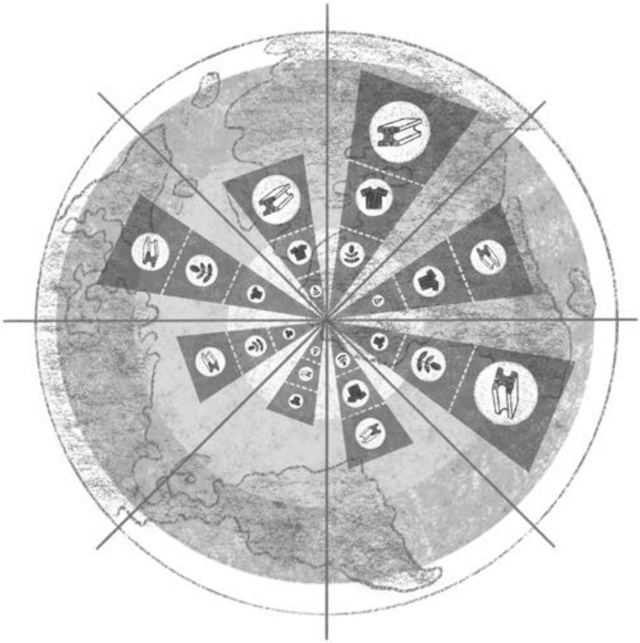
Swiss National Science Foundation
73 NRP Sustainable Economy
National Research Programme
Laboratory for Applied Circular Economy (LACE)

Synthesis note of the LACE project n°3

Estimating resource budgets for a sustainable economy

Considering resources as the physical "currency" of our economy, Earth system boundaries can be translated into resource budgets, determining a sustainable global annual consumption of resources



Original paper reference:
Desing et al. (2020). Ecological resource availability: a method to estimate resource budgets for a sustainable economy. *Global Sustainability* 3, e31, 1-11. https://doi.org/10.1017/sus.2020.26

The use of primary resources in a sustainable economy depends on its environmental impacts

Natural resources are the basis of our economy, their exploitation having enabled the progress of humankind over the past centuries. Even though Earth's resources are increasingly consumed, the physical availability of most of them is still abundant (albeit decreasing). Hence, **the main limitation to the input of primary resources into a sustainable economy is not their quantity but the impacts associated with their extraction, processing and disposal**, which cause the surpassing of the safe limits of many Earth system processes. A representative example is fossil fuels: countries around the world have engaged in decreasing greenhouse gas emissions because of the risk of destabilizing the climate system beyond safe limits and not because of their physical scarcity.

Setting a resource budget for sustainable consumption and production activities

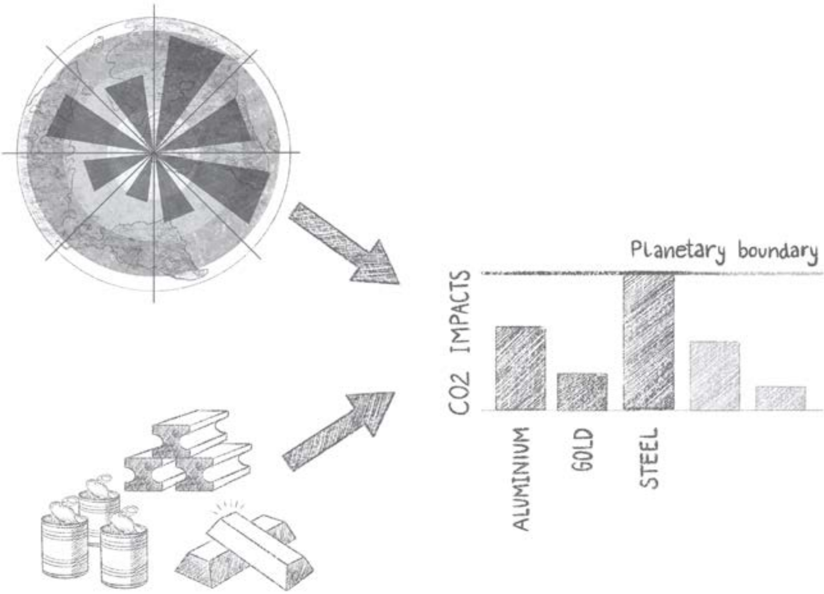
Reducing the environmental burden of resource use is essential for building a sustainable economy. Indeed, the increasingly popular circular economy approach aims at doing so by using products and materials as long as possible to maintain their value in the economy. Nevertheless, materials cannot be cycled indefinitely due to irreversible losses necessitating primary material input. Hence, resource consumption needs to be limited to what the Earth system can tolerate. However, a practical question remains open: **How can the Earth's safe limits be quantified and made tangible for governments, companies and individuals in order to integrate them into their decision-making?**

The above question is at the core of the research carried out by researchers of Empa, the Swiss Federal Laboratories for Materials Science and Technology, in the context of the Swiss National Research Programme "Sustainable Economy" (NRP 73) – project "Laboratory for Applied Circular Economy" (LACE).

In order to solve this issue, the researchers developed the **"Ecological Resource Availability" method that translates Earth system boundaries into annual resource budgets (expressed in units of mass flow, i.e. kg/year), setting a maximum level of resources that can be used globally without impacting Earth system processes irreversibly.**

The Ecological Resource Availability method

The Ecological Resource Availability method can be implemented through 5 consecutive steps. In order to simplify the comprehension of the method, the following paragraphs will illustrate the application of the different steps on the concrete example of metals.



Simplified illustration of the ERA method based on the metal example and the scientific paper

1

Selection of Earth system boundaries: the very first step of the methodology is the definition of the sustainability objective on which the rest of the analysis will be based. For the example of metals, the selected objective is the protection of the Holocene-like state of the Earth system, i.e. the state of the Earth during the geological period of the last 12’000 years. In order to describe this objective, the planetary boundary framework is used, which describes boundary values (above which irreversible changes, like climate change, are expected to happen) for 9 crucial Earth system processes. To show that this framework can be expanded, a tenth boundary describing renewable energy potentials is added.

2

Resource segment definition: the second step of the Ecological Resource Availability method consists in the selection of the resource segment to be investigated. Such a segment can include one or several resources, also depending on the data source used. For the resource segment metals, 14 major metals are included (aluminium, copper, steel, cast iron, zinc, lead, tin, nickel, gold, silver, platinum, titanium, chromium and stainless steel).

When the resource segment comprises more than one resource, the fraction that each single resource (in this case, each metal) contributes to the total mass flow of the segment needs to be specified. For current material use patterns, this information can be found in existing databases, such as the "Mineral resources data system" for metals.

3

Allocation of safe operating space: in order to link the Earth system boundaries to the resource under analysis, a share of each planetary boundary needs to be allocated to the metal resource segment. This process needs to be based on an allocation method (see box on page 5), such as the grandfathering approach: the shares of planetary boundaries are assigned to the resources based on their historic impact shares. This means in practice that if the production of steel is responsible for 9 % of today's global CO_2 emissions, then the resource steel will be assigned to this share within the CO_2 boundary.

4

Environmental impacts of resource production and end-of-life treatment: the environmental impacts caused on the selected boundaries by primary production and end-of-life treatments (such as incineration, landfill, dispersion - e.g., abrasion, and sewage treatment) of metals are calculated. This is done by using Life Cycle Assessment, based on average global data.

Allocation methods

Allocation methods are often used in environmental policy for the sustainable management of resources. They are also used in international negotiations for attributing greenhouse gas emissions permits or quotas to the different countries.
Within the many different allocation methods that exist, the grandfathering approach is widely known and used. Such an approach takes a status-quo perspective, allocating shares based on past ("inherited") impact shares. Other approaches are based on various principles (economic efficiency, equity...) and allocation criteria (population, GDP, history, costs, etc.) that can be combined (e.g. GDP per capita).

5

Upscaling of resource production: this last step of the Ecological Resource Availability method aims at identifying the boundary limiting an increase in production of the resource. To do so, the individual impacts of each metal of the segment are combined to an overall unit impact. Then, the production volume of the metal segment is increased stepwise (thus increasing its environmental impacts) until one boundary is crossed. In the case of metals, CO_2 is the limiting boundary (i.e. the one that is crossed first) due to today's carbon-intensive production technology. Within the segment, steel contributes the most to CO_2 emissions, because of its large production shares.

The results show that with the primary metal production of 2016, it would take 1'500 years to deplete the metal ores. However, the production surpasses by a factor of 40 the selected planetary boundaries. In other words, metal production would have to be 40 times smaller to avoid irreversibly changing our climate. This proves that the pressing constraint for a sustainable economy is the environmental impacts caused by metal production and end-of-life treatments and not their physical availability.

Conclusion

The Ecological Resource Availability method has proven efficient at translating Earth system boundaries into global resource budgets. Because of its flexible design, it can be used to consider different technologies, allocation principles and sustainability objectives. This allows evaluating the effects of different scenarios on the sustainable consumption scale of resources for the future. Such scenarios can be used as a basis for decision-making, e.g. for sustainable resource governance and the design of effective policies. Furthermore, the results of the application of the methodology on the case of metals demonstrate how it can be used to support present policies. Indeed, the results prove the relevance of the current societal and political focus on CO_2.

In this paper, the Ecological Resource Availability method is implemented by using global average data to calculate global budgets. However, often environmental conditions differ at a regional level. Thus, the method could be further developed by considering regional boundaries and regionalized impact assessment. Another limitation lies in the allocation method. The grandfathering approach rescales today's socioeconomic system to fit within Earth system boundaries. However, since today's world economy already transgresses 6 boundaries, such a rescaling would imply a significant downscaling of resource production and final demand, leaving large parts of the global society without access to basic services. This scenario is therefore to be seen as indicative only.

Consequently, it is necessary to define allocation principles that allow a decent life for a growing global population. Such further steps will be tackled in future research.

About the NRP 73

This research project is part of the National Research Programme "Sustainable Economy: resource-friendly, future-oriented, innovative" (NRP 73) of the Swiss National Science Foundation (SNSF).

NRP 73 aims to generate scientific knowledge about a sustainable economy that uses natural resources sparingly, creates welfare and increases the competitiveness of the Swiss economy. NRP 73 takes account of the environment, the economy and society as well as all natural resources and stages of the value chain.

Sustainable Economy
National Research Programme

Further information on the National Research programme can be found at:
www.nfp73.ch

About the LACE

The Laboratory for Applied Circular Economy (LACE) is an inter- and trans-disciplinary project that gathers researchers from three Swiss higher-education institutions, and from various disciplines: environmental and material sciences, business administration, as well as law and political sciences. The LACE project is working together with seven well-known partner companies in order to show how the resource-efficient patterns of the circular economy and related business models can be introduced into the value chains of the participating companies. The aim of this project is to demonstrate that the principles of circular economy can be ecologically beneficial and profitable for Swiss companies. The sanu durabilitas foundation is knowledge-transfer partner of the LACE project.

Empa Materials Science and Technology

Universität St.Gallen

UNIL | Université de Lausanne

Further information on the Laboratory for Applied Circular Economy can be found at:
www.nrp73.ch/en/projects/circular-economy/laboratory-for-circular-economy

About sanu durabilitas

The sanu durabilitas foundation is an independent Think and Do Tank based in Biel/Bienne. Its aim is to develop new practice-oriented and effective solutions for the transition towards a sustainable Switzerland which are being applied in economy, policy and public administration, and also to improve the institutional framework conditions for sustainability. In collaboration with partners from research, business, politics, administration and civil society, sanu durabilitas identifies promising solutions, develops them further, tests their application in the field, draws up recommendations, and brings them to the attention of decision-makers and the general public. The current focus areas of sanu durabilitas are circular economy, sustainable use of soils, and social cohesion in a changing society.

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