Addressing the sustainability science trilemma: Goals, Pathways and Opportunities

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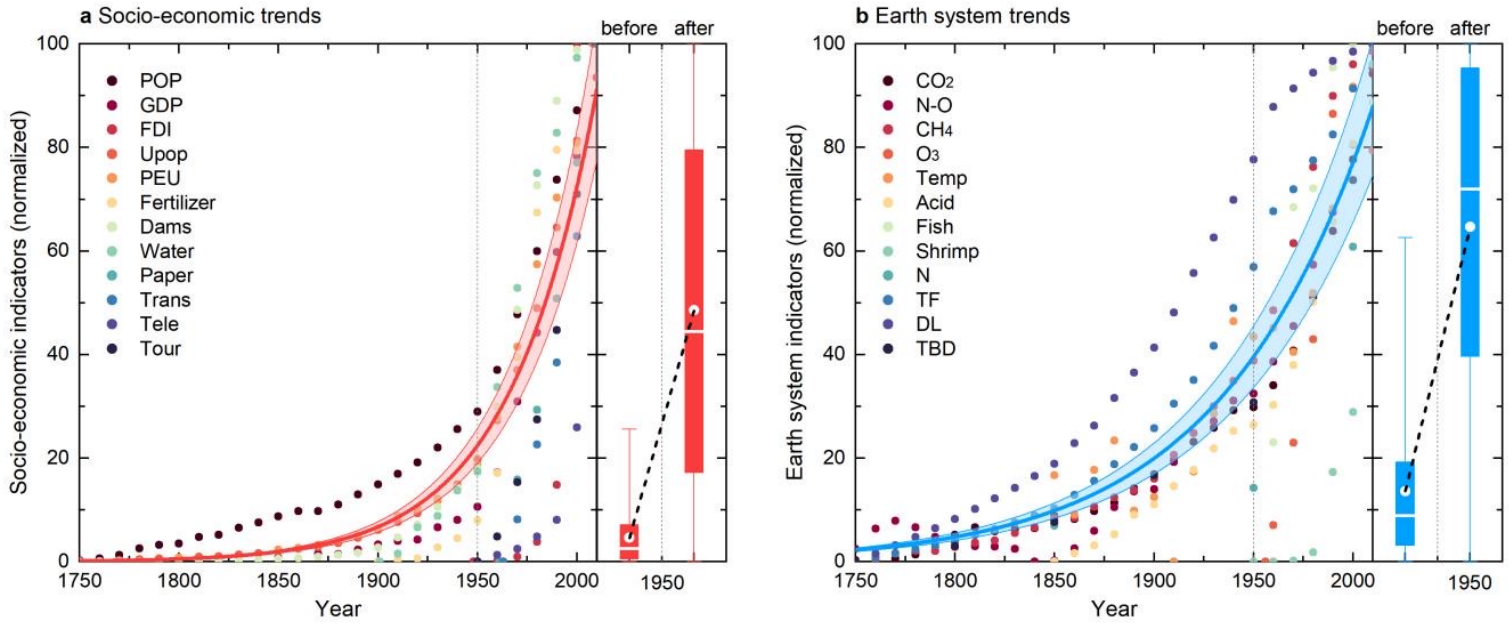
“Transformations and accelerations”

History and growing challenges of sustainable development

	1st Agricultural revolution 第一次农业革命	1st and 2nd Industrialization 第一次和第二次工业革命	Current globalization age (3rd and 4th industrialization) 当前全球化时代 （第三和第四次工业革命）
Historical period 历史时期	10,000 BC and 2000 BC 公元前 10000-2000 年	17th century-1940s 17 世纪-1940 年代	1980s-now 1980 年代到现在
Population 人口数量	Small 小	Rapid growth 快速增长	Population explosion 人口大爆炸
Technological level 技术水平	Domestication of plants and animals 植物和动物的驯养	Steam engine, electricity, machinery, modern transportation 蒸汽机，电力，机器，现代交通	Internet, genes, etc. 因特网，基因技术等
Resource and energy demand 资源和能源需求强度	Low 低	Rapid growth 快速增强	High 高
Resource and energy supply 资源和能源供给能力	High 高	Depleting 降低	Inadequate 不足
Spatial division of labor and global uneven development 劳动地理分工与全球不均衡发展	Incipient specialization and division of labor within “tribes” 生产专业化的初始阶段以及部落内的劳动分工	Colonialism and 1st international division of labor 殖民主义兴起以及第一次世界劳动分工	Integrated global production network; global north vs. global south 整合的全球生产网络，北半球 vs. 南半球

Since 1950, we have entered the “Great Acceleration” period…



- Figure 1 illustrates the 'Great Acceleration' of human activities since the industrial revolution began in 1750, and the resulting alterations to the Earth's systems, including increases in greenhouse gas emissions, ocean acidity, deforestation, and loss of biodiversity
- The majority of the curves follow a similar trend, with a notable shift occurring after 1950. It appears that there was a significant acceleration in 1950.

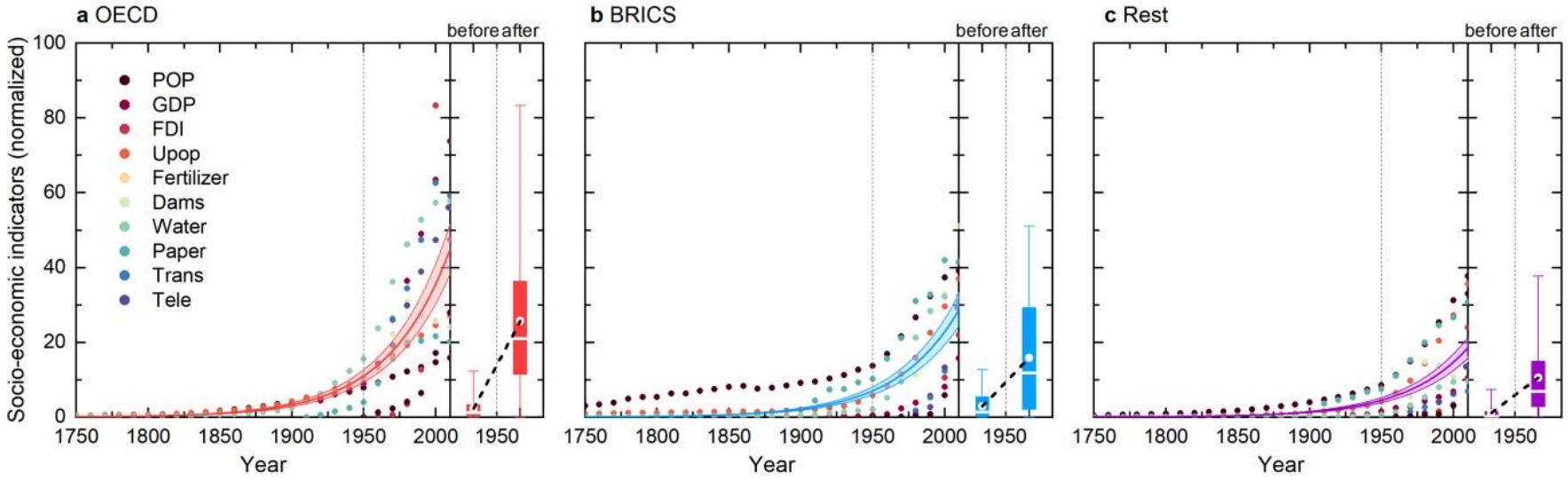
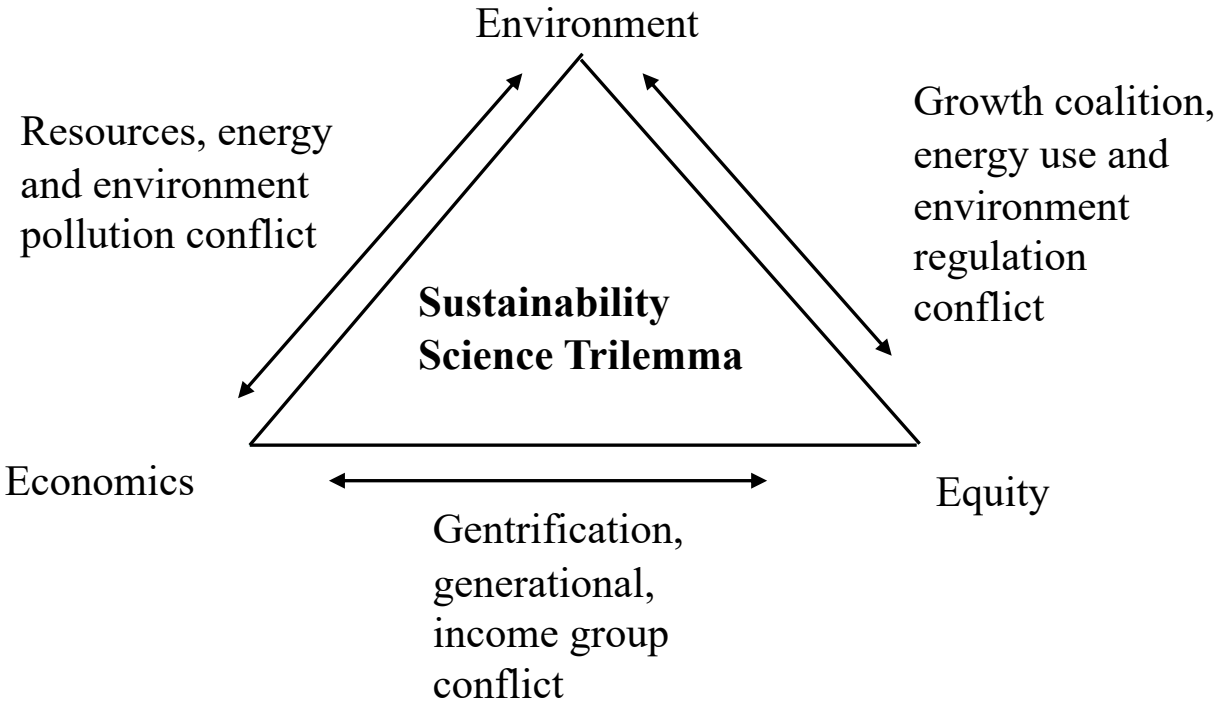


Fig. S1 The Great Acceleration in socio-economic trends from 1970 to 2020 between OECD, BRICS, and the other countries

- The significant alterations to the Earth‘s systems are closely linked to changes occurring within the global socio-economical system; Most importantly, they occur simultaneously.

- The average normalized increment of 24 socio-economic indicators increased by almost 10 and 5 times respectively, after 1950 compared to the period before. This resulted in the division of the global socio-economic system into a 5:3:2 ratio between the OECD, BRICS, and the rest of the countries, as shown in Figure S1

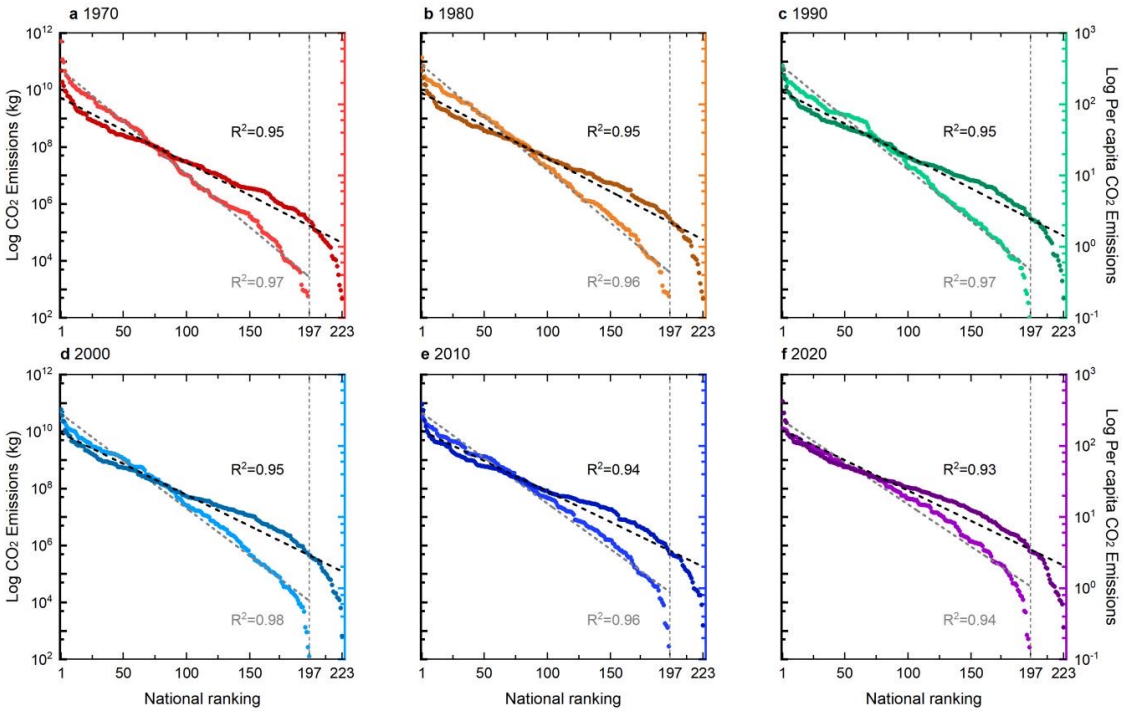
A crossroad: the sustainability science trilemma?



Sustainability Science Trilemma (Zhang X., 2022, developed from Campbell, 1996)

What is common?
the wicked ‘common tragedy’ problem?

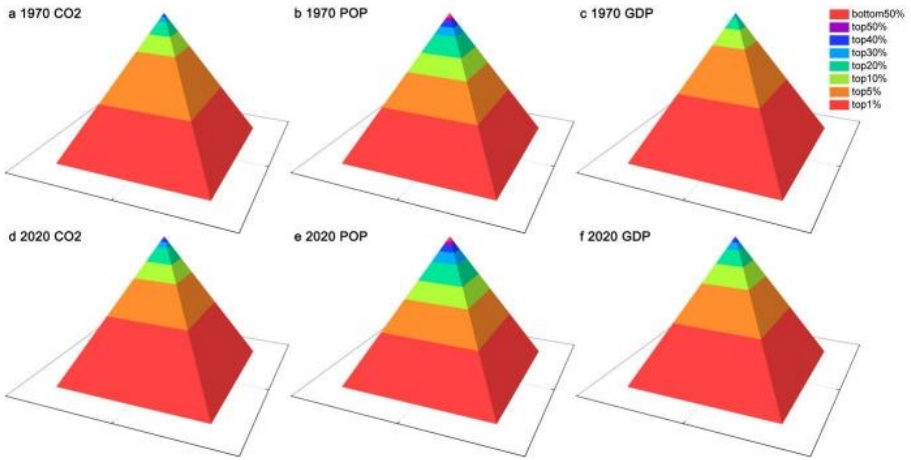
The hierarchy of global carbon dioxide emissions （as a proxy ） at the national level



Ranking of total CO_2 emissions in 223 countries (left axis) and per capita CO_2 emissions (right axis) in 197 countries from 1970 to 2020. Unit：CO_2 kg/yr

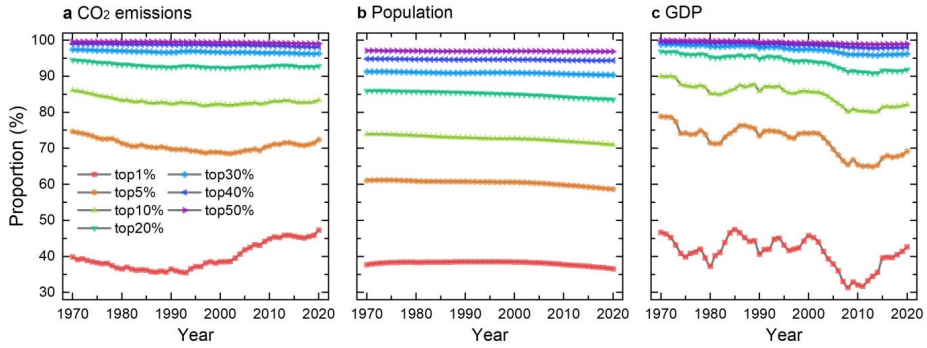
- Nearly 80% of countries globally have achieved the ideal state of Zipf's law between CO_2 emissions and development (Figure 2), and the distribution of CO2 emissions is close to this power-law (R2 between 0.93-0.96).
- The gap in CO_2 emissions between countries has not significantly decreased with the development of global society. The top 5% of countries (11) contribute three-quarters of the global total CO_2 emissions, while the top 40% of countries (89) contribute nearly 99% of the total global CO_2 emissions.

Data source: https://edgar.jrc.ec.europa.eu/report_2022#data_download

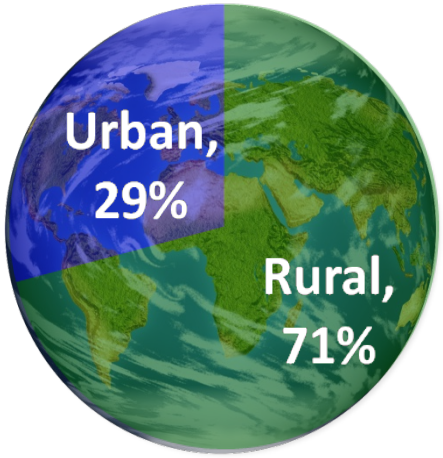


- Throughout history, the gap in total CO_2 emissions between countries with different income levels has been increasing.
- The difference between high- and low-income countries has grown wider, while the gap between high- and middle-income countries (including upper-middle and lower-middle income countries) is narrowing.

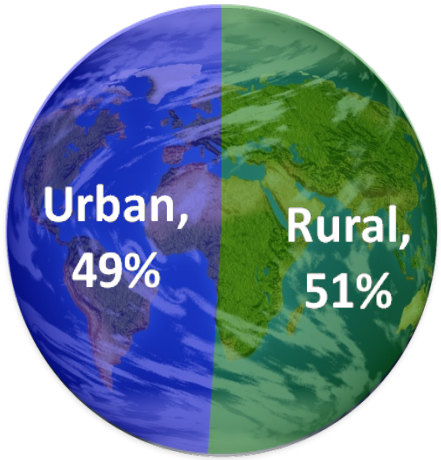
- Between 1970-2020, the total CO_2 emissions of the top 10% of high-income countries decreased to only 0.9 times of their original amount, while the total carbon emissions of the top 10% of upper-middle, lower-middle, and low-income countries increased to 4.6, 3.9, and 5.2 times of their original amounts, respectively.



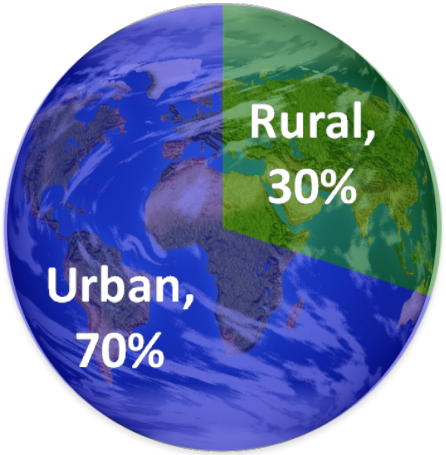
Urban and Rural Population



1950



2007

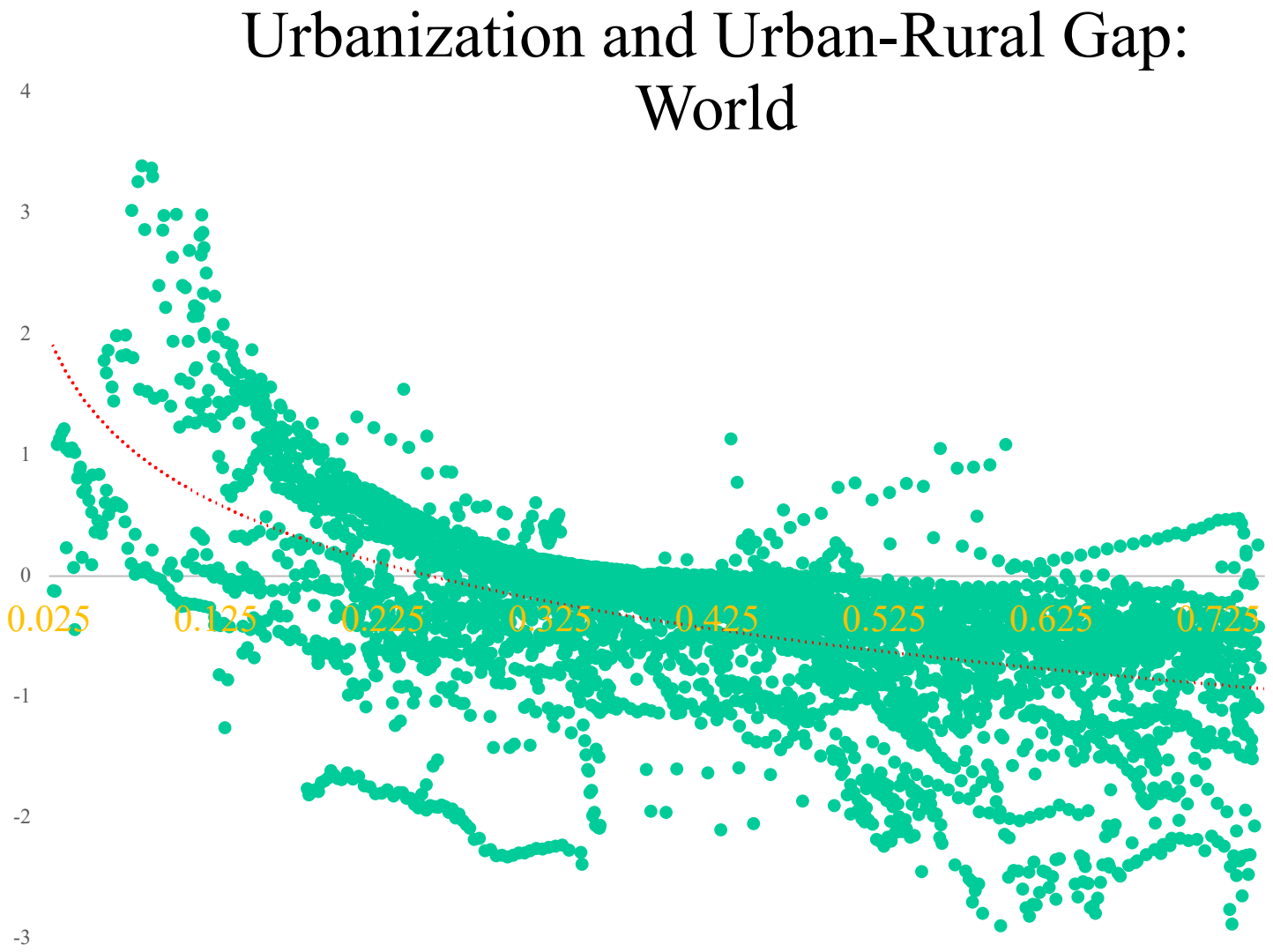


2050

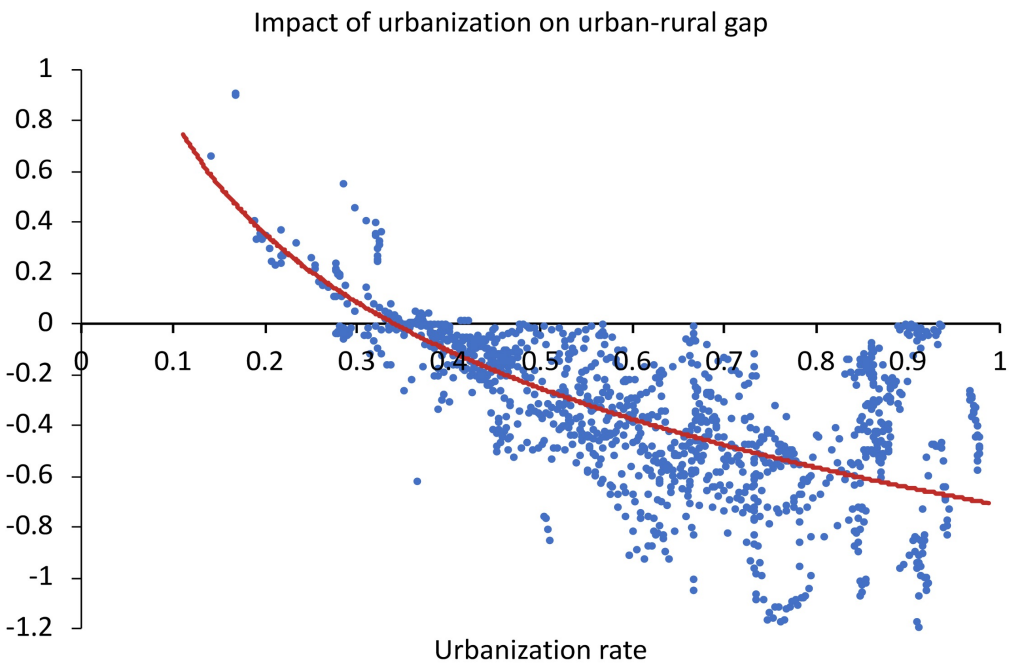
(United Nations Department of Economic and Social Affairs/Population Division, 2007)

50%

One way out: urbanization?



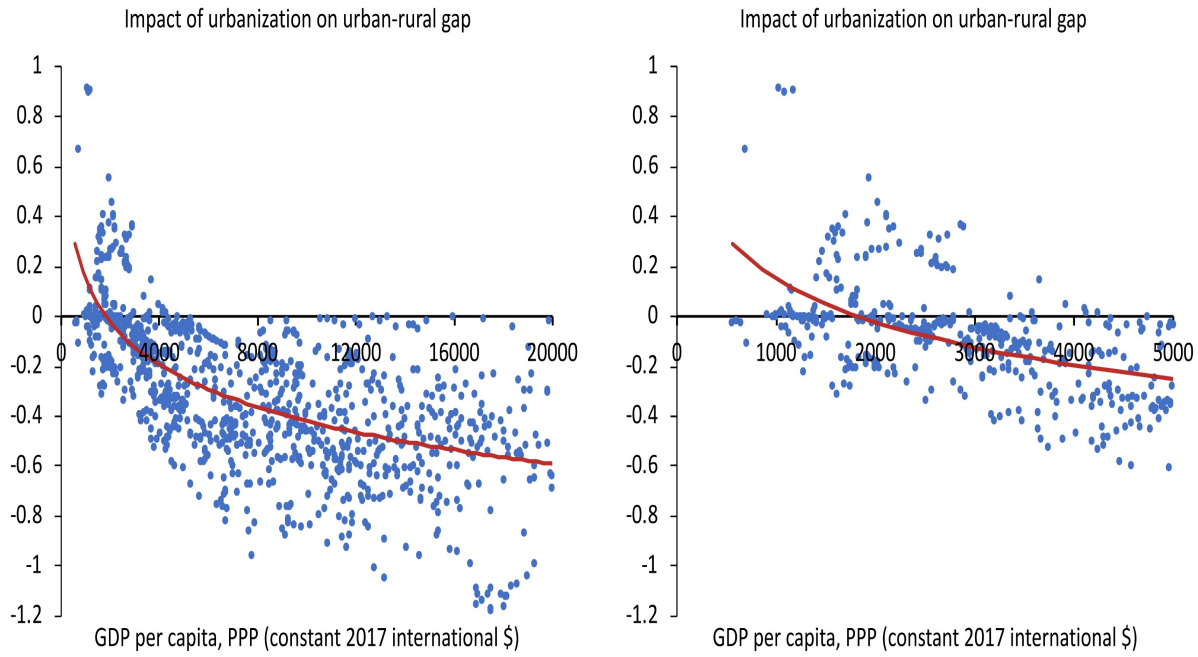
Impact of urbanization on the urban-rural gap



Urbanization rate and impact of urbanization on the urban-rural gap

- Most of the early immigrants are rich and better educated. Therefore, when they migrate, the average income in rural areas will decline in the short term;
- **When urbanization reaches a certain level (about 30%), the ratio is about 40% for African countries,** low educated and relatively poor rural residents start to migrate, which helps to reduce the gap between urban and rural areas;
- In the data sample of 90 economies, 81 economies exceeded the threshold of 30% urbanization rate by 2017;
- Developing countries can adopt urbanization as a strategy to curb income inequality

Impact of global urbanization on urban-rural gap (GDP per capita)



GDP per capita and the impact of urbanization on the urban-rural gap

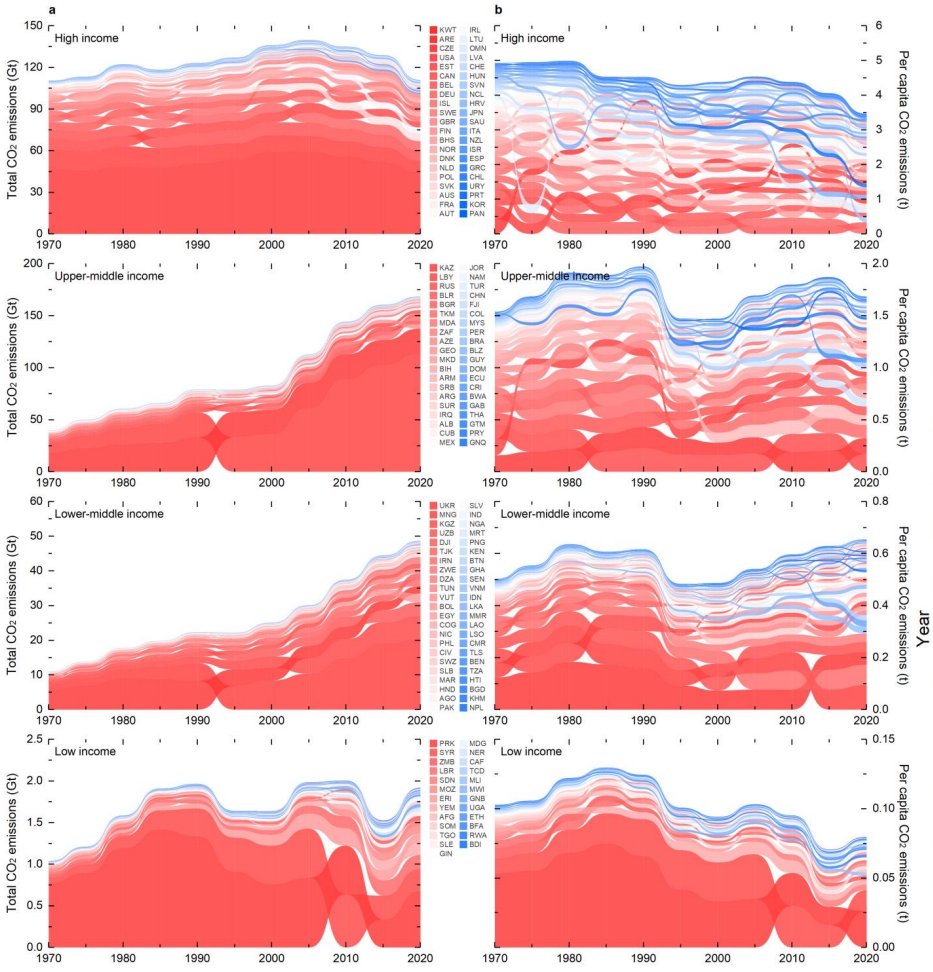
- When the per capita GDP reaches US $2000, urbanization helps to reduce inequality within the country by narrowing the urban-rural gap;
- In 2017, 78 of the 90 economies in the sample had a GDP per capita greater than US $2000;
- For the vast majority of countries in the world, promoting urbanization can help narrow urban-rural gap and inequality within countries

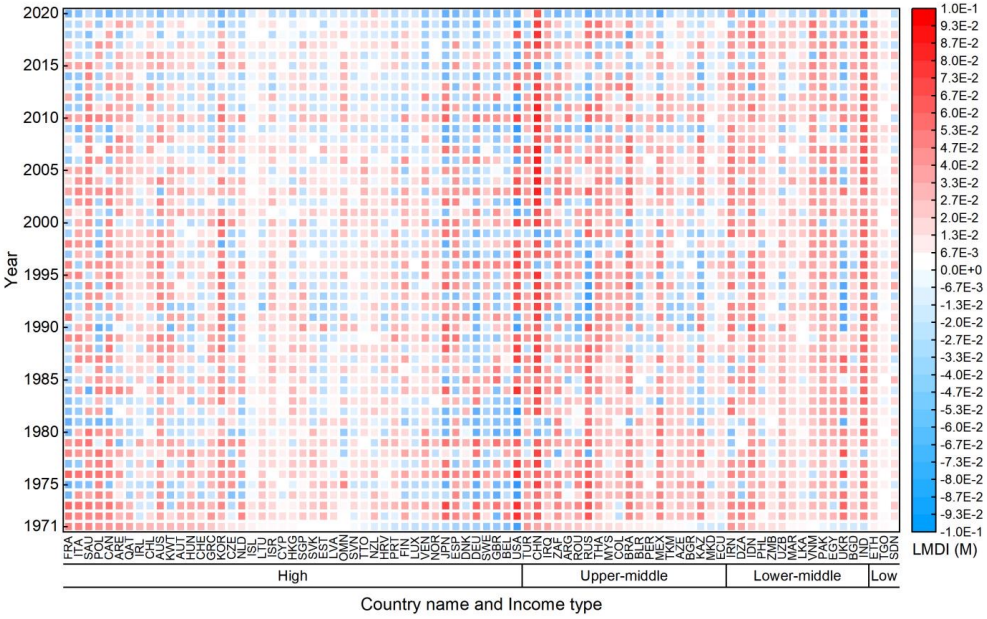
Sustainability Science Trilemma: externalities of development across scale?

Scale: spatial-temporal

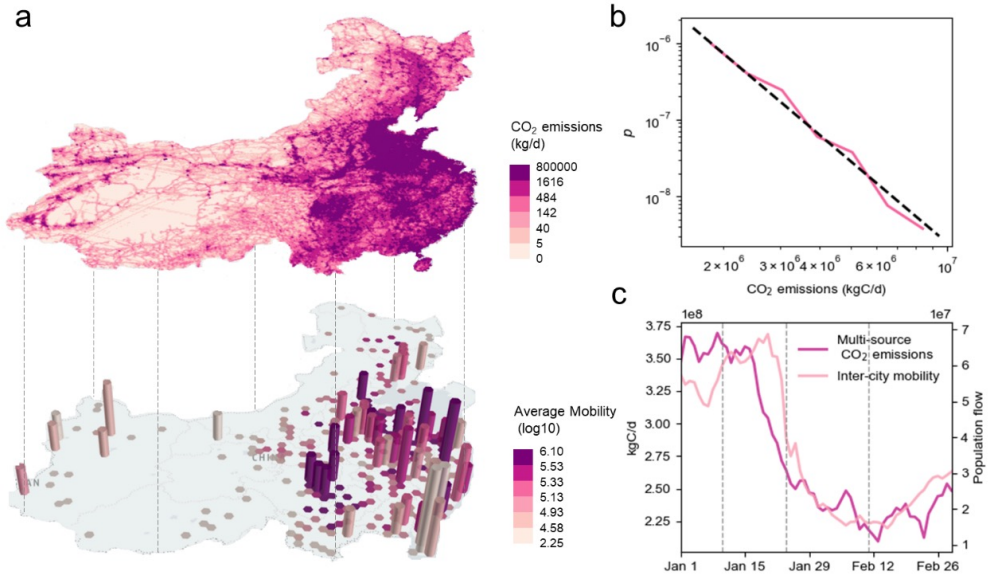
National scale:

- ‘Inverted U-curve**:**the United States and Europe
- ‘J-curve’, the CO_2 emissions accounts from China and India
- ‘S-curve’ :Central Africa and other low-income countries
- Upper-middle (‘M-curve’) and lower-middle income countries (‘Z-curve’)

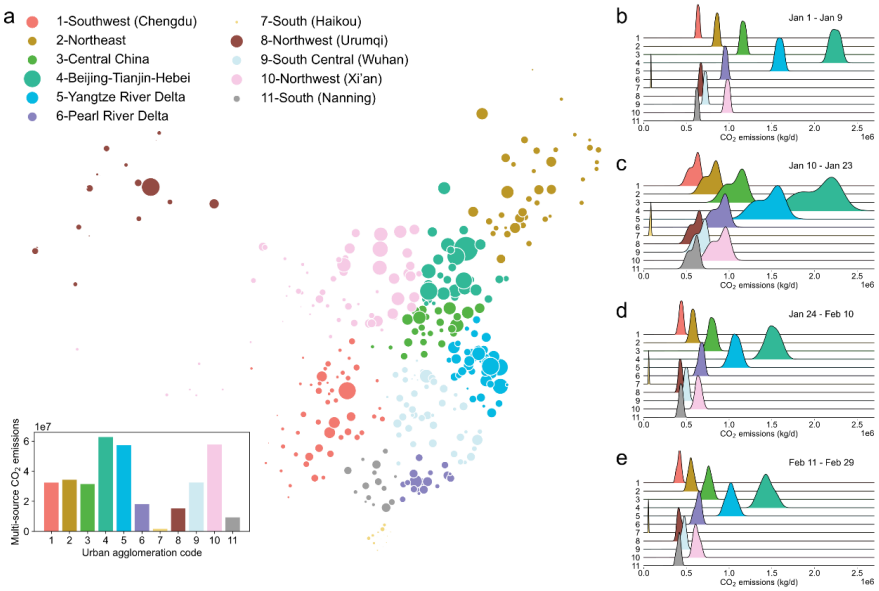




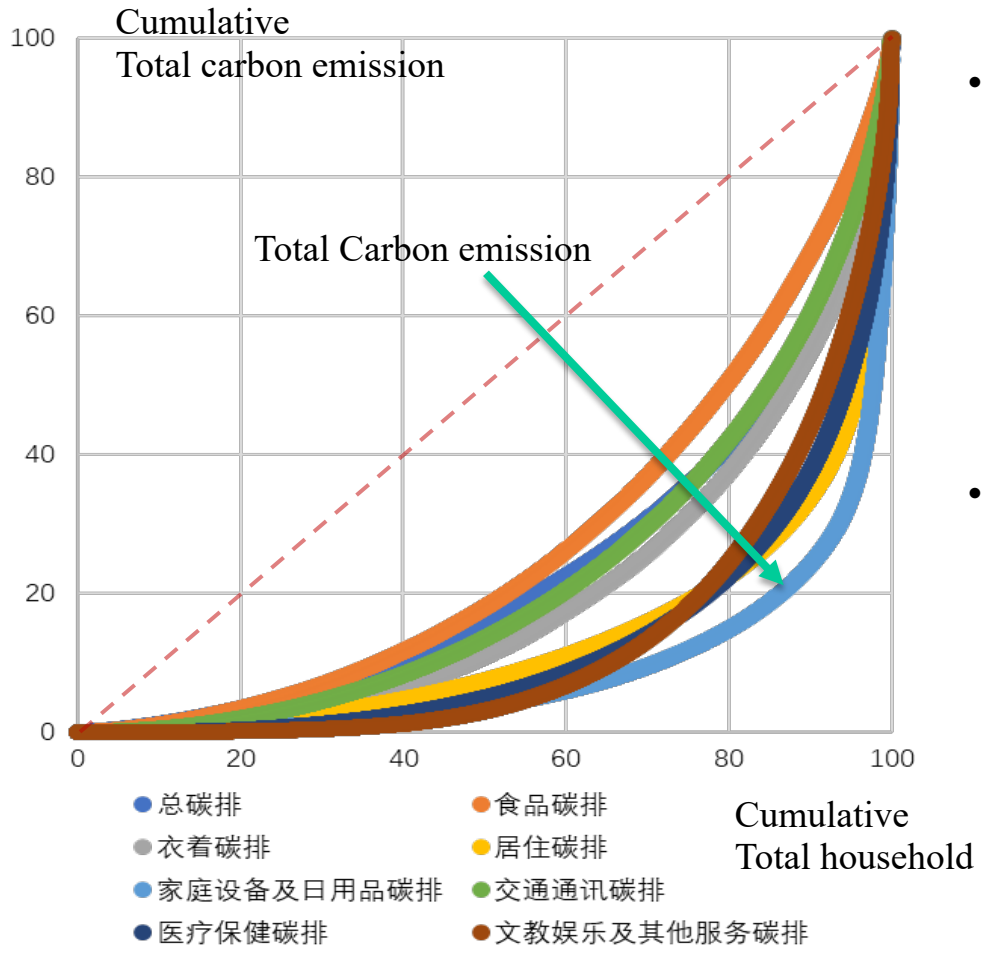
City scale:



- Spatial-temporal synchronization between population mobility and multi-source CO_2 emissions;
- Spatial structure affects CO_2 emissions;
- urban agglomerations can be re-delineated through human mobility driven CO_2 emissions



- **Household scale: CO_2 emission and inequality of household consumption in China**



- Half of all households that produce the least amount of total CO2 emissions are responsible for only 16% of the total carbon emissions. In stark contrast, the 5% of households with the highest carbon emissions are responsible for 30% of the total CO2 emissions.
- When classified by household net income, the top 10% of households generate 23% of consumption-based CO2 emissions. Interestingly, this is nearly equivalent to the share of consumption-based CO2 emissions generated by the bottom 40% of households.

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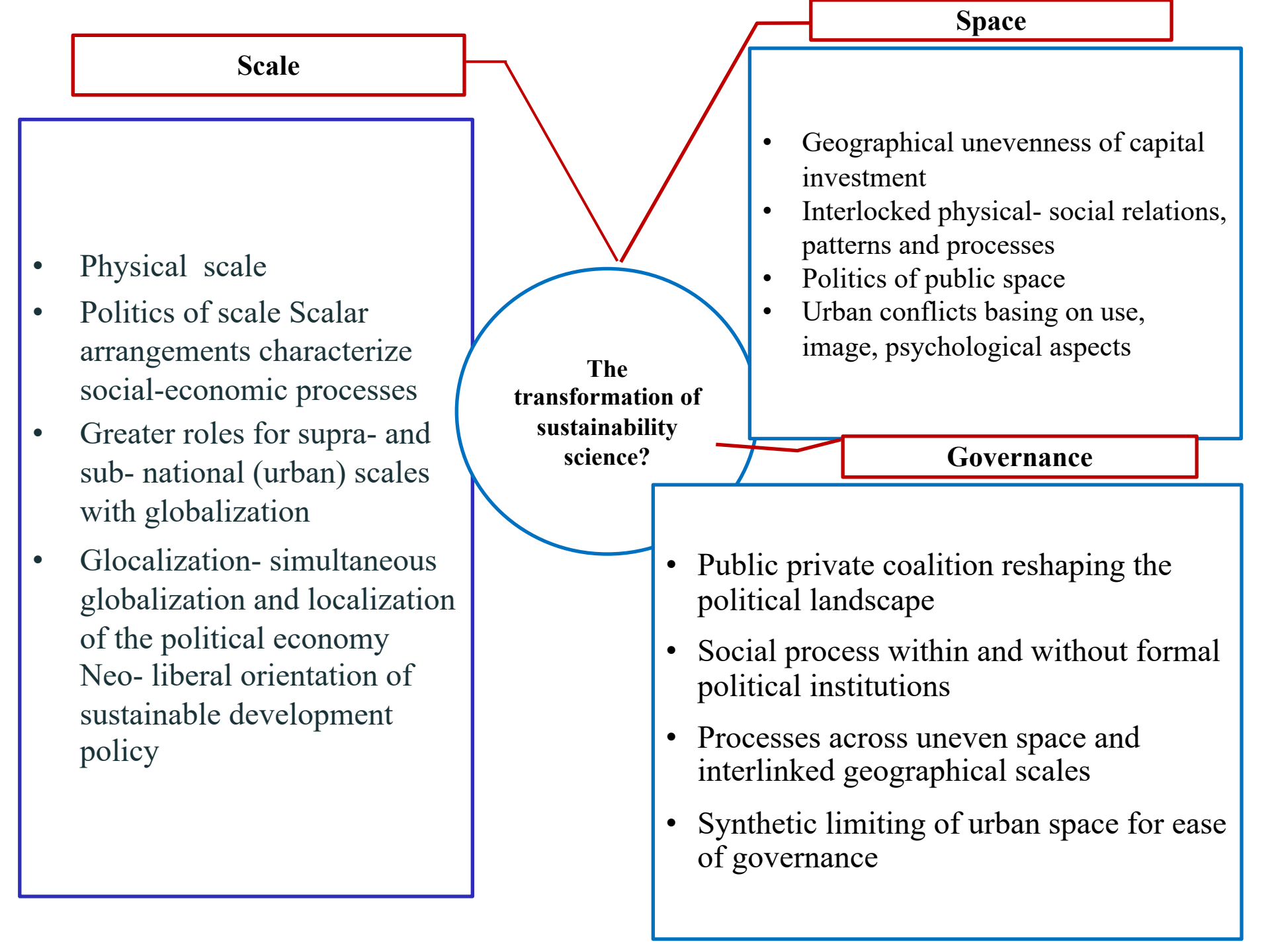
… Review & Rethinking?…

Sustainability Science: the way out?

	Classical Marxism	Neoliberalism	Polanyianism	Actor-Network Theory
Causes for change	Crisis-laden capitalist accumulation	Market competition + individual choice	"Double movements"	Associations of heterogeneous Elements
Epistemology	Historical, dialectical materialism	Methodological individualism; Praxeology	Substantivism; interactivism	Post-structuralism; post-modernism; material-semiotic; constructivist
Ideal vision for society	Communism	Marketization, deregulation, privatization	Freedom in the complex society and limited market	Political agenda is sidelined
Social-nature relations	Nature is appropriated, commodified, and thingified by capitalism	The neoliberalization of nature; market forces override ecology	Human-nature interactions, human adaptation to natural environments	The constitutive role of non-humans in the fabric of social life, and distributed agency of human and non-human actants
Problems with global south countries' Sustainable development	Accumulation crisis; excessive productive capacity; imbalance in economy; waning development momentum	State-dominance and social exclusion	Over & under marketization	Perceptive dichotomy （isolated development）
Opportunities for global south countries' Sustainable development	State capitalism; developmental state	Marketization, decentralization	Regulated marketization	A rising mentality of harmonious development and "common destiny": carbon neutral goal, SDGs?


Scale
Space
Governance
The transformation of sustainability science?
• Physical scale
• Politics of scale Scalar arrangements characterize social-economic processes
• Greater roles for supra- and sub- national (urban) scales with globalization
• Glocalization- simultaneous globalization and localization of the political economy Neo- liberal orientation of sustainable development policy
• Geographical unevenness of capital investment
• Interlocked physical- social relations, patterns and processes
• Politics of public space
• Urban conflicts basing on use, image, psychological aspects
• Public private coalition reshaping the political landscape
• Social process within and without formal political institutions
• Processes across uneven space and interlinked geographical scales
• Synthetic limiting of urban space for ease of governance

The Sustainability Science Trilemma

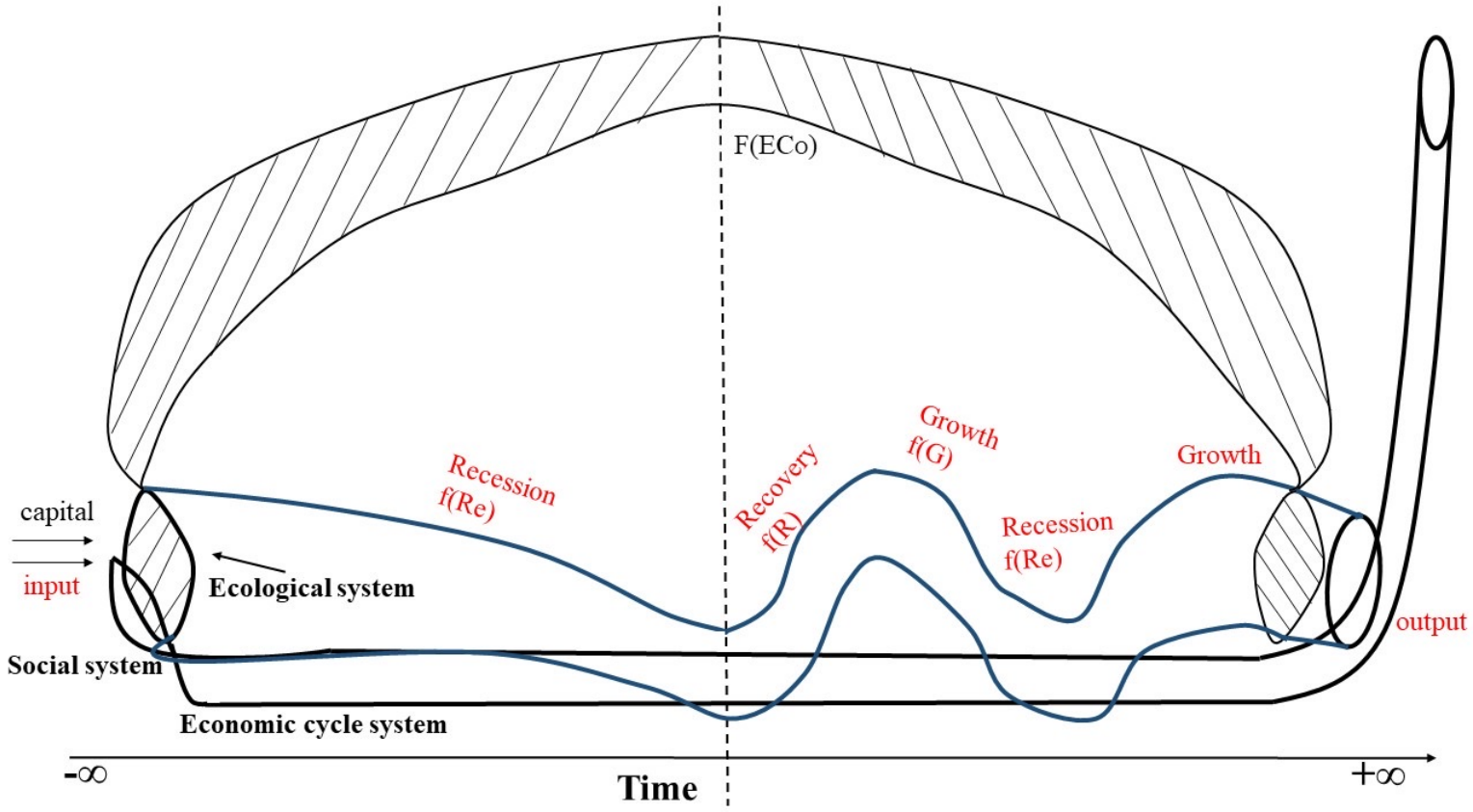
- Sustainability should be conceived as dynamic, relational and multi-dimensional, encompassing all four of social, economic, ecological and governance spheres, and across scales, on which sustainability takes on variegated forms (Kearns and Turok, 2004). We need to dissolve the distinctions and trade offs among *eco-centric, anthropocentric* and complex ecosystem network approaches towards sustainability.
- The global rapid urbanization process has led to the rising disputes around socio-economic-ecological sustainability that are perceived as the interplay and confrontation of ***five*** groups of actants ***across scales***, as embodied in particular projects, cities, industries, nations or events. These include state, capital, actors, time and nature.
- The objective is to grasp the complexity, interactions of dynamics crystalized in the struggles of the five groups of forces, and identify how it gives rise to a new, uneven pattern and pathways towards sustainability in the global south countries. In order to construct the theoretical framework, the below questions need to be answered:

➢ *Resource and energy security: how to ensure reliable resources and energy supply?*

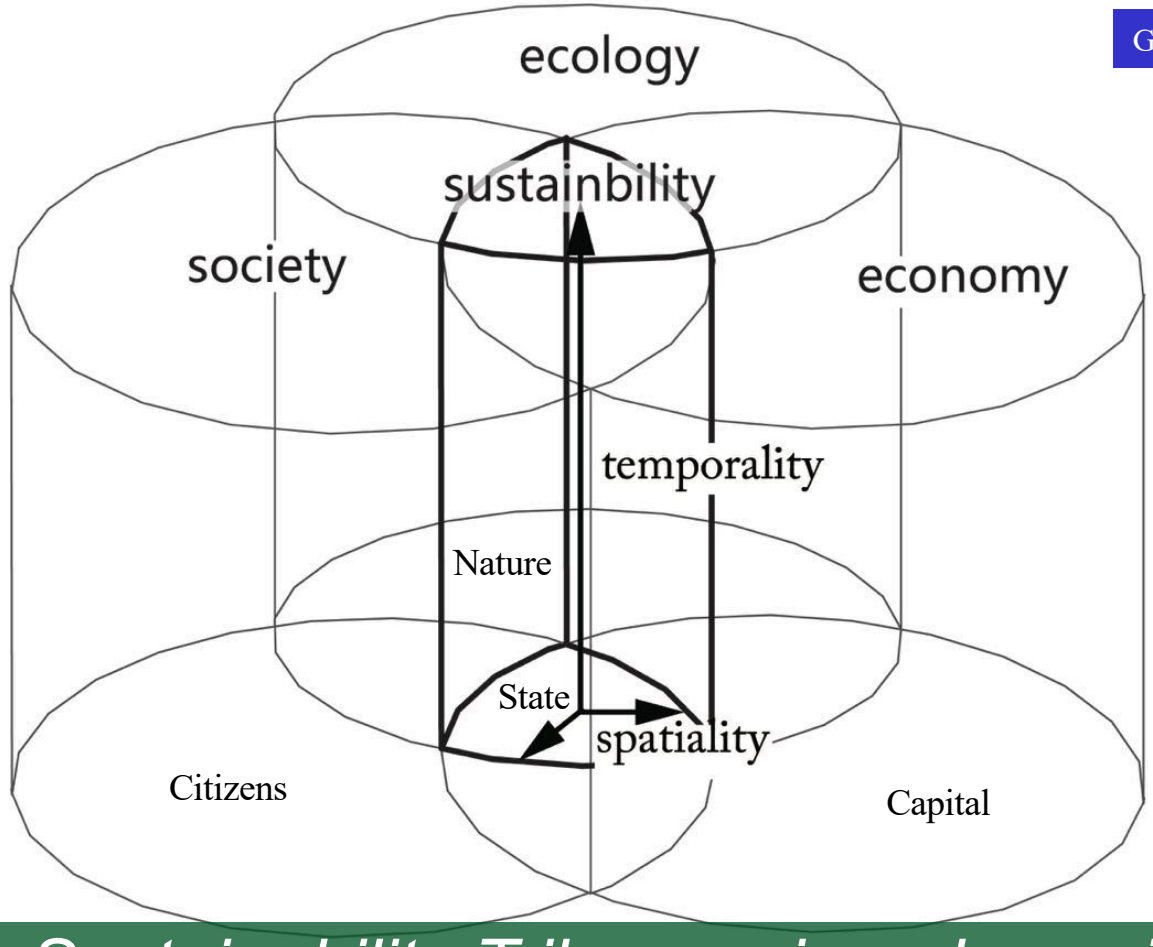
➢ *Resource and energy equity: how to ensure equitable and affordable resources and energy to different income groups across global and local scales?*

➢ *Environmental externalities: how to prevent negative environmental impact or reduce environmental damage through market, policy and social solutions?*

➢ *Governance: how to strive for an optimal 'trade off' pathway by considering diversifying and targeting coping governance strategies that can address the Sustainability Trilemma in the post carbon era?*


F(ECo)
Recession
f(Re)
Recovery
f(R)
Growth
f(G)
Recession
f(Re)
Growth
capital
input
Ecological system
Social system
Economic cycle system
output
-∞
Time
+∞

Governance?



Defining *the Sustainability Trilemma in a dynamic view…*

Resources governance

Three mechanisms of resource governance and transformation

		Market-drive	Government-led	Social network
Transaction Fees	Asset specificity	0	++	+
	Uncertainty	++	0	+
	Transaction Frequency	++	0	+
Tools	Incentive intensity	++	0	+
	Administrative control	0	++	+
Performance	Administrative control	++	0	+
	Cooperative adaptation	0	++	+
Contract law system		+++	0	+
Degree of flexibility		+++	+	++
Operational logic		Price mechanism	Command authority	Social Relations
Conflict Resolution		Bargaining	Administrative authority	Reciprocal Norms
Membership		Free choice	Section distribution	Constructing Nature of power identity
Membership		Decentralized	Top-down	Bottom-up

Table 1: Three mechanisms on governance and transformation

0: weak
+:strong
++ :stronger
++++ : strongest

THANKS!