A socio-metabolic perspective on sustainability

Universität für Bodenkultur Wien
Department für Wirtschafts- und Sozialwissenschaften
Institute of Social Ecology

Helmut Haberl

The Social Dynamics of the Technosphere

A workshop exploring contributions of the social sciences to a future „Max Planck Institute for Geoanthropology", June 3-4, 2021

This presentation is based on research that has received funding from the the European Research Council (ERC) under the European Union's Horizon 2020 research and innovation programme (MAT_STOCKS, grant agreement No 741950).

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Sustainability as dynamic equivalence between mode of subsistence and capacities of natural system

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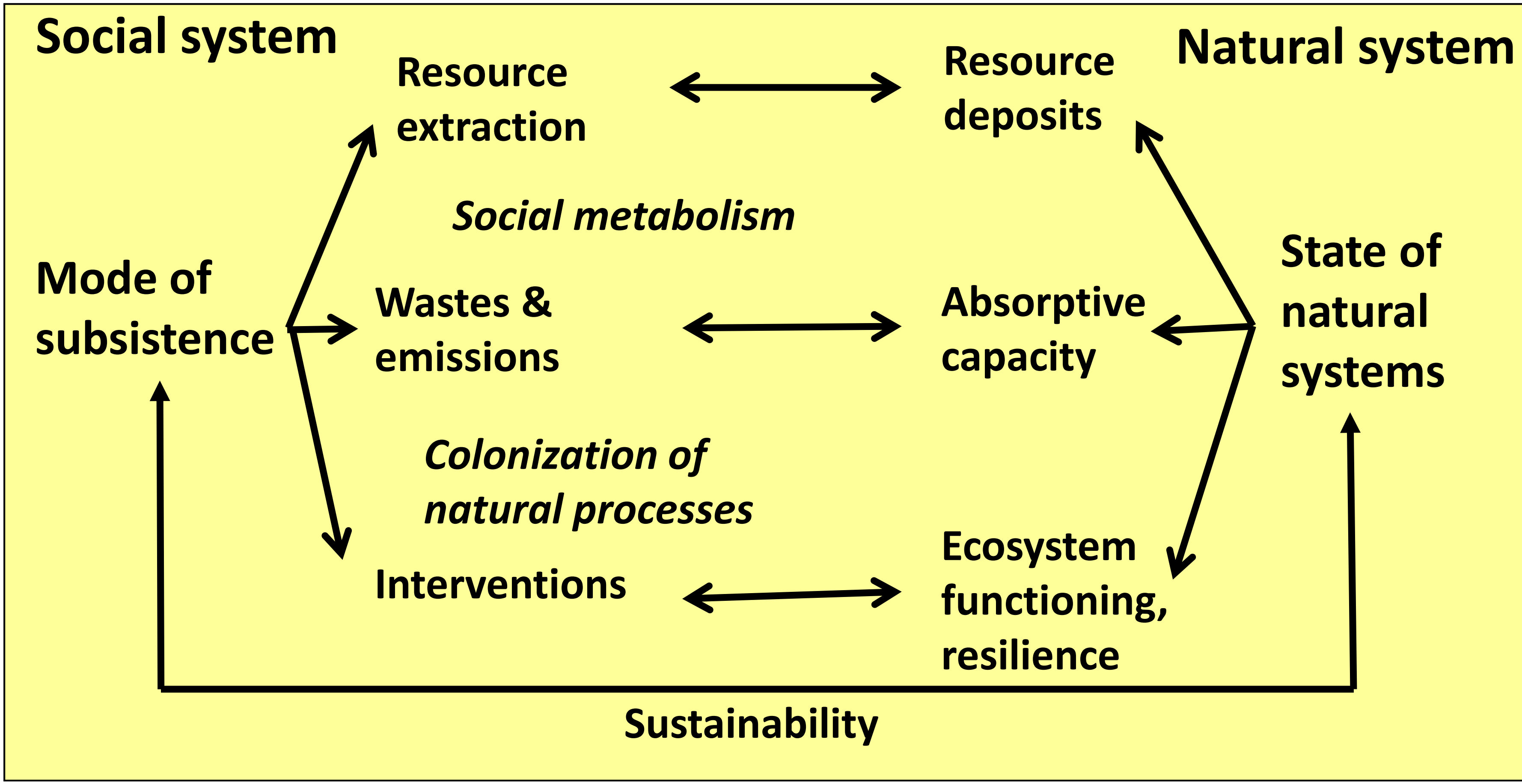

Fischer-Kowalski *et al.*, 1997. *Gesellschaftlicher Stoffwechsel und Kolonisierung von Natur.* G+B Facultas.

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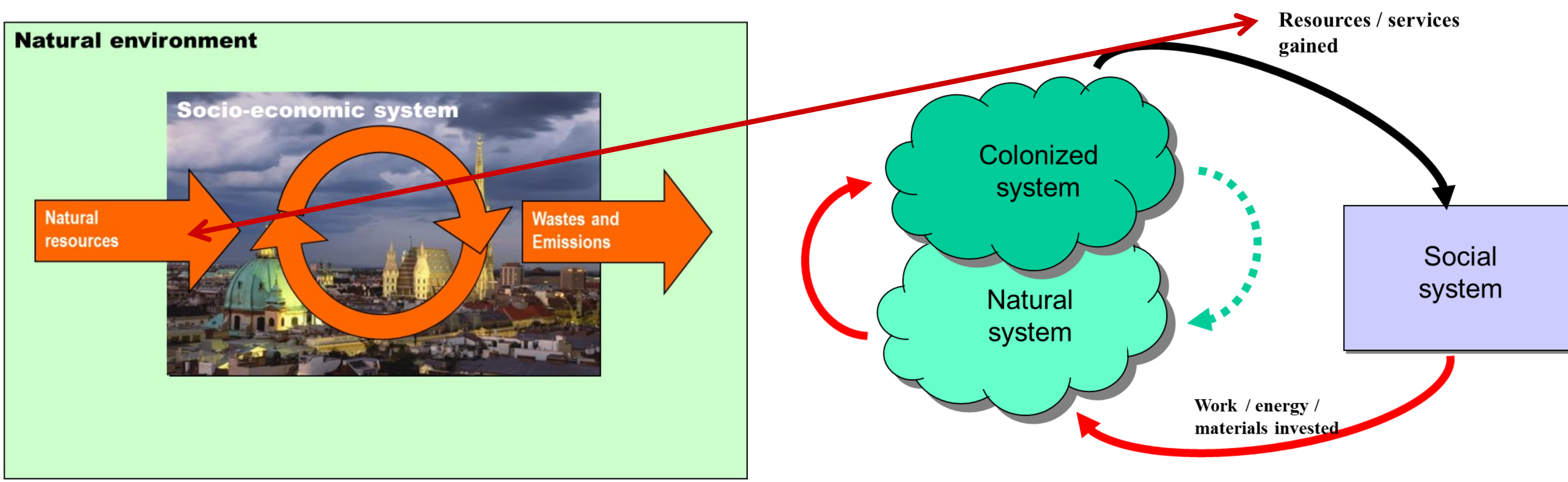
Concepts to operationalize society-nature interaction

Social metabolism | **Colonization of natural processes**



Material Flow Analysis (MFA): Domestic Material Consumption

Human appropriation of biocapacity, e.g. HANPP

e.g. Haberl *et al.* 2004. *Land Use Policy* **21**, 199–213.

Social metabolism: A systemic perspective on resource use

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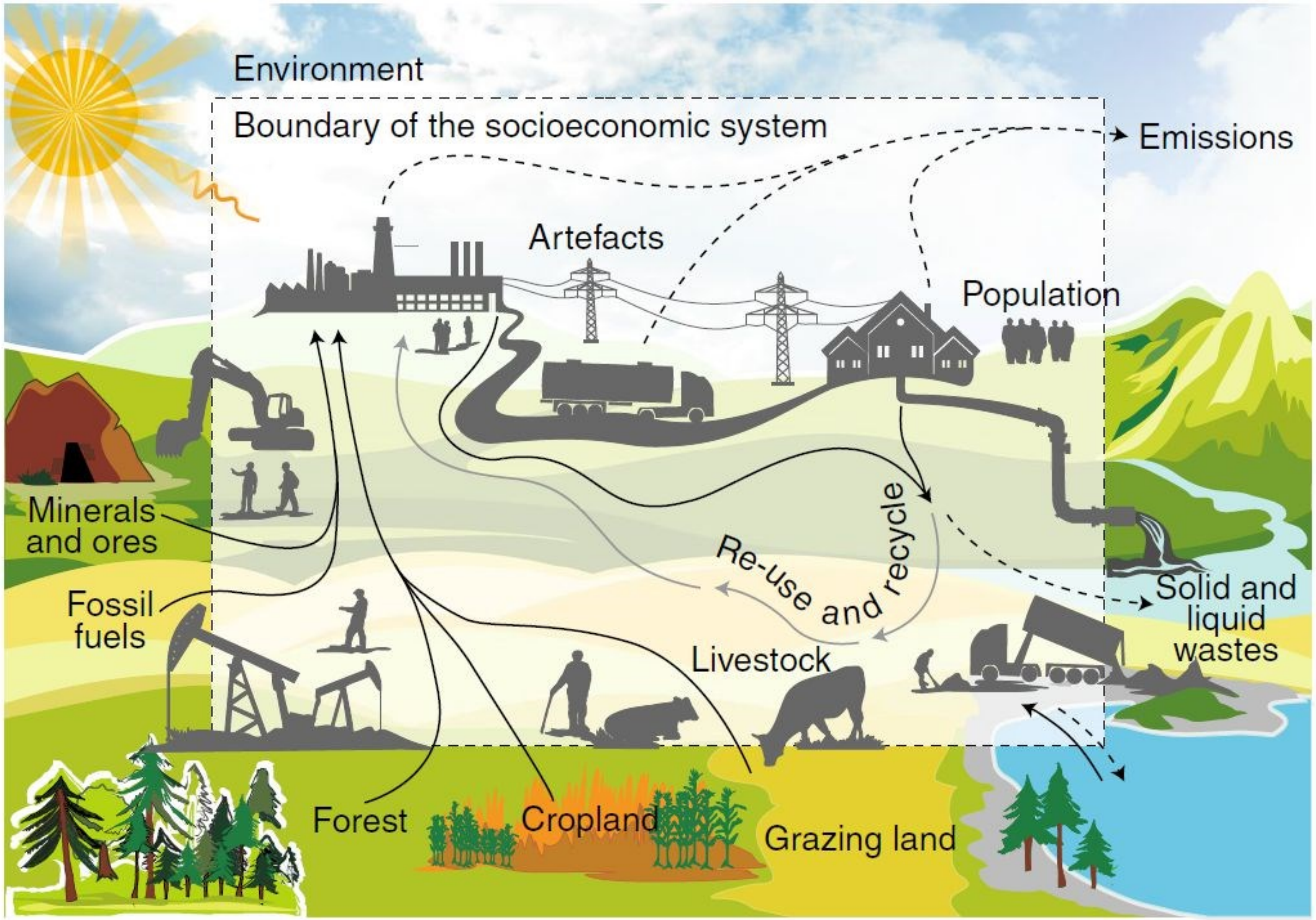

Haberl *et al* 2019. *Nature Sustainability* **2**, 173–184

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The family tree of socio-metabolic research

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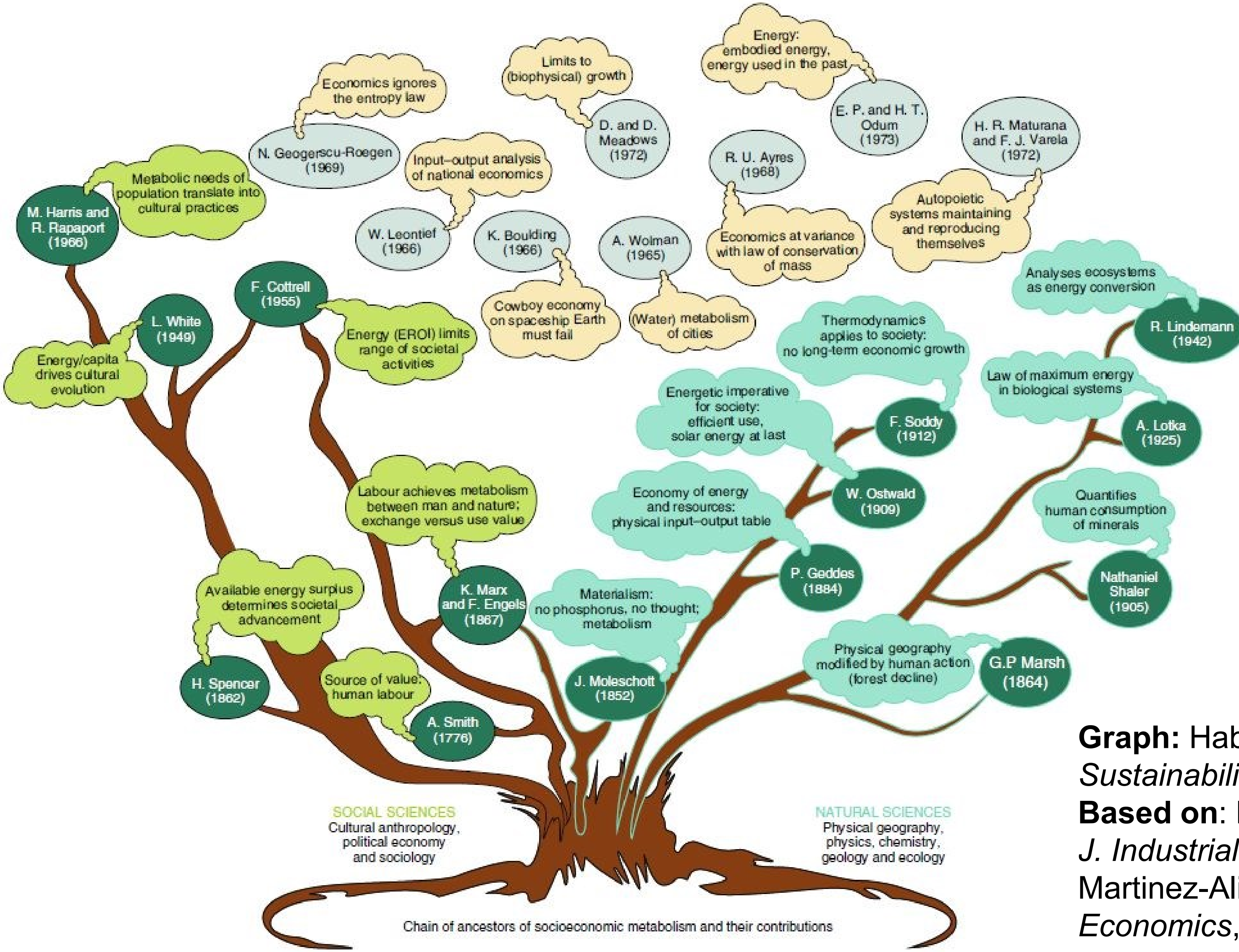

Graph: Haberl *et al* 2019. *Nature Sustainability* **2**, 173–184
Based on: Fischer-Kowalski 1998, *J. Industrial Ecol*. 2, 107-136, Martinez-Alier, 1987, *Ecological Economics*, Blackwell

Social metabolism: relations to sustainability and the biosphere

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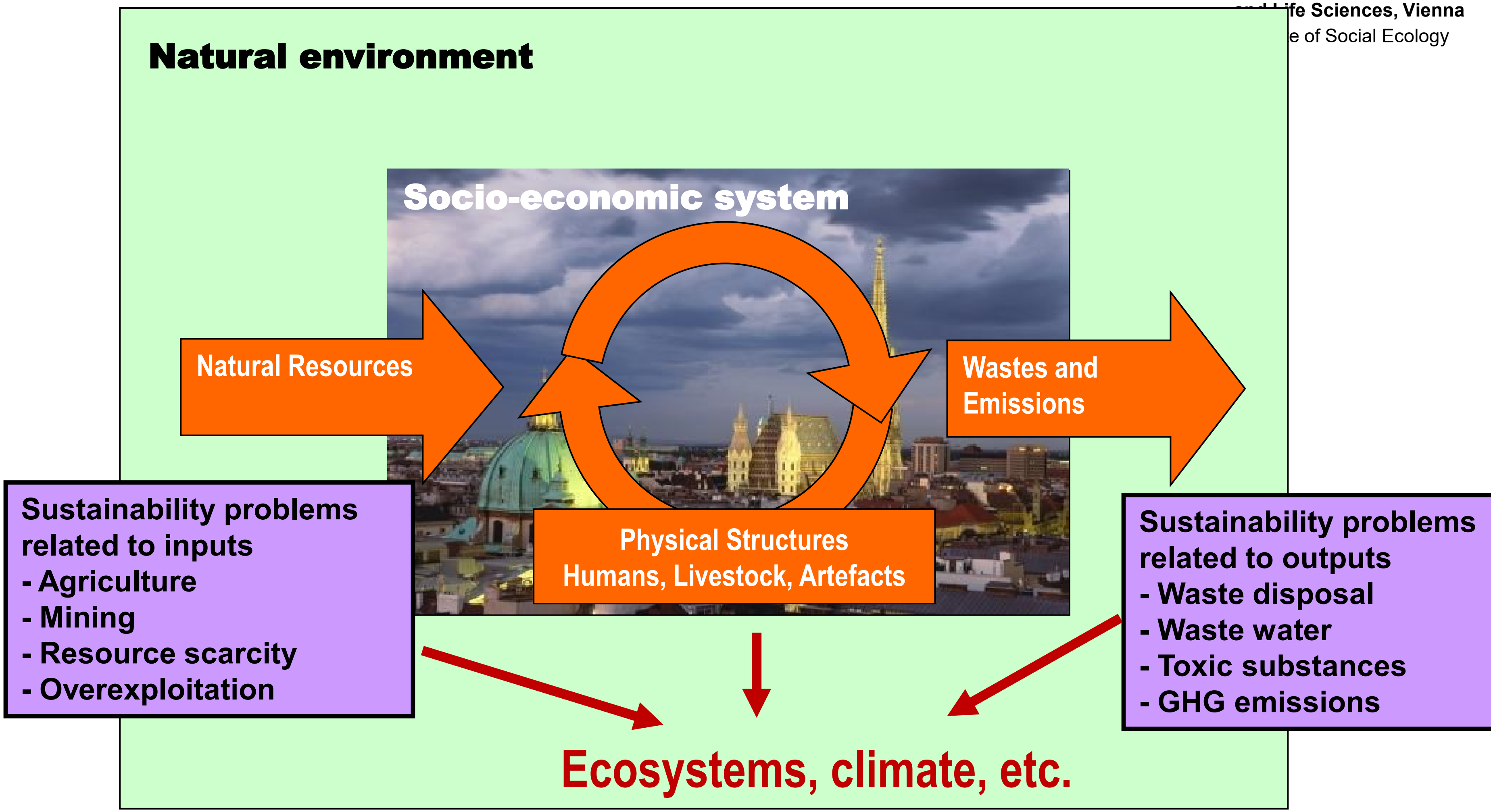

The classical approach: Eco-efficiency

Decoupling: can resource use and emissions decline while the economy is growing?

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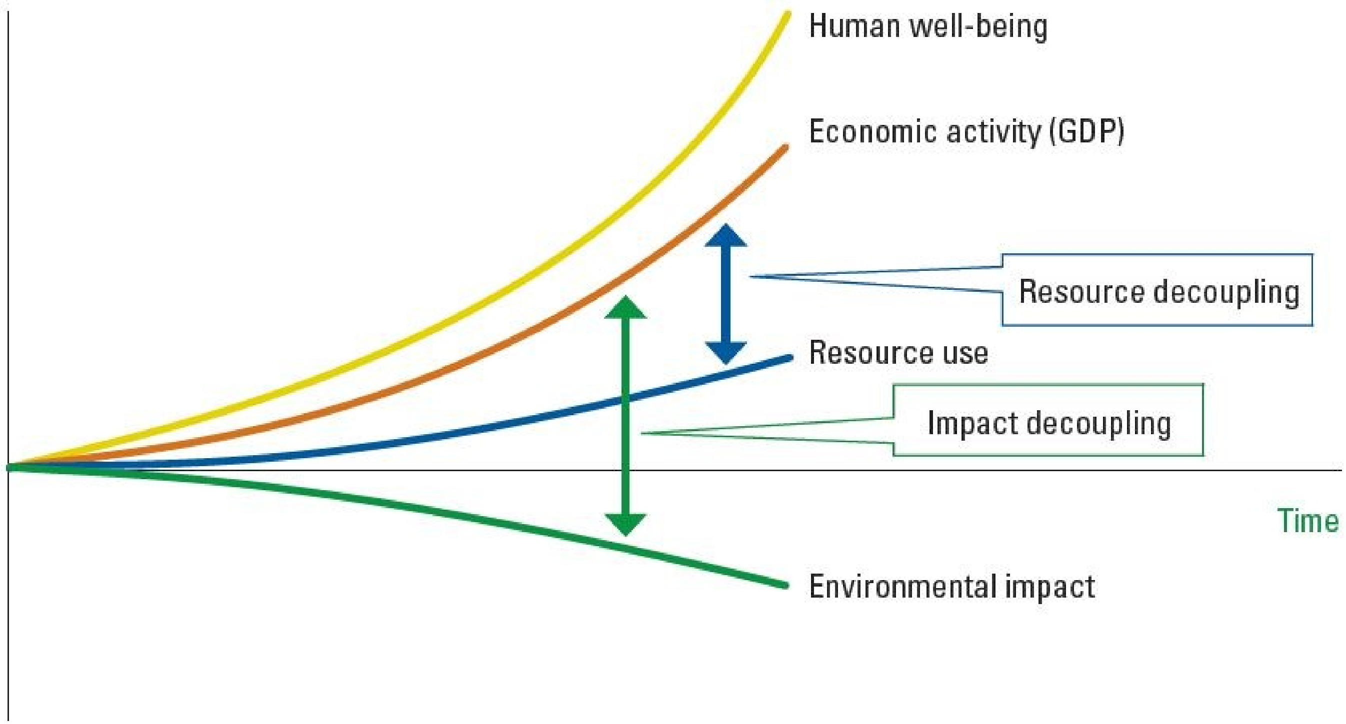
Relative decoupling:
- Resource use per unit GDP or impacts decline, but total amount of resources grows
- GDP grows faster than resource use

Absolute decoupling:
resource use or impacts decline while GDP grows



Most sustainability or climate policies explicitly or implicitly are focused on decoupling

The *Gospel of Eco-Efficiency is good,* but not nearly good enough

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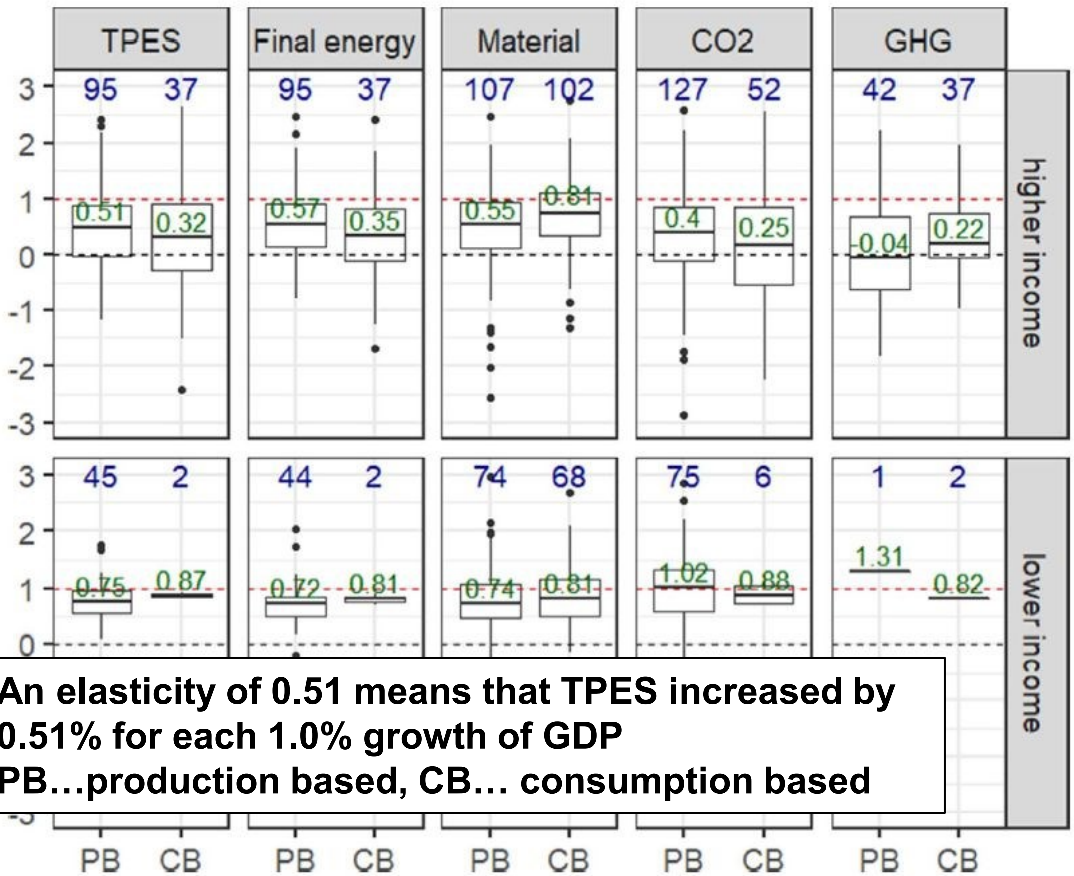
Observed GDP elasticities in the last decade



An elasticity of 0.51 means that TPES increased by 0.51% for each 1.0% growth of GDP
PB…production based, CB… consumption based

Current sustainability strategies rely on promoting a „decoupling“ of GDP from resource use or emissions

The 1.5°C target requires a linear absolute reduction of CO2 by 3.3%-5% of the emissions in 2020 per year. This requires a *qualitatively new approach* for socio-ecological transformation

erc Haberl *et al.*, 2020, *Environmental Research Letters* **15**, 065003

TPES… total primary energy supply, GHG… greenhouse gas

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Why material stocks are important

- They transform resources into services such as shelter, nutrition or mobility.
- Building up and maintaining stocks requires large amounts of resources.
- They shape social practices (including production and consumption), thereby creating path dependencies for future resource use (“lock-in”)

GHG emissons from fossil fuels required for using existing infrastructures until the end of their lifetime almost exhausts the emission budget for the 1.5°C target (Smith *et al*. 2019. *Nature Communications* 10, 101)

The stock-flow-service nexus

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Stocks Buildings, infra-structures, machinery

Flows Energy, materials

Services Contributions to social well-being

Fotos: Helmut Haberl

Haberl *et al* 2017. *Sustainability* **9**, 1049
Kalt *et al.* 2019, *Energy Res & Social Sci*, **53**, 47-58

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Stocks, flows and a glimpse on services (global 1900-2015)

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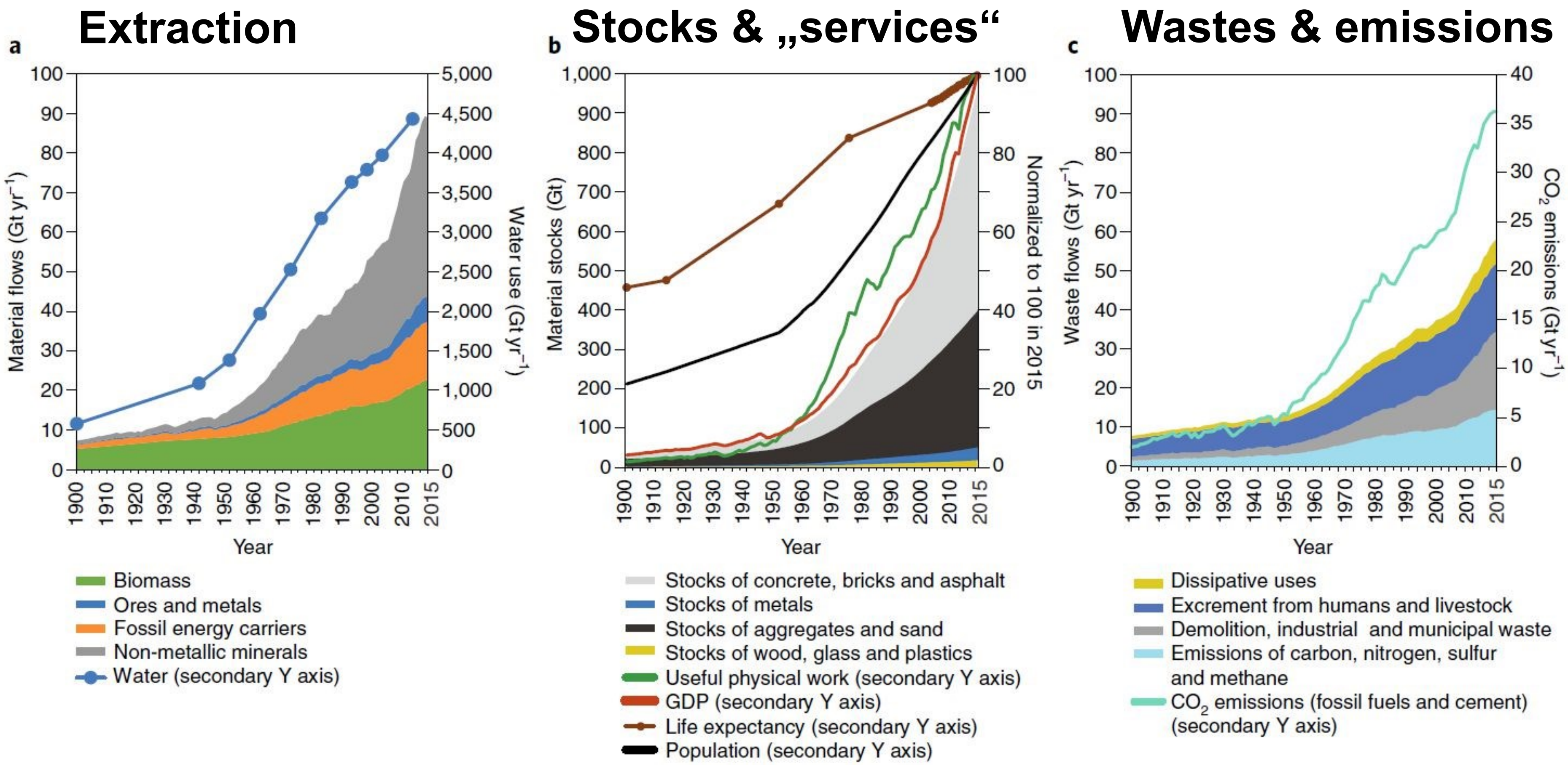

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Haberl *et al*. 2019. *Nature Sustainability*, **2**, 173–184

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Maintenance and expansion: systemic interrelations of stocks and flows

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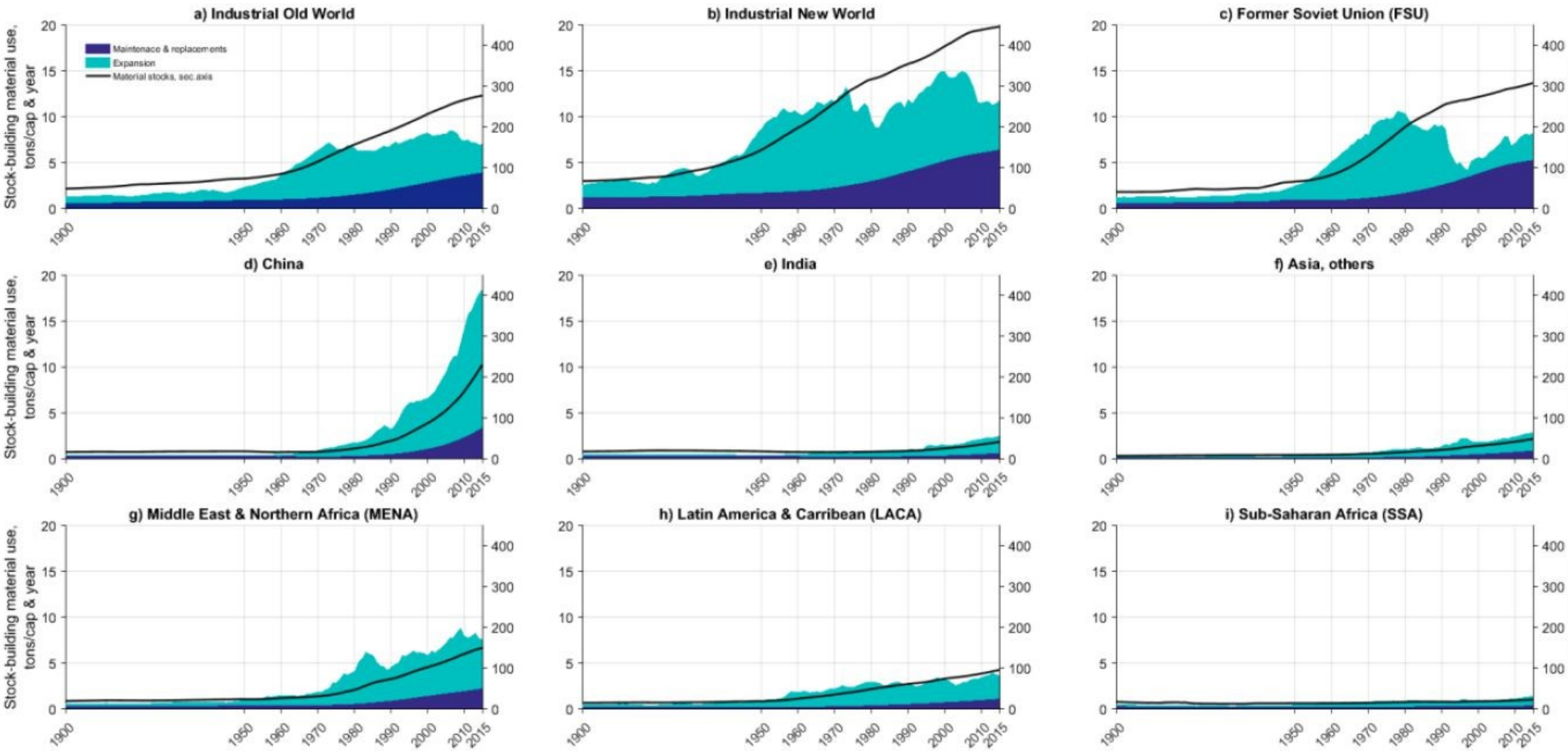
Dark blue: Maintenance & replacement of stocks

Turquoise: Expansion of stocks, **black line:** Mass of stocks



Wiedenhofer *et al.* forthcoming. **Do not cite or distribute!**

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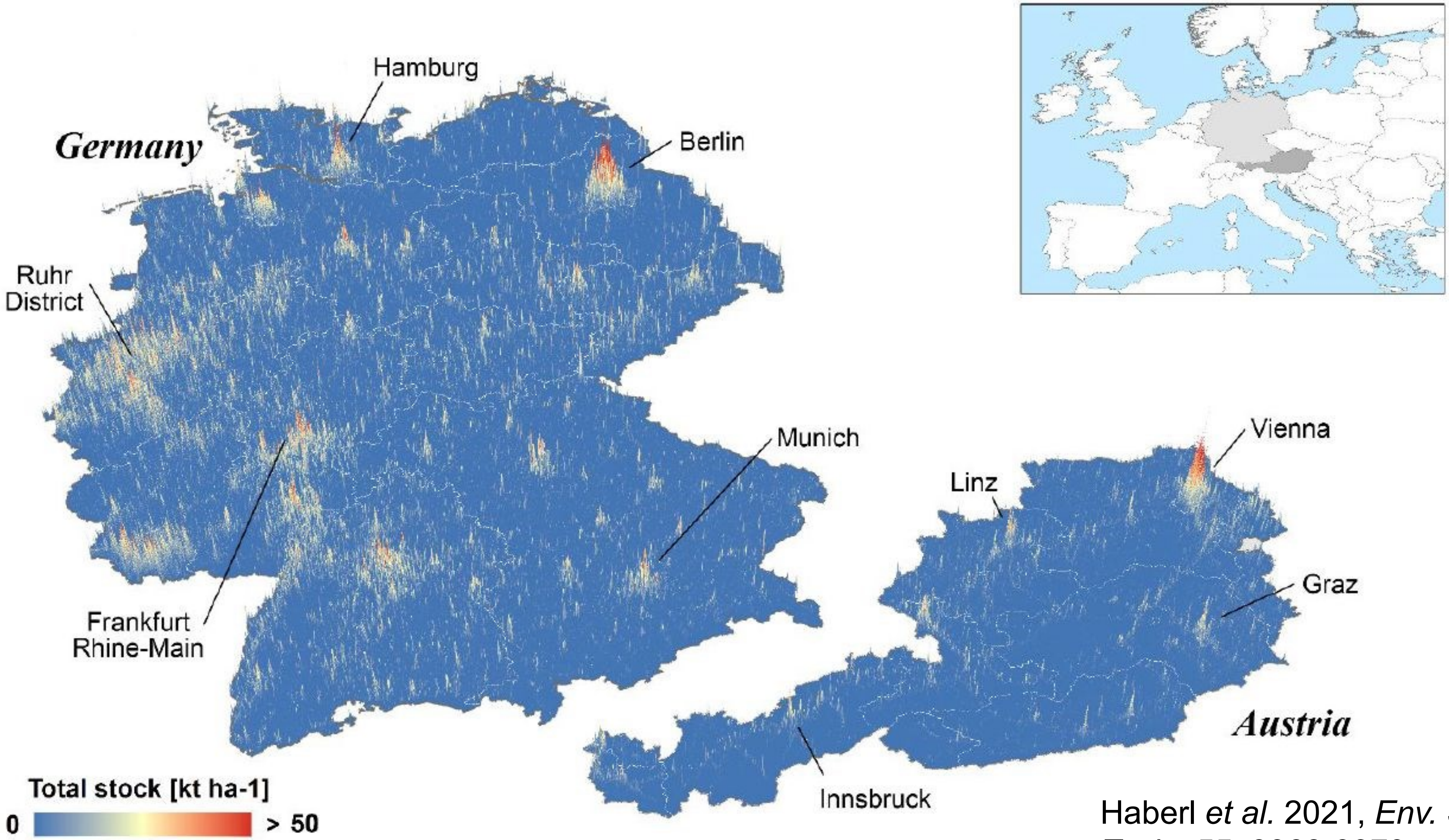
Mapping material stocks
Austria & Germany 2018



Haberl *et al.* 2021, *Env. Sci. Tech.*, **55**, 3368-3379

Fig 2. Three-dimensional maps of total material stocks in buildings and infrastructures in Germany and Austria (2018; 100m resolution), measured as kt/ha (1 kt = 1,000 metric tons; 1 ha = 10^4 m^2 = 0.01 km^2).

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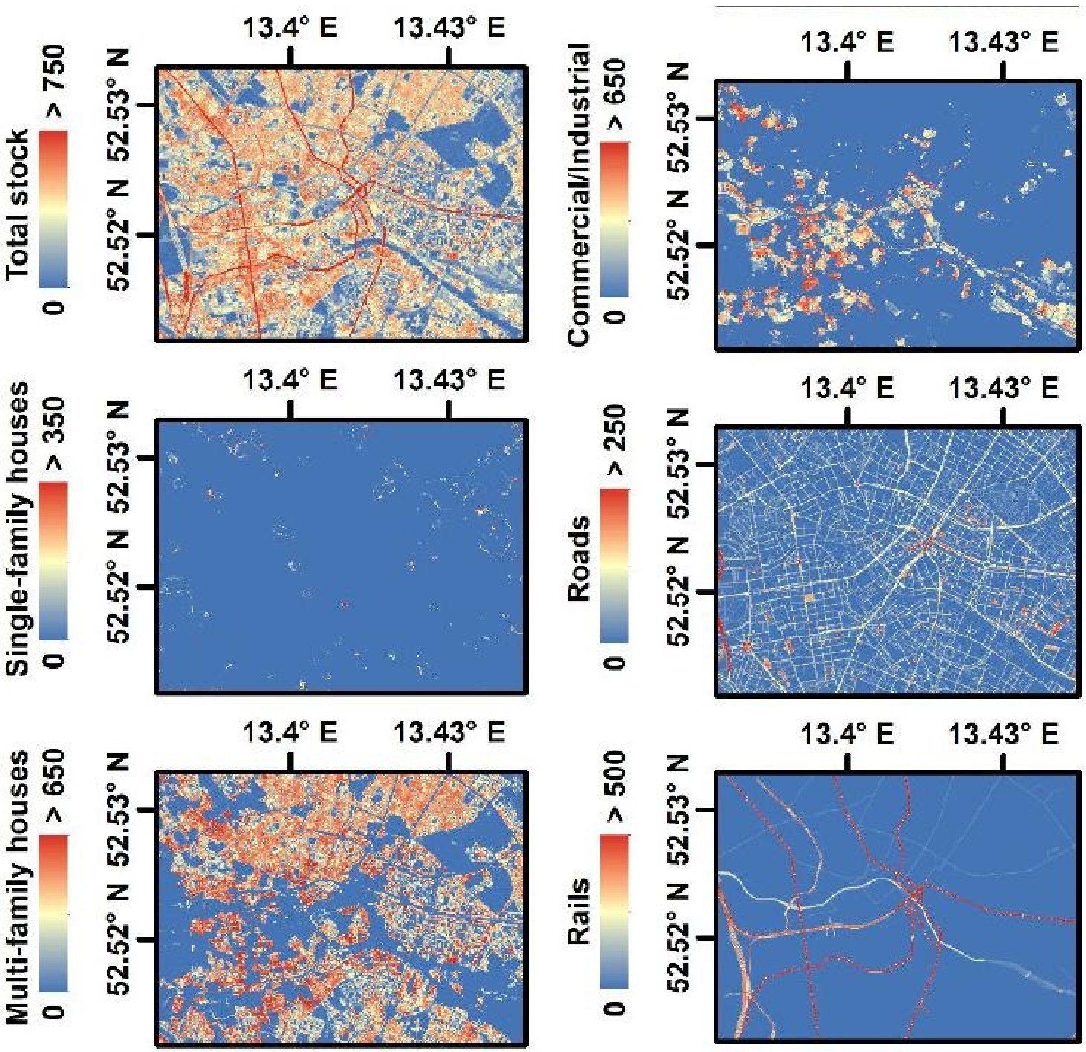
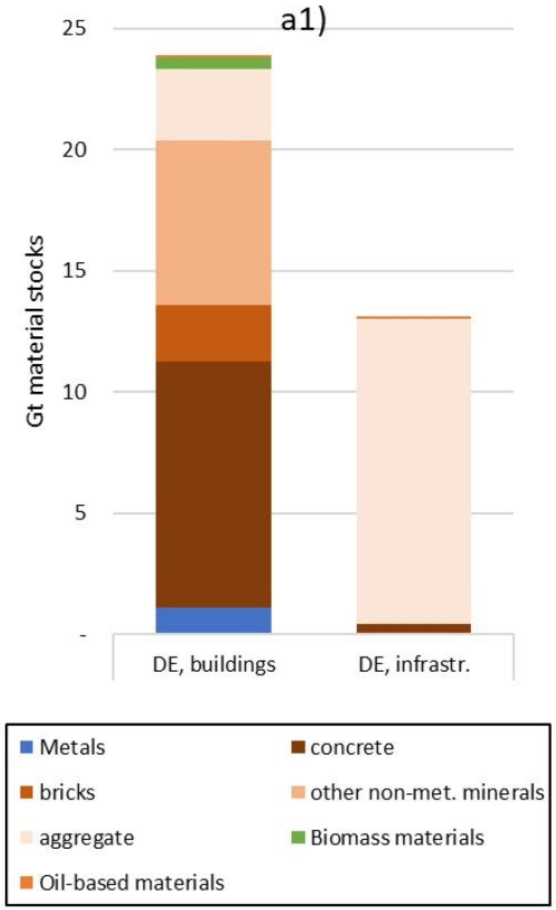
Most material stocks are in buildings and infrastructures

Berlin, 2018



Germany



Haberl *et al.* 2021, *Env. Sci. Tech.*, **55**, 3368-3379

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Scenarios for stock development and GHG emissions 2050

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- **GDP-driven scenarios:** GDP development taken from IPCC-SSP2, assumptions on GDP per unit of stock ratio.
  - A GDP-driven high: Constant GDP/stock ratio
  - B GDP-driven low: Trend GDP/stock ratio, only selected results shown here
- **Population-driven scenarios:** Population development (UN median) and assumptions on per capita stocks in 2050.
  - C Convergence1970: Contraction-convergence of global per capita stocks at industrial level of 1970
  - D Convergence2015: Convergence of global per capita stocks at ind. level of 2015
- **Decarbonisation pathways**
  - Trend: little or no improvements in CO_2 intensity of TPES
  - Full decarbonization of energy system in 2070, 2060, 2050, 2040 & 2030
  - C emissions from cement production (calcination) and coke use in blast furnaces continue (hard to decarbonize)*

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Krausmann *et al.*, 2020, *Global Env. Change*, **61**, 102034
* Davis *et al.*, 2018, *Science* **360**, 1419

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Global Material Stock Scenarios
1970-2050

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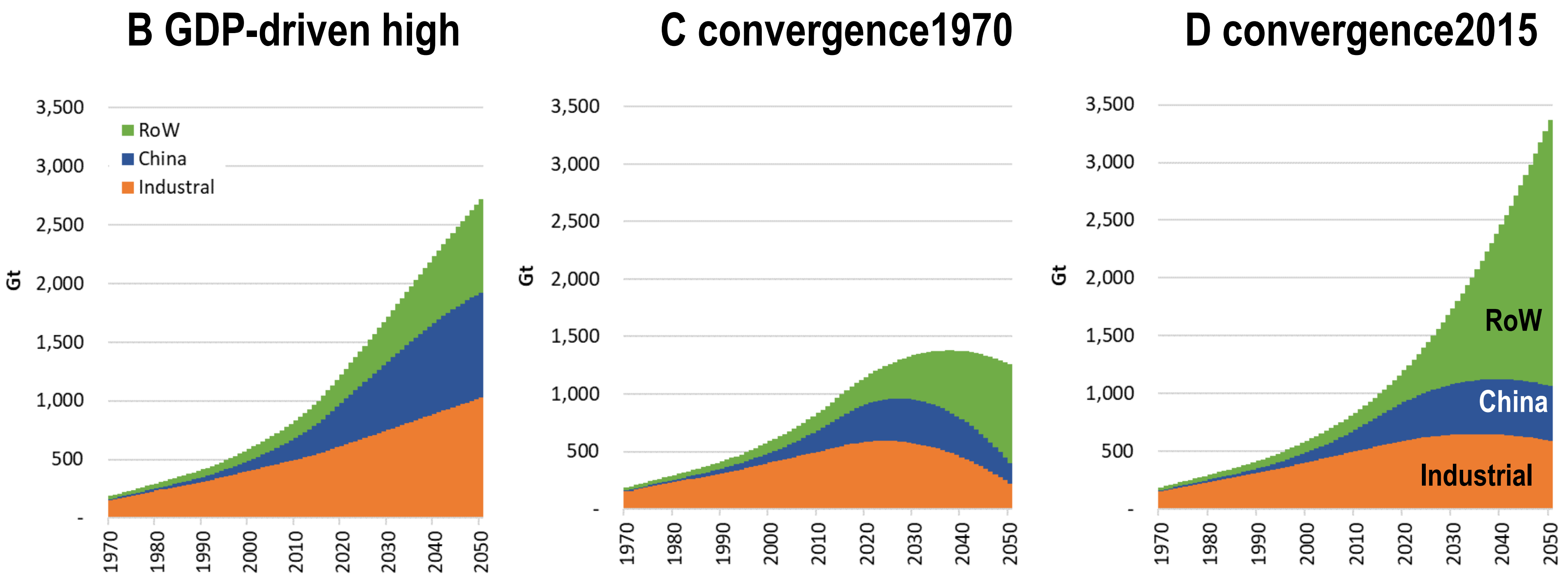

Krausmann *et al.*, 2020, *Global Environmental Change*, **61**, 102034

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Scenario results:
Development of CO_2 emissions 1970-2050
(without additional decarbonization)

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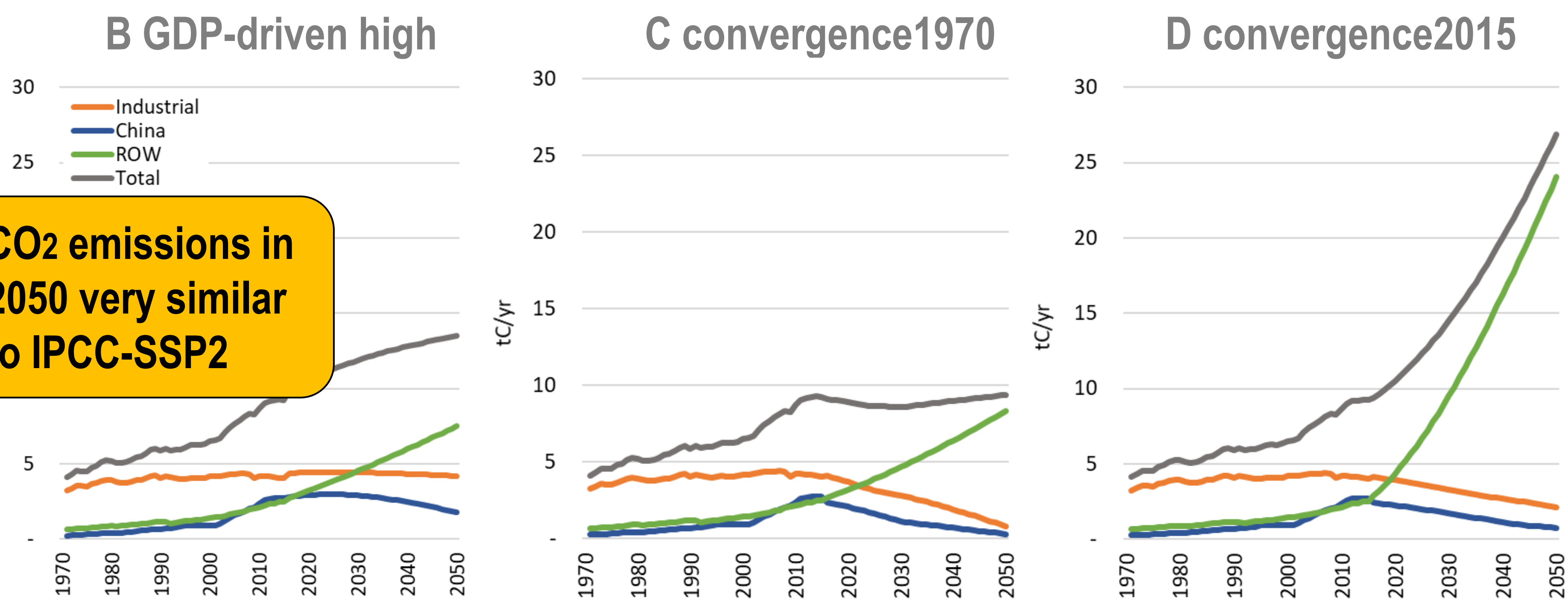

CO_2 emissions in 2050 very similar to IPCC-SSP2

Krausmann *et al.*, 2020, *Global Environmental Change*, **61**, 102034

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Global circularity and resource use
1900-2015

Input cycling 43% → 27%
Output cycling 46% → 40%

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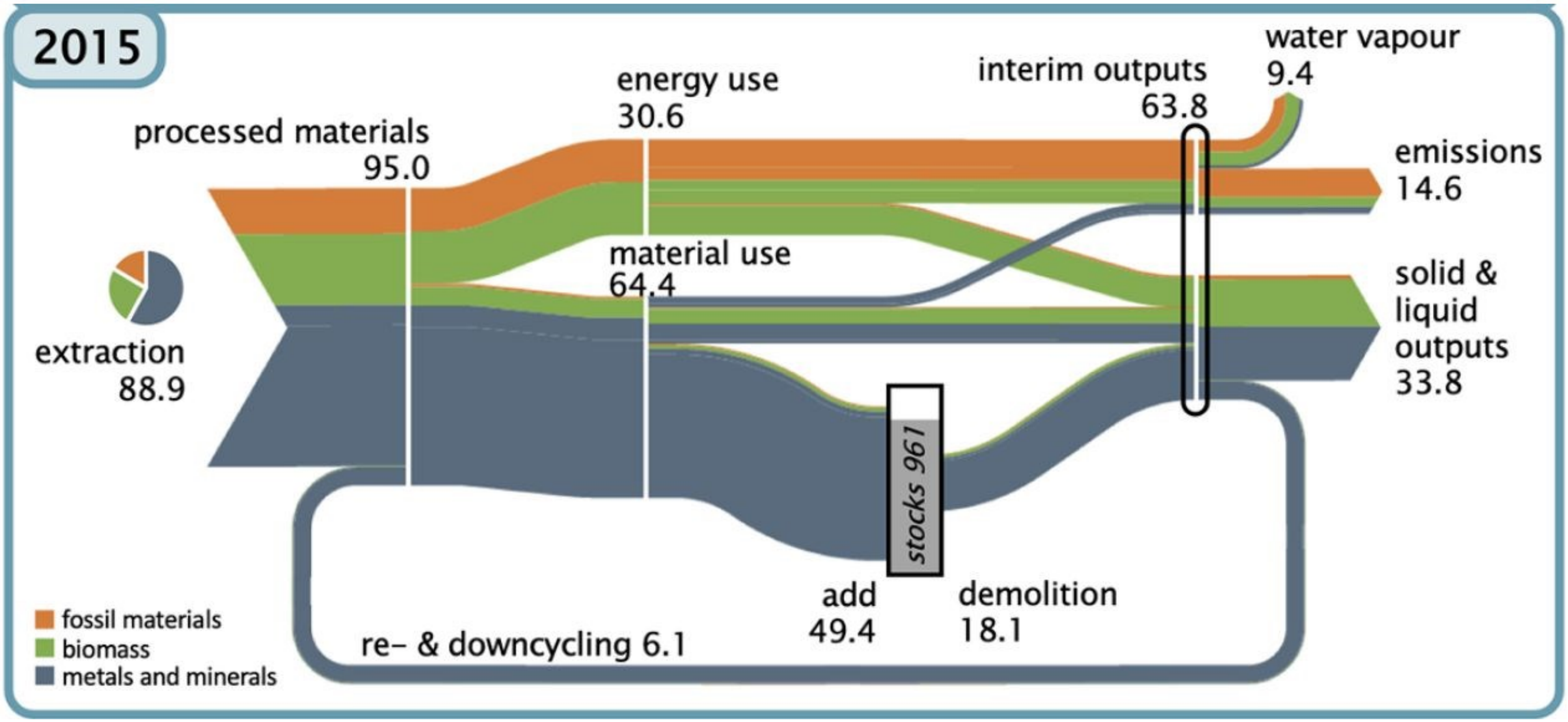

Haas *et al.* 2020, *Resources, Conservation & Recycl.* **163**, 105076

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Stocks and flows vs. social progress

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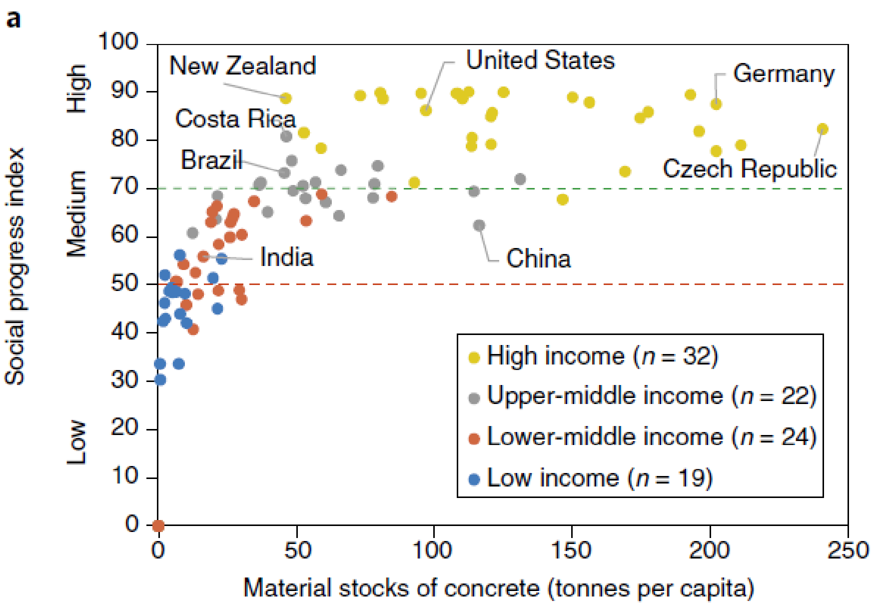
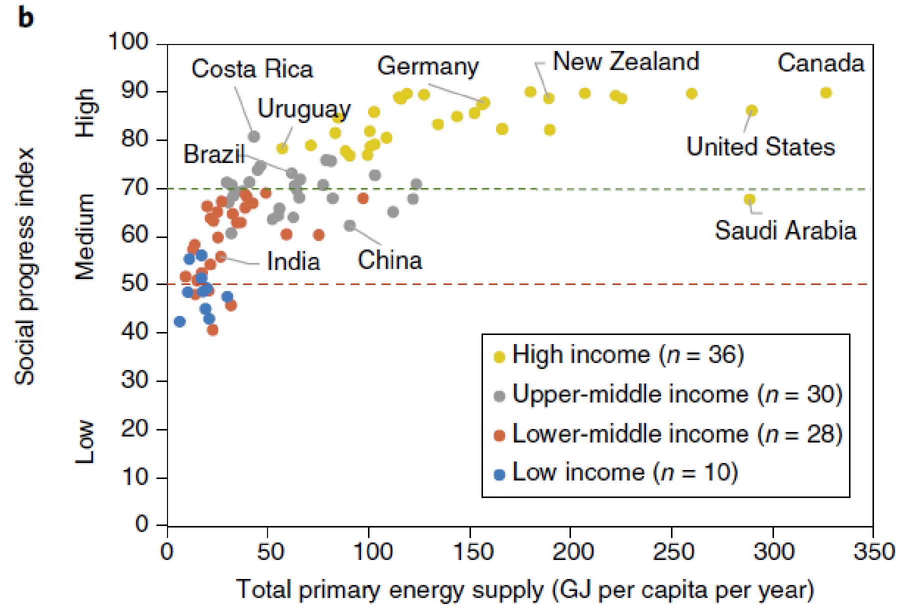
Concrete stocks



Primary energy supply



The Social Progress Index (SPI) is an outcome-based index of social wellbeing con-sidering nutrition, shelter, water, sanitation, safety, access to knowledge, freedom, human rights, environmental quality, but no monetary indicators such as GDP

Haberl *et al* 2019. *Nature Sustainability* **2**, 173–184

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Provisioning systems link resource use to societal well-being

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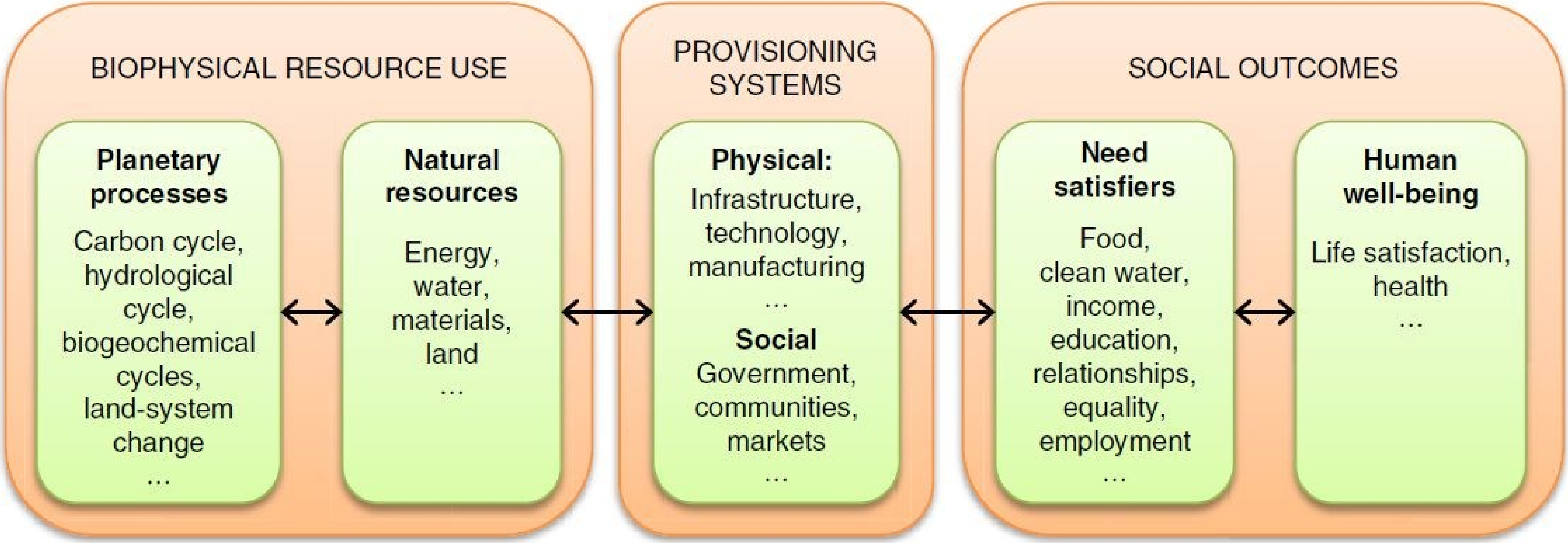

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Conceptualizing services: the energy service cascade

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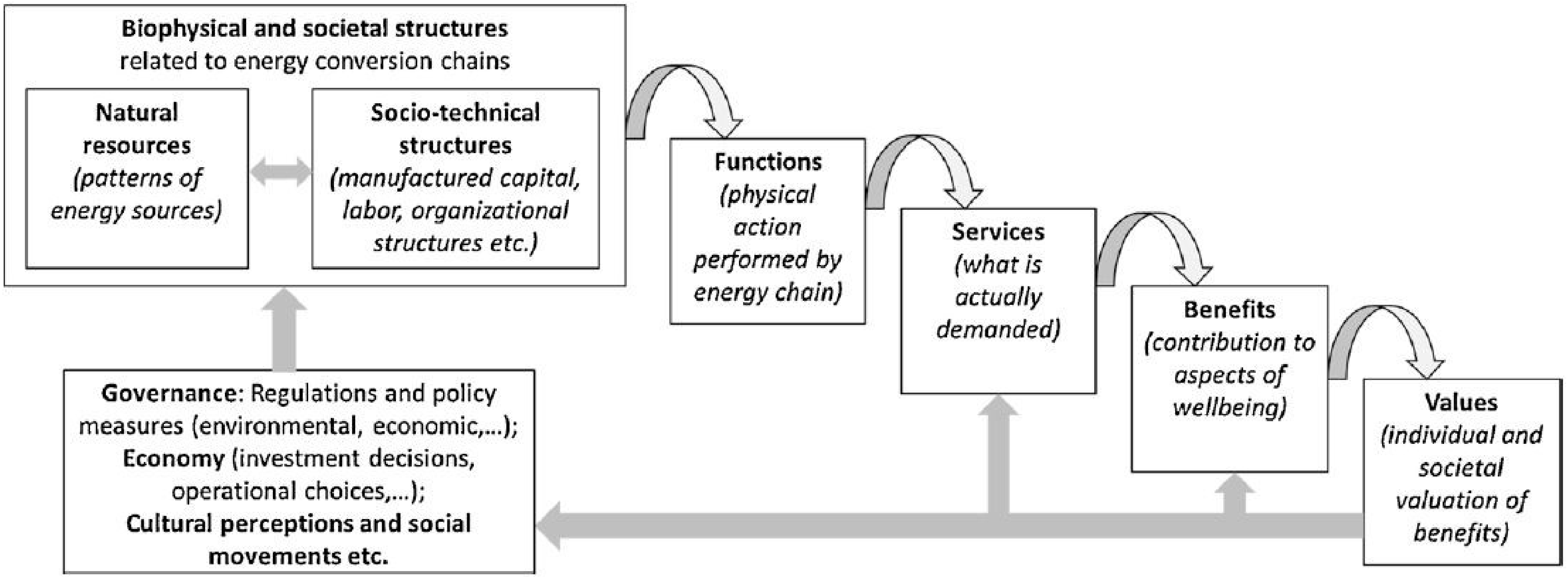

Fig. 1. The 'Energy Service Cascade' (ESC) as adapted and expanded from Haines-Young and Potschin [9,18].

Understanding contributions to social well-being requires more than just counting contributions to GDP

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Kalt *et al.*, 2019. *Energy Research & Social Sciences* **53**, 47-58

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The social embeddedness of the SFS nexus in provisining systems

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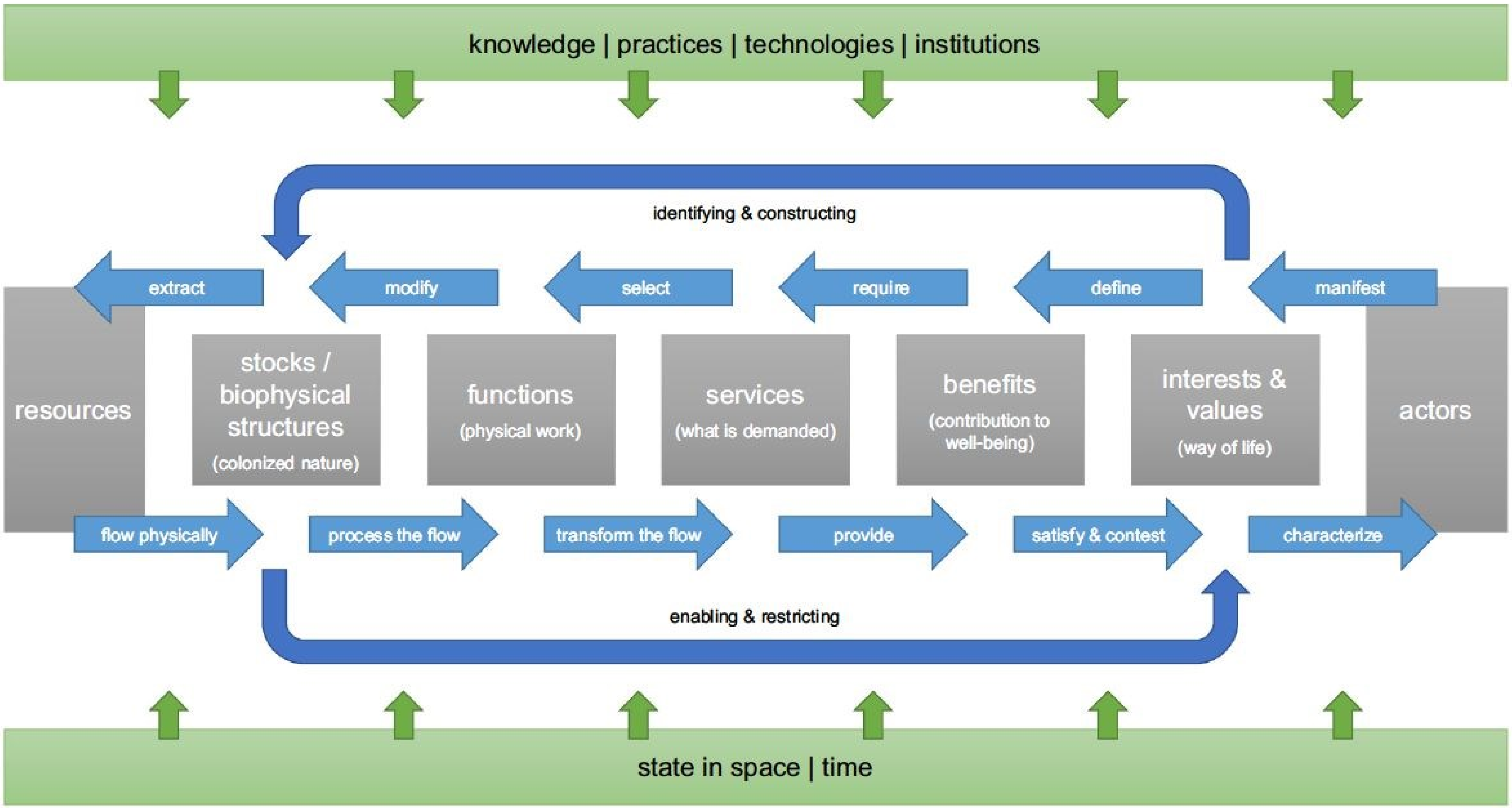

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Plank *et al.* 2021. *Ecol. Econ.*, **187** 107093

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The spiraling constriction of the socio-metabolic corridor

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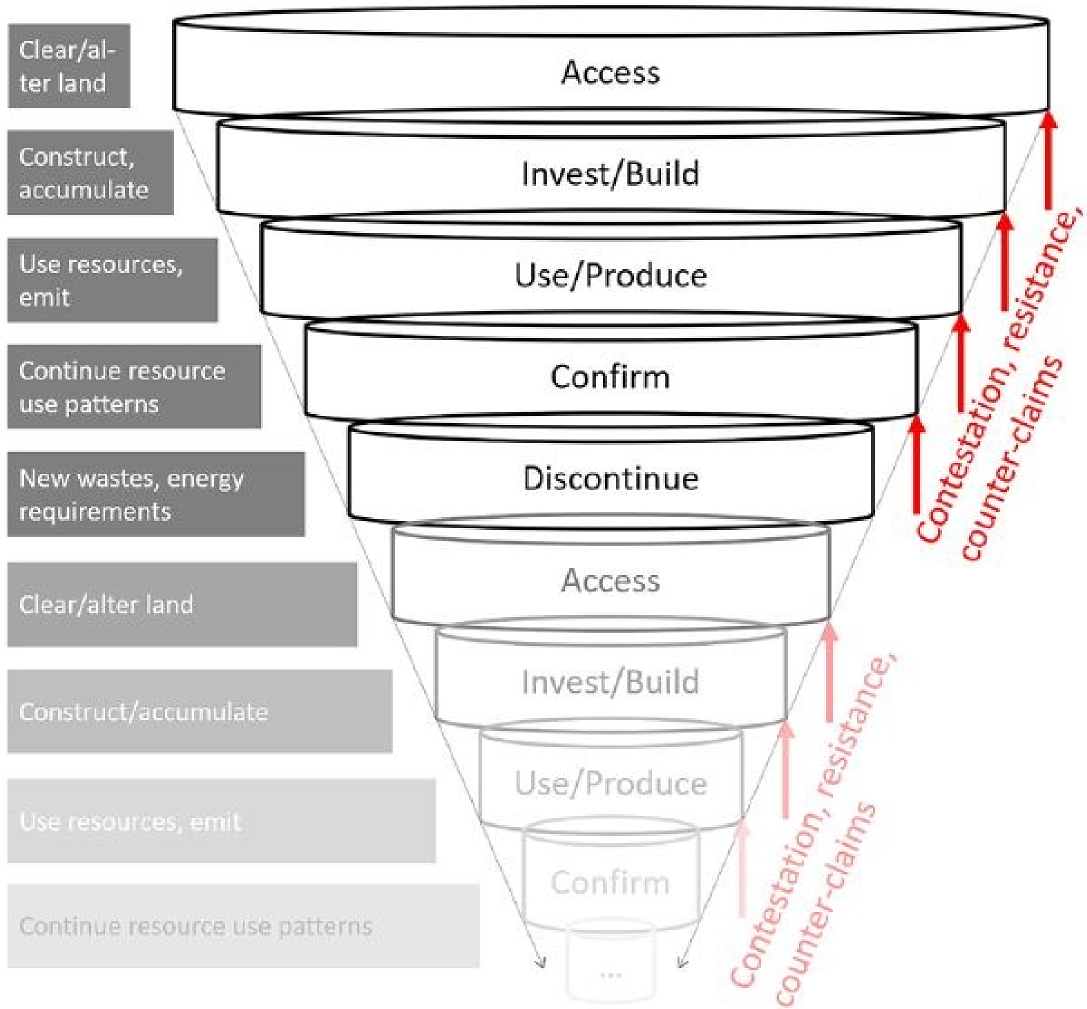

Provisioning systems are built in several steps (access, invest/build, use/produce, confirm, discontinue). Each of this steps creates new fixes that constrict the sociometabolic corridor. How long legacies created in such processes last, depends on the durability of the infrastructures as well as institutions created along the way.

Schaffartzik *et al.* 2021. *Sustainability Science*, doi.org/10.1007/s11625-021-00952-9

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Nexus approaches relating social metabolism to services and practices

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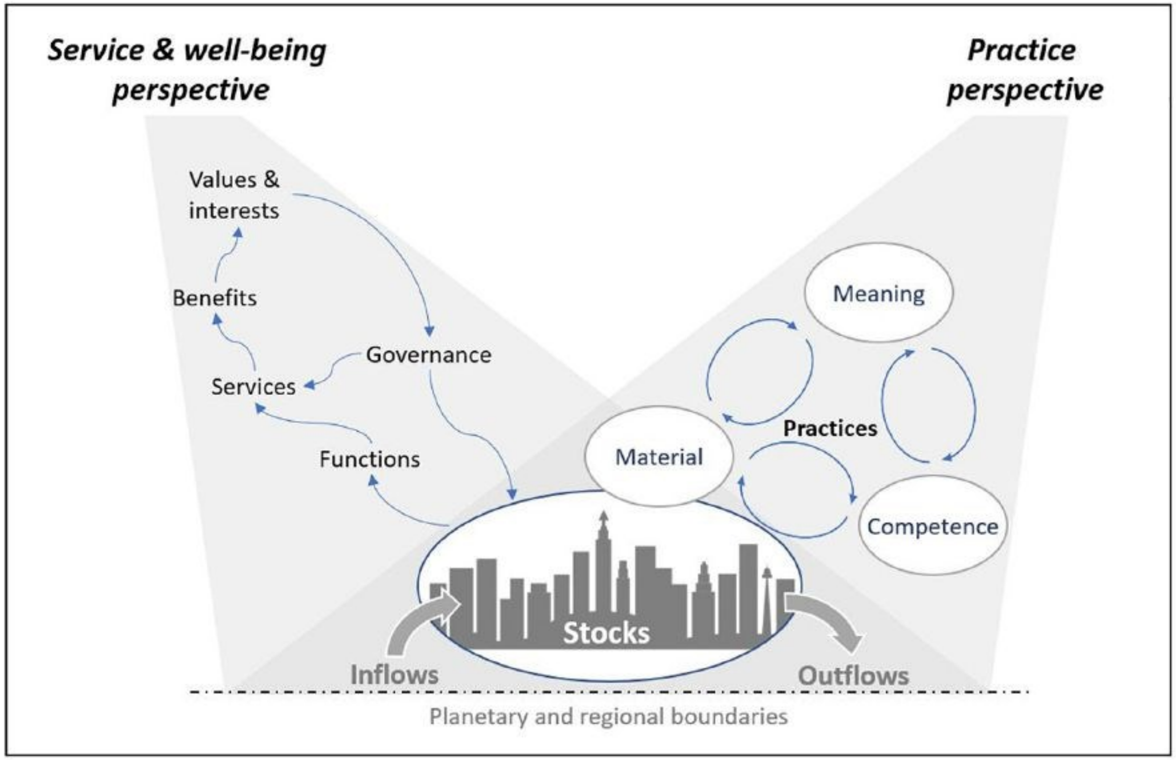
The stock-flow-service nexus: services are derived from specific stock-flow combinations. Purposes of ‚resource use‘ are diverse and potentially conflicting. Broadens concepts of eco-efficiency.

The stock-flow-practice nexus: focuses on the interrelations between the routines of everyday life and stock-flow constellations. Connects theories of practice with social metabolism thinking.

Both nexus approaches provide heuristic models for interdisciplinary sustainability research to analyze the key role of material stock patterns for (un)sustainability.



Haberl, H., M. Schmid, W.Haas, D. Wiedenhofer, H. Rau, V. Winiwarter 2021. *Ecological Economics*, **182**, 106949. https://doi.org/10.1016/j.ecolecon.2021.106949

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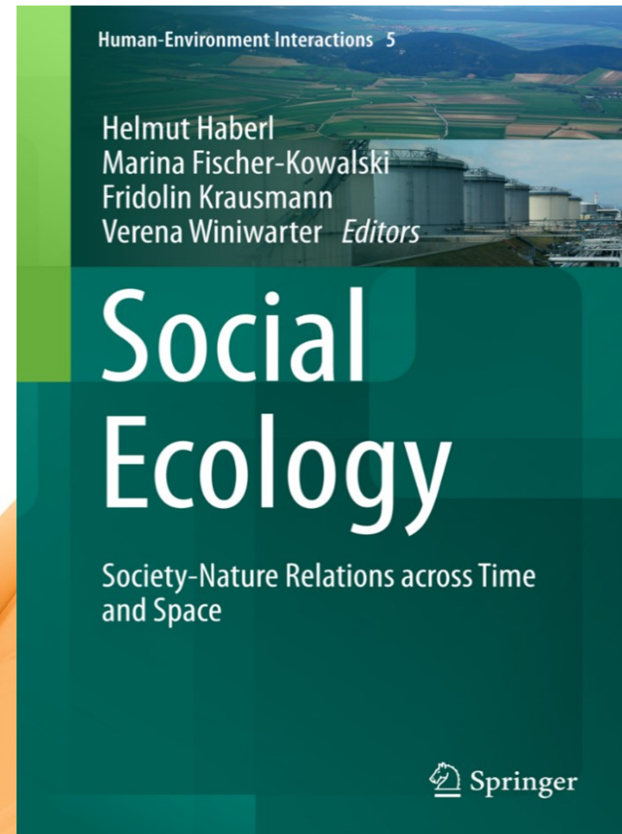
https://www.wiso.boku.ac.at/en/institut-fuer-soziale-oekologie-sec/data-download/



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Conclusions

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- **Construction of buildings and infrastructures** requires a major part of the physical resources used by societies
- The dissipative use of resources (energy!) is shaped largely by the **quantity, quality and spatial patterns of society's material stocks**
- Meeting **ambitious climate targets** will not allow any new long-lived (>8-10 years) structures locking societies into new GHG emissions, plus refurbishing all existing structures to zero-carbon standards in ~30 years
- As long as stocks grow, **full circularity is theoretically impossible**. Even if net additions to stock were zero, full circularity would still be thermodynamically impossible (downcycling & waste can't become zero)
- Alternative development models are needed in which a **good life requires much lower material stocks and resource flows, consistent with the need to reduce GHG emissions to zero** (or below)

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Stock-flow relations in social metabolism

Nine world regions 1900-2015

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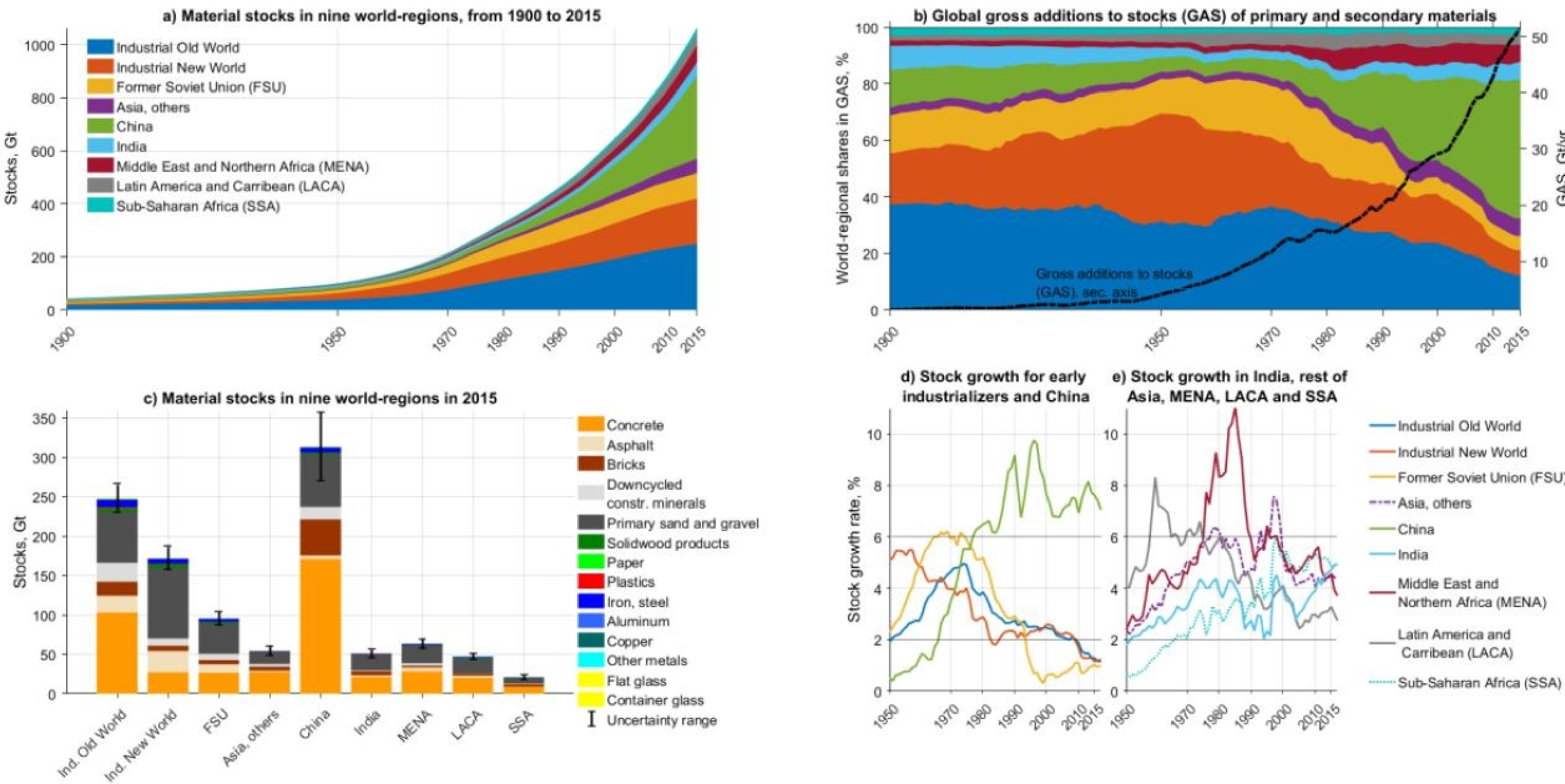

Wiedenhofer *et al.* forthcoming. **Do not cite or distribute!**

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The sustainability triangle

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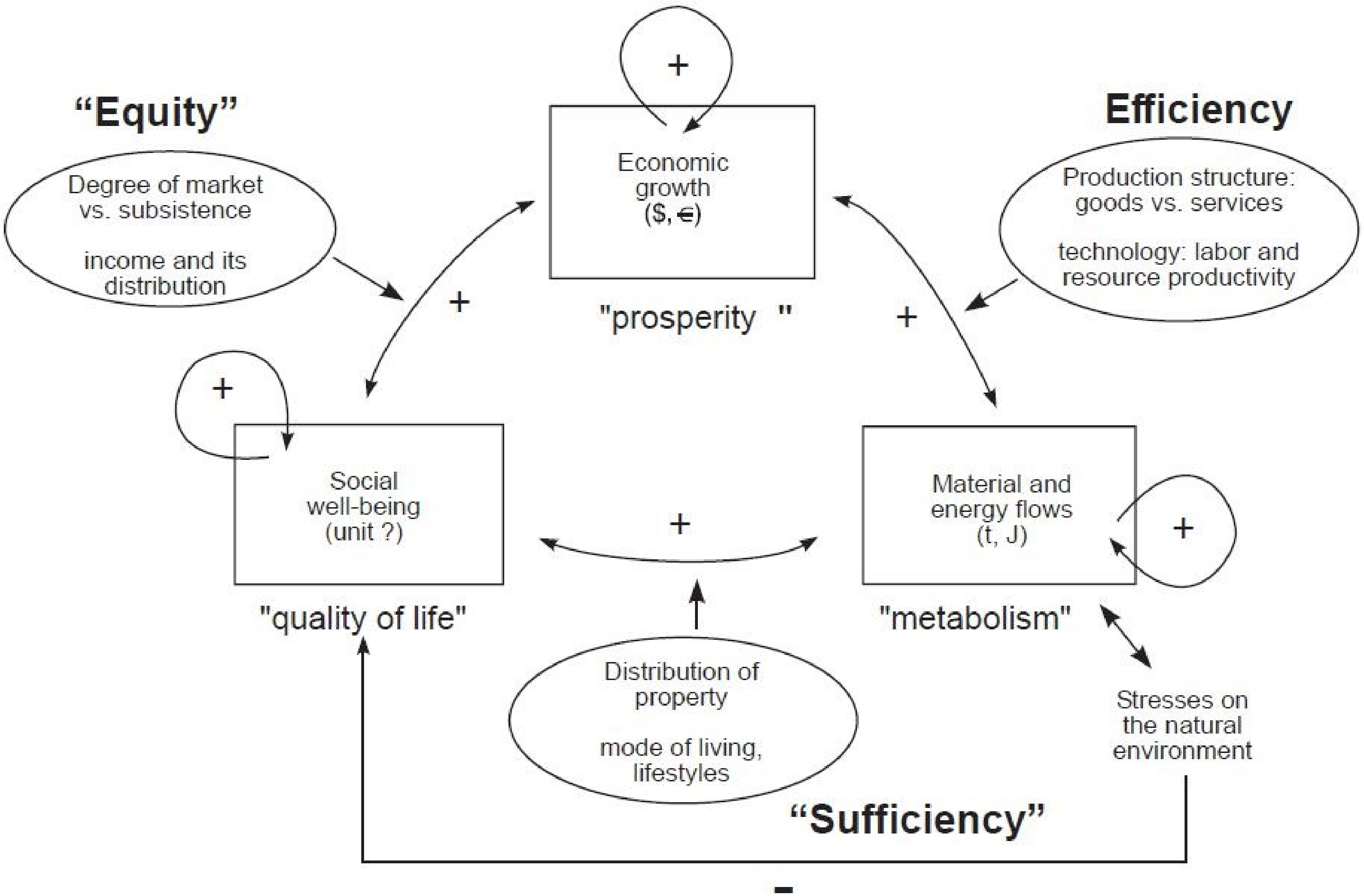

Haberl *et al.*, 2004. *Land Use Policy* **21**, 199-213

The Stock-Flow-Practice nexus

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Practices are routine activities that are embedded in social relations, infrastructu-res, perception and context. Consumption happens as part of practices.

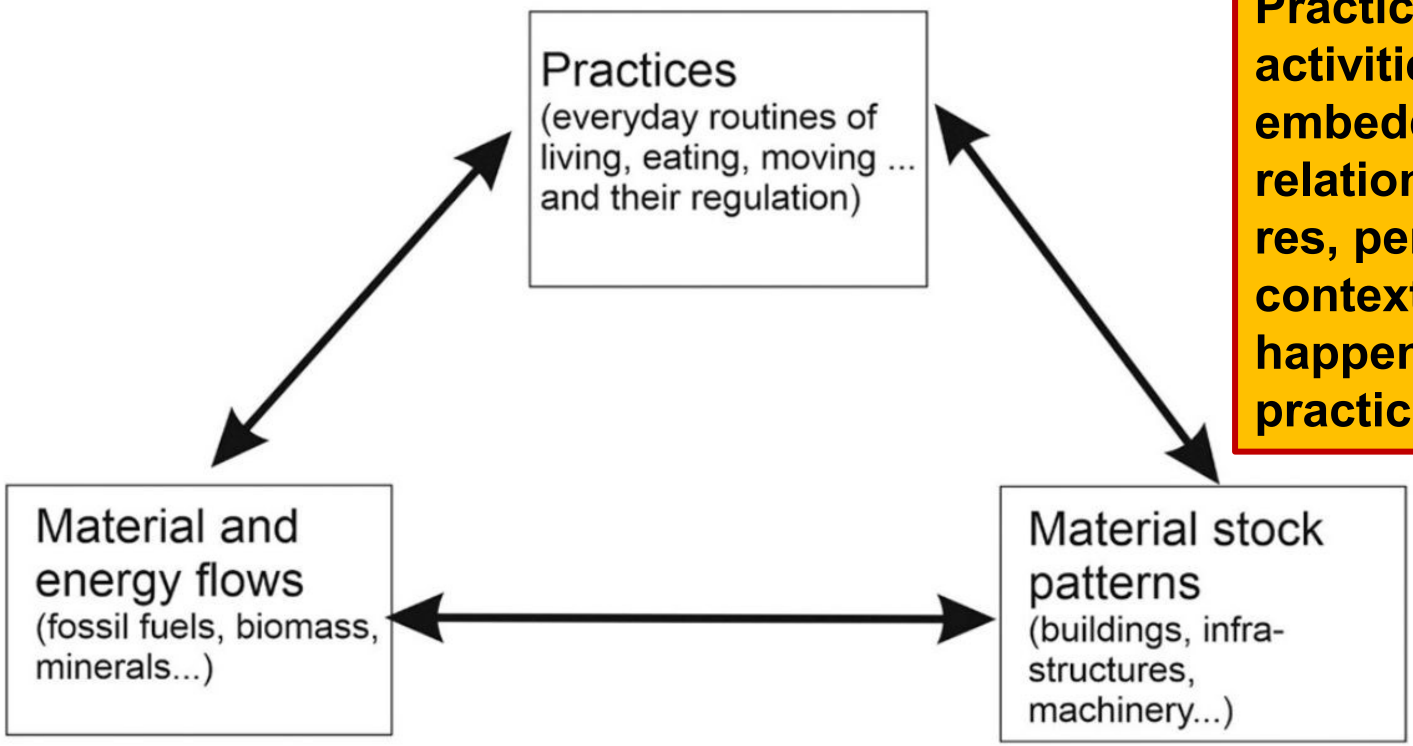

Fig. 1. The Stock-Flow-Practice nexus (SFP nexus). Own graph, based on the SFS nexus graph in Haberl et al. (2017).

Remaining carbon budget in 2050 (1.5°C goal): Decarbonization pathways

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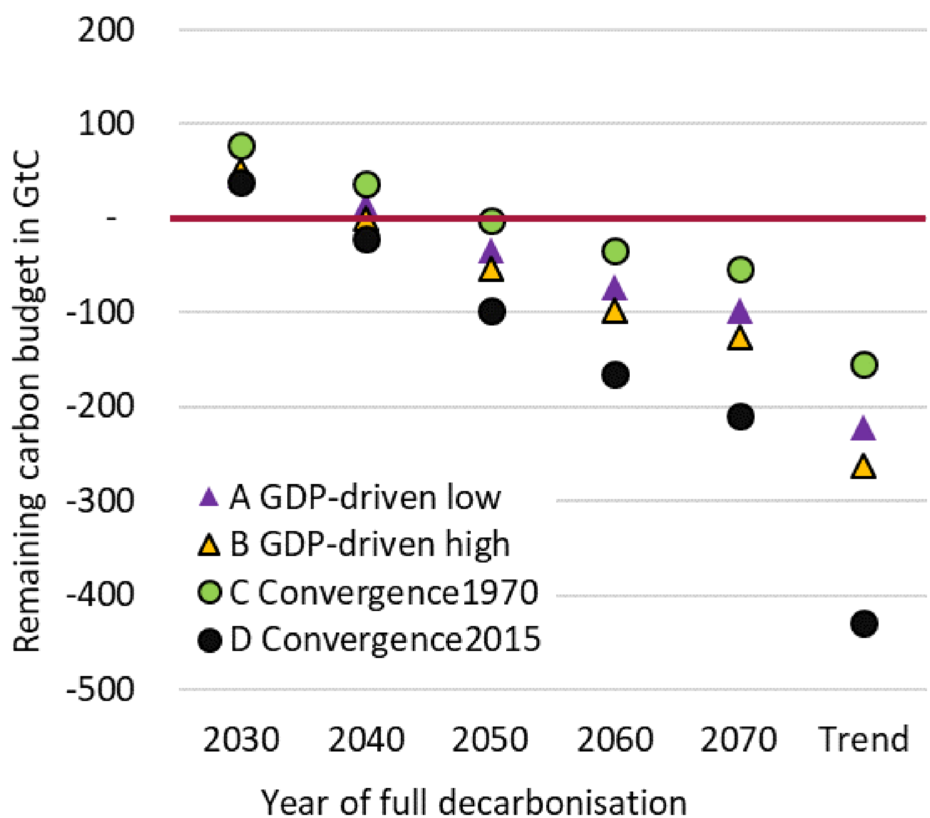

Negative values: Cumulative emissions exceed the available budget of 150 GtC.

Source: Own calculations, C budget from IPCC 2018

Krausmann *et al.*, 2020, *Global Environmental Change*, **61**, 102034

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Future services from stocks
- *many viewpoints*

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- **Continuation of the past *(plus large technol. options)***
  Material stocks and exergy tightly coupled with GDP; reducing resource use will reduce wealth; only nuclear, CCS, BECCS and/or geoengineering available to cope with climate change (many IAM runs)
- **Techno-optimistic „eco-efficiency" view**
  Highly efficient systems allow delivery of simililar service levels with half the final energy and almost zero CO_2; achievable through huge changes in investment patterns (e.g. Grubler *et al.*, 2018, *nature Energy* **3**, 515)
- **Socioecological transformation**
  Services / use values emerge in historically contingent societal processes. Different patterns of material stocks and resource flows co-evolve with socioeconomic institutions and structures

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