From Global Material Footprint to Product Material Footprints

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Challenges of Sustainability Research

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Content

Relevance of the material footprint within the sustainable development goals (SDGs)

Environmental impacts of raw material extraction

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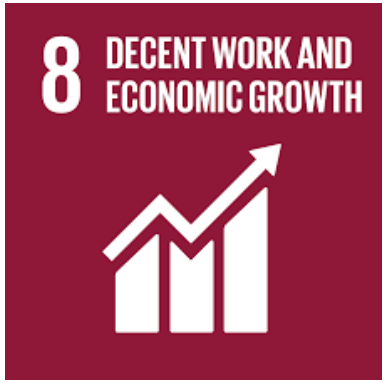
Material footprint for SDG monitoring

The material footprint is used as indictor for SDG 8 and SDG 12.



Target 8.4: Improve progressively, through 2030, global resource efficiency in consumption and production and endeavor to decouple economic growth from environmental degradation.

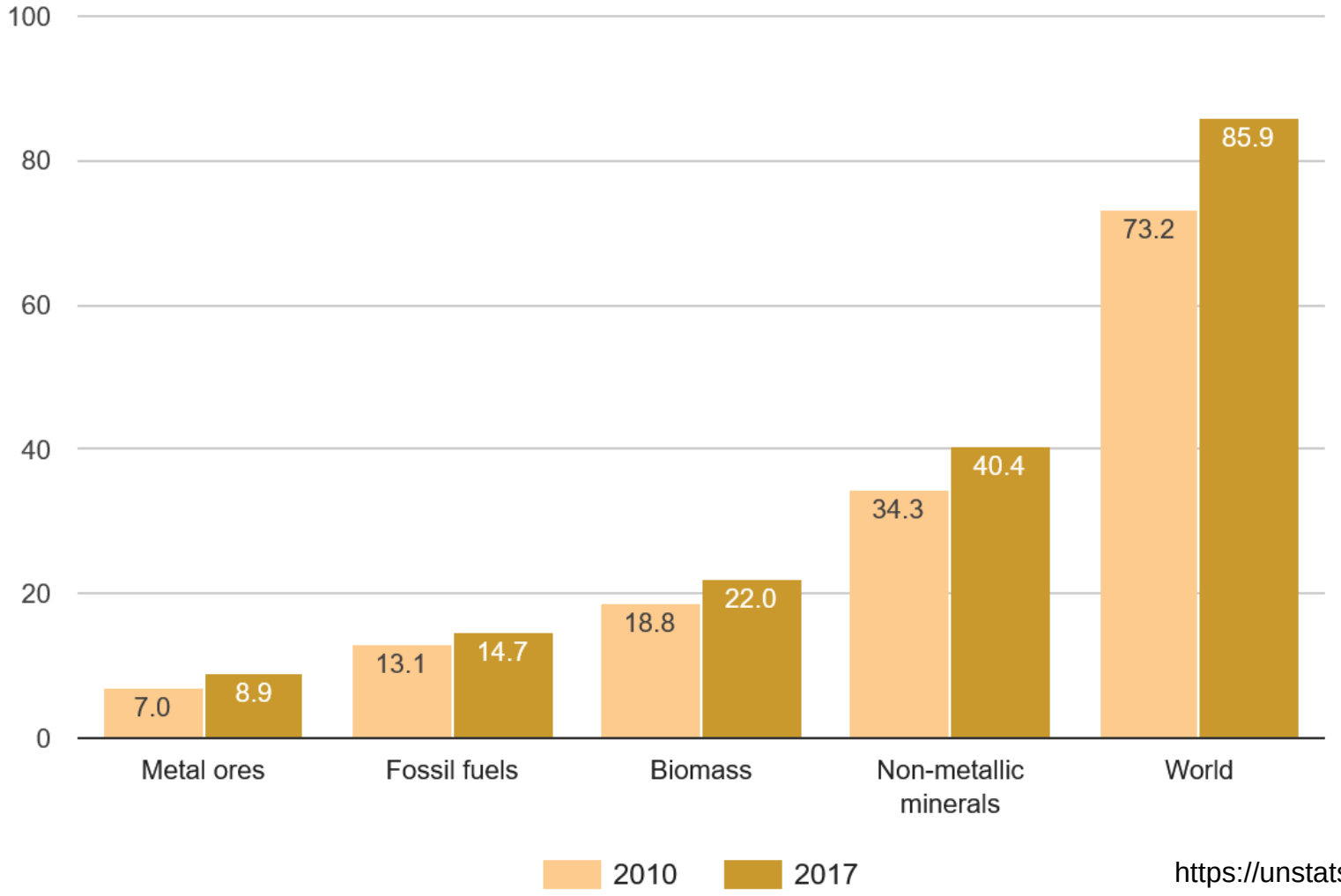
Indicator 8.4.1: Material footprint, material footprint per capita, and material footprint per GDP

Target 12.2: By 2030, achieve the sustainable management and efficient use of natural resources.

Indicator 12.2.1: Material footprint, material footprint per capita, and material footprint per GDP

However, up to now there is no target level of sustainable material footprint defined.

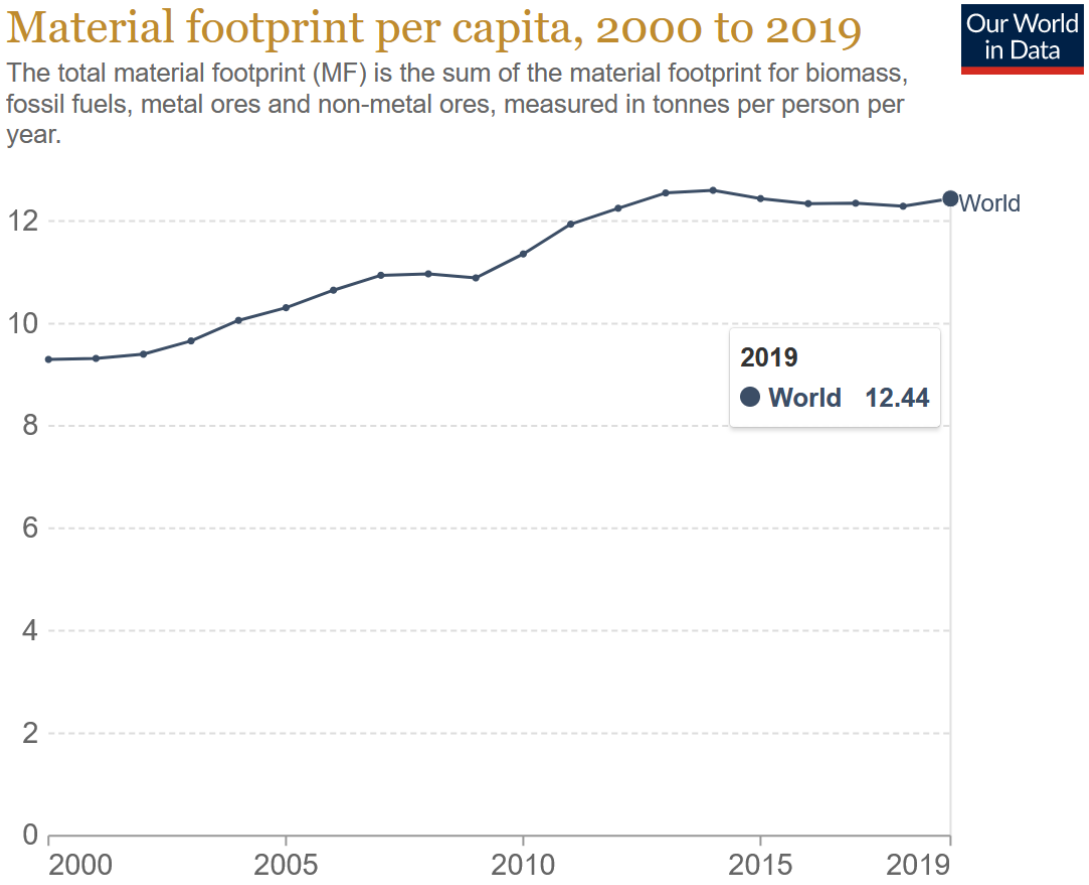
The material footprint in 2010 and 2017

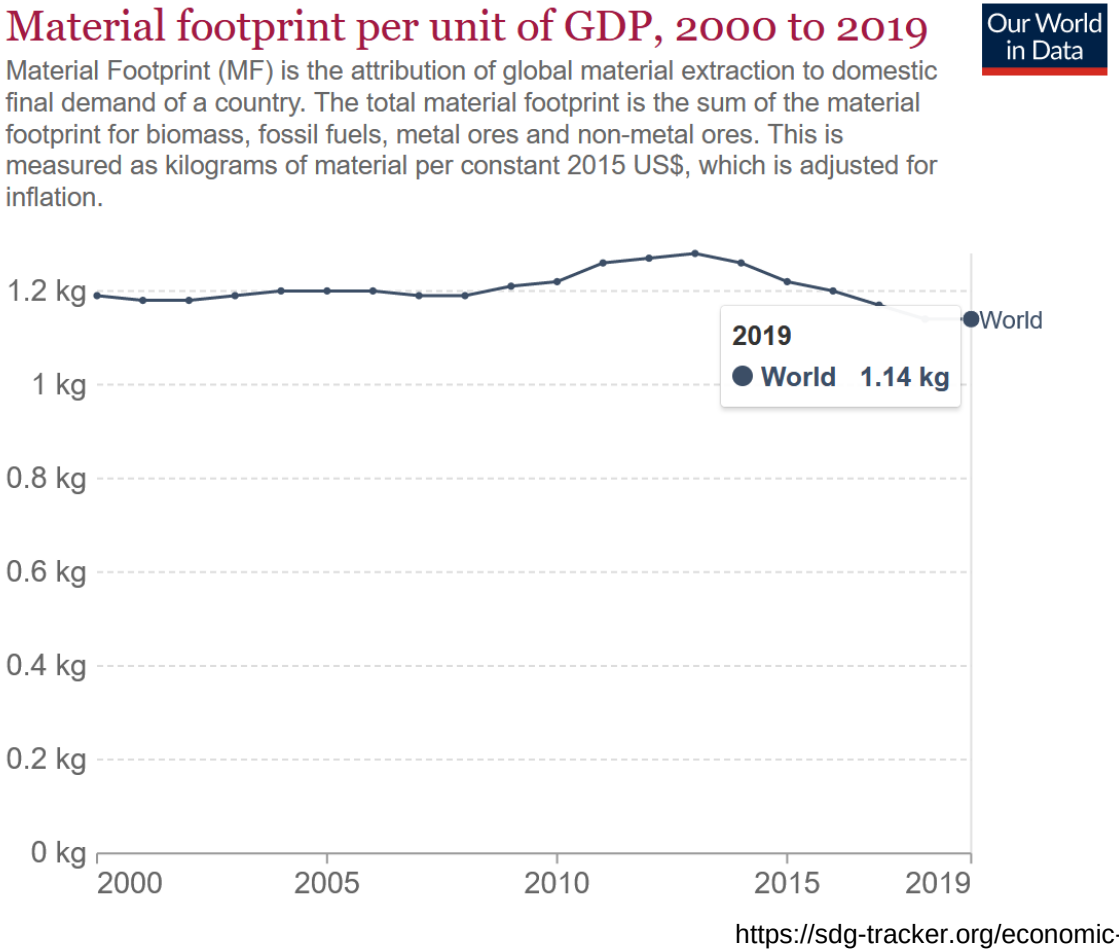


https://unstats.un.org/sdgs/report/2020/goal-12

From 2010 to 2017 the global material footprint grew from 73 to 86 billion tons a 17.5 % increase.

Material footprint per capita and per unit GDP from 2000 to 2019





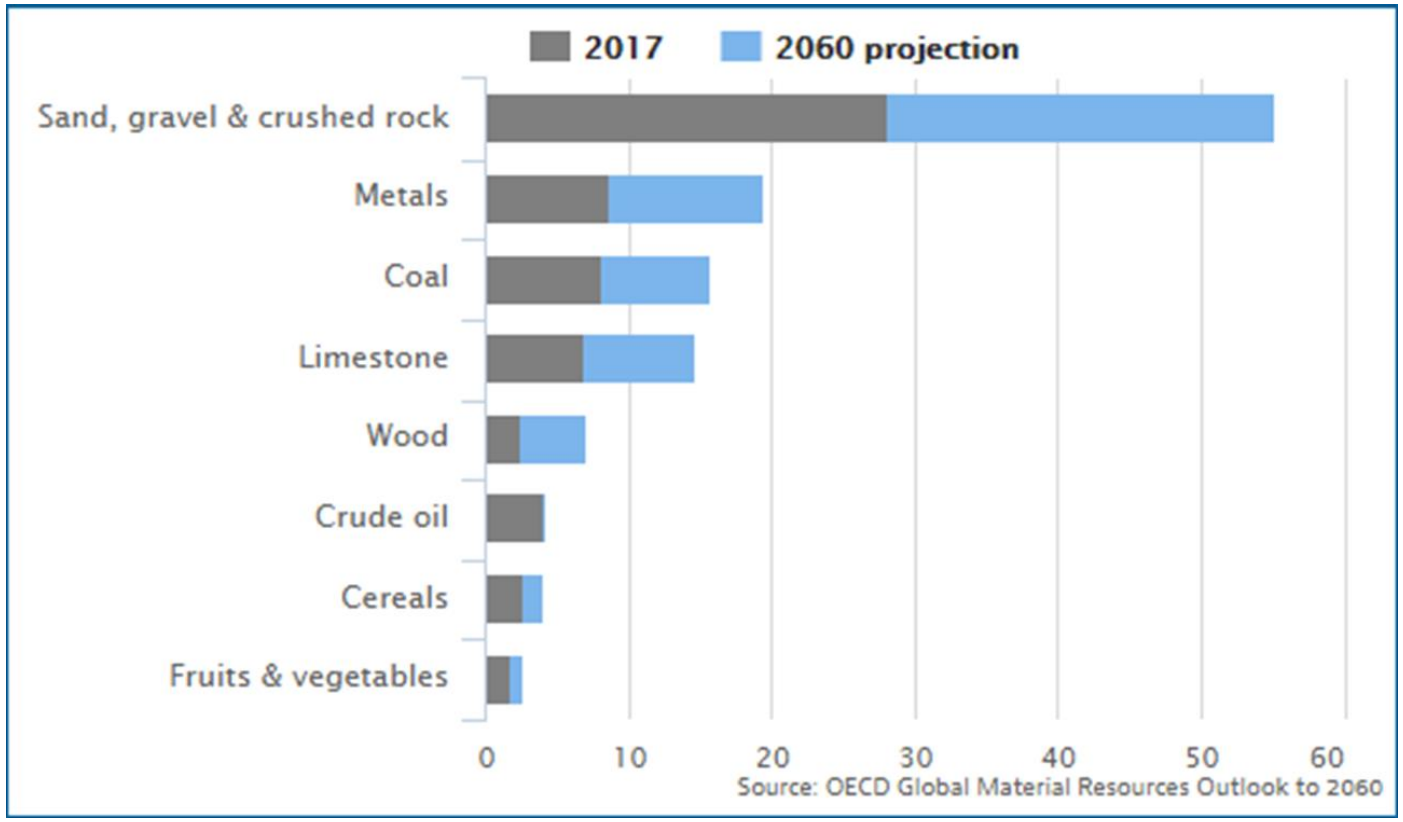
https://sdg-tracker.org/economic-growth

The material footprint per capita grew from 9.3 to 12.4 tons a 34 % increase.

The material footprint per unit GDP dropped from 1.19 kg/US$ to 1.14 kg/US$ a 4 % decrease.

Future projections of raw material consumption

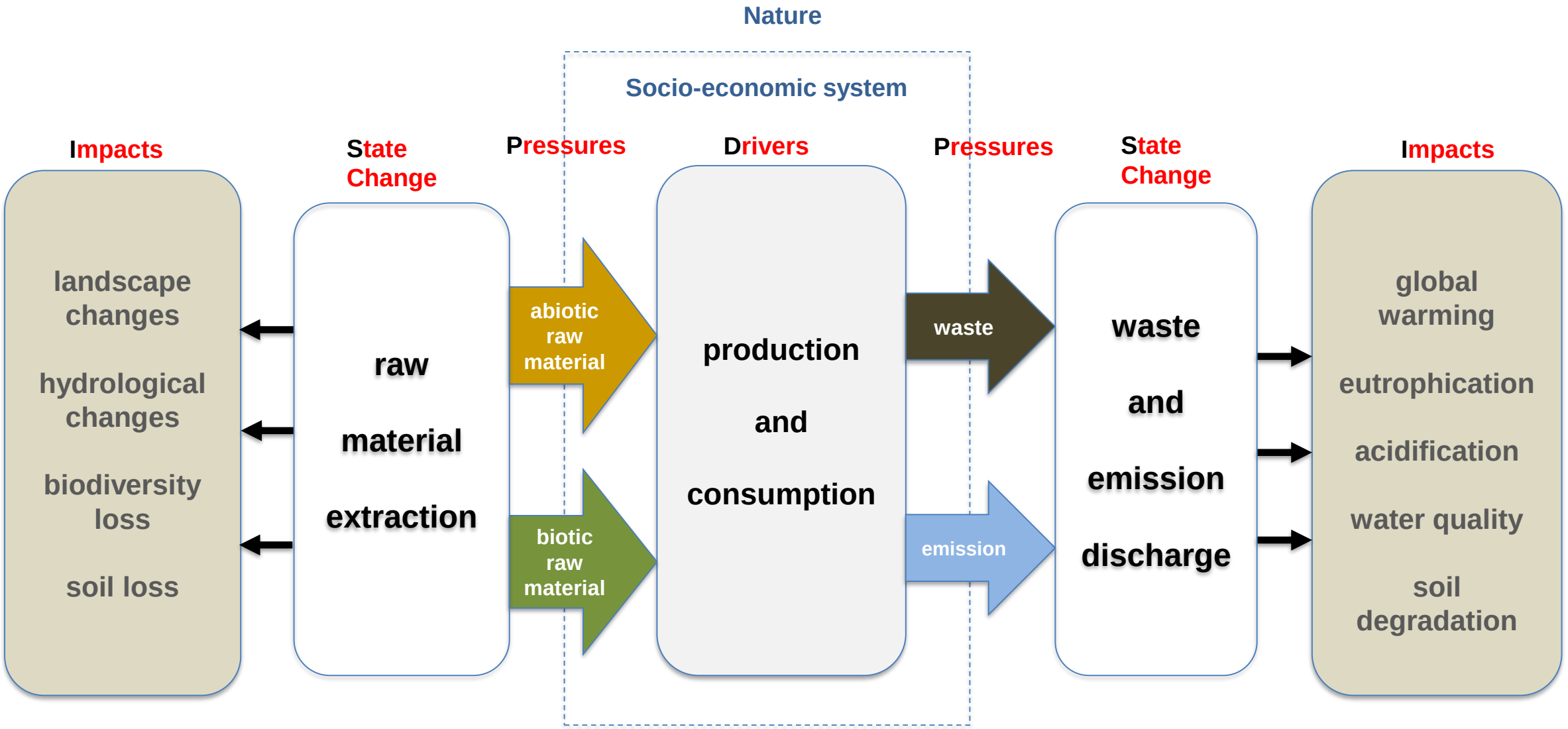
Current raw material consumption could double by 2060.



(OECD 2018)

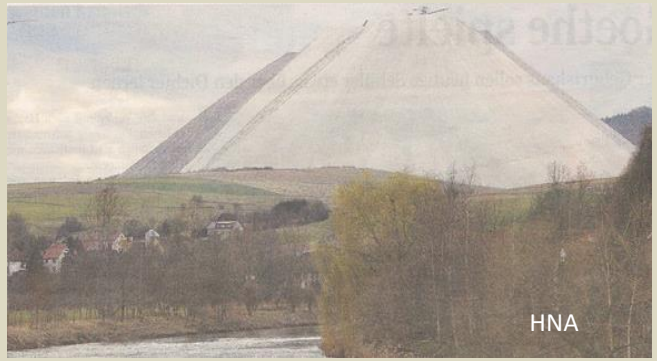
The growth is dominated by material use for production of goods and energy. Main consumer is the construction and building industry.

DPSI framework



Major environmental impacts of raw material extraction

landscape changes



hydrological changes

biodiversity loss

soil loss

Nature

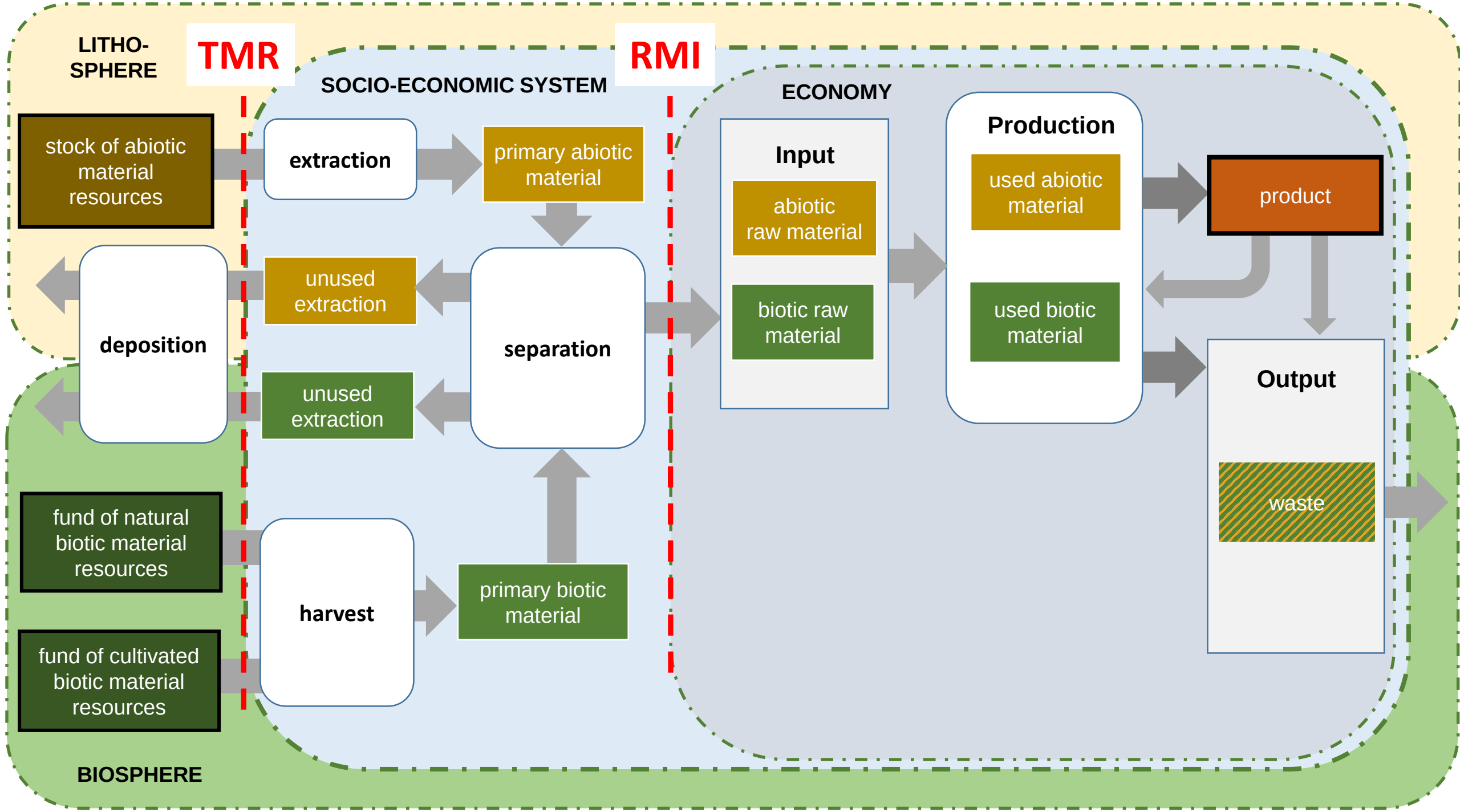
Socio-economic System

raw material extraction

abiotic raw material

biotic raw material

The Product Material Footprint (PMF) was developed to assess the environmental impacts of material use for a product or service.


LITHO-
SPHERE
TMR
RMI
SOCIO-ECONOMIC SYSTEM
ECONOMY
stock of abiotic material resources
extraction
primary abiotic material
Input
abiotic raw material
biotic raw material
Production
used abiotic material
used biotic material
product
deposition
unused extraction
separation
unused extraction
Output
waste
fund of natural biotic material resources
harvest
primary biotic material
fund of cultivated biotic material resources
BIOSPHERE

PMF as Life Cycle Impact Assessment Method

resources

MDPI

Article

Measuring Product Material Footprint as New Life Cycle Impact Assessment Method: Indicators and Abiotic Characterization Factors

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Abstract: The global economy is using growing amounts of natural resources such as raw materials, water, and land by making and using goods, services, and infrastructure. Aspirations on international, regional, and national levels e.g., the Sustainable Development Goals, the EU flagship initiative Roadmap to a Resource Efficient Europe or the German Program for Resource Efficiency are showing an urgent need to bring the global raw material use down to sustainable levels. An essential prerequisite to identify resource efficient options and to implement resource efficiency measures and solutions is the ability to compare different products or services regarding their raw material use. Until today, there is no internationally standardized approach defined and no software supported calculation method including the necessary data basis available to measure the raw material intensity of products. A new life cycle impact assessment (LCIA) method Product Material Footprint PMF is described. Two indicators are used to quantify the PMF: the Raw Material Input RMI and the Total Material Requirement TMR. The calculation of global median values for the characterization factors CF_{RMI} and CF_{TMR} of abiotic materials was done based on different databases. This article presents the methodological approach of the PMF, the calculation results for CF_{RMI} of 42 abiotic materials and CF_{TMR} of 36 abiotic materials, and the implementation of the LCIA method into the software openLCA for use with the ecoinvent database.

Keywords: product material footprint; new life cycle impact assessment method; abiotic materials; raw material input; total material requirement; characterization factors

resources

MDPI

Article

Biotic Part of the Product Material Footprint: Comparison of Indicators Regarding Their Interpretation and Applicability

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Abstract: The product material footprint (PMF) represents a central instrument to assess the potential environmental impacts of products and services based on their life-cycle-wide material use. Within the life cycle impact assessment framework, the indicators raw material input (RMI) and total material requirement (TMR) have been used for its calculation, but so far, only abiotic materials have been considered. This research analyses the requirements and indicators for the assessment of the biotic part of the PMF. The central question is whether the indicators RMI_{biotic} and TMR_{biotic} are suitable for this purpose or if they need to be adapted. For comparison, the indicator cumulative raw material demand (CRD) is applied. The indicator concepts of RMI, TMR, and CRD are compared by defining the system boundaries for determining the biotic parts of the footprint. To test the applicability, the production of wheat bread is assessed as a case study. The characterization factors of wheat grains are determined and each of the three indicators is implemented in the software openLCA for use with the ecoinvent database. The results show that RMI_{biotic} and TMR_{biotic} are suitable indicators for the quantification and assessment of the biotic part of the PMF. While $CRD_{abiotic}$ provides the same information as $RMI_{abiotic}$, both indicators differ regarding the biotic part. The CRD per definition does not consider biotic inputs from agriculture and forestry and thus conveys insufficient information on the used and unused biomass extraction for the product LCA. The ratio of RMI_{biotic} to the net annual increment and TMR_{biotic} to the net primary production could be used for absolute sustainability assessment.

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Keywords: resource use; material flows; life cycle impact assessment; system boundary; agriculture

https://doi.org/10.3390/resources8020061

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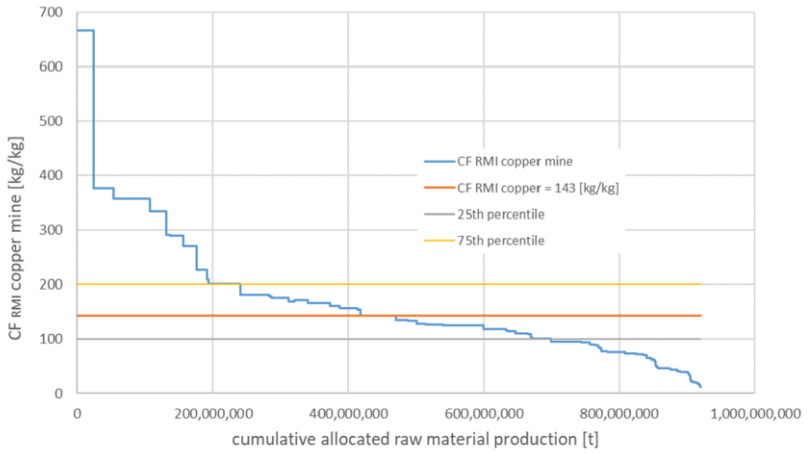
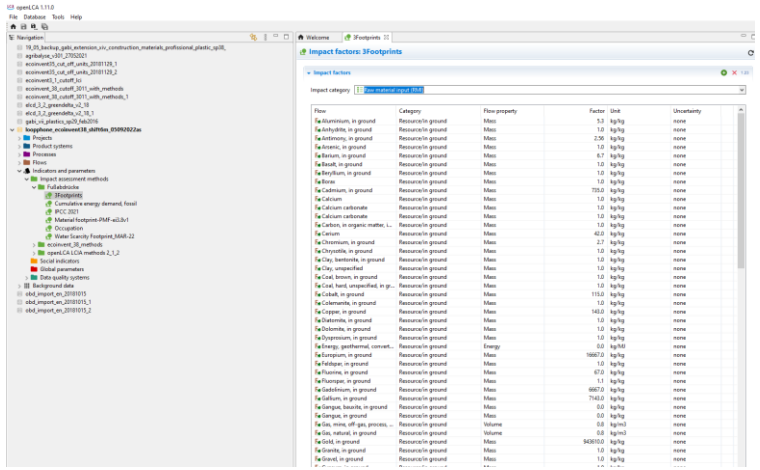
Four steps to calculate the PMF

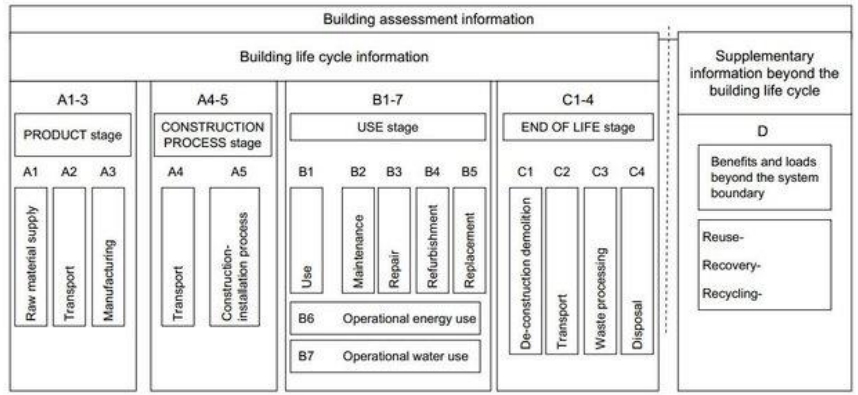
1. Determination of characterization factors



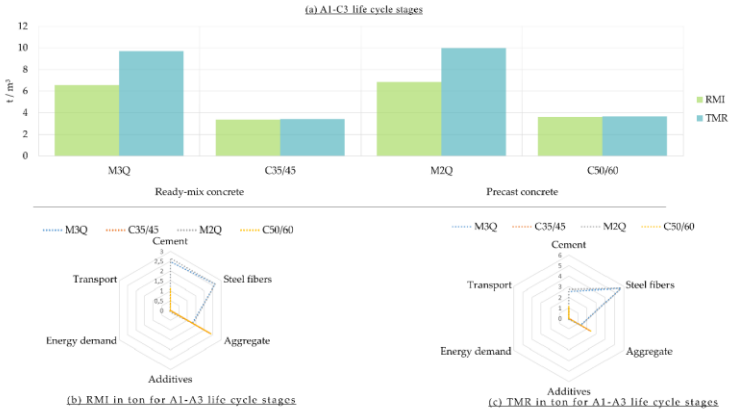
2. Implementation in LCA Software



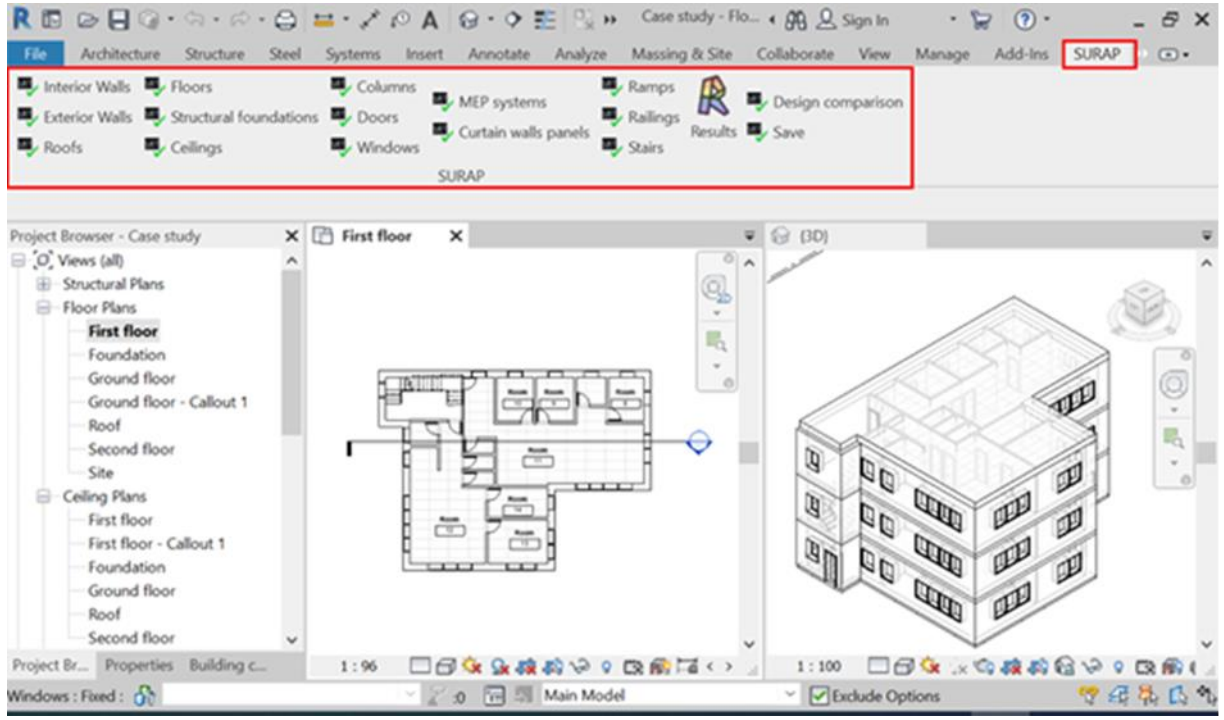
3. Modelling of product system

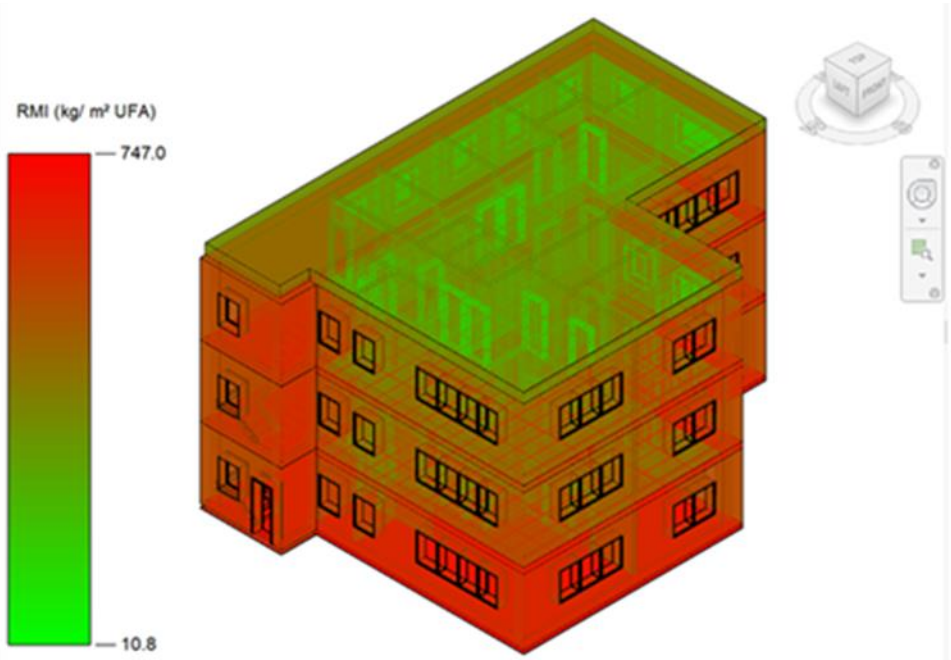


4. RMI and TMR as material footprint results



Sustainable Resource Application (SURAP)





Software solution for real time calculation and visualization of the material footprint of design options based on digital planning information.

Future research outlook

Update data: Most of the data used to calculate the characterization factors are based on the year 2014 or later. Therefore, a regular update of the material footprint data needs to be implemented.

Increase precision: Currently, the calculation is based only on the content of the material in the raw material. In the future, the process efficiency and dissipation should be included.

Include regionalization: The current results represent global averages values based on international markets and supply chains. The accuracy of the material footprint could be further improved by a spatially-explicit assessment.

Evaluation of results: The material footprint indicators could be used for absolute sustainability assessments. RMI_{biotic}, e.g. to assess primary biomass used in production in terms of net annual increment.

Thank you very much for your kind attention!

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