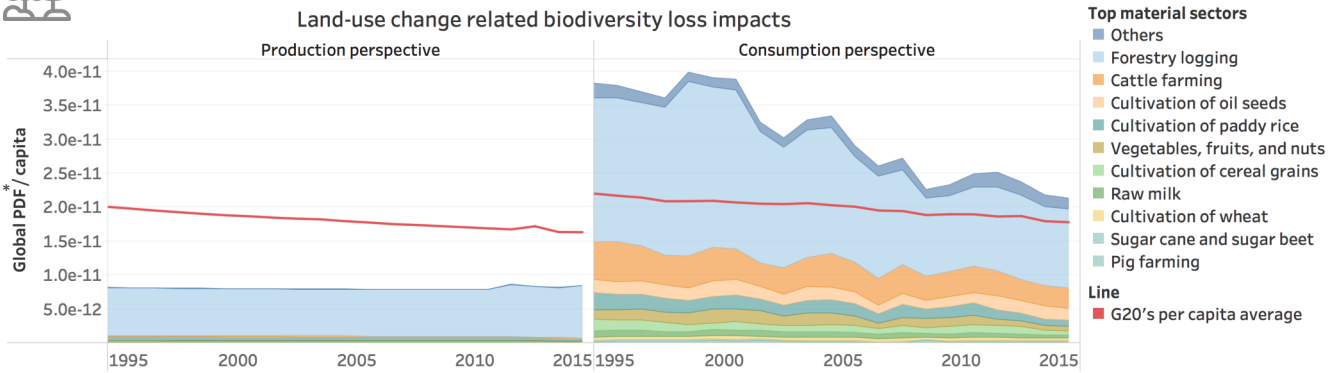
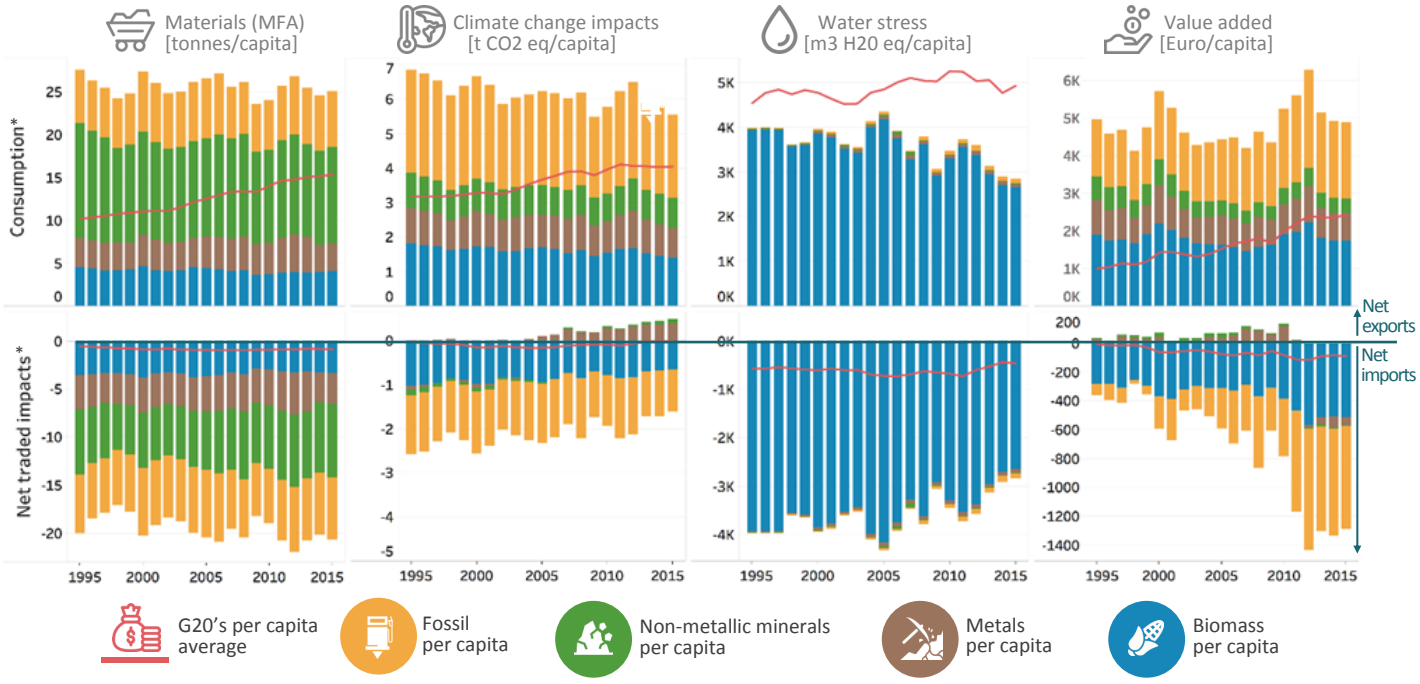


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- From both the production and consumption perspectives, most of the material-related climate change impacts are caused by the production of steel, chemicals, cement manufacturing and petroleum refining.
- From a consumption perspective, crude oil extraction is also a key sector.
- There is almost no water stress within the Japanese territory from a production perspective. This is due to the low irrigation requirements and abundance of renewable water sources to cover demand.
- Land-use related biodiversity loss in Japan is much lower than the average levels in the G20.
- Both water stress and land-use related biodiversity loss in Japan are much higher in the consumption perspective than in the production perspective. For water stress, it is still below G20 average.
- Imports of wood are the main source of land-use related biodiversity loss, followed by beef cattle.
- Imports of wheat and other crops from water-scarce regions are the main sources of water stress.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Japan (1995-2015)*



*Data after 2011 was nowcasted.
*_Consumption:_ Impacts throughout the supply chain from goods imported and consumed in Japan.
*_Net traded impacts:_ Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Japan is a net importer of fossils, non-metallic minerals, metals and biomass. As a consequence, a considerable fraction of the environmental impacts related to Japan's material consumption are outsourced to other countries.

Except for climate change impacts of metals, levels of both material trade and related environmental impacts have been stable since 1995.

Climate change impacts of metals have changed since 2005. Although Japan is a net-importer of metal resources by amount, metal processing with high greenhouse gas emissions takes place within Japan (e.g. steel production for export), leading to increasing domestic net emissions.

In general, material-related impacts of climate change per capita in Japan are about 50% higher than the G20 average.

A significant fraction of Japan's material-related value added is generated abroad due to the import of food and fossils (mainly petroleum).

Future trends and potential Decoupling

Material-related environmental footprints in Japan have slightly declined since 1995. However, material footprint and climate change impacts are high compared to the G20 average.

Material intensity in Japan slightly improved in the past two decades. Circular economy solutions and resource efficiency strategies throughout the supply chain (including in the design phase) in key sectors like iron and steel production could help lower material demand and related environmental impacts.

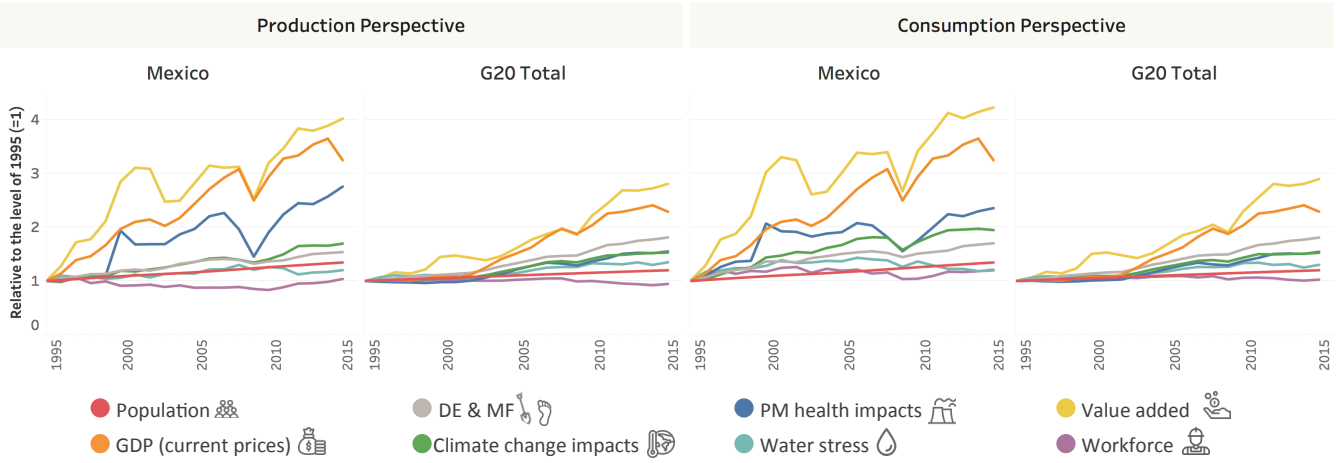
The economy currently relies heavily on imported fossils as an energy source. Increasing the mix of renewable energy sources could help lower Japan's material-related climate change impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Mexico

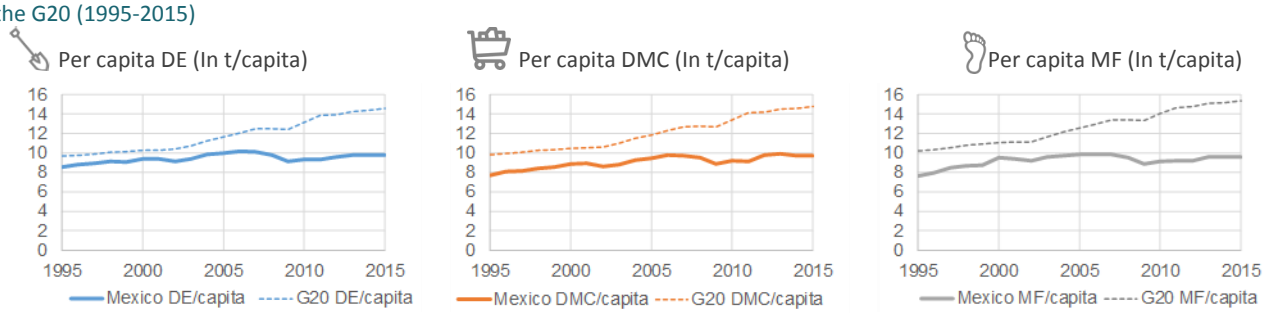
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Mexico and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction (DE), domestic material consumption (DMC), and material footprint (MF) per capita in Mexico and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **35%** and GDP multiplied more than threefold.

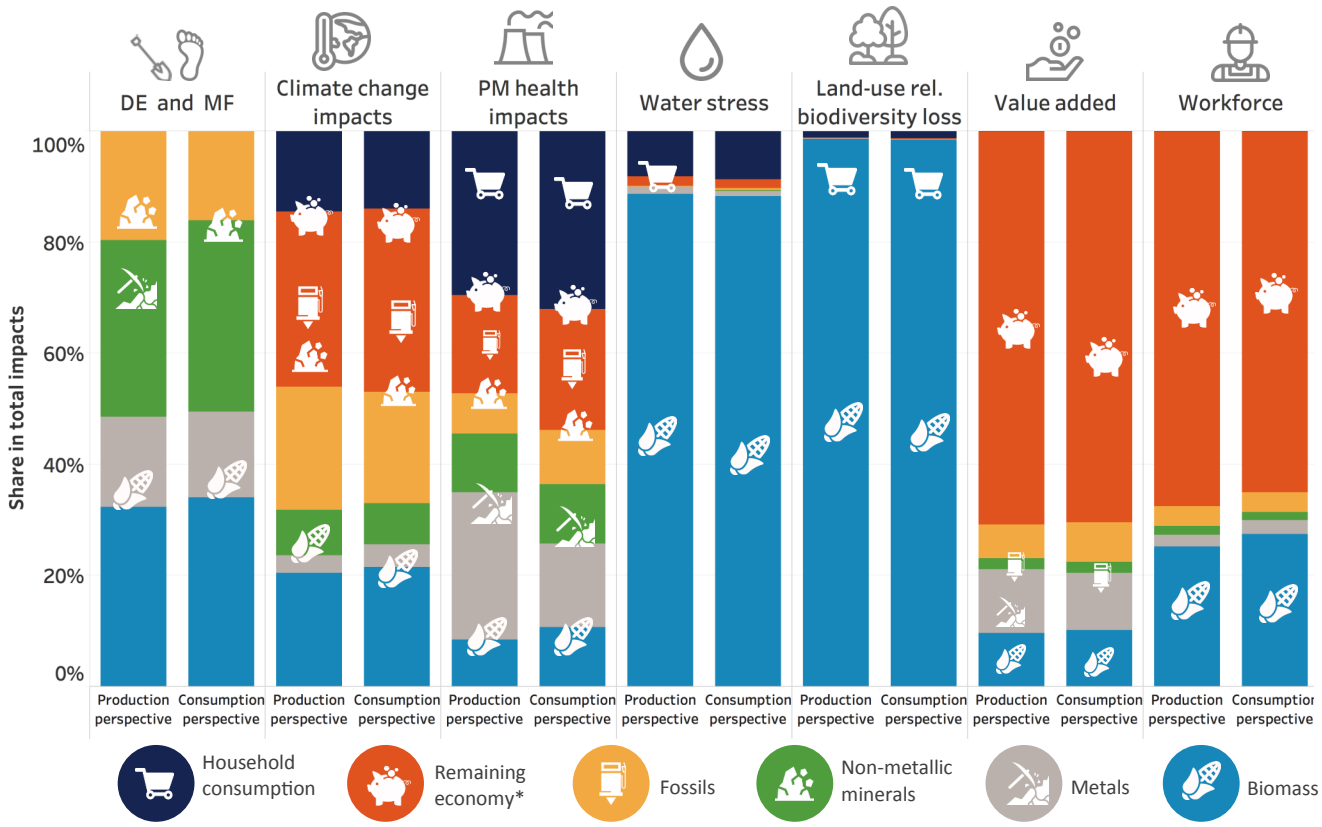
Domestic extraction, domestic material consumption and material footprint slightly increased (slower than G20 average).

In 2015, domestic extraction, domestic material consumption and material footprint were all at 10 tonnes per capita (below G20 average of 15 tonnes per capita for all three indicators).

There was relative decoupling of domestic extraction, domestic material consumption, material footprint and all environmental impacts from GDP. Outdoor particulate matter health impacts related to resource extraction and processing more than doubled and showed the lowest degree of decoupling.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Mexico (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals and biomass resources represented one third each of domestic extraction amounts and material footprint.

The extraction and processing of natural resources accounted for more than 50% of Mexico's total climate change impacts from both a production and a consumption perspective (similar to G20 average).

From a production perspective, about half of outdoor particulate matter related health impacts are caused by resource extraction and processing. This was higher than the G20 average.

Both from a production and consumption perspectives, households contributed to about 30% of particulate matter related health impacts.

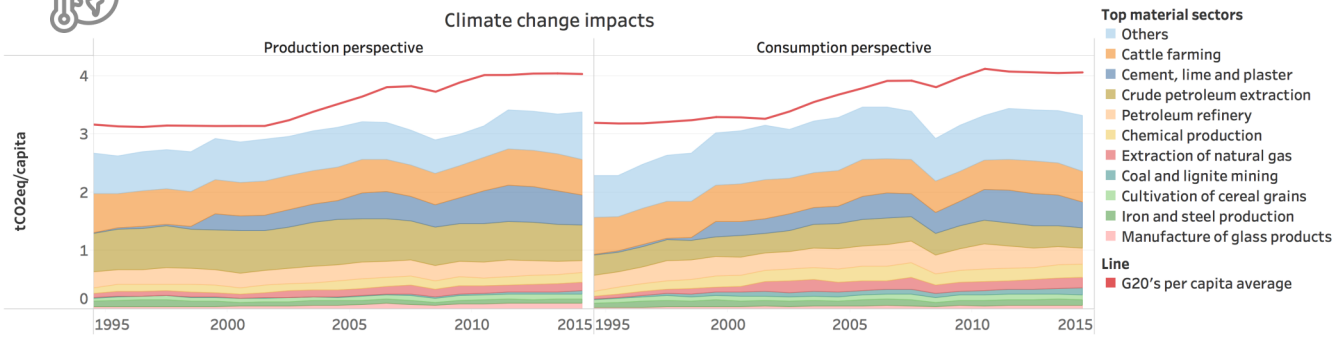
In line with other G20 countries, Mexico's water stress and land use-related biodiversity impacts were caused mainly by biomass production.

The material sector contributed to approximately 30% of value added, slightly higher than the G20 average.

One third of the workforce in Mexico was employed in the resource extraction and processing sectors (most of them in agriculture).

Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Mexico (1995-2015)*



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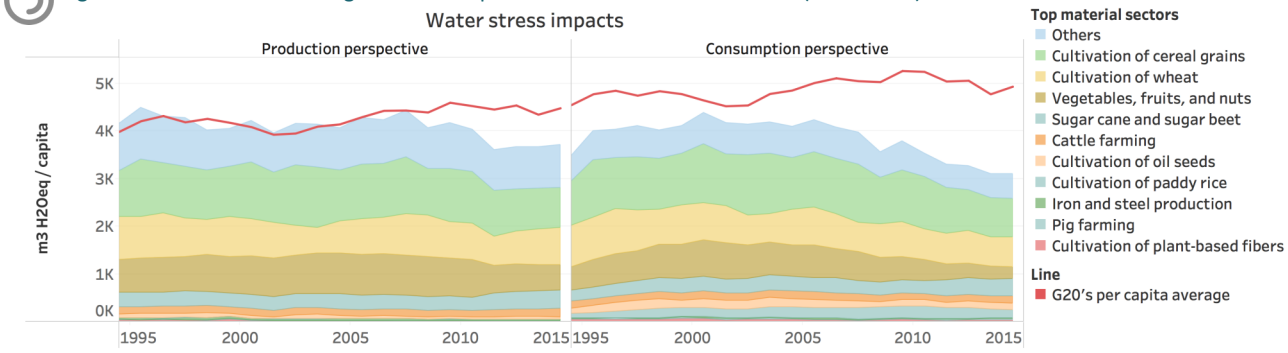

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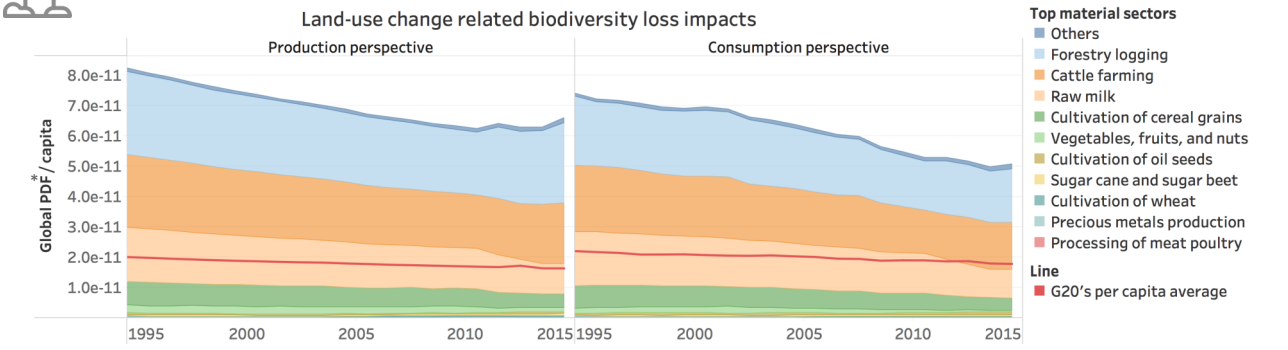
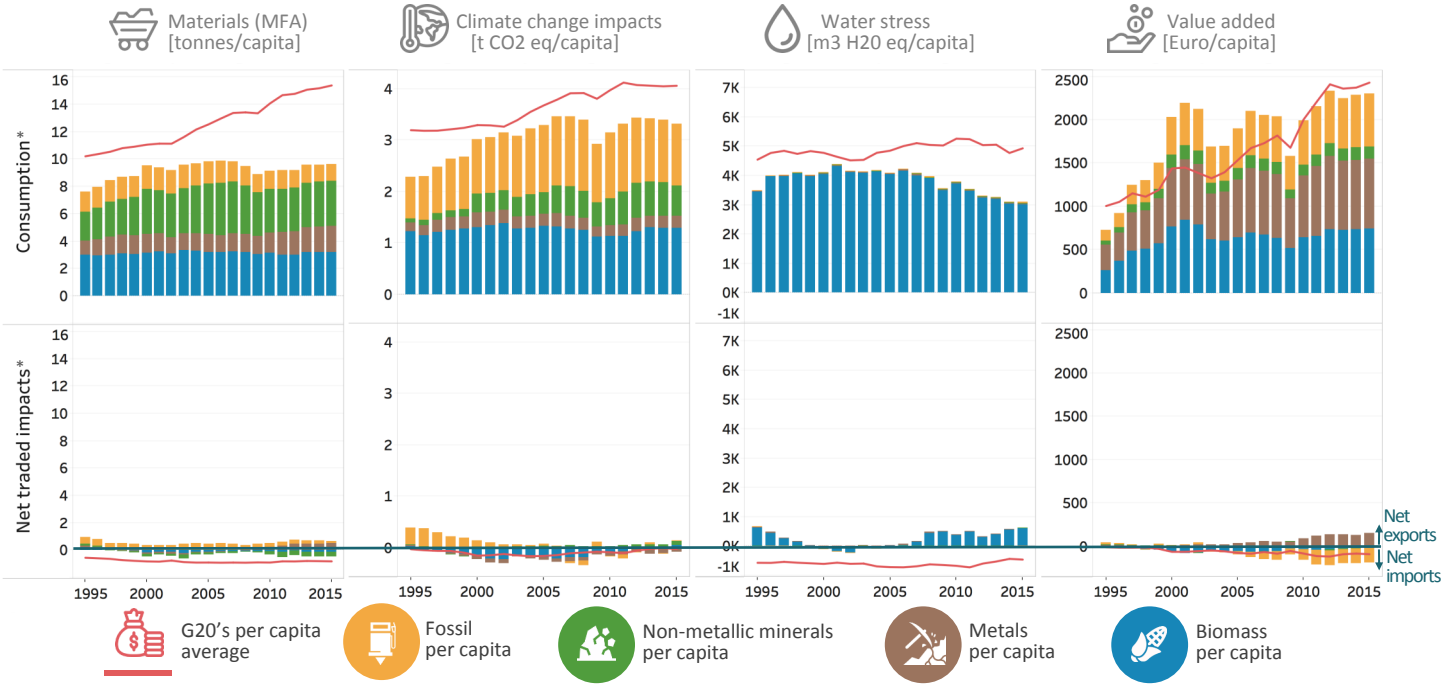


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by petroleum extraction and refining, cattle farming and cement manufacturing.
- Material related climate change impacts remained below the G20 average (-20%) from both the production and consumption perspectives.
- Most materials with large climate change impacts (petroleum products, beef and other food) are directly consumed by households.
- Construction is the major industrial end-use sector of climate-intensive materials (16% of total material-related impacts), followed by manufacture of motor vehicles (6%) and furniture production (4%).
- Mexico has many water-scarce regions. Water stress impacts were comparable to the G20 average from a production perspective and lower than this average from a consumption perspective.
- Water stress was caused mainly by the production of cereal grains (mainly corn), wheat, vegetables, fruits, nuts, and sugar cane. Water stress was lower from a consumption perspective than from a production perspective. This was due to exports of vegetables, fruits, nuts and wheat.
- Land use related biodiversity loss was more than three and two times higher than the G20 average in the production and consumption perspectives, respectively. Biodiversity loss was mainly caused by forestry, beef and dairy production and reflects rich megadiverse status of Mexico.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Mexico (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Mexico.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Mexico is a net exporter of fossils and metals and an importer of non-metallic minerals and biomass. Traded amounts are low in comparison to overall material consumption.

Climate change impacts related to traded materials were low in comparison to overall consumption impacts.

Only trade of metals created net value added within Mexico. For fossils and biomass, cheap resources were exported (e.g. crude oil) while more expensive ones were imported (e.g. refined oil and chemicals).

Future trends and potential Decoupling

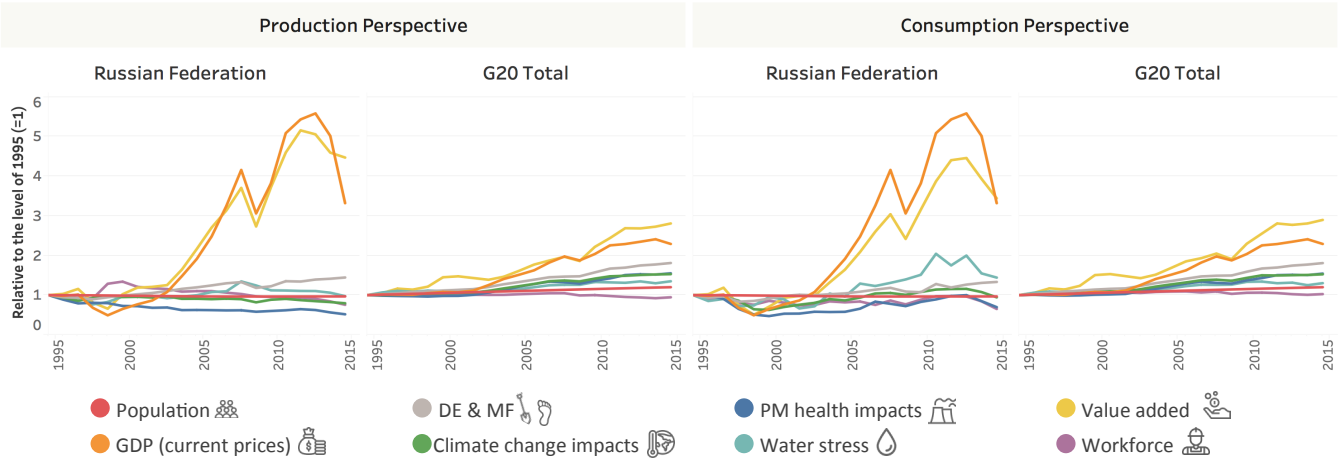
- Scenarios developed by the IRP forecast a more than threefold increase of GDP and a population growth of between +9% and +25% until 2060.
- If ambitious resource efficiency policies are introduced, Mexico could achieve an absolute decoupling of domestic material extraction and domestic material consumption from GDP by 2060. Overall, domestic extraction and domestic material consumption are projected to increase until 2060 by ~20% and ~25%, respectively, in the resource efficiency scenario.
- Mexico harbors valuable ecosystems at high risk of biodiversity loss. Policies to protect biodiversity and regulate agriculture and forestry are critical.
- An increase in water use efficiency for agricultural production could reduce water scarcity impacts.
- Mexico suffers from particulate matter pollution caused by metal processing (iron and steel production), cement production and resource use (e.g. traffic from households). Installing air abatement technologies and improving transportation are essential steps to decrease pollution.
- Circular economy solutions, including proper waste management and increased material recycling rates would also be beneficial.
- A large build-up of infrastructure is anticipated in the next decades. This will result in enhanced resource demands and environmental impacts. Material efficient urban design is therefore critical.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Russia

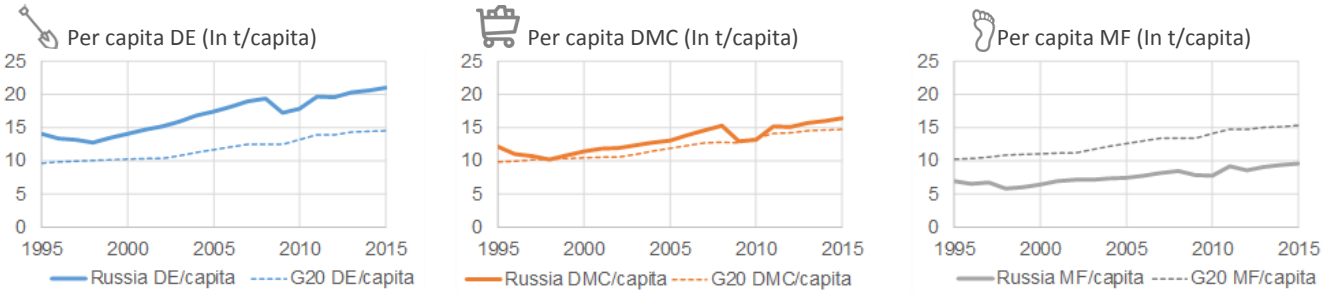
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Russia and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Russia and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **5%** and GDP multiplied threefold (with high fluctuations in-between).

Domestic extraction, domestic material consumption and material footprint all increased, following G20 average trends.

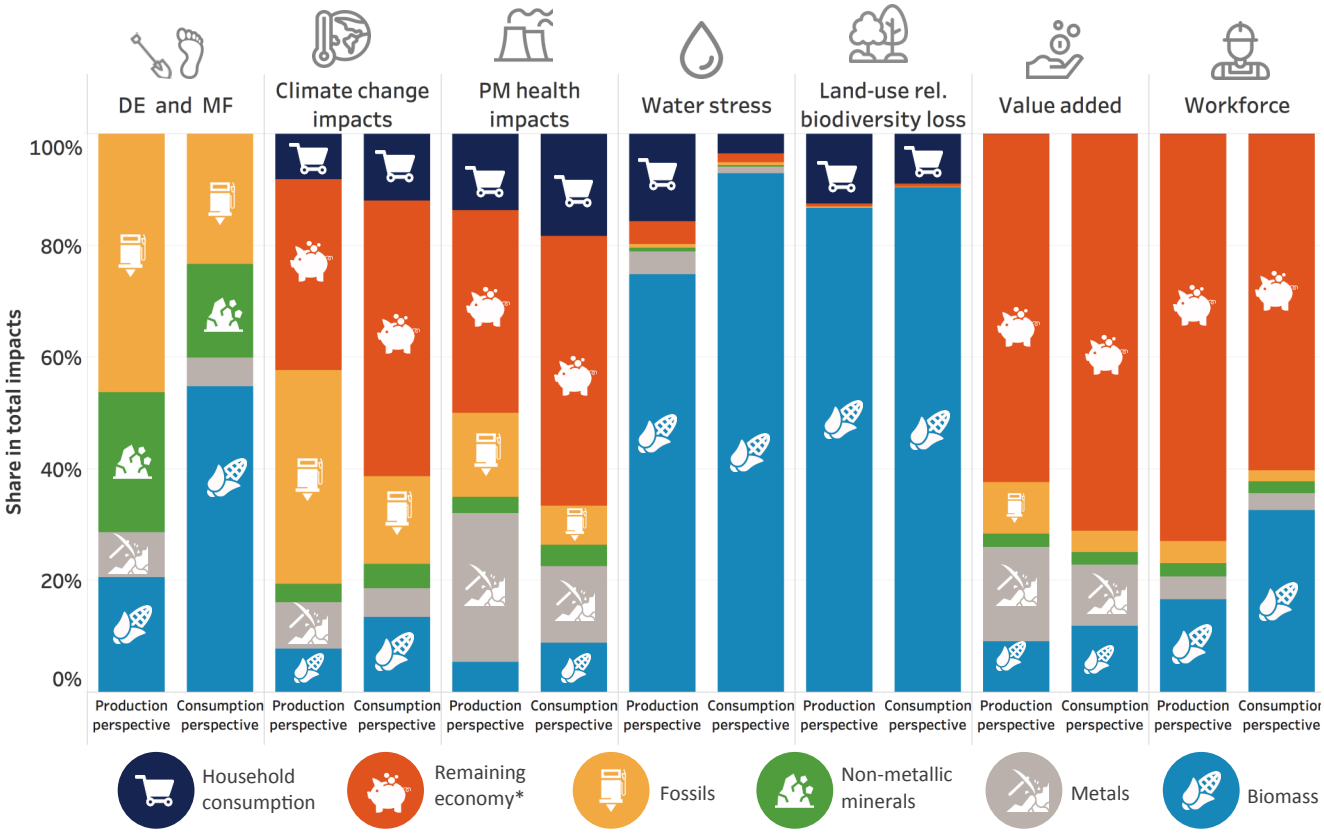
In 2015, domestic extraction was **21** tonnes per capita (higher than the G20 average of 15 tonnes per capita) while material footprint was **10** tonnes per capita (lower than the G20 average). This is due to Russia's status as a resource exporting nation.

Material related environmental impacts decoupled from GDP.

Particulate matter related health impacts showed the strongest absolute decoupling (in both perspectives) from GDP.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Russia (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Unlike the G20 average, fossils dominated domestic extraction amounts while biomass caused most of the material footprint.

The extraction and processing of natural resources accounted for almost 60% of Russia's total climate change impacts from a production perspective and almost 40% from a consumption perspective (the G20 average was approximately 50% from both perspectives).

The extraction and processing of natural resources accounted for almost half of Russia's total outdoor particulate matter health impacts from a production perspective and one third from a consumption perspective (higher than G20 average). Metal processing caused more than a quarter of Russia's outdoor particulate matter health impacts.

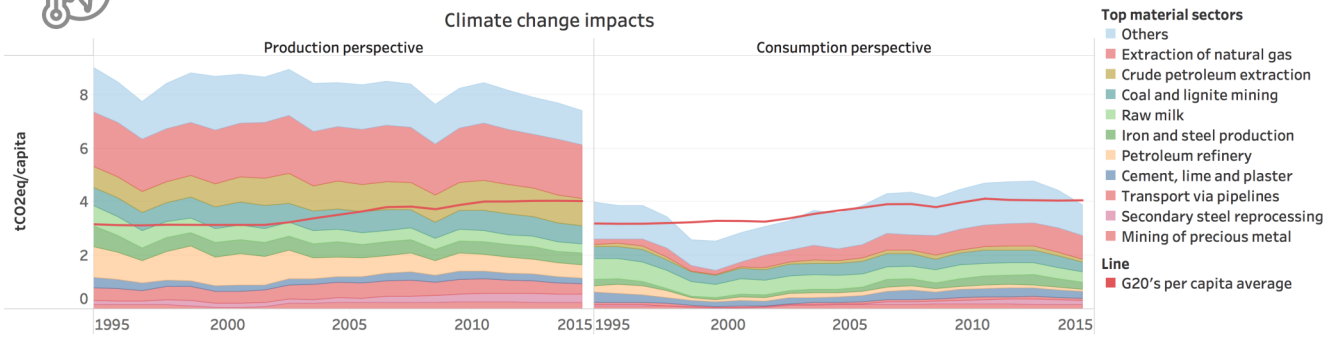
In line with other G20 countries, Russia's water stress and land use-related biodiversity impacts were caused mainly by biomass production from both perspectives.

The material sector contributed to almost 40% of value added from a production perspective and to about 30% of value added from a consumption perspective. This is higher than the G20 average (which is less than 20%).

From a production perspective, about 25% of all workforce in Russia worked for the extraction and material processing sectors. From a consumption perspective, this share was about 40% (mainly due to low-paid jobs in agriculture for food imports).

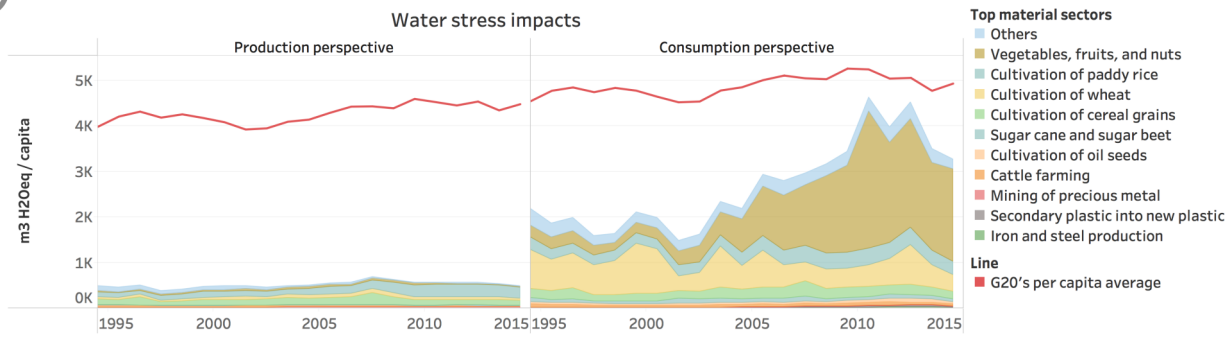
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Russia (1995-2015)*



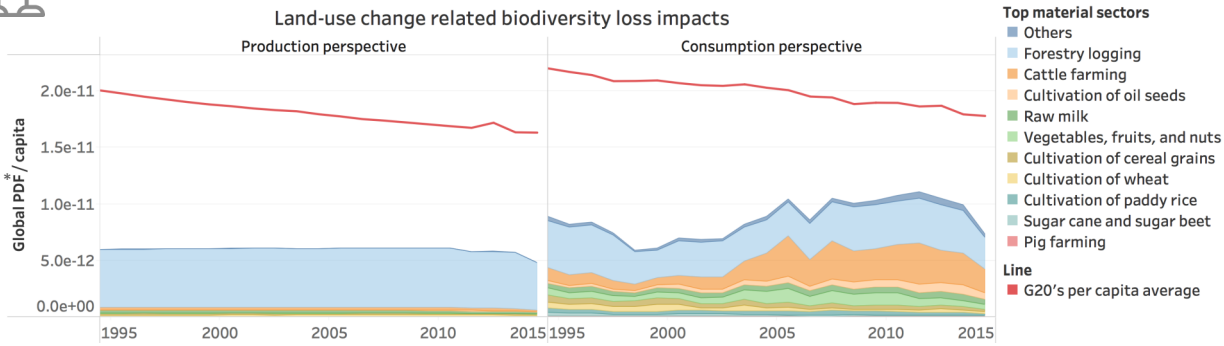
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Russia (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Russia (1995-2015)*

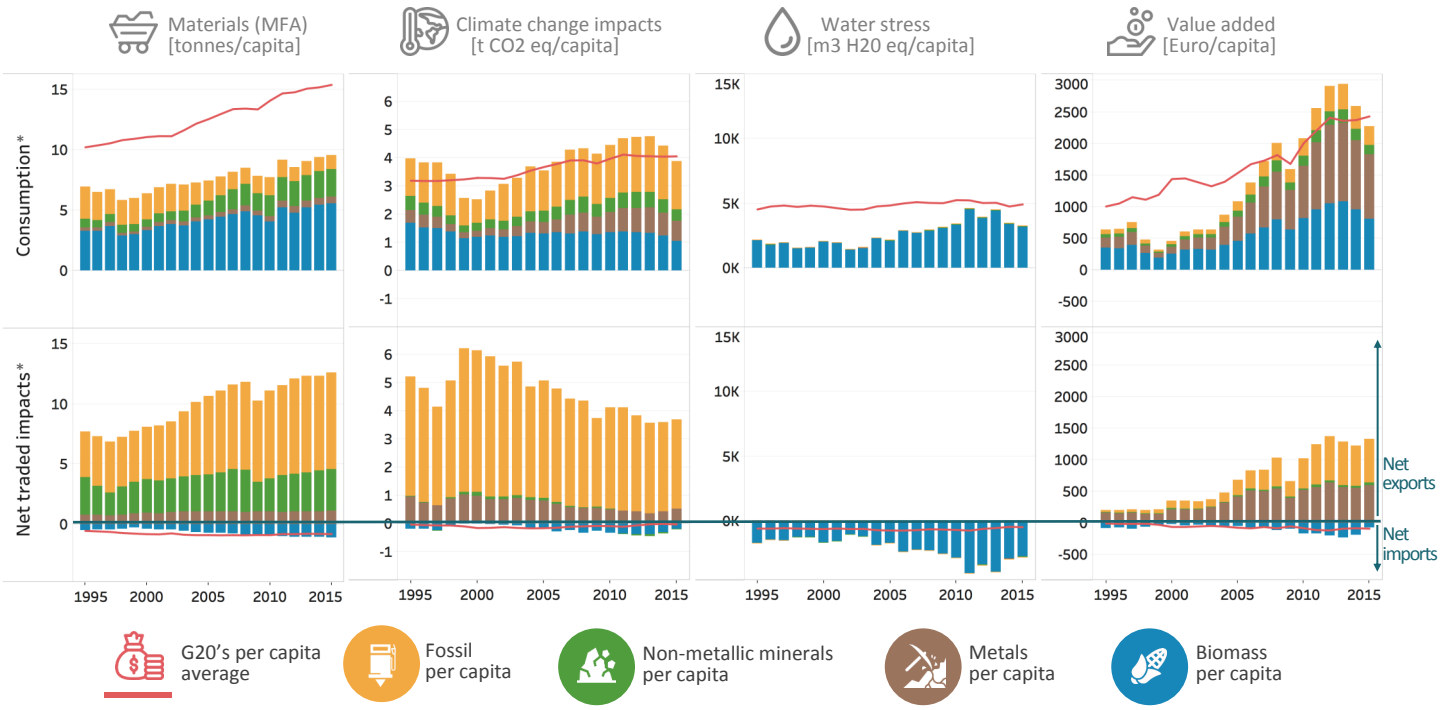


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by natural gas extraction, petroleum extraction and refinery, coal mining, iron and steel production and raw milk production.
- From a production perspective, material related climate change impacts were more than 85% higher than the G20 average.
- From a consumption perspective, material related climate change impacts were similar to the G20 average. The difference to the production perspective is mainly due to emissions caused by the extraction and processing of exported fossil fuels.
- Materials with large climate impacts (natural gas, petroleum) are often directly consumed by households especially for heating and mobility.
- A major industrial sector using climate-intensive materials is the construction industry.
- From a production perspective, water stress impacts are much lower than the G20 average. Paddy rice and cereal production caused most of these impacts.
- Water stress was higher from a consumption perspective than from a production perspective (but still lower than G20 average) due to imports of vegetables, fruits, nuts, and wheat.
- Land use related biodiversity loss was considerably lower than the G20 average. This loss was mostly caused by forestry (from both perspectives) and cattle farming (from a consumption perspective).

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Russia (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in Russia.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Russia is a net exporter of all material types except biomass.

Considerably more climate change impacts were caused by material exports than by material imports. This is especially the case for fossils, since more than two thirds of domestic climate change impacts related to fossils production were due to exported fuels.

More water stress was caused by imports than exports, due to food imports.

For all material types but biomass, material trade created net value added within Russia (mainly fossils and metals).

Future trends and potential Decoupling

Russia is a major exporter of fossil fuels with significant impacts on climate change in the use, extraction, and processing phases (e.g. losses of natural gas during extraction and pipeline transportation). An improved management in the extraction and processing phase and an overall significant reduction of fossil resource extraction will be needed to meet the Paris Agreement.

Russia is also an exporter of iron and steel products. This does not only lead to climate change impacts, but to particulate-matter related health impacts within Russia. Reducing emissions of particulate matter and substances that form particulate matter in the atmosphere (e.g. SOx and NOx) is therefore essential.

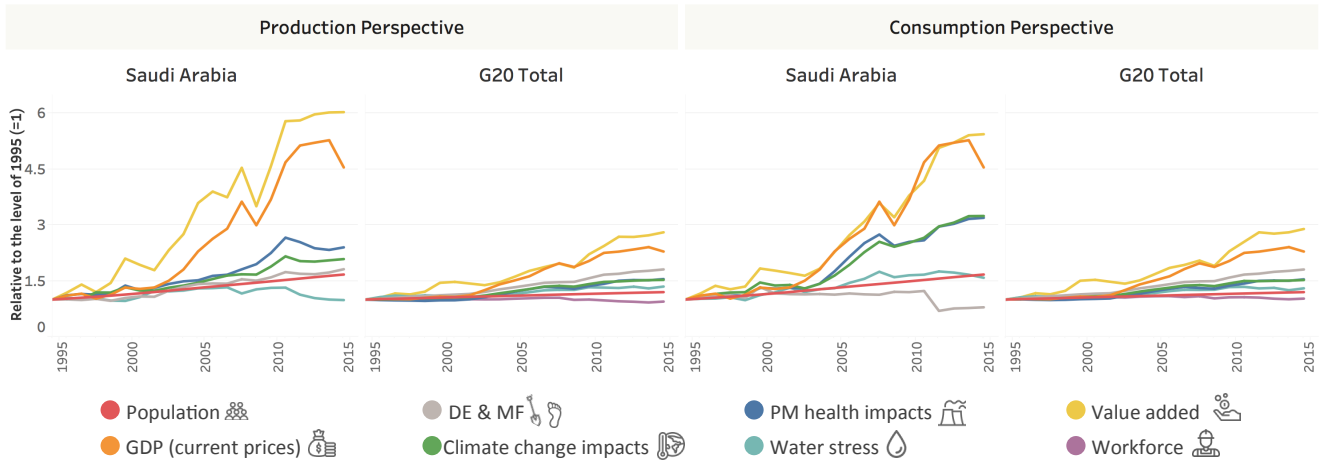
Material efficient urban design and circular economy solutions could help lower the material-use related climate change impacts of the construction sector.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Saudi Arabia

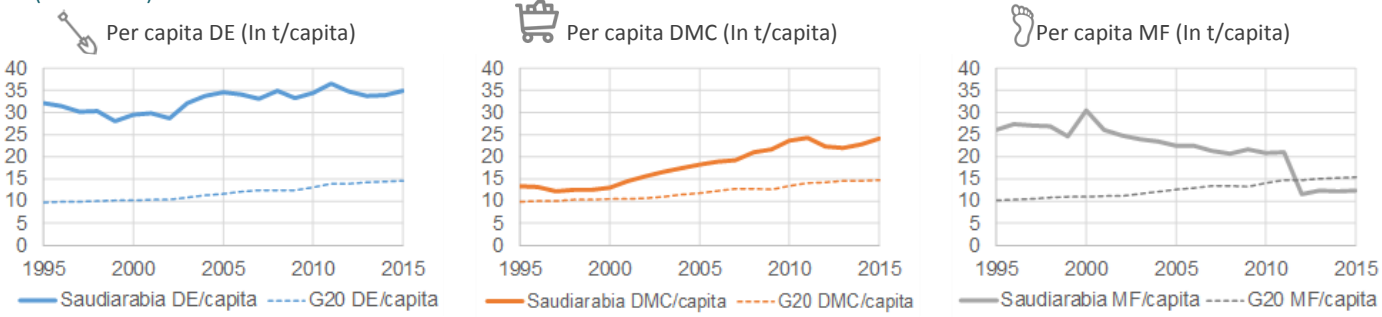
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Saudi Arabia and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Saudi Arabia and in the G20 (1995-2015)



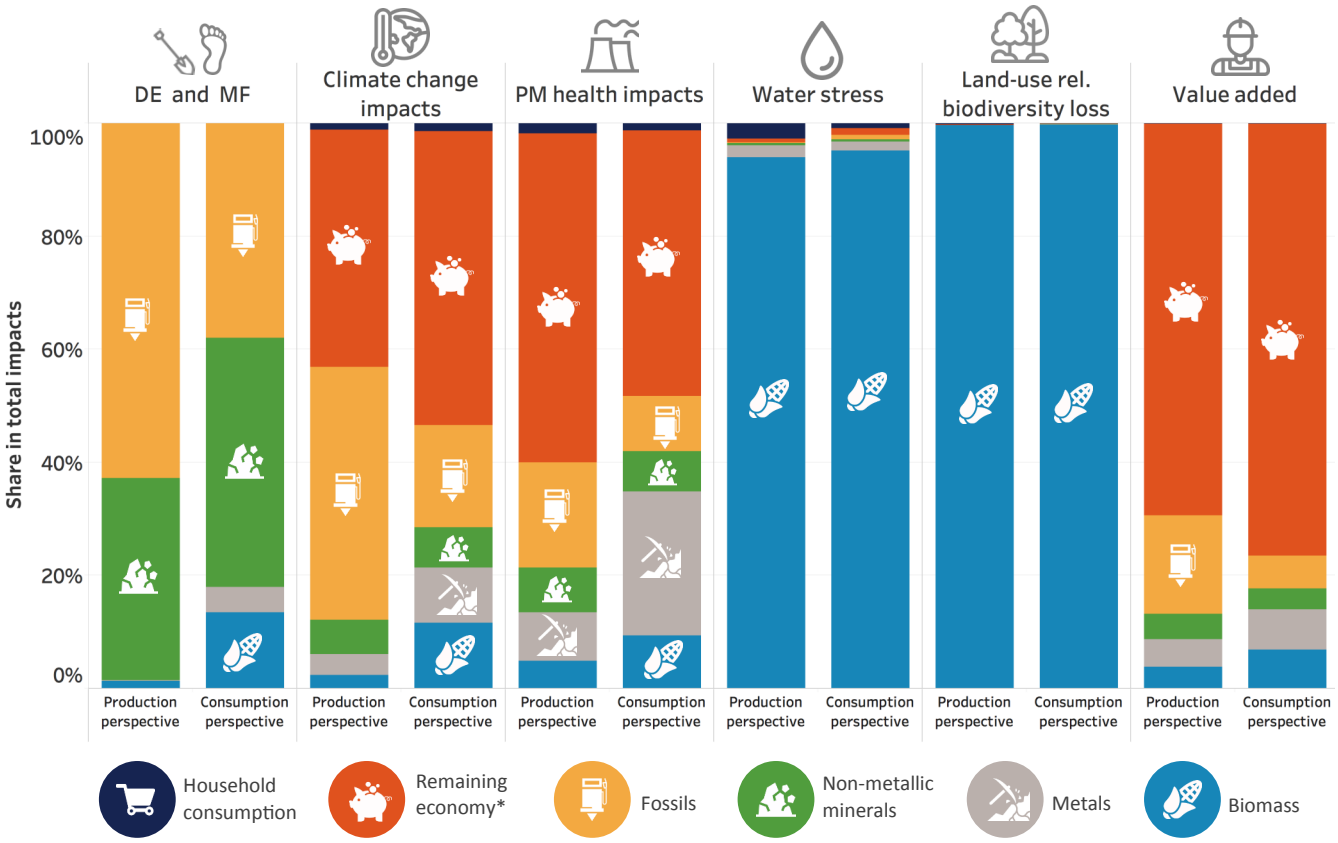
Source: IRP database

From 1995 to 2015

- GDP increased more than **fourfold** and population increased by **2/3**.
- Domestic resource extraction remained at a high level and was more than double the per-capita value of the G20 average.
- Per-capita material footprint decreased and is now comparable to the G20 average.
- Climate change and particulate matter health impacts related to resource extraction and processing increased by a factor of **2-3** and are higher than the G20 average.
- From a consumption perspective, water stress increased with population growth.
- Saudi Arabia experienced a relative decoupling from national GDP of both material use and impacts as well as added value (related to material production).

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Saudi Arabia (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, OECD, Pfister et al. 2011, Chaudhary et al. 2016, Cabernard et al. 2019

Saudi Arabia is a major global oil producer. Hence, fossil resources made up more than 60% of domestic extraction and 40% of its material footprint. Both numbers are significantly higher than the G20 average of 20%.

From a production perspective, climate change impacts were dominated by fossil resource extraction and processing and were higher than the G20 average.

From a consumption perspective, the contribution of resources to climate change is comparable to the G20 average (50%).

In line with other G20 countries, water stress and land-use related biodiversity impacts were caused mainly by biomass cultivation.

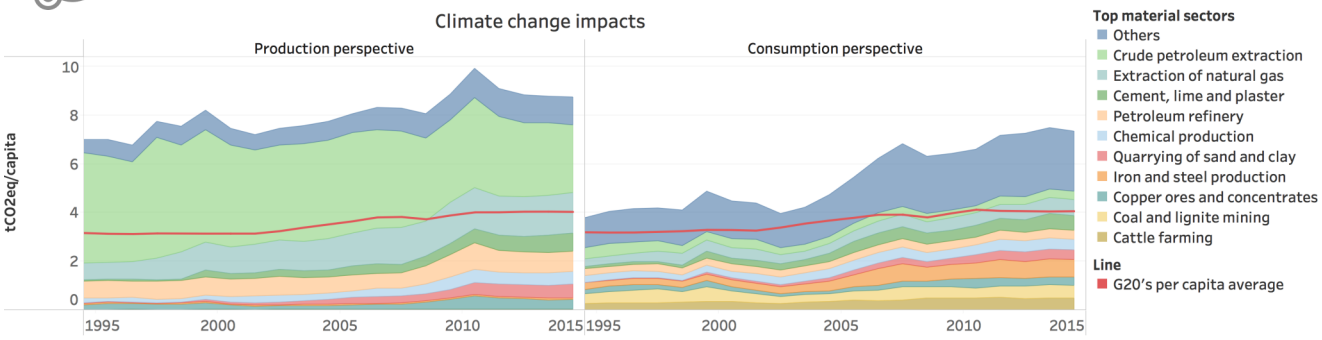
Outdoor particulate matter related health impacts were caused mainly by the remaining economy (e.g. electricity from fossil resources). However, the share of impacts from extraction and processing activities was higher than the G20 average. This is due to the extraction and refining of oil (production perspective) and to metal imports (consumption perspective).

Economic value added of resource extraction and processing in Saudi Arabia is larger than the G20 average.

Resource extraction and processing provides approximately 30% of all jobs in Saudi Arabia, mostly in the petroleum extraction and refinery sectors.

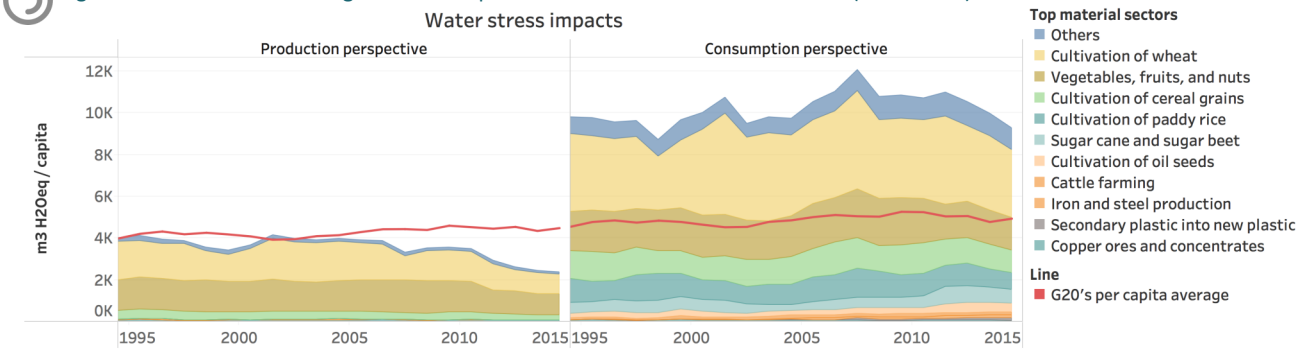
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Saudi Arabia (1995-2015)*



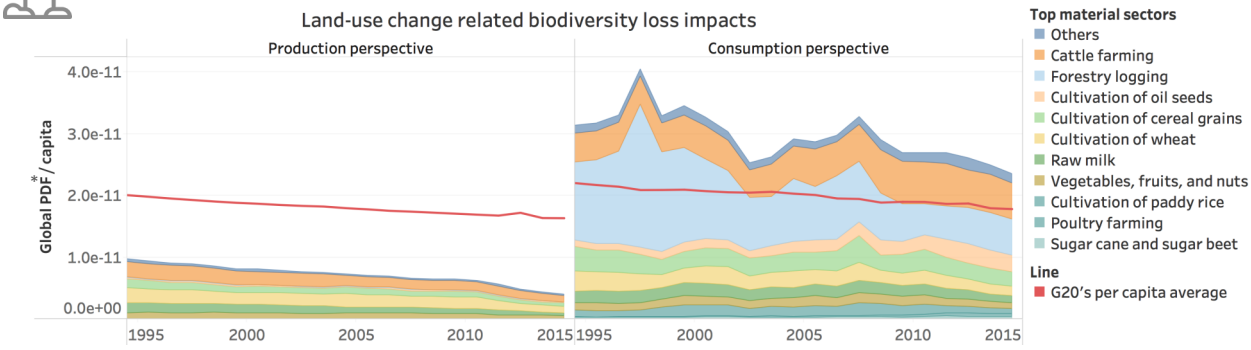
*Data after 2011 was nowcasted.
Source: Exiobase v3.4, Eora 26, FAOSTAT, Cabernard et al 2019

Figure 5: Water stress from agricultural crop and material sectors in Saudi Arabia (1995-2015)*



*Data after 2011 was nowcasted.
Source: Exiobase v3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Saudi Arabia (1995-2015)*

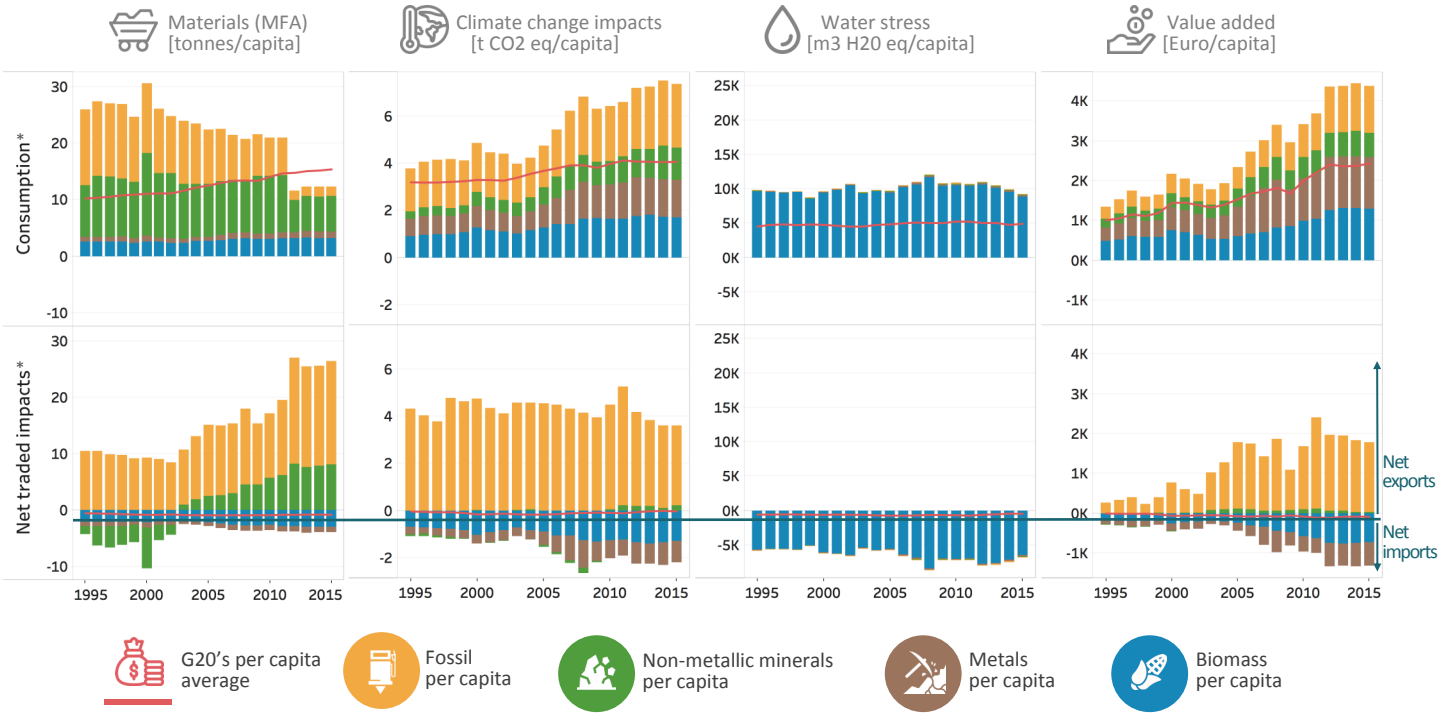


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: Exiobase v3.4, Eora 26, FAO, OECD, Pfister et al. 2011, Chaudhary et al. 2016, Cabernard et al 2019

- Climate change impacts increased and were higher than the G20 average from both a production and consumption perspective.
- Saudi Arabia is the top oil exporter in the world. From a production perspective, petroleum extraction and refinery as well as natural gas extraction cause more than 60% of domestic greenhouse gas emissions. Further important sectors are cement manufacturing, chemical production and quarrying of sand and clay.
- From a consumption perspective, iron and steel manufacturing, cattle farming and coal mining are important sources of climate change impacts, in addition to petroleum extraction and refinery as well as natural gas extraction.
- Despite severe waster scarcity in Saudi Arabia, levels of water stress from agriculture activities were below the G20 average in the production perspective due to a strong reliance on food imports.
- From a consumption perspective, water stress levels remained stable and were about 50% higher than the G20 average. The main contributing food products were wheat and other cereals, vegetables, fruits, nuts, and paddy rice.
- From a production perspective, land-use related biodiversity loss remained low due to limited agricultural activities.
- From a consumption perspective, land-use related biodiversity loss decreased but remained above the G20 average. This is mainly due to imports of beef, wood, oil seeds, and cereals.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Saudi Arabia (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in Argentina.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase 3.4, Eora 26, FAOSTAT, Pfister and Bayer 2014, Boulay et al. 2017, Cabernard et al 2019

More materials (particularly fossils) were exported than domestically consumed.

Oil extraction and refining for export caused a high share of climate change impacts.

From a consumption perspective, metals and food imports contributed to about 40% of the material-related climate change impacts.

Due to natural water constraints, Saudi Arabia relies on imports of many food products. Therefore, impacts of water stress and land-related biodiversity loss related to those imports occurred in other countries.

Since 2005, Saudi Arabia maintained a high net trade surplus (value added) for fossil resources (oil).

Future trends and potential Decoupling

Several types of environmental impacts have decoupled relatively from GDP in Saudi Arabia. Opportunities for further improvement exist, for example by transforming the domestic energy sector, which relies mainly on oil and gas, to renewable energy systems (particularly solar energy).

An overall significant reduction of fossil resource use will be needed in order to meet the Paris Agreement.

Impacts from food imports could be lowered by sourcing food products from locations with lower water stress and biodiversity vulnerability.

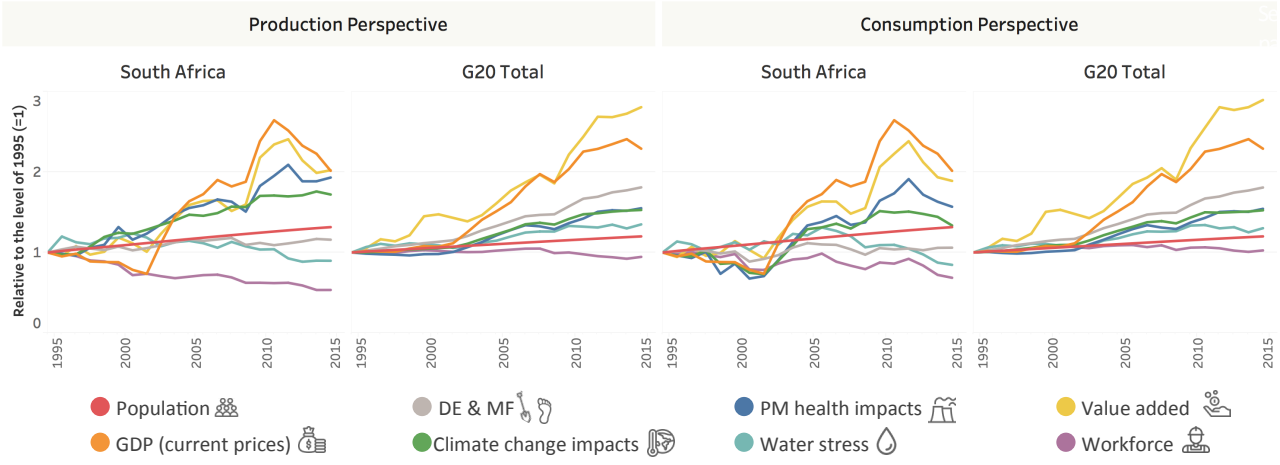
Circular economy solutions and resource-efficiency policies are critical to lower the impact of materials, e.g. the elevated metal use from a consumption perspective.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | South Africa

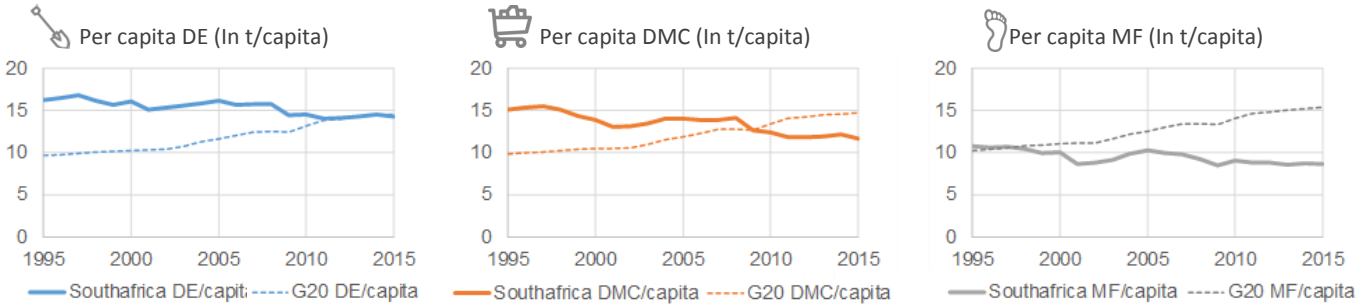
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in South Africa and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in South Africa and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **32%** and GDP **doubled** (with high fluctuations in-between).

Per-capita domestic extraction, domestic material consumption and material footprint slightly decreased. Domestic material consumption and material footprint fell below G20 average.

In 2015, domestic extraction was **15** tonnes per capita while material footprint was **9** tonnes per capita. This is due to South Africa's status as a resource exporting nation.

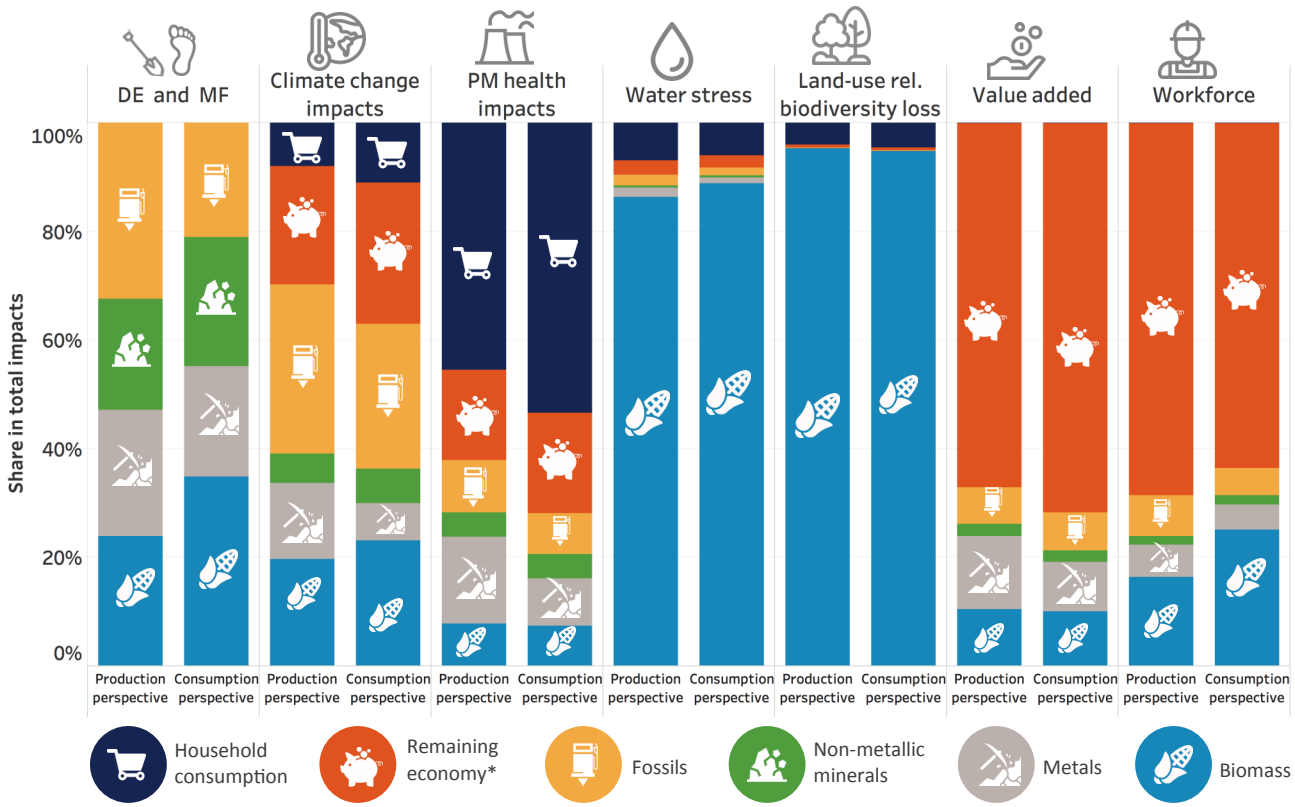
Material related environmental impacts decoupled from GDP.

From a production perspective, climate change impacts related to material extraction and processing increased and were about **50%** higher than the G20 average.

From a consumption perspective, climate change impacts related to material extraction and processing were similar to the G20 average.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in South Africa (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Unlike the G20 average, fossils dominated domestic extraction amounts, followed by biomass and metals. Most of the material footprint was caused by biomass.

The extraction and processing of natural resources accounted for almost 70% of South Africa's total climate change impacts from a production perspective and 60% from a consumption perspective (the G20 average was approximately 50% from both perspectives).

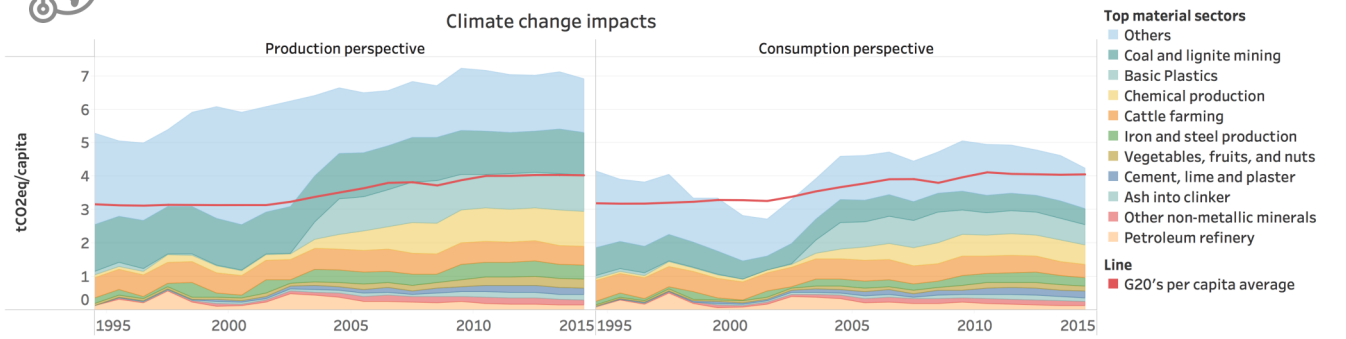
Outdoor particulate matter related health impacts mainly came from households (use of solid fuels for cooking).

In line with other G20 countries, South Africa's water stress and land use-related biodiversity impacts were caused mainly by biomass production.

The material sector contributed more than 30% to value added from a production perspective and about 25% from a consumption perspective. This is higher than the G20 average (less than 20%).

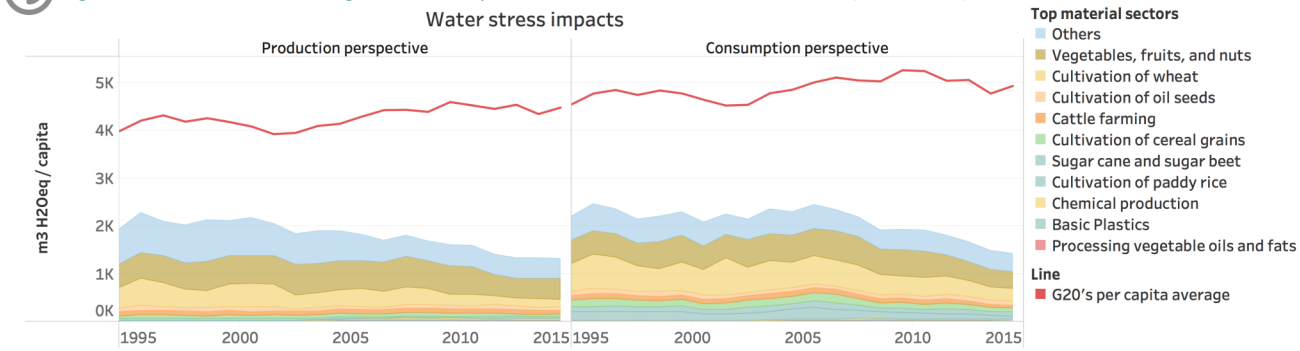
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in South Africa (1995-2015)*



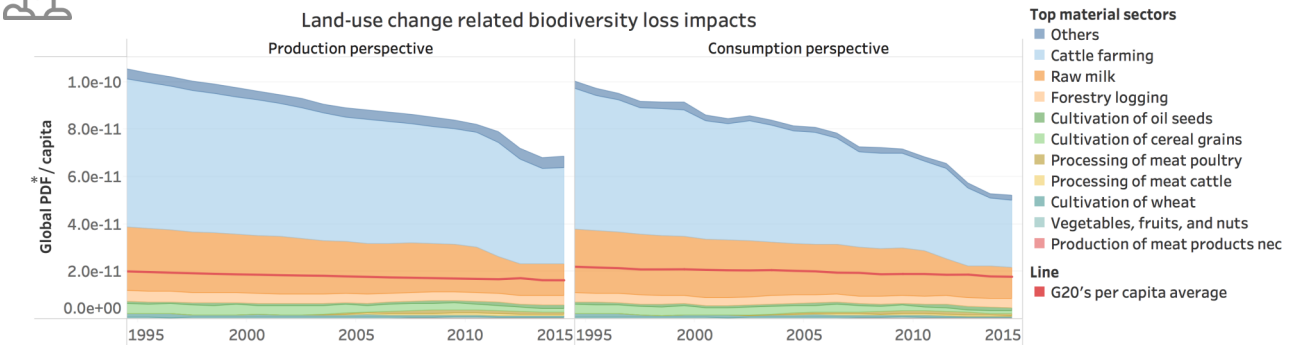
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in South Africa (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in South Africa (1995-2015)*

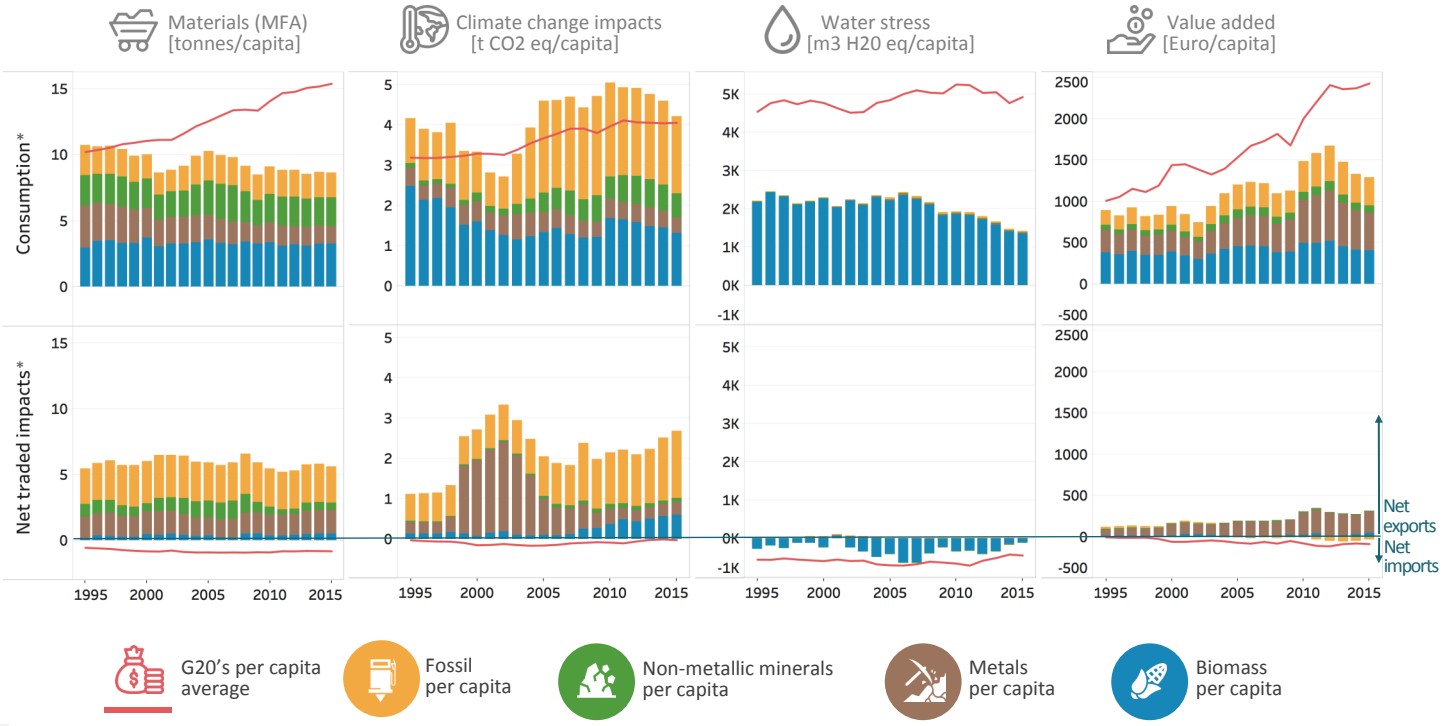


*Data after 2011 was nowcasted.
PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by coal mining, plastics manufacturing, production of chemicals, and cattle farming.
- Material related climate change impacts remained more than 50% higher than the G20 average from a production perspective.
- From a consumption perspective, material related climate change impacts were similar to the G20 average. This is due to emissions caused by the extraction and processing of materials that are exported.
- South Africa has many water-scarce regions, but overall water stress impacts are lower than the G20 average and declined over time.
- Water stress was dominated by the production of vegetables, fruits, nuts, and wheat.
- Land use related biodiversity loss was much higher than the G20 average, caused mostly by beef and dairy production.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in South Africa (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in South Africa.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

South Africa is a net exporter of all material types.

More climate change impacts were caused by material exports than by material imports.

More water stress was caused from imports than exports, due to imports of biomass from water-scarce countries.

For all material types but fossils, material trade created net value added within South Africa. For fossils, cheap resources were exported (e.g. coal) while more expensive ones were imported.

Future trends and potential Decoupling

South Africa suffers from particulate matter pollution caused by resource use. Lowering solid fuel burning in households and improving fuels are essential steps to decrease pollution.

The electricity mix relies heavily on coal. More renewables could decrease the environmental impacts of material processing.

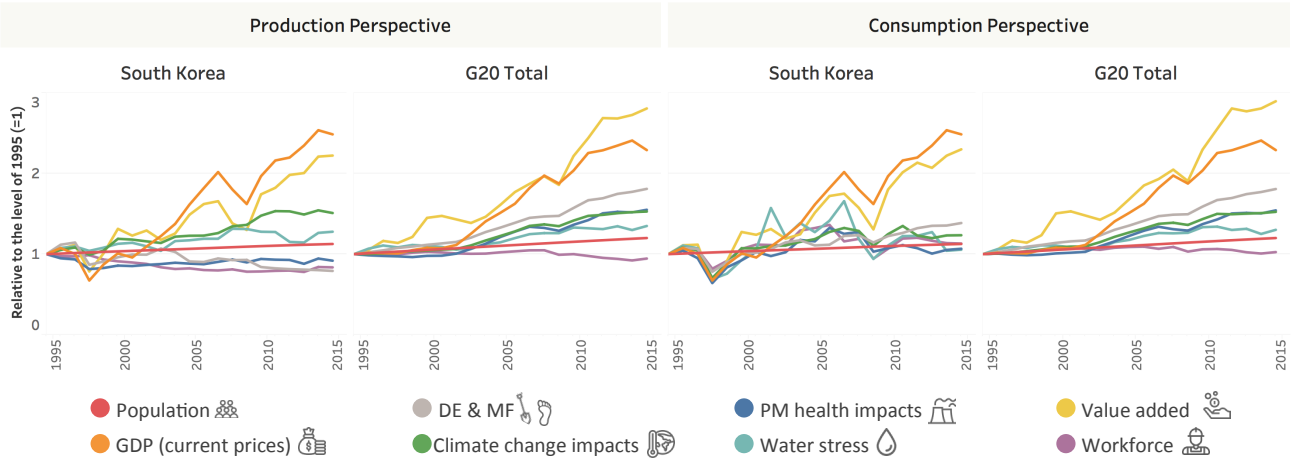
A large build-up of infrastructure is anticipated in the next decades. This will result in enhanced resource demands and environmental impacts. Material efficient urban design is therefore critical.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | South Korea

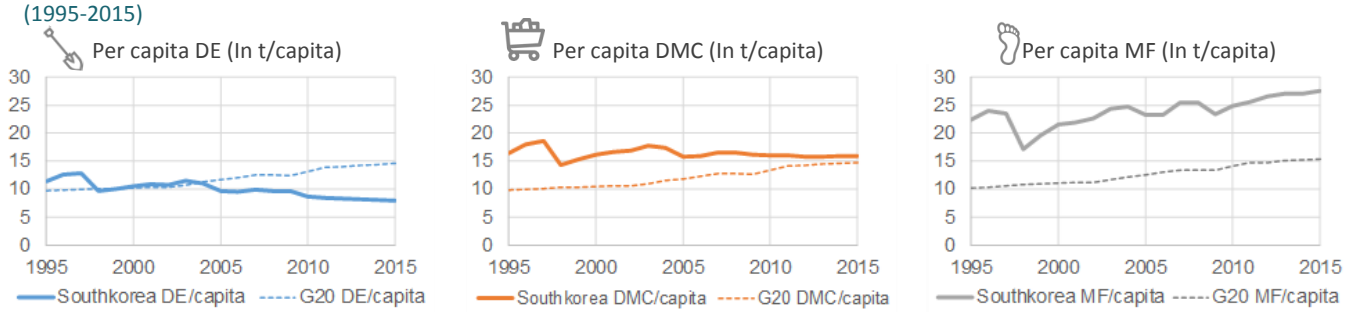
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in South Korea and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in South Korea and in the G20 (1995-2015)

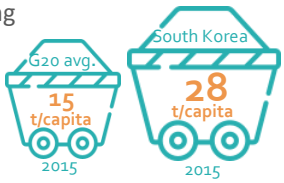


Source: IRP database

From 1995 to 2015

While population increased by **13%**, the economy underwent a recession in the beginning of this period and recovered afterwards. GDP was 2.5 times higher in 2015 than in 1995.

Material footprint increased to **28** tonnes per capita (G20 average was 15 tonnes per capita in 2015).



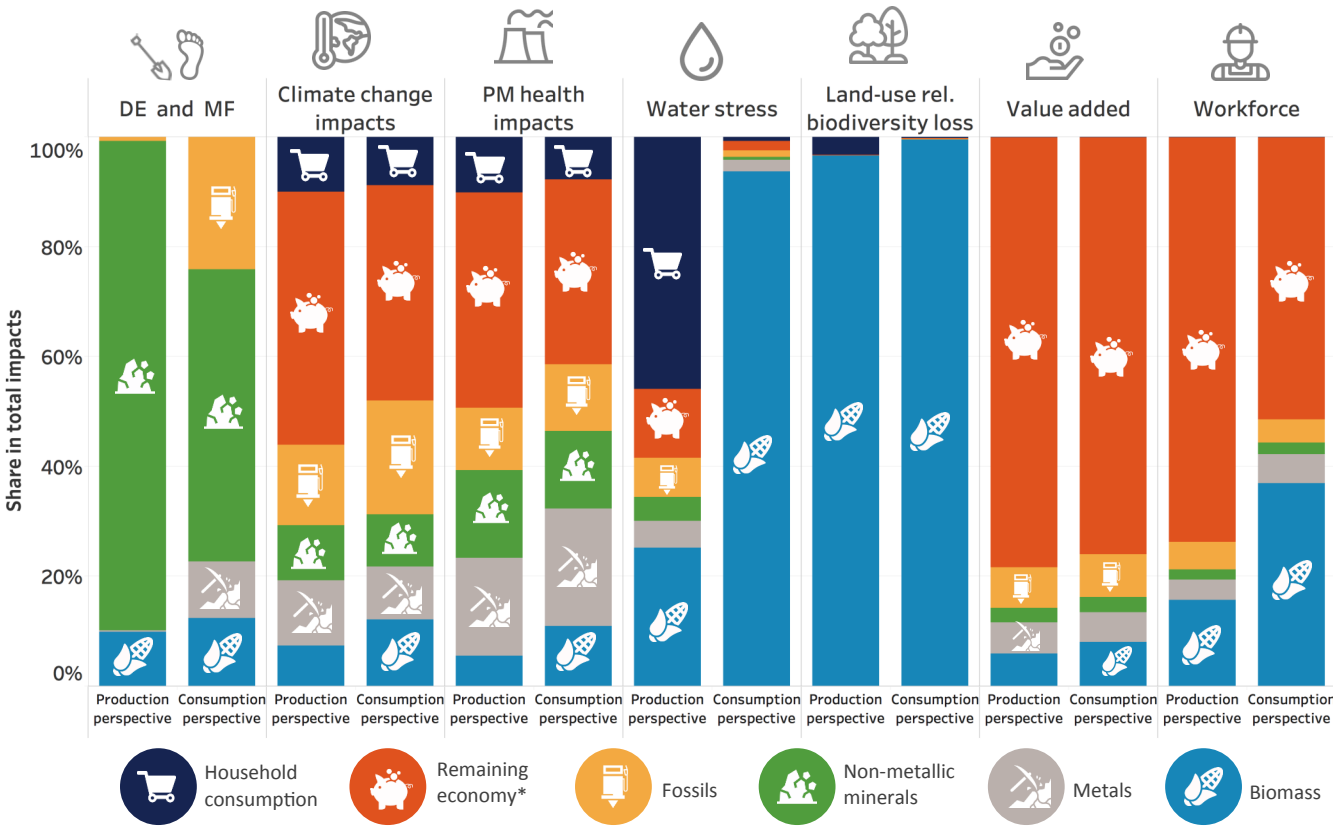
This increase occurred in the supply chain of imported products, while domestic extraction of materials decreased to **8** tonnes per capita.

South Korea experienced a relative decoupling of domestic extraction, material footprint and material-related environmental impacts from GDP from a consumption perspective.

Per-capita climate change impacts related to material extraction and processing slightly increased, and the absolute level of material-related climate change impacts remained high (**80%** higher than G20 average from a consumption perspective).

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in South Korea (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated the domestic extraction amounts, but contributed less to the material footprint and only caused a minor share of environmental impacts.

From a production perspective, the extraction and processing of natural resources accounted for more than 40% of total climate change impacts. From a consumption perspective, these accounted for more than 50% of total climate change impacts. The G20 average from both perspectives was approximately 50%.

Levels of water stress and land use-related biodiversity loss were low within the country. From a consumption perspective, biomass resources dominated these impacts.

About 50% of outdoor particulate matter related health impacts were caused by material production. Most of these emissions came from energy inputs (from cement production, iron and steel manufacturing and coal electricity used for material processing).

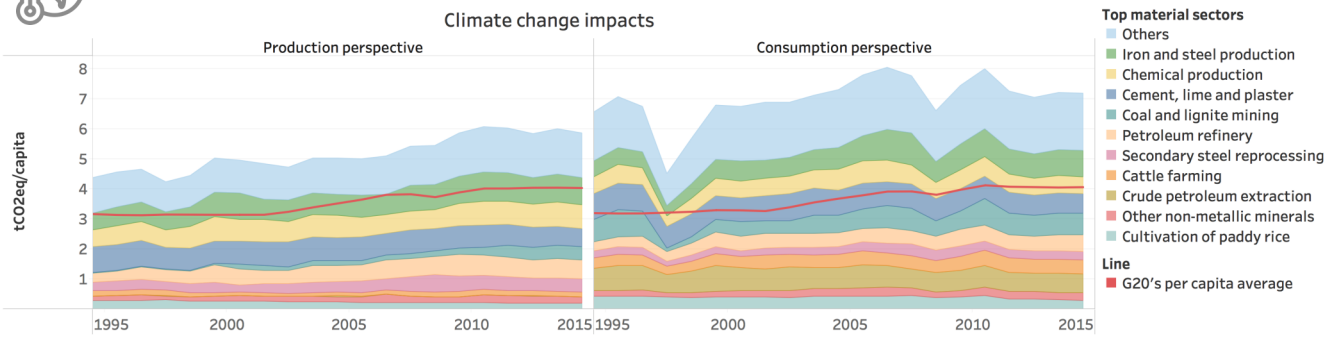
Both from a production and consumption perspective, more than 20% of economic value added was created through the extraction and processing of resources. This is comparable to the G20 average.

Materials production contributed to less than 30% of domestic jobs. South Korea relied on low-income workforce in agriculture abroad for food imports.

For all indicators, the share related to material extraction and processing is higher from a consumption perspective than from a production perspective.

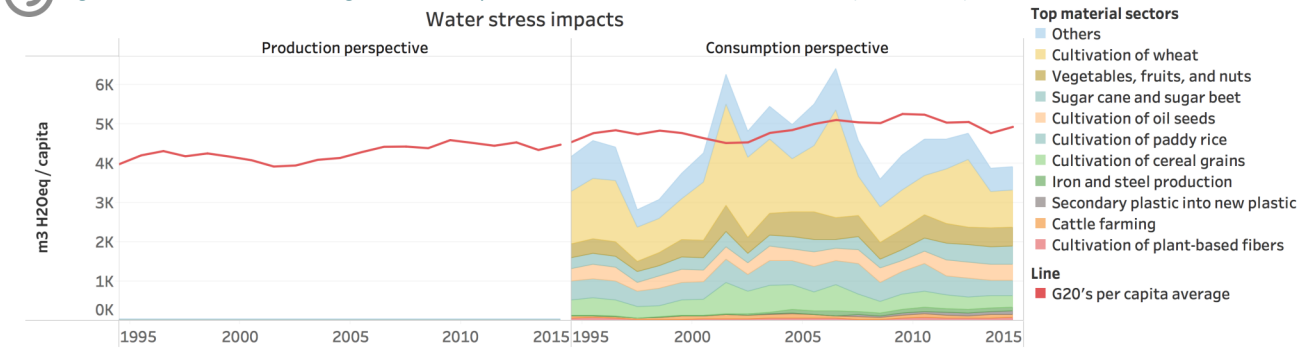
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in South Korea (1995-2015)*



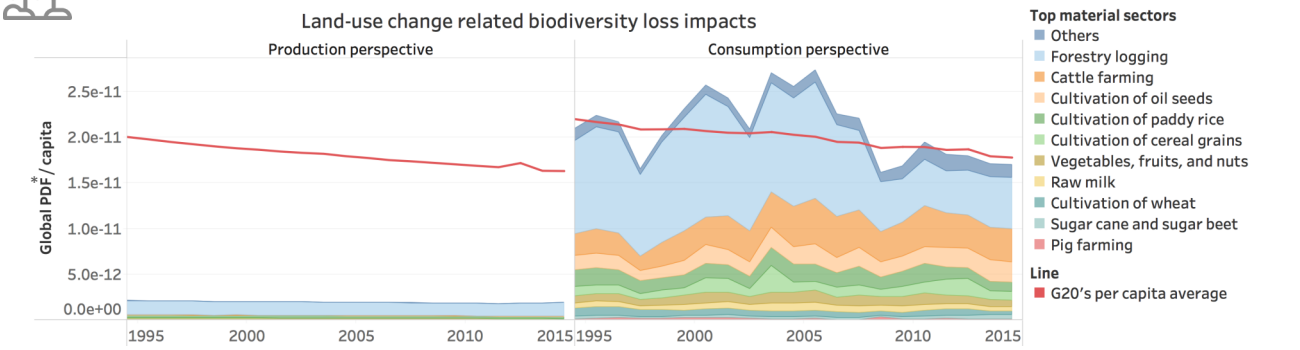
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in South Korea (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in South Korea (1995-2015)*

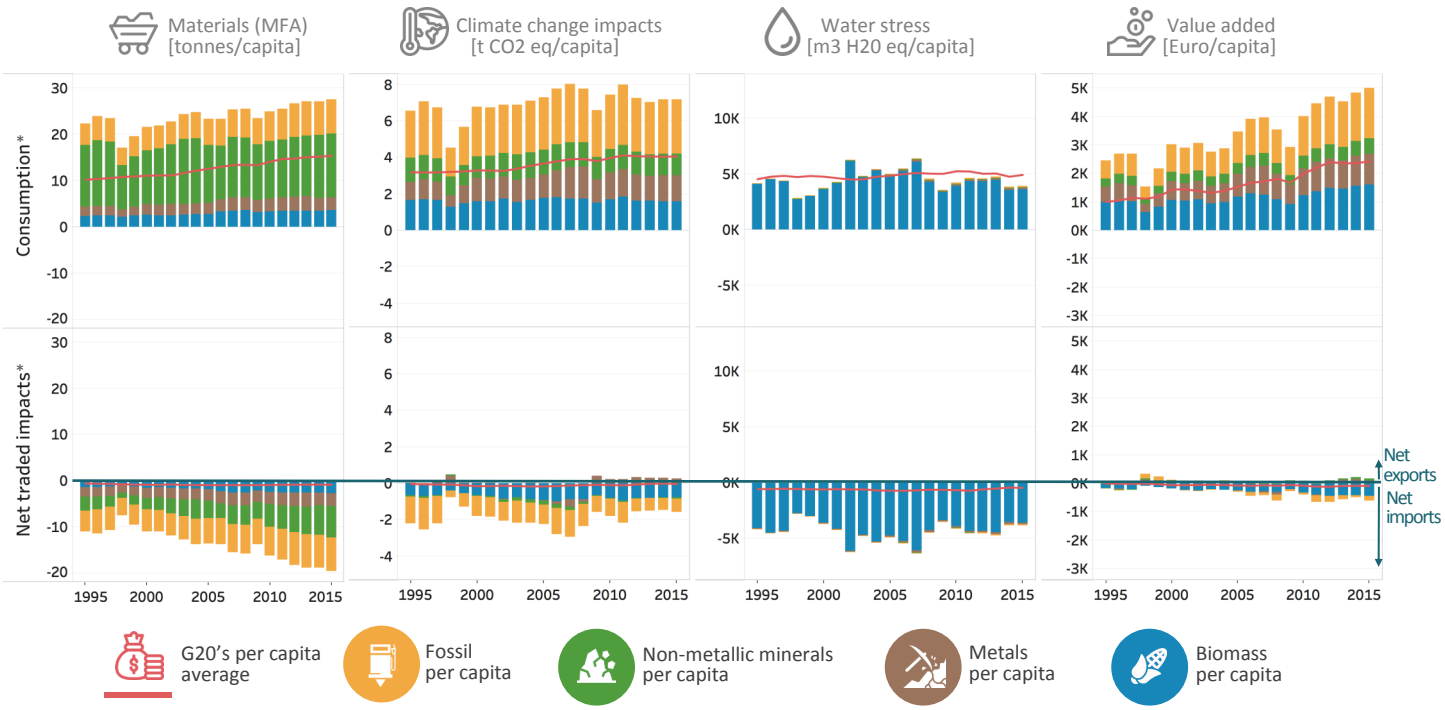


*Data after 2011 was nowcasted.
PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Most material-related climate change impacts were caused by the production of iron and steel, chemicals, cement, coal and lignite mining and petroleum refining. The construction sector, the machinery manufacturing industry, and chemical refineries were the largest end-using sectors of high-impact materials.
- From a production perspective, climate change impacts were almost 50% higher than the G20 average. From a consumption perspective, they were 80% higher than the G20 average. This difference is mainly due to imports of crude oil, coal, beef and rice.
- The construction sector, the machinery manufacturing industry, and chemical refineries caused the largest share of material-related climate impacts.
- Minerals played a key role for South Korea's automobile, electrical, and electronics industries; as well as for the construction sector.
- From a production perspective, water stress remained low due to low irrigation requirements and low water stress. From a consumption perspective, water stress levels was similar to the G20 average, with high fluctuations due to food imports, especially wheat.
- From a production perspective, land use-related biodiversity loss was much lower than the G20 average. From the consumption perspective, land use-related biodiversity loss was comparable to the G20 average. Imported products from forestry, cattle farming, and oil seed cultivation are the main causes of this loss.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in South Korea (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in South Korea.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- South Korea is a net importer of all material types.
- More environmental impacts are caused by material imports than by material exports.
- Almost all water consumption impacts occur outside of South Korea.
- The net value added for traded materials was rather low.

Future trends and potential Decoupling

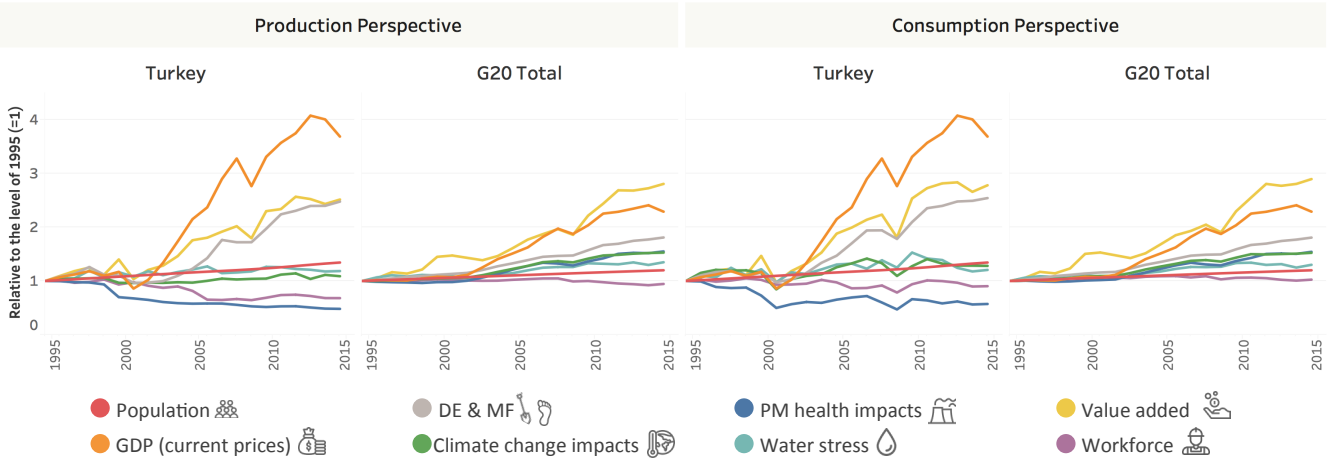
- Scenarios developed by the IRP forecast a GDP increase of 128% to 145% and a slight decrease of population of 6% to 12% until 2060.
- If ambitious resource efficiency policies are introduced, South Korea could see almost zero growth of domestic material extraction and domestic material consumption until 2060.
- Per-capita material-related climate change impacts have slightly increased in the past two decades and material footprint and climate change impacts per capita remain high compared to the G20 average. Resource efficiency strategies along the entire supply chain including material use are critical, especially for fossils and food products.
- South Korea still relies heavily on fossils as an energy source. More renewable energies, a rapid exit from coal, and less natural gas-based power production would decrease the impacts of fossil extraction and metal and mineral processing.
- Material efficient urban design and circular economy solutions could help lower the material-use related climate change impacts of the construction sector.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | Turkey

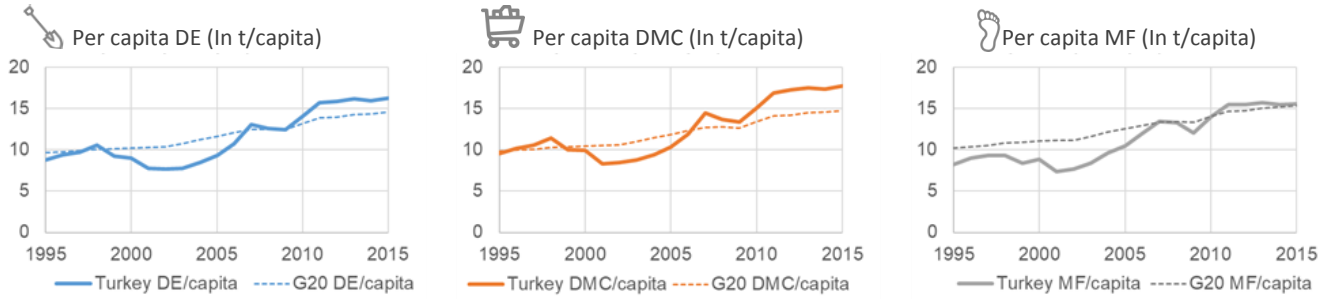
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in Turkey and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in Turkey and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population grew by **34%** and GDP increased by almost a factor of **4**.

Domestic extraction, domestic material consumption, and material footprint increased, following similar trends as G20 average.

By 2015, domestic extraction reached **16** tonnes per capita; domestic material consumption reached **18** tonnes per capita; and material footprint reached **16** tonnes per capita. The G20 average for all of these indicators was 15 tonnes per capita.

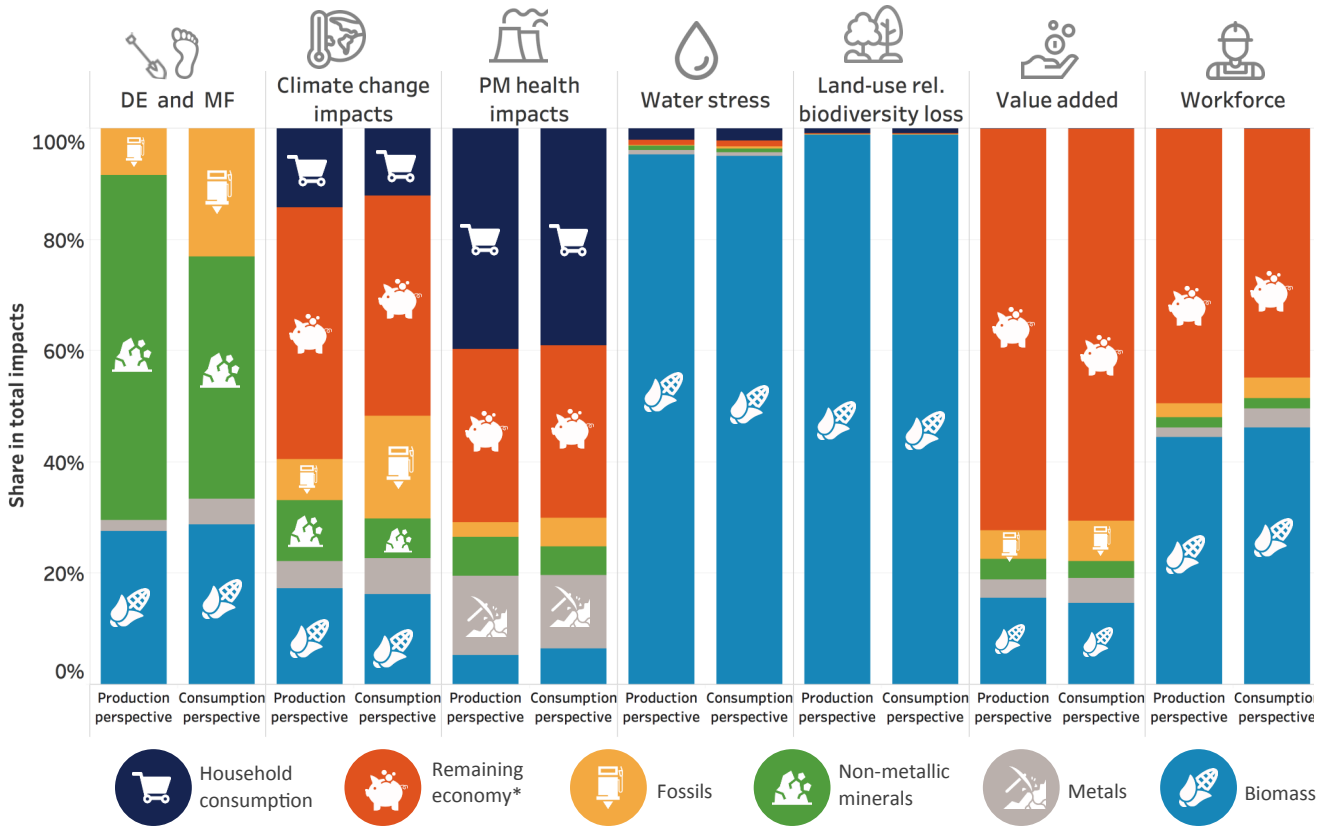
16 t/capita | 18 t/capita | 16 t/capita

All material related environmental impacts decoupled from GDP from both the consumption and production perspectives.

Outdoor particulate matter health impacts showed the strongest absolute decoupling from GDP.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in Turkey (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated the domestic extraction amounts, but contributed less to material footprint and only caused a minor share of environmental impacts.

From a production perspective, the extraction and processing of natural resources accounted for approximately 40% of total climate change impacts. From a consumption perspective, these accounted for less than 50% of total climate change impacts. The G20 average was approximately 50% from both perspectives.

Outdoor particulate matter related health impacts came mainly from households (coal-based heating, personal transport, electricity) and the remaining economy.

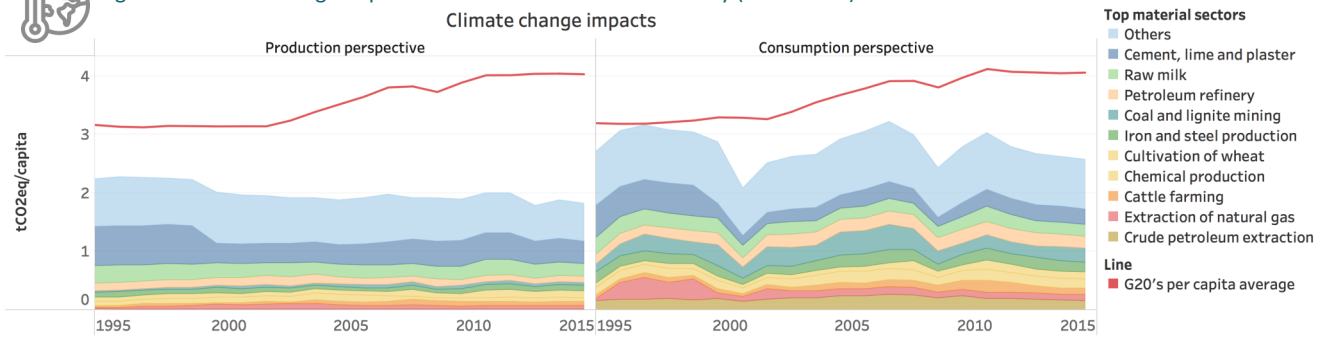
In line with other G20 countries, water stress and land use-related biodiversity impacts were caused mainly by biomass production.

The material sector contributed to almost 30% of value added from both a production and consumption perspective. The G20 average of this contribution was approximately 20%.

From both a consumption and production perspective, more than 50% of the workforce is used for the production of materials, mainly for low-paid jobs in the agriculture sector.

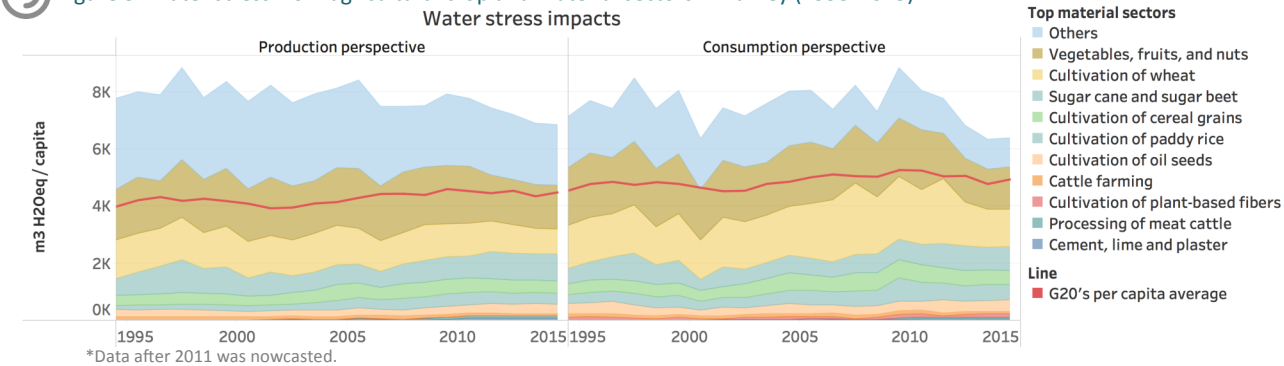
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in Turkey (1995-2015)*



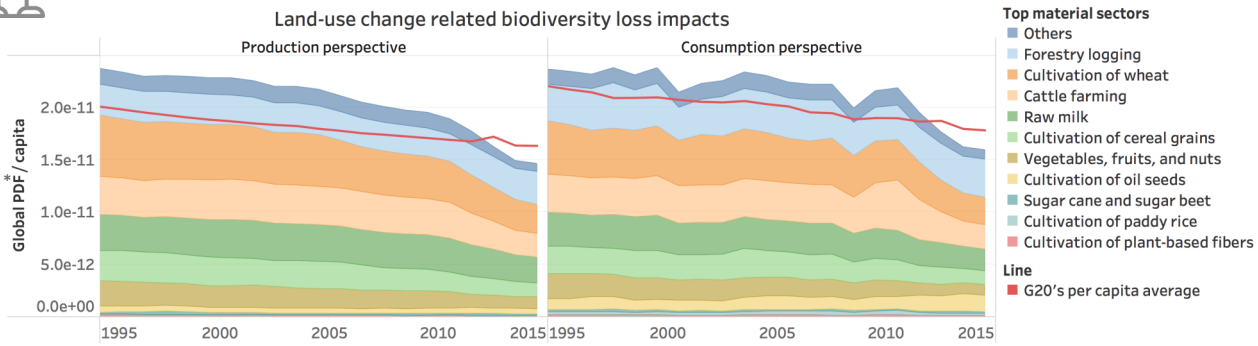
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in Turkey (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in Turkey (1995-2015)*

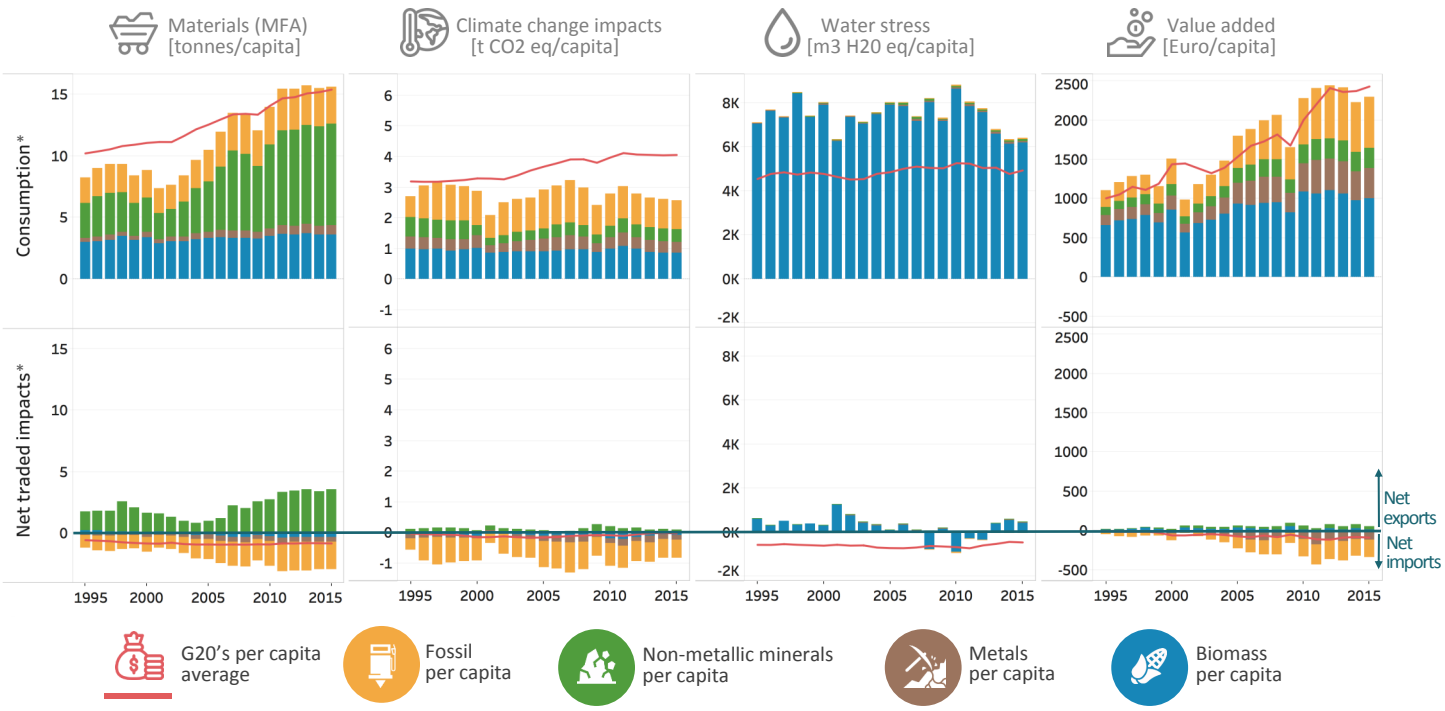


*Data after 2011 was nowcasted.
**PDF:* Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- From a production perspective, material-related climate change impacts were mainly caused by cement and raw milk production. From a consumption perspective, cement played a lower, but still significant role.
- From a consumption perspective, in addition to the above, sectors with major contributions to material-related climate change impacts included petroleum refinery, coal and lignite mining, iron and steel production, wheat cultivation and chemical production, due to imports.
- Material related climate change impacts slightly decreased. From a production perspective, these were almost 50% less than the G20 average. From a consumption perspective, these represented more than 30% less than the G20 average.
- Food products with large climate impacts (processed food) were mainly consumed by households.
- The construction, hotel and restaurant, textile, and clothing sectors were the major industrial end-users of climate-intensive materials.
- Water stress impacts were much higher than the G20 average (more than 50% from a production perspective and more than 25% from a consumption perspective). This was caused by domestic agriculture in water-scarce regions.
- From a production perspective, water stress was dominated by agriculture, particularly by the cultivation of vegetables, fruits and nuts, sugar beet, and wheat.
- Land use related biodiversity loss was similar in magnitude to the G20 average. From both a consumption and a production perspective, major contributing sectors included forestry, wheat and milk production, as well as cattle farming.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in Turkey (1995-2015)*



*Data after 2011 was nowcasted.
**Consumption:* Impacts throughout the supply chain from goods imported and consumed in Turkey.
**Net traded impacts:* Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Turkey is a net importer of all material types, except non-metallic minerals, which are exported in large amounts. Almost all fossils are imported to Turkey.

More climate change impacts are caused by imports than by exports. This is mainly due to fossil imports.

For water stress, net trade fluctuated between negative and positive over the years and is not significant compared to total water stress of Turkey.

For all fossils and metals, material trade created relevant net value added outside of Turkey, while small amounts of net value added were created for non-metallic minerals and biomass inside Turkey.

Future trends and potential Decoupling

Turkey has relatively low levels of per capita greenhouse gas emissions compared to the G20 average but is likely to experience major climate change impacts. The reduction of dependency on fossil energy sources would help mitigate climate change impacts related to material use. This reduction should be paired with appropriate adaptation measures.

A large share of climate impacts related to materials came from the tourism sector and textile industry. Improving material productivity and efficiency in these sectors could help decouple environmental impacts from economic growth.

Circular economy solutions, including proper waste management and material recycling would also be beneficial.

Turkey suffers from water scarcity in large parts of the country. Improving the management of water resources and increasing resource efficiency in the agriculture sector are of critical importance.

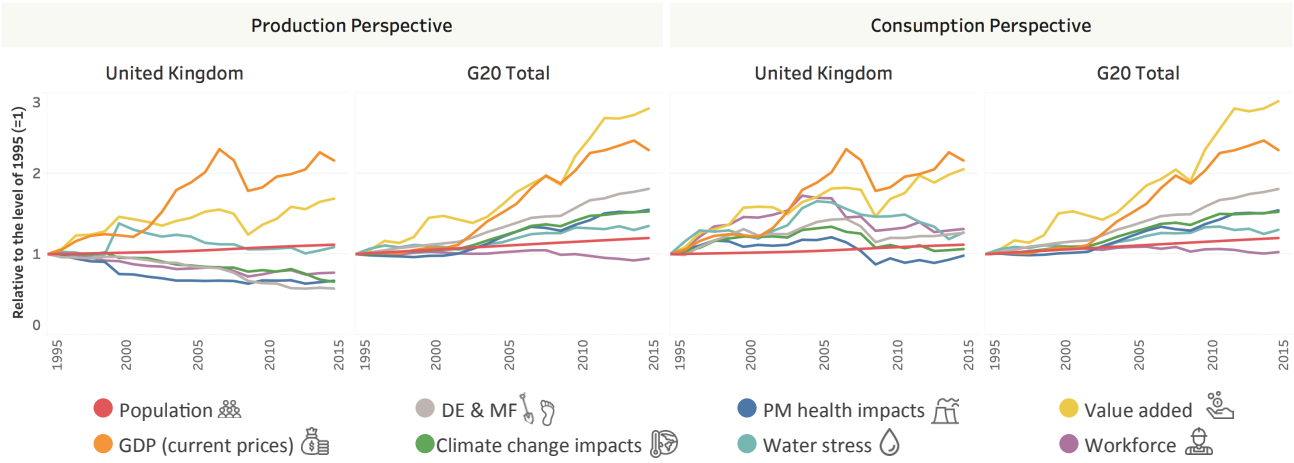
Turkey harbors many endemic species and thus significant biodiversity loss risks. Efforts to protect unique ecosystems have shown positive results and should be continued.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | United Kingdom

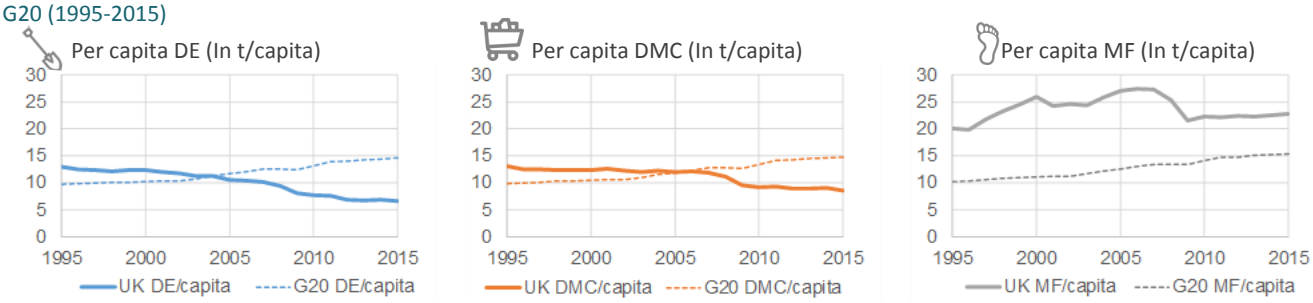
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in the United Kingdom and in the G20 (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in the United Kingdom and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015

Population increased by **12%** while GDP more than doubled (with some fluctuations).

The domestic extraction and domestic consumption of materials decreased and fell below the G20 average.

Material footprint fluctuated between **20** tonnes per capita (1995), **27** tonnes per capita (2007) and **23** tonnes per capita (2015). The G20 average in 2015 was 15 tonnes per capita.

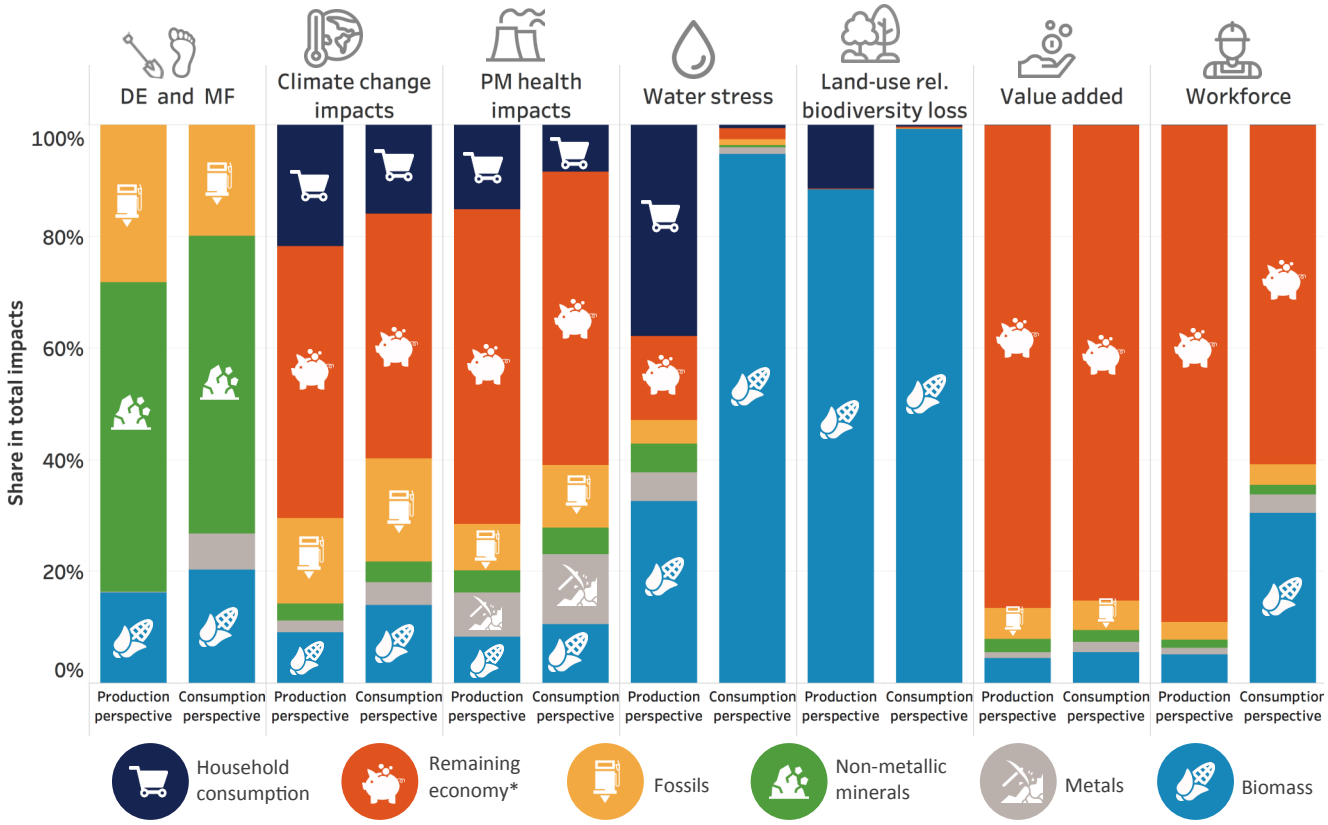
Domestic extraction, domestic material consumption, material footprint and all environmental impacts decoupled from GDP. However, material-related climate change impacts were **25%** higher than G20 average in a consumption perspective in 2015.

From a consumption perspective, water stress was slightly higher than G20 average and remained stable.

From both a production and consumption perspective, particulate matter health impacts (related to resource extraction and material processing) showed the strongest absolute decoupling of all environmental impacts from GDP.

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, material-related environmental and socio-economic impacts in the United Kingdom (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Non-metallic minerals like sand and gravel dominated domestic extraction amounts and material footprint, but only caused a minor share of environmental impacts.

There is nearly no metal mining within the United Kingdom.

From a production perspective, the extraction and processing of natural resources accounted for 30% of the United Kingdom's total climate change and particulate matter health impacts. It accounted for 40% of these impacts from a consumption perspective.

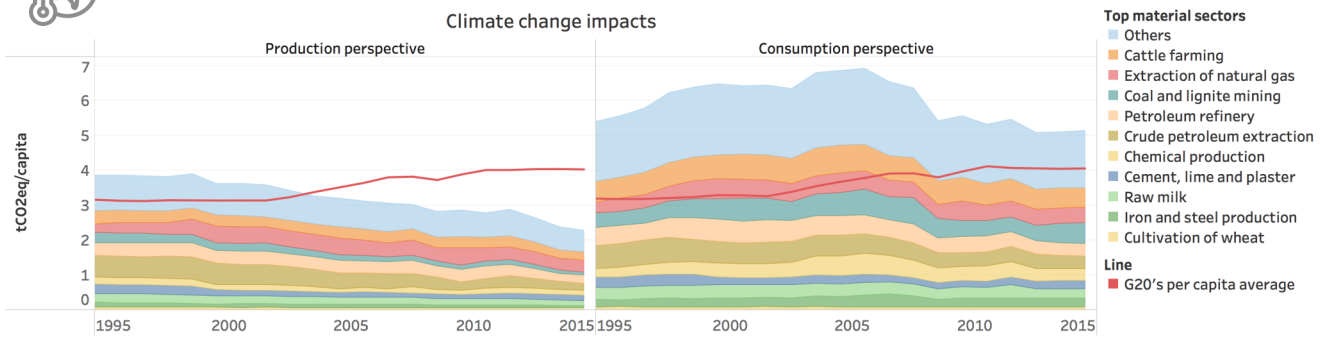
In line with other G20 countries, water stress and land use-related biodiversity impacts were mainly caused by biomass production from a consumption perspective.

The material sector contributed to a minor share of value added as well as domestic jobs (both less than 20%). It relied on low-income workforce in agriculture outside the United Kingdom for food imports.

For all indicators, the share related to material extraction and processing was comparable or higher from a consumption perspective than from a production perspective.

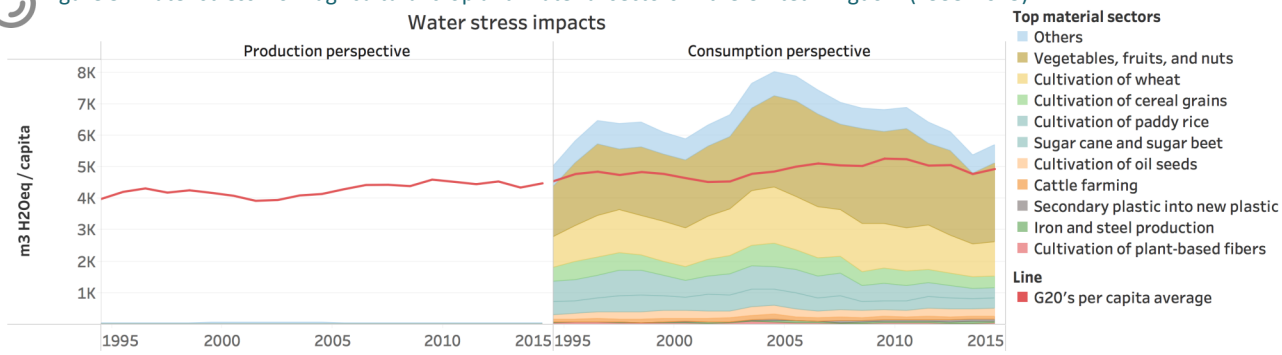
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in the United Kingdom (1995-2015)*



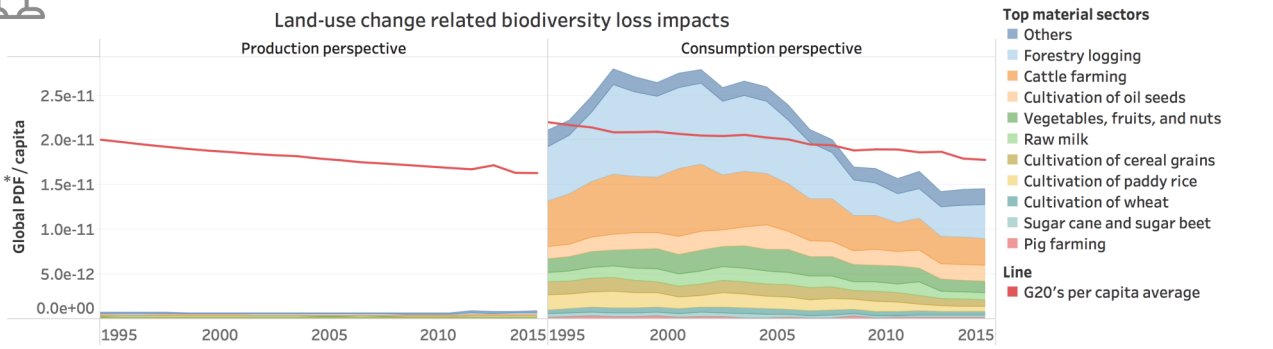
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in the United Kingdom (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in the United Kingdom (1995-2015)*

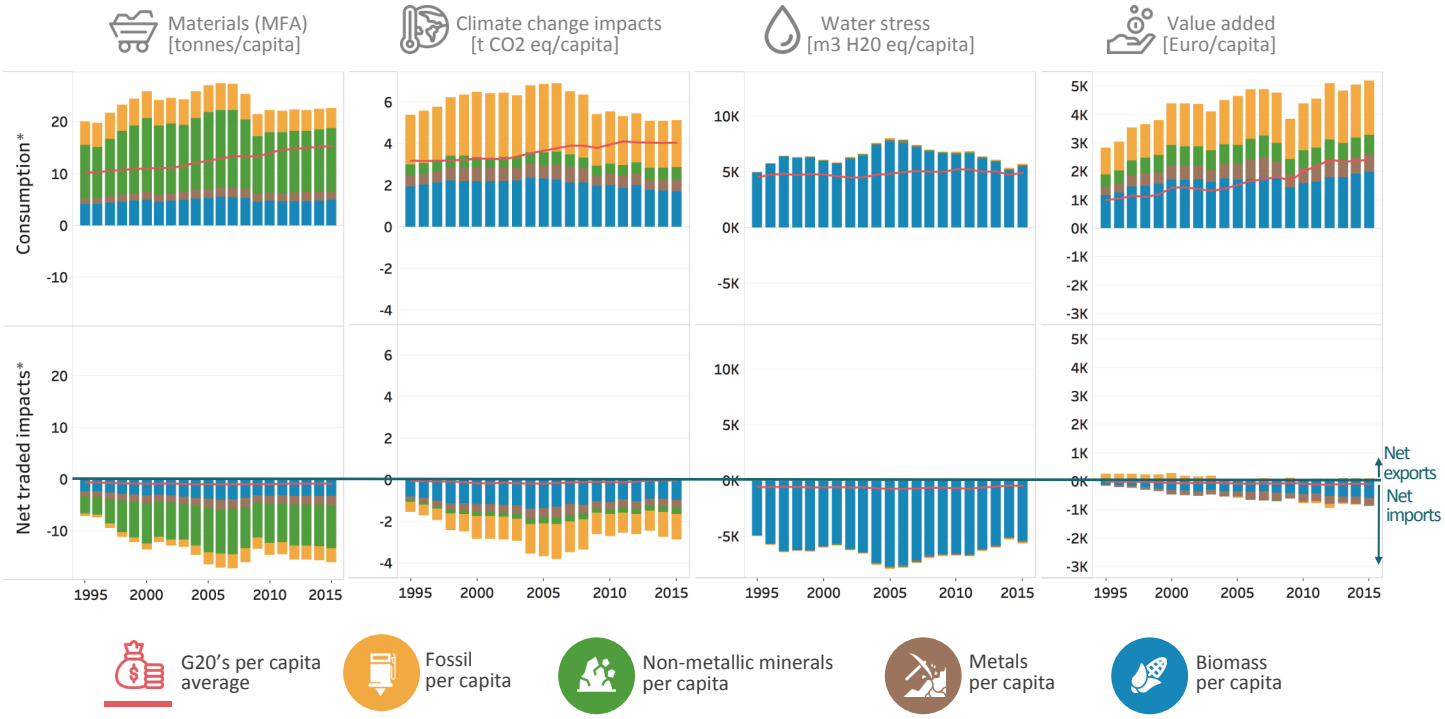


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- From a production perspective, material-related climate change impacts were mostly caused by natural gas extraction, petroleum extraction and refining, and cattle farming. Climate change impacts decreased below the G20 average.
- From a consumption perspective, material-related climate change impacts were more than 25% higher than the G20 average. This is due to imports of goods with large embodied greenhouse gas emissions for domestic consumption (e.g. coal, steel, chemicals and cattle products).
- Materials with large climate impacts are often directly consumed by households, especially fossil fuels for mobility and heating, and food.
- The construction sector was the largest industrial end-user of climate-intensive materials.
- From a consumption perspective, water stress was slightly larger than the G20 average, due to imports of vegetables, fruits, nuts, wheat and other cereals, rice, sugar, and oil seeds from water-scarce locations. From a production perspective, water stress is not relevant due to the availability of sufficient amounts of renewable water.
- From a production perspective, land use-related biodiversity loss was very low compared to the G20 average.
- From a consumption perspective, land use-related biodiversity loss was slightly lower than the G20 average after 2008. Main causes of this biodiversity footprint are imports of wood, beef, oil seeds, vegetables, fruits and nuts from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in United Kingdom (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in the United Kingdom.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

The United Kingdom is a net importer of all material types (much higher reliance on trade than the G20 average).

More environmental impacts are caused by material imports than by material exports. Almost all water stress and land-use related biodiversity loss is due to imports of agricultural products.

While most material-related environmental footprints are caused abroad, a comparably low net value added was generated outside of United Kingdom for material imports.

Future trends and potential Decoupling

Scenarios developed by the IRP forecast an increase of GDP by more than 100% with a rather small population increase (24%-27%) until 2060.

If ambitious resource efficiency policies are introduced, domestic material extraction could increase by about 40% and domestic material consumption could increase by about 30% until 2060.

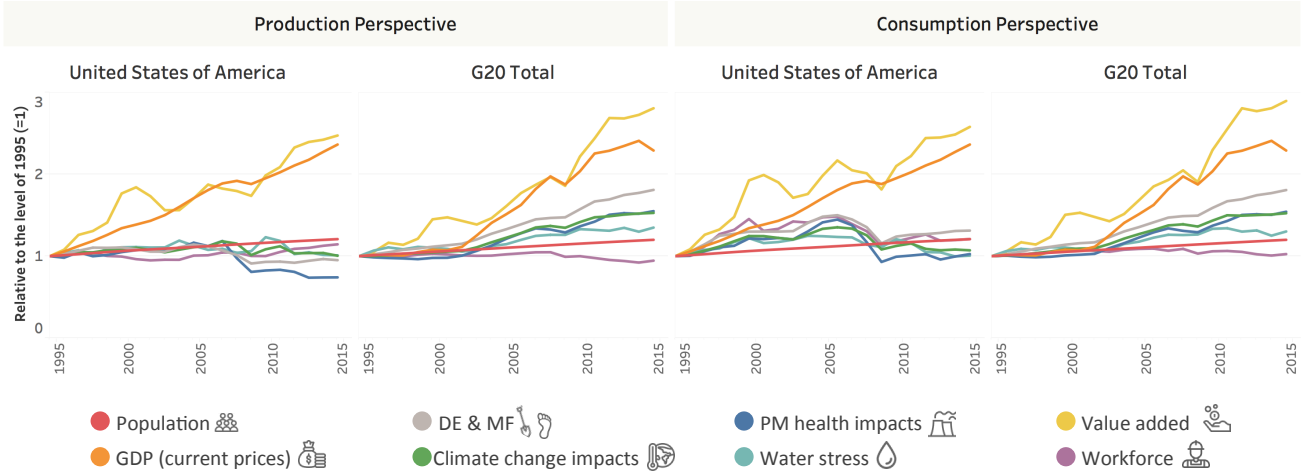
From a consumption perspective, material footprint and all environmental impacts per capita remained above or comparable to the G20 average. From a production perspective they declined. Resource efficiency and circular economy strategies, as well as responsible sourcing along the entire supply chain (with a special focus on agricultural products for water stress and land-use related biodiversity loss) are critical to lower these impacts.

NATURAL RESOURCE USE IN THE GROUP OF 20

Status, Trends, and Solutions | USA

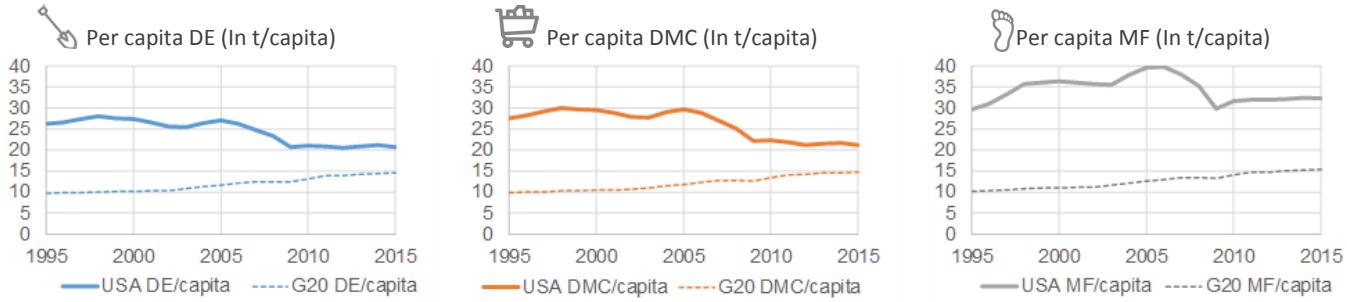
STATUS AND TRENDS OF NATURAL RESOURCE USE

Figure 1: Socio-economic indicators, domestic extraction, material footprint, and material-related environmental impacts in the USA and in the G20 (1995-2015)*



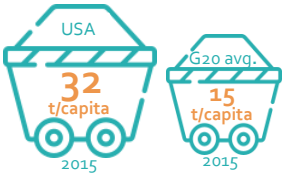
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4 and Cabernard et al. 2019

Figure 2: Domestic extraction, domestic material consumption, and material footprint per capita in the USA and in the G20 (1995-2015)



Source: IRP database

From 1995 to 2015



Population grew by **21%** and GDP more than **doubled**.

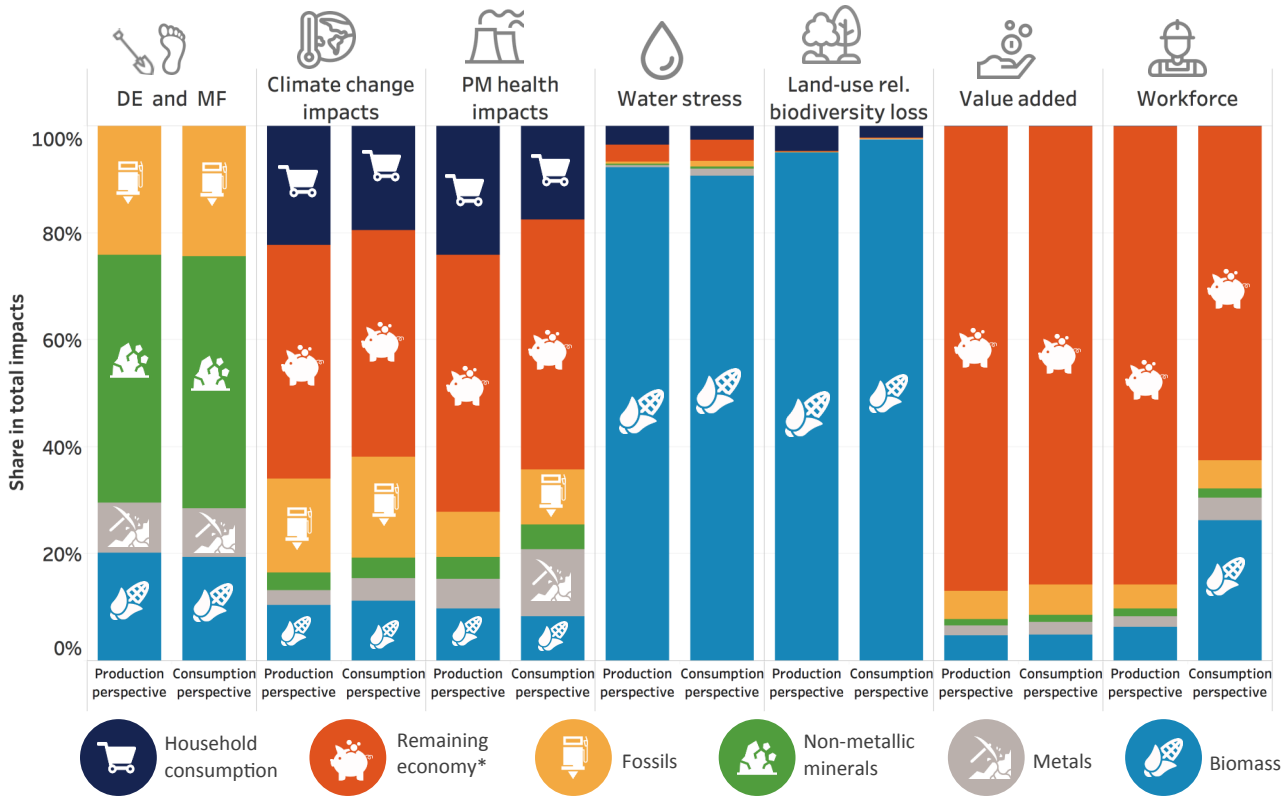
Material footprint increased from **30** tonnes/capita in 1995 to **40** t/capita in 2007 and then dropped again to **32** t/capita (G20 average was at 15 tonnes/capita in 2015).

This slight overall increase occurred in the supply chain of imported products, while domestic extraction and domestic consumption of materials decreased.

Per-capita climate change and water stress impacts related to material extraction and processing slightly decreased, but the absolute level remained above G20 average (more than **double** the G20 average impacts for climate change and **1/3** higher for water stress, from a consumption perspective).

Contribution of Natural Resources by Category

Figure 3: Contribution of resource types to domestic extraction, material footprint, and total environmental and socio-economic impacts in the USA (2015)



*Remaining economy refers to activities other than resource extraction and processing (e.g. manufacturing of finished products, construction).
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

In line with G20 average, non-metallic minerals like sand and gravel dominated the share of domestic extraction amounts and material footprint, but contributed to only a minor share of environmental impacts.

The extraction and processing of natural resources accounted for up to 40% of USA's total climate change impacts from both a production and consumption perspective (the G20 average was approximately 50% from both perspectives).

In line with other G20 countries, USA's water stress and land use-related biodiversity impacts were caused mainly by biomass production.

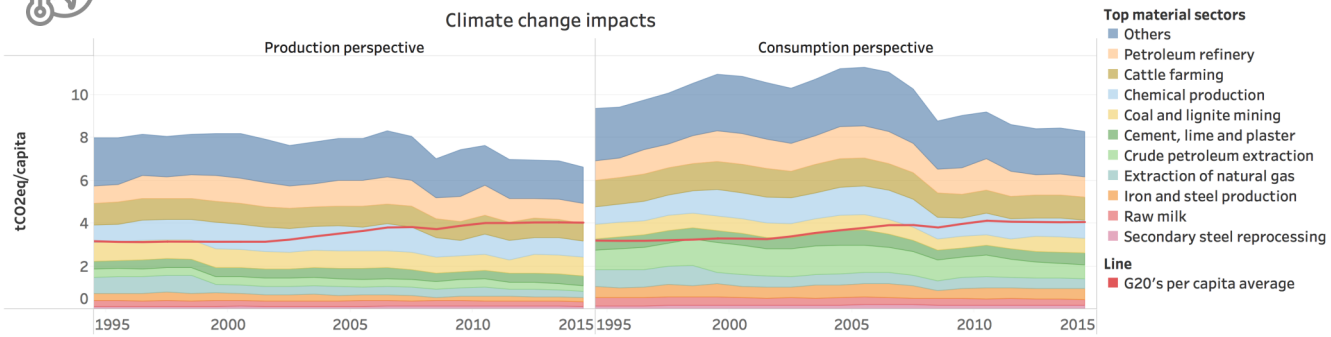
Outdoor particulate matter (PM) related health impacts mainly came from the remaining economy (e.g. fossil electricity and transport).

The material sector contributed to a minor share of value added as well as domestic jobs (both less than 20%) and relied on low-income workforce in agriculture outside of USA for food imports.

In general, for all indicators but workforce, the share related to material extraction and processing from a consumption perspective was comparable to the share related to material extraction and processing from a production perspective.

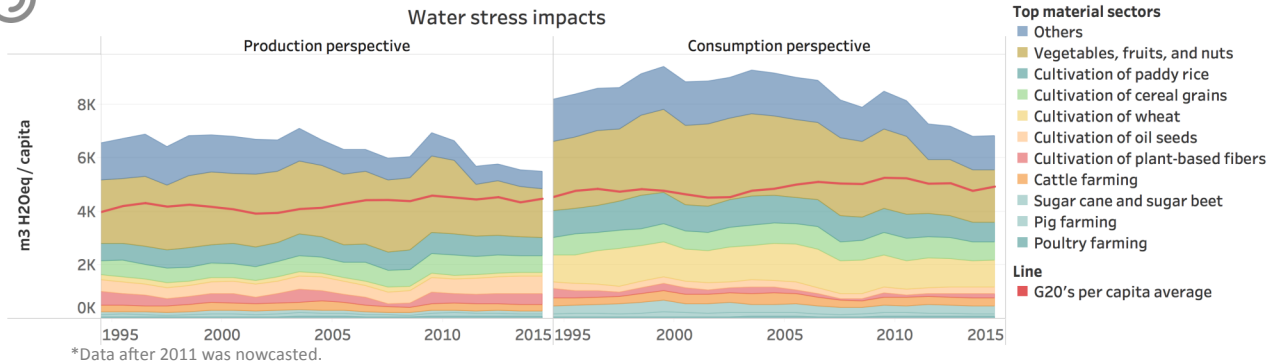
Key Sectors and Resources

Figure 4: Climate change impacts from material sectors in the USA (1995-2015)*



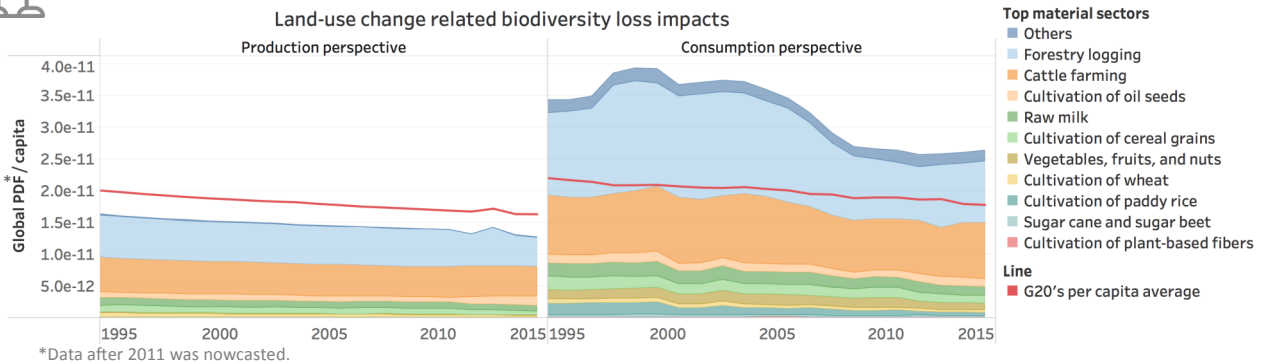
*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 5: Water stress from agricultural crop and material sectors in the USA (1995-2015)*



*Data after 2011 was nowcasted.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

Figure 6: Land-use related biodiversity loss from agricultural crops and material sectors in the USA (1995-2015)*

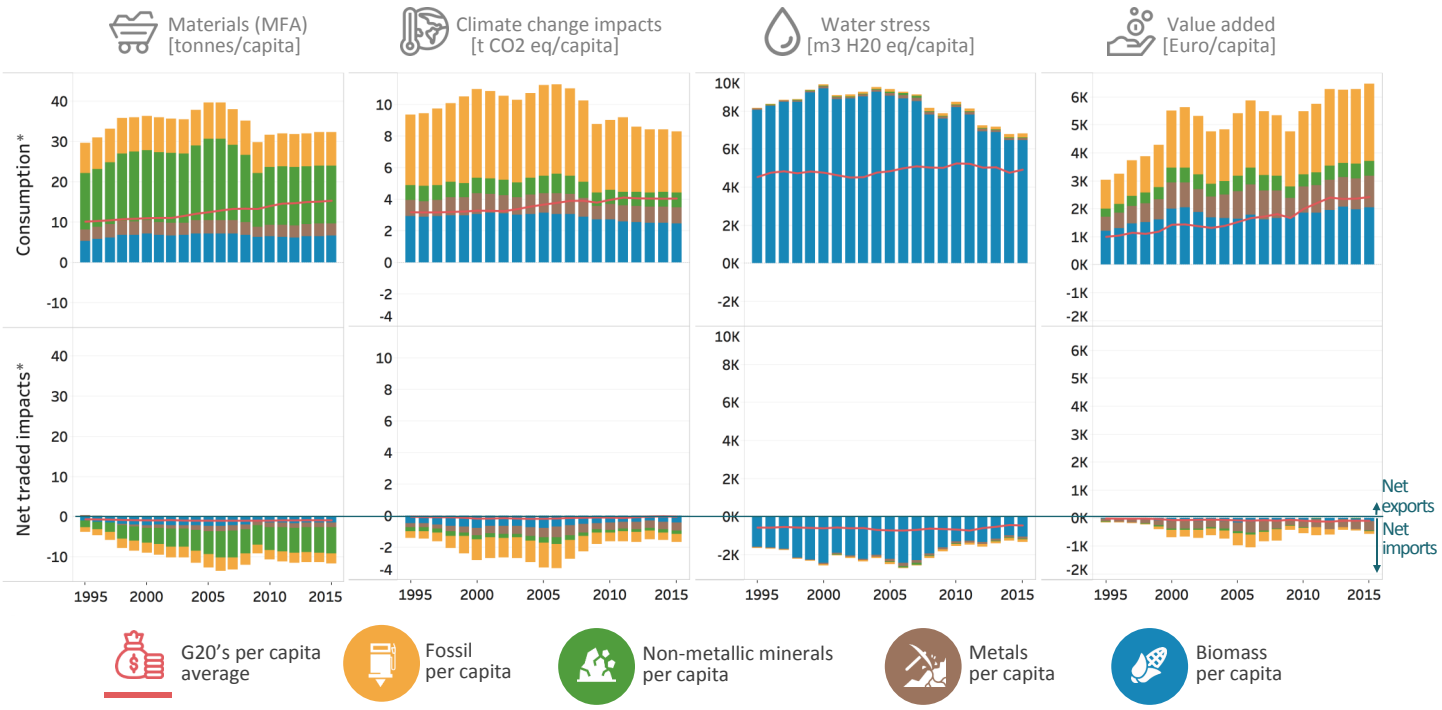


*Data after 2011 was nowcasted.
*PDF: Potentially disappeared fraction of species
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

- Material-related climate change impacts were mainly caused by the refining of petroleum, chemical production, coal mining, cattle farming, and extraction of crude oil and natural gas.
- Climate change impacts decreased slightly, but remained much higher than the G20 average (in 2015 double from a consumption perspective).
- Materials with large climate impacts (oil, fossil fuels including natural gas) are often directly consumed by households especially for mobility, heating and food (particularly beef).
- Major industrial sectors using climate-intensive materials are construction and motor vehicle manufacturing.
- Water stress is dominated by agricultural activities, such as the production of vegetables, fruits, nuts, paddy rice, corn and other cereals, oil seeds and additionally wheat from a consumption perspective.
- Water stress is higher than the G20 average from both a production and consumption perspective.
- From a production perspective, land use-related biodiversity loss is slightly lower than the G20 average. However, from a consumption perspective, land use-related biodiversity loss, is higher than the G20 average due to imports of wood and beef from regions with high ecological value.

The environmental effects of trade

Figure 7: Per-capita consumption footprints (above) and net traded impacts (below) in the USA (1995-2015)*



*Data after 2011 was nowcasted.
Consumption: Impacts throughout the supply chain from goods imported and consumed in the USA.
Net traded impacts: Difference between material-related impacts from a production and consumption perspective.
Source: IRP database, Exiobase v3.4, Cabernard et al. 2019

USA is a net importer of all material types (with significantly higher levels of trade activity than the G20 average). Accordingly, more environmental impacts are caused outside of USA from material imports than within its borders (from material exports).

Nevertheless, the majority of material related impacts caused by US consumption occur within the country (see magnitude of bars in upper and lower graphs) – except for land use.

For all material types, net value added was higher outside of the USA than inside.

Future trends and potential Decoupling

Scenarios developed by the IRP forecast an increase of GDP by more than a factor of 2 and a population growth of +30% until 2060.

If ambitious resource efficiency policies are introduced, USA could see an absolute decoupling of domestic material extraction and domestic material consumption from GDP until 2060.

Per-capita material-related environmental impacts have slightly decreased in the past two decades. However, material footprint and all environmental impacts per capita remain much higher than the G20 average. Resource efficiency strategies along the entire supply chain like phasing out outdated technologies, material efficient design, and clean energy could help decrease these impacts.

For more information contact:

Secretariat of International Resource Panel (IRP)
Economy Division
United Nations Environment Programme
1 rue Miollis
Building VII
75015 Paris, France
Tel: +33 1 44 37 14 50
Fax: +33 1 44 37 14 74
Email: resourcepanel@unep.org
Website: www.resourcepanel.org