ENV-610: Ecological Economics

Decoupling, IPAT and Kaya, green growth or degrowth, sufficiency and quality of life

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Short bio: Gino Baudry

2007-2008: Bachelor in Economics (IEMN-IAE, University of Nantes)

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2009-2010: Master 2 in Energy Economics (Polytechnique chair: CEA, IFP - Paris)

2010-2012: Political Advisor (Agence Région Pays de la Loire - Nantes)

2012-2016: PhD in Economics (LEMNA, GEPEA, University of Nantes)

2016-2017: Post-Doc (MOBI, VUB - Brussels)

2017-2019: Research associate (CEP, Imperial College London)

2019-2022: Research fellow (CEP, ICL)

Since Feb. 2022: Scientific collaborator (LEURE, EPFL)

Plan

Introduction & Definitions

Ecological footprint

Environmental Kuznets curve

IPAT formula

Kaya identity

Energy dependency

Limits to efficiency

Beyond the GDP indicator

Some reading suggestions

INTRODUCTION

What is decoupling ?

Gross Domestic Product (GDP)

- Origin: The recent GDP concept was developed by the American economist Simon Kuznets in 1934.
- Definition: GDP measures the monetary value of final goods and services produced in a given country in a given period of time.

- Formula:

$$Y = C + I + G + (X – M)$$

$$\text{with } Y\,(C^+, I^+, G^+, X^+, M^-)$$

With

Y: GDP

C: consumption

I: investment

G: public spending

X: export

I:import

Economic growth

- Definition: The current economic model is based on the **transformation of raw natural resources** and generating added value through the resulting trade in goods and services. The sum of these added values is known as GDP, its yearly growth is known as economic growth.

- Formula: $$\Delta Y = (Y_t - Y_{t-1}) / Y_{t-1}$$

With

ΔY: Economic growth

Y_t: Economic growt at time t

Y_{t-1}: Economic growt at time t-1

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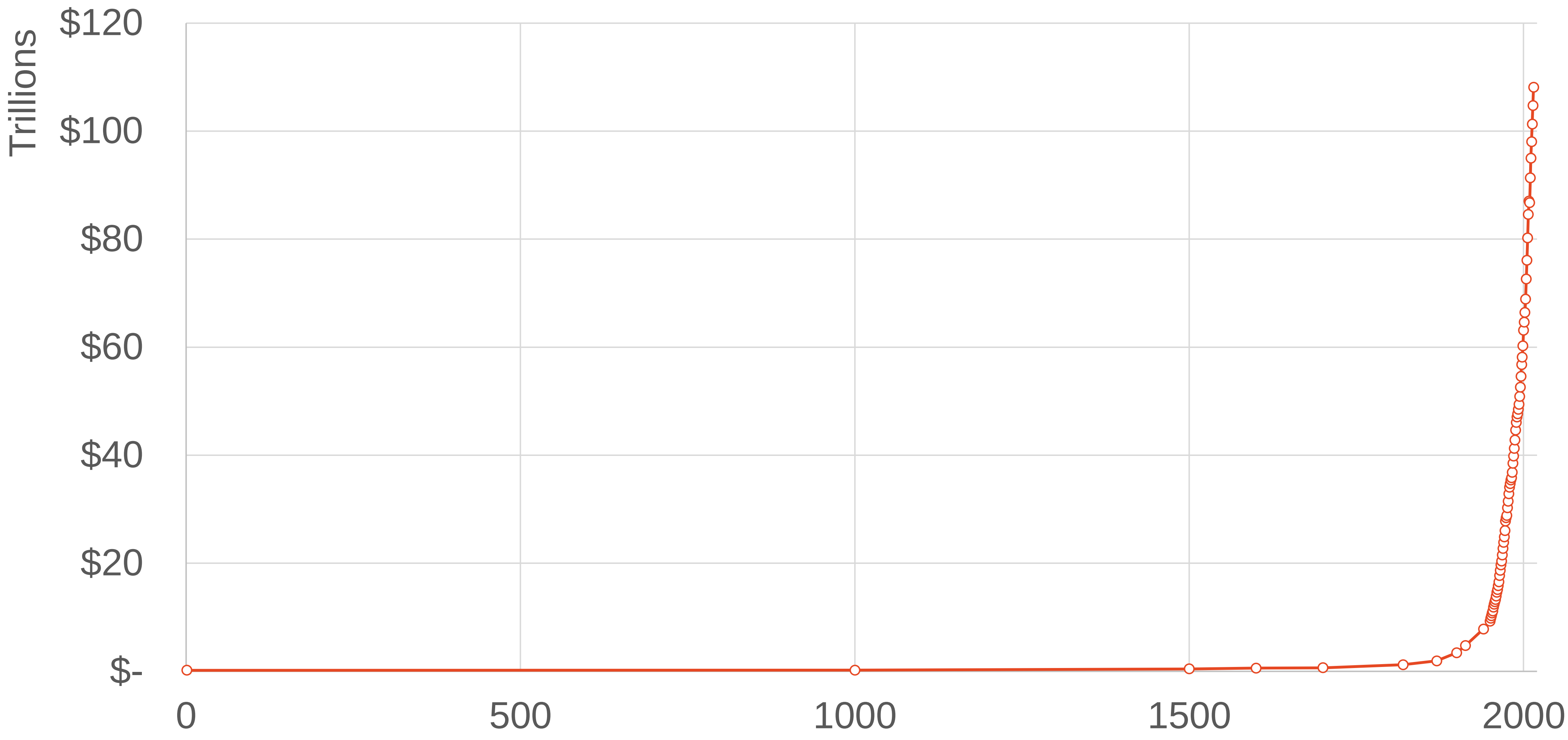
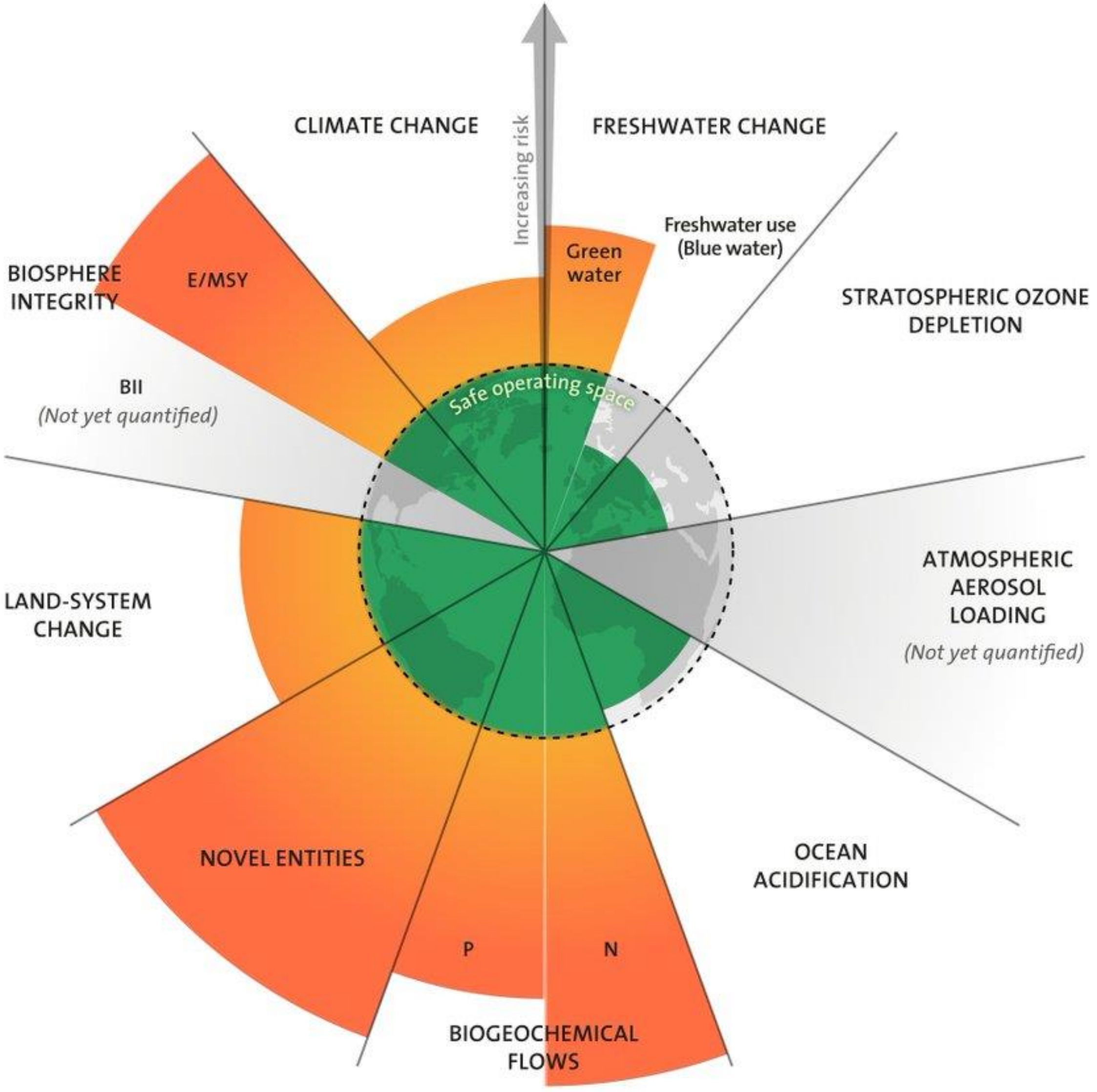
Gross Domestic Product (GDP)



Estimated GDP over the last millennia (2011$)

Reference: World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm

Limits to Growth



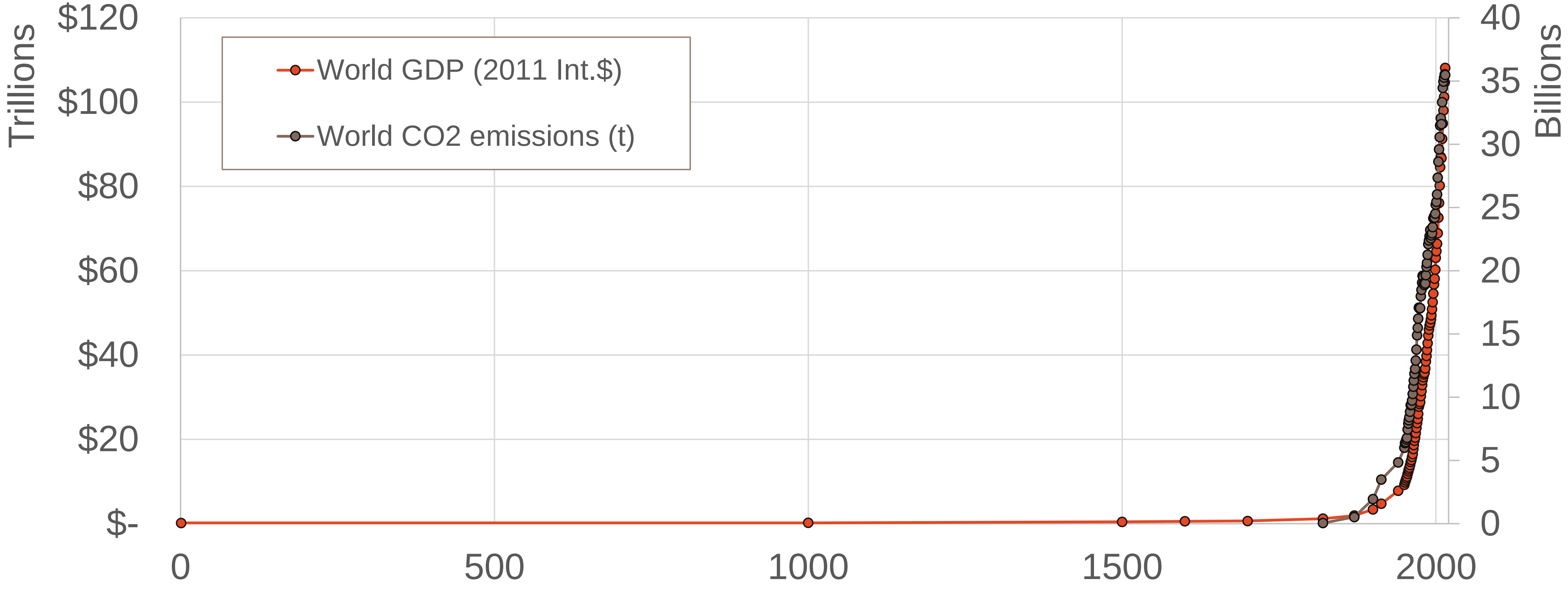
Planetary boundaries:

1. Stratospheric ozone depletion
2. Biosphere integrity
3. Chemical pollution and release of novel entities
4. Climate Change
5. Ocean acidification
6. Freshwater & global hydrological cycle
7. Land system change
8. Nitrogen, phosphorus flows to biosphere & oceans
9. Atmospheric aerosol loading

Sixth planetary boundaries have been crossed (so far…)

Reference: Stockholm Resilience Centre, https://www.stockholmresilience.org/research/planetary-boundaries.html; key publication: Steffen et al. 2015

GDP & CO_2 emissions



Estimated GDP (left axis) and CO_2 (right axis) over the last millennia

Reference: World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Global Carbon Project 2021 (1.0) [Data set]: https://doi.org/10.18160/gcp-2021

Decoupling

- Definition: Decoupling economic growth from resource use and emissions to stay within planetary boundaries.

- Typical production function: let us assume output (Y):

  (1) $Y = AF(L, K, H, N)$

  With: $Y\ (L^+, K^+, H^+, N^+)$

- Relative or weak decoupling: Both Y and N growth in the same direction, but N in a much lower extent:

  (2) $x_1 Y = AF(x_1 L, x_1 K, x_1 H, 0.5\ x_1 N)$

- Absolute or strong decoupling: N is stable or decreases while Y increases :

  (3) $x_1 Y = ANF(x_1 L, x_1 K, x_1 H)$

With

Y: Production or GDP

A: Technology

L: Labour

K: Capital

H: Human capital

N: Natural capital

Reference: Parrique T., et al., 2019. Decoupling debunked: Evidence and arguments against green growth as a sole strategy for sustainability. European Environmental Bureau, eeb.org/decoupling-debunked; Hubacek et al., Evidence of decoupling consumption-based CO_2 emissions from economic growth, Advances in Applied Energy Volume 4, 19 November 2021 https://doi.org/10.1016/j.adapen.2021.100074

EPFL LEURE

LIMITS TO GROWTH

Ecological footprint

Ecological Footprint (EF)

Definition: The Ecological footprint measures “the ecological assets that a given population or product requires to produce the natural resources it consumes and to absorb its waste.” Developed in 1990 by Wackernagel & Rees at the University of British Columbia.

Concept: Expressing the demand into a requirement for productive areas (e.g., grasslands for livestock, forest for carbon sink) compared against the ability of the biocapacity to supply these ecological assets

Formula: $EF = \Sigma(T_i/Y_i) \times EQF_i$

With

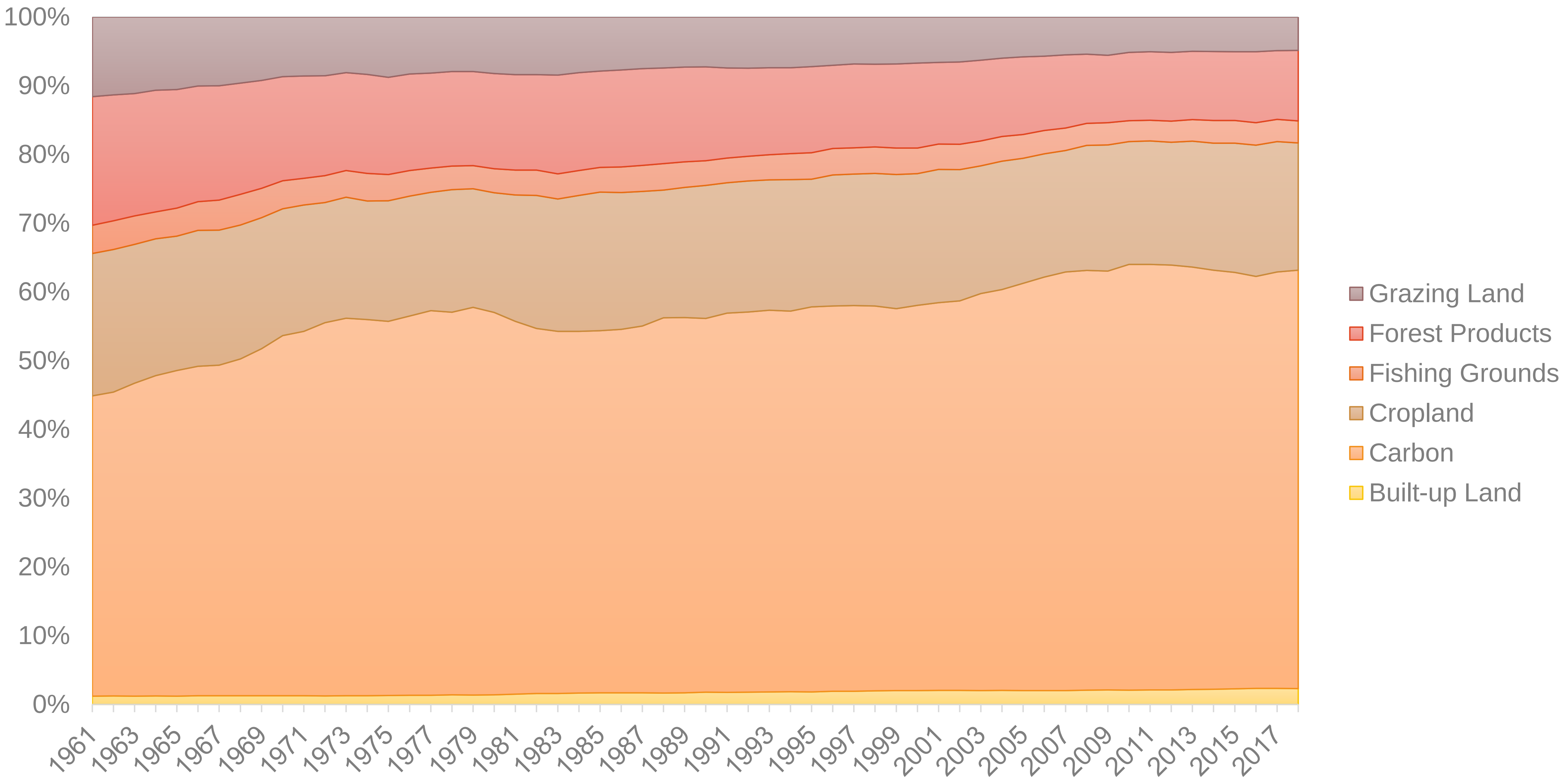
T_i : Tons by product i

Y_i : World yield by product i

EQF_i : Equivalence factor by product i

Reference: Global footprint network: https://www.footprintnetwork.org/our-work/ecological-footprint/

Global ecological Footprint per source



Reference: Global footprint network: https://www.footprintnetwork.org/our-work/ecological-footprint/

Earth Overshoot Day (EOD)

Definition: EOD estimates the date all the biological resources that the Earth can renew during the entire year have been used.

Formula: EOD = B/EF x 365

With

B : Earth biocapacity

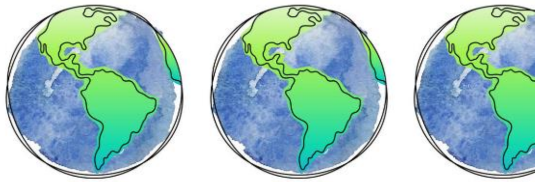
EF : Ecological footprint

Example: EF for Switzerland is 4.35 gha per person

While its global biocapacity is 1.6 gha

Equivalent to 2.75 Earths if everyone lived like the Swiss

Equivalent to 134^{th} day, i.e. 14^{th} of May



Reference: Global footprint network: https://www.footprintnetwork.org/our-work/ecological-footprint/

Your Earth Overshoot Day

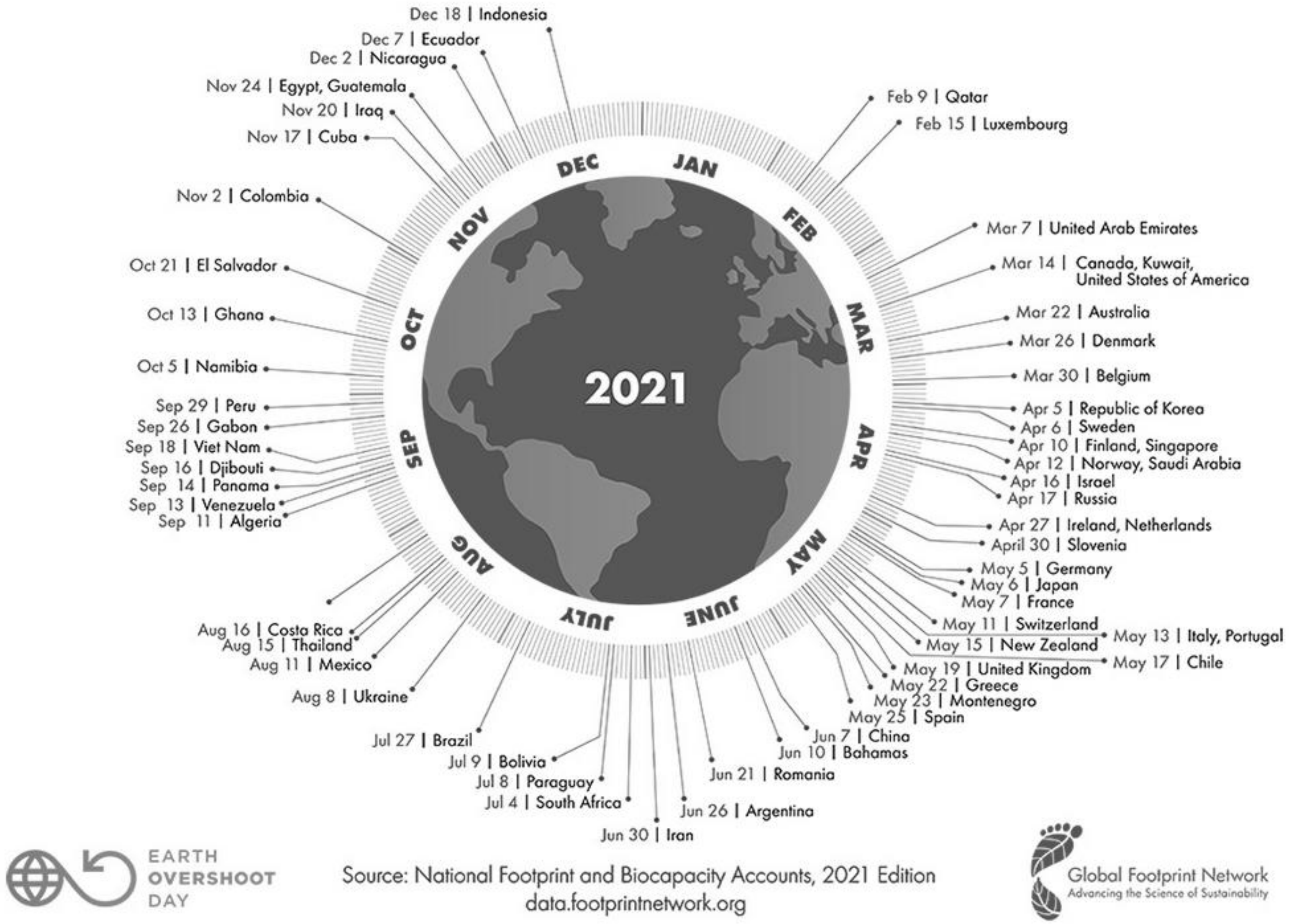
Mine: 2017-2018

Mine: 2021

Feel free to compute your own

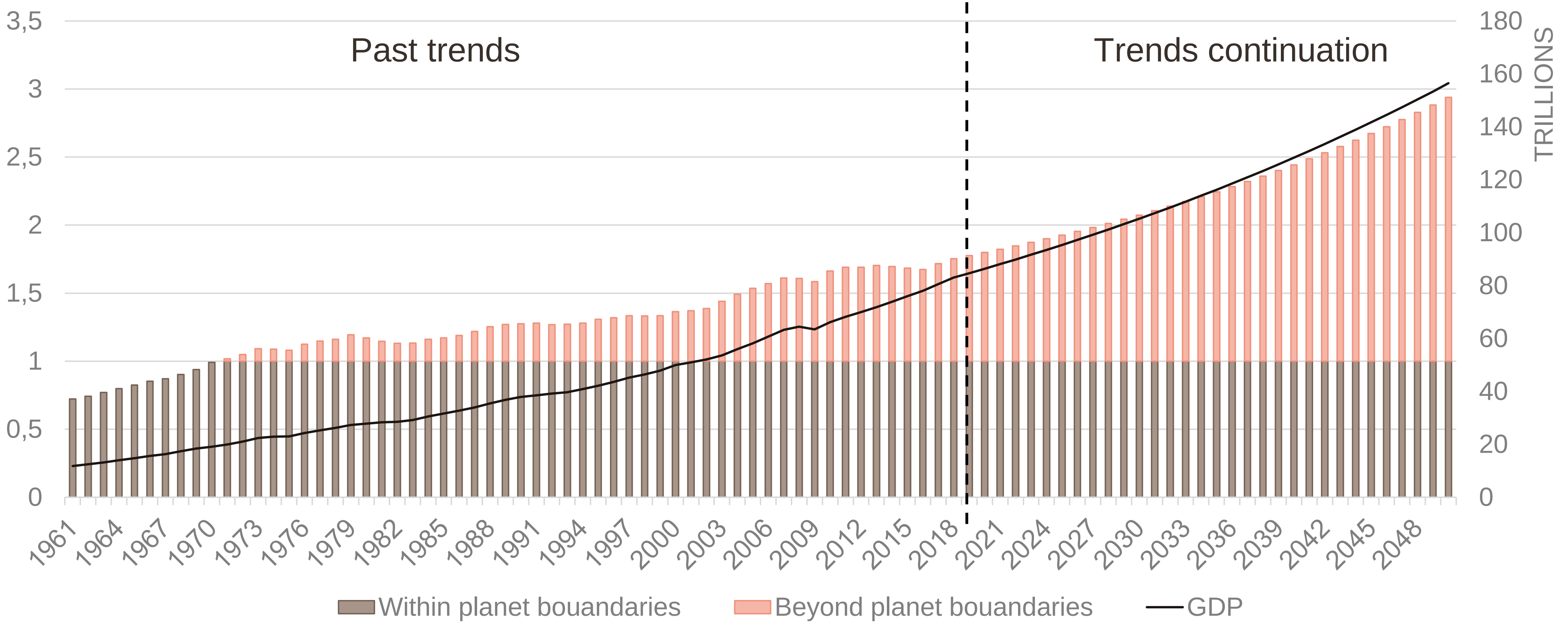
Reference: https://www.footprintcalculator.org/home/en

Earth Overshoot Day per country



Reference: Global footprint network: https://www.footprintnetwork.org/our-work/ecological-footprint/

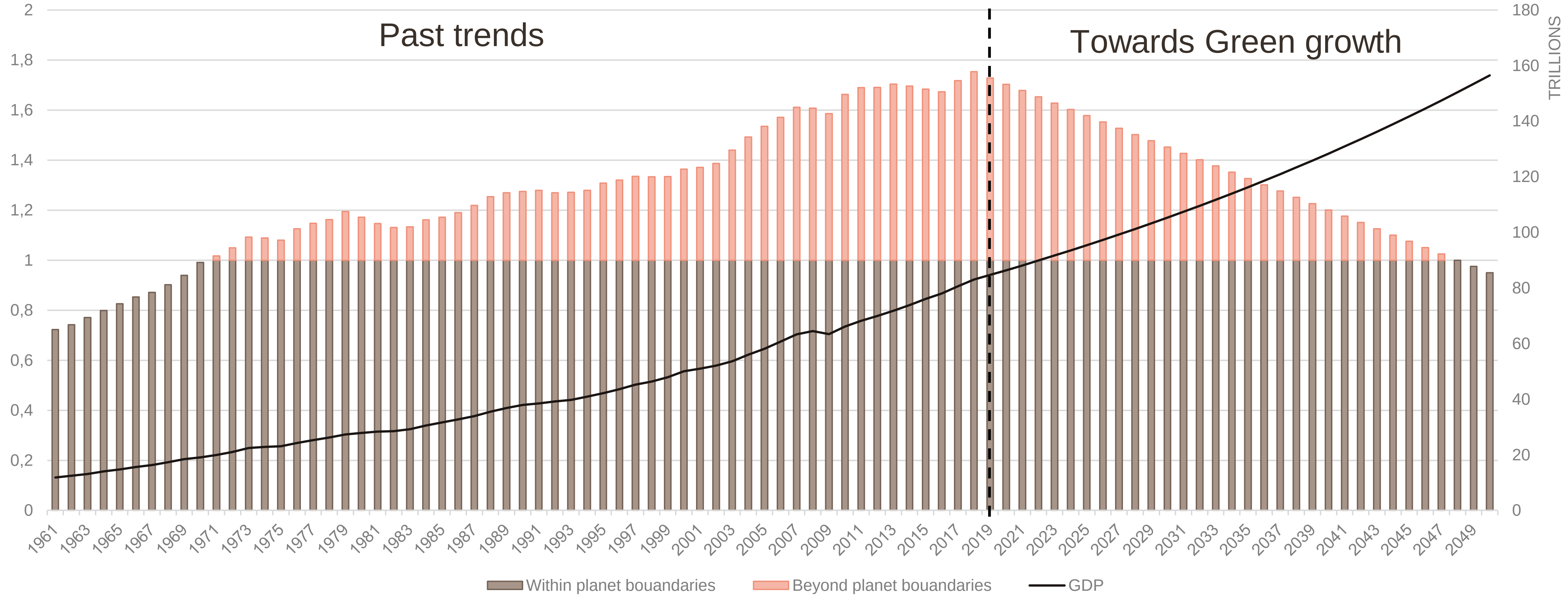
Global footprint



Illustrative trends: Assuming on average 2% GDP growth and a slight decoupling of growth and ecological footprint (left axis EF in planets, right axis GDP in $2011)

Reference: Global footprint network, data: https://api.footprintnetwork.org/v1/data/5001/all/earth

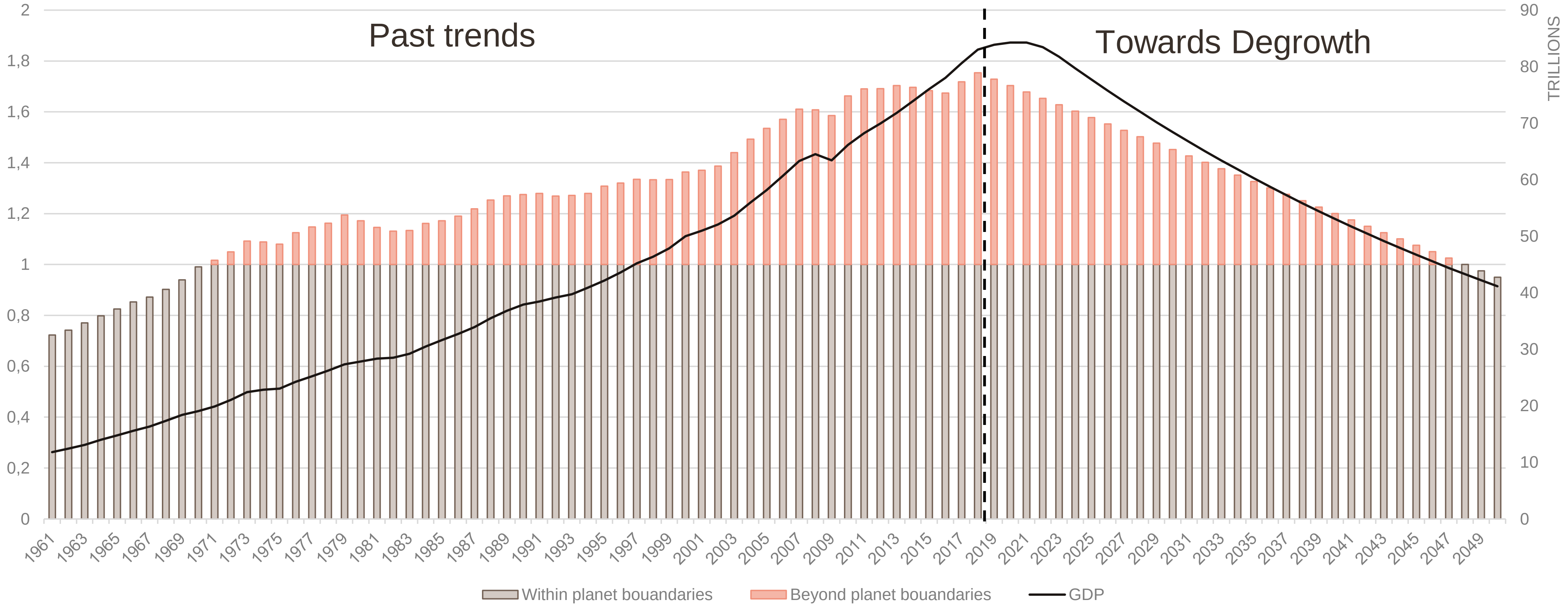
Green growth illustration



Towards green growth: “fostering economic growth and development while ensuring that natural assets provide the resources and environmental services on which our well-being relies*”(left axis EF in planets, right axis GDP in $2011)

Reference: Global footprint network, data: https://api.footprintnetwork.org/v1/data/5001/all/earth; *OECD definition

Degrowth illustration



Towards degrowth: “a planned reduction of energy and resource use designed to bring the economy back into balance with the living world in a way that reduces inequality and improves human well-being” (left axis EF in planets, right axis GDP in $2011)

Reference: Global footprint network, data: https://api.footprintnetwork.org/v1/data/5001/all/earth

POLL

Do you think green growth will enable us to come back in the planetary boundaries (in time)?

DECOUPLING

The Environmental Kuznets curve (EKC)

Kuznets curve

Original Kuznets curve:

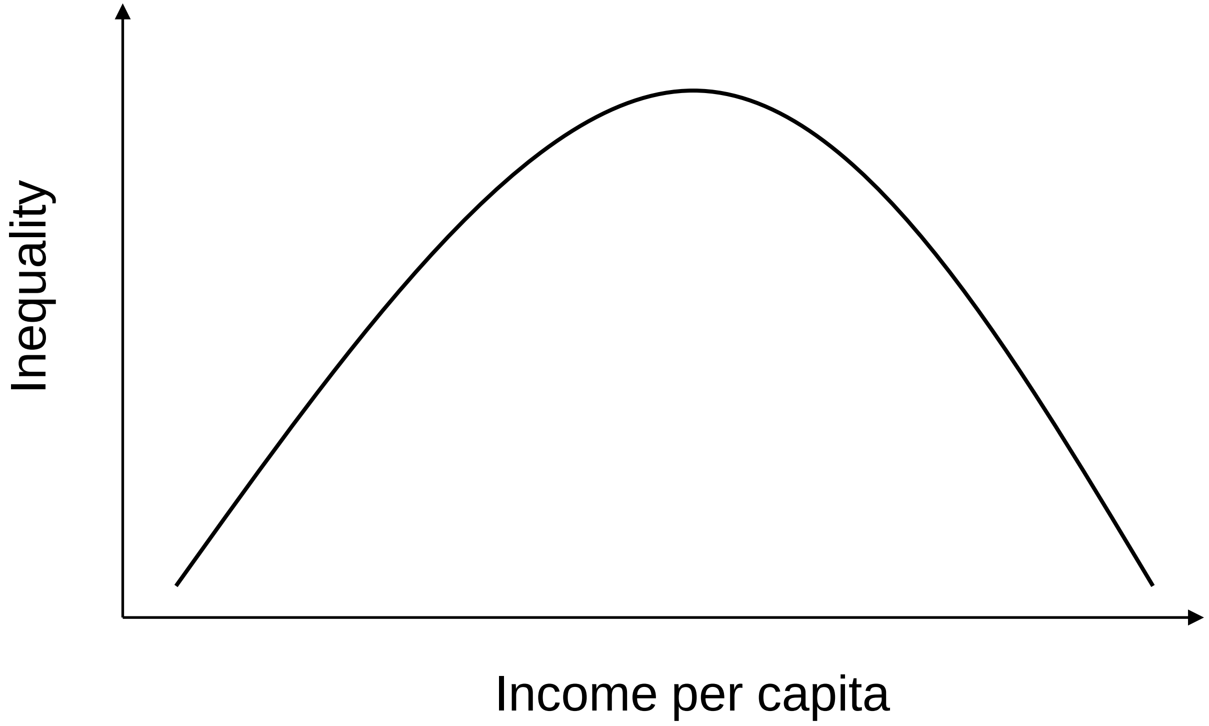
relationship between income per capita and inequality

Country development path:

(1) Predominance of traditional farming and livestock

(2) Industrialization

(3) Services become the dominant sector



Towards the Environmental Kuznets curve

Environmental Kuznets Curve (EKC):

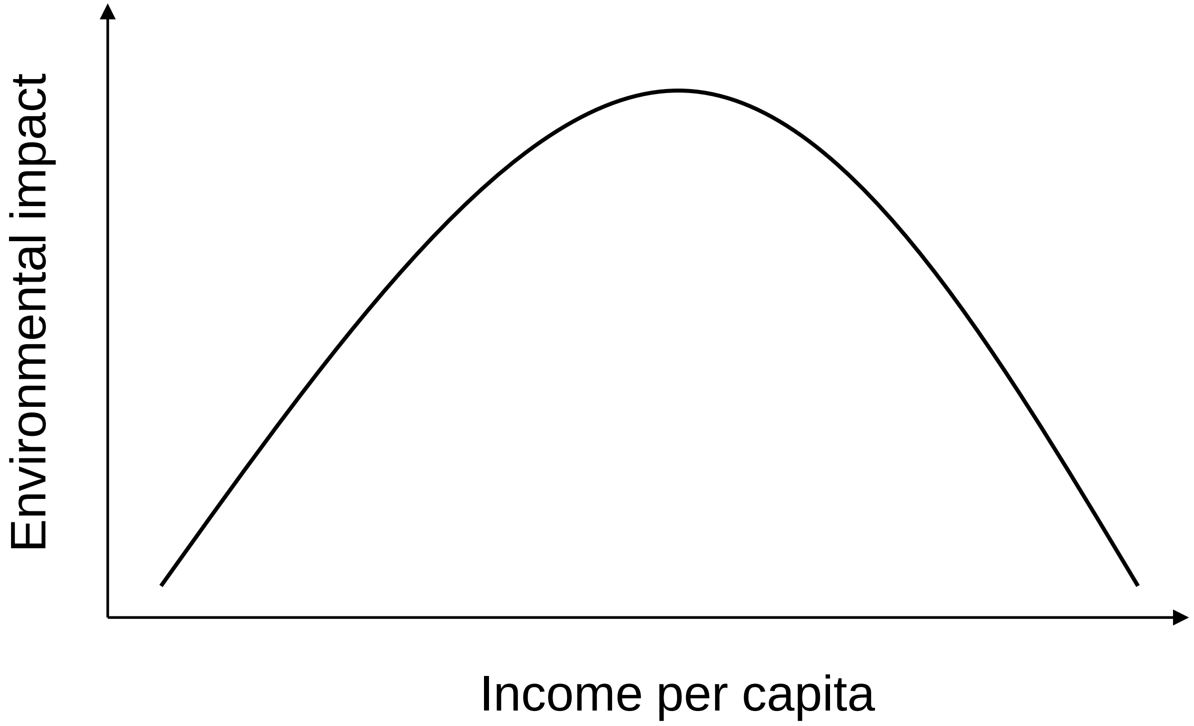
relationship between income per capita and environmental impacts

Country development path:

(1) **rural**: low level of environmental impacts thanks to low level or production, production with little env. impact and scattered population

(2) **industrialisation**: increasing environmental impacts per inhabitant with little mitigation

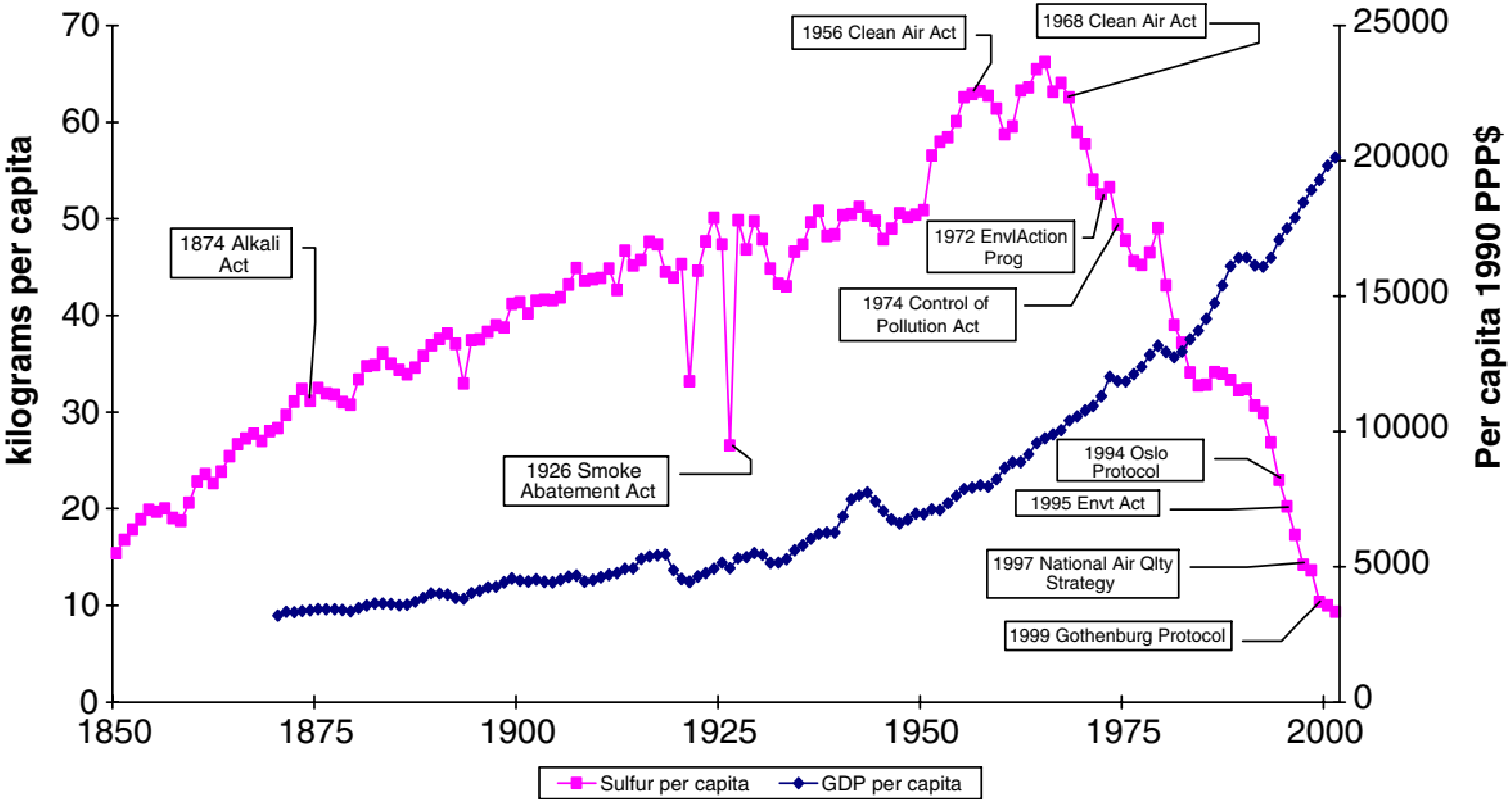
(3) **tertiarization**: slower growth of population, production and environmental impacts, with transfer from industry to services and ever more mitigation



Rationales behind the EKC

- Growing competition for resources forces firms to take care of these resources
- As affluence and pollution rise, a population's priorities move from material safety to environmental quality, and governments shift their policies from promoting growth 'at any cost' to protecting and preserving the environment (the economy can 'afford' to protect the environment)
- As affluence rises, inequality decreases (cf. classic Kuznets curve), so that the wider population has a stronger influence on policy-making and can better defend its interests
- As time passes and affluence increases, the country has more options for protecting the environment: a working State, technical solutions

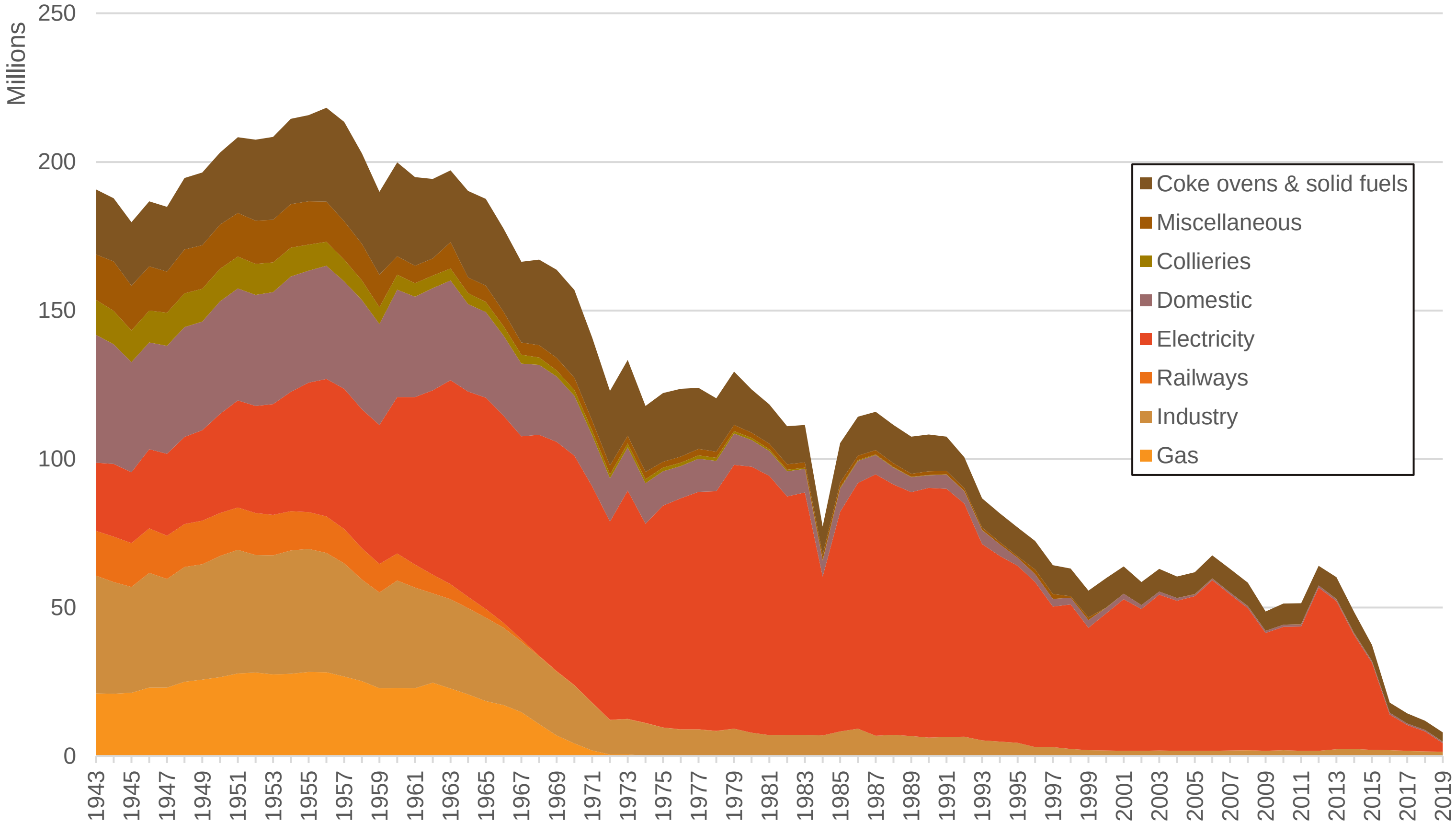
Empirical evidence of EKC (SO_x) in the UK



Sulphur emissions per capita (1850-2001) in the UK, and selected air pollution regulations in the UK

Markandya, Anil, Alexander Golub et Suzette Pedroso-Galinato (2006) "Empirical Analysis of National Income and SO_2 Emissions in Selected European Countries", *Environmental and Resource Economics* 35(3): 221-257.

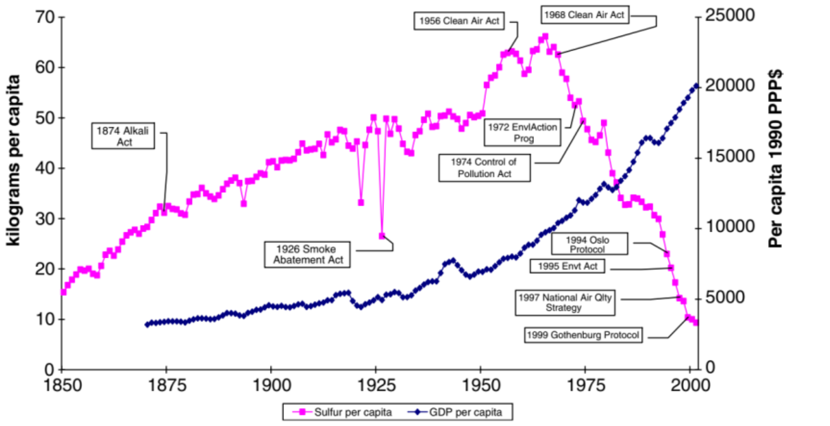
Empirical evidence of EKC (SO_x) in the UK



Coal per end-use in the UK (Mt) from 1943 to 2019

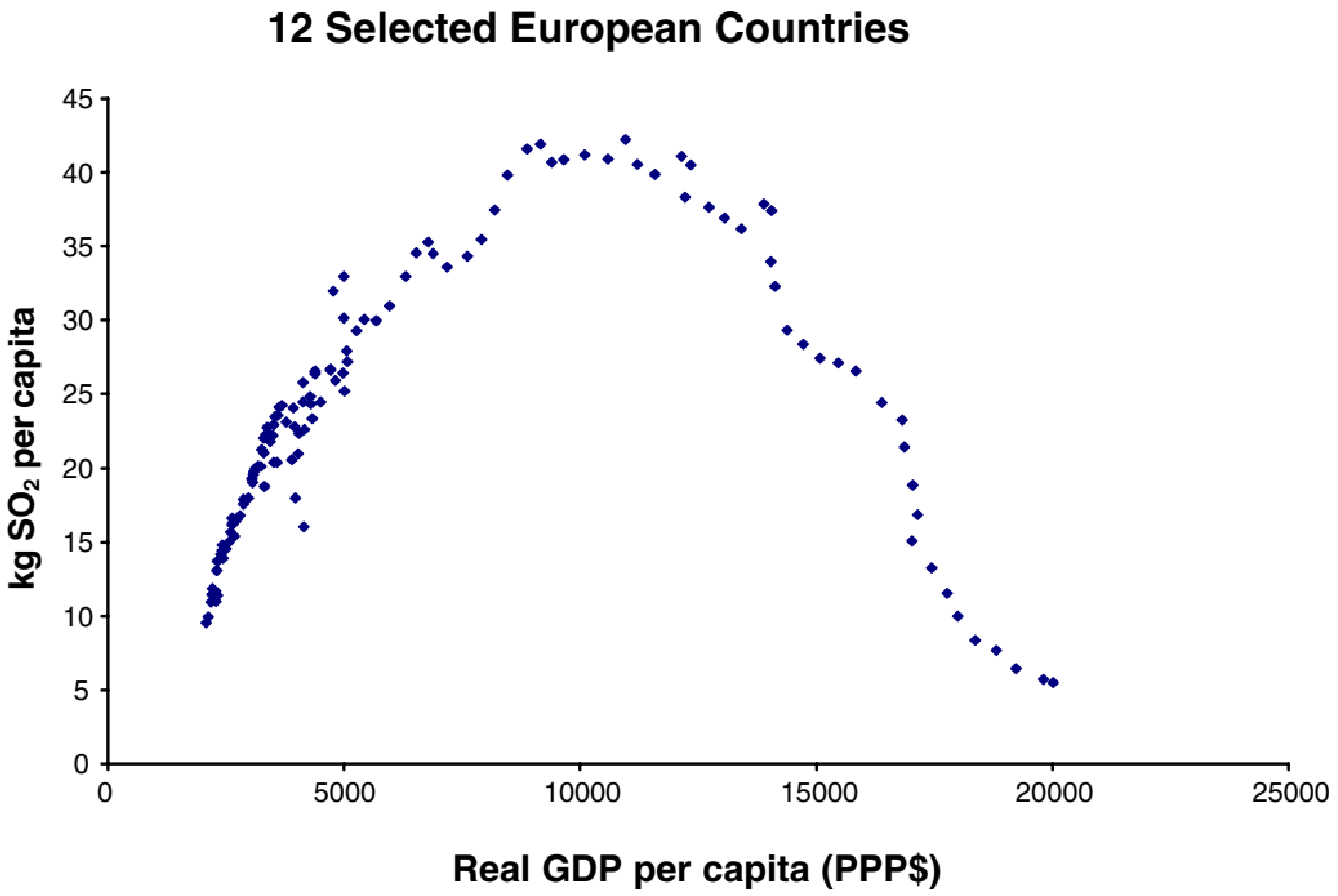
SO_2 emissions have declined by 95% sine 1990 in the UK

Sulphur emissions per capita (1850-2001) in the UK, and selected air pollution regulations in the UK



Reference: Markandya, Anil, Alexander Golub et Suzette Pedroso-Galinato (2006) "Empirical Analysis of National Income and SO_2 Emissions in Selected European Countries", *Environmental and Resource Economics* 35(3): 221-257; Our World in data, Data: https://ourworldindata.org/death-uk-coal; originally published by the UK's Department for Energy and Climate Change (DECC) in 2013. Updated in 2018 by the UK's Department for Business, Energy & Industrial Strategy (BEIS).

Empirical evidence of EKC (SO_2) in the EU



Data for 1870-2001 for twelve European countries: Austria, Belgium, Denmark, Finland, France, Germany, Italy, Netherlands, Norway, Sweden, Switzerland and UK

Markandya, Anil, Alexander Golub et Suzette Pedroso-Galinato (2006) "Empirical Analysis of National Income and SO_2 Emissions in Selected European Countries", *Environmental and Resource Economics* 35(3): 221-257.

Empirical evidence of EKC (CO_2) in the UK

(one of few countries with decreasing CO_2 emissions)

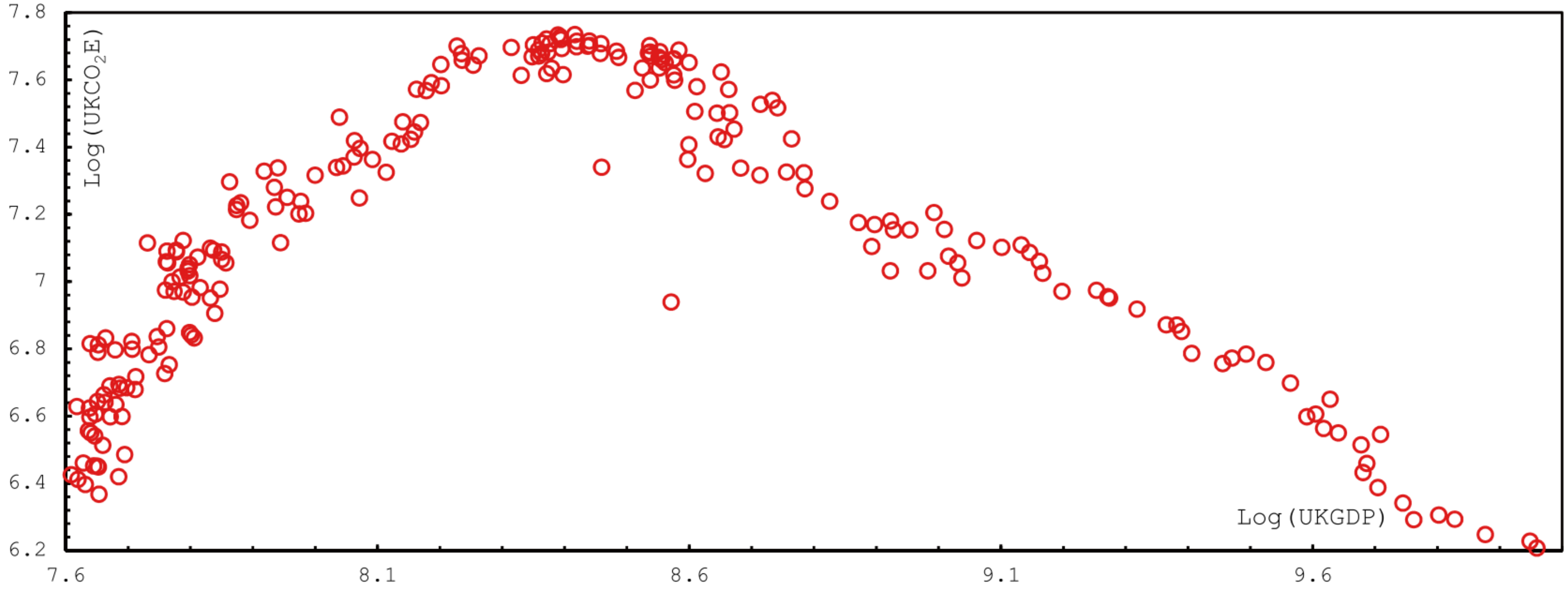


Fig. 1 Environmental Kuznets Curve in the UK

Phase (2): fast increase of CO_2

Phase (3): slower decrease of CO_2

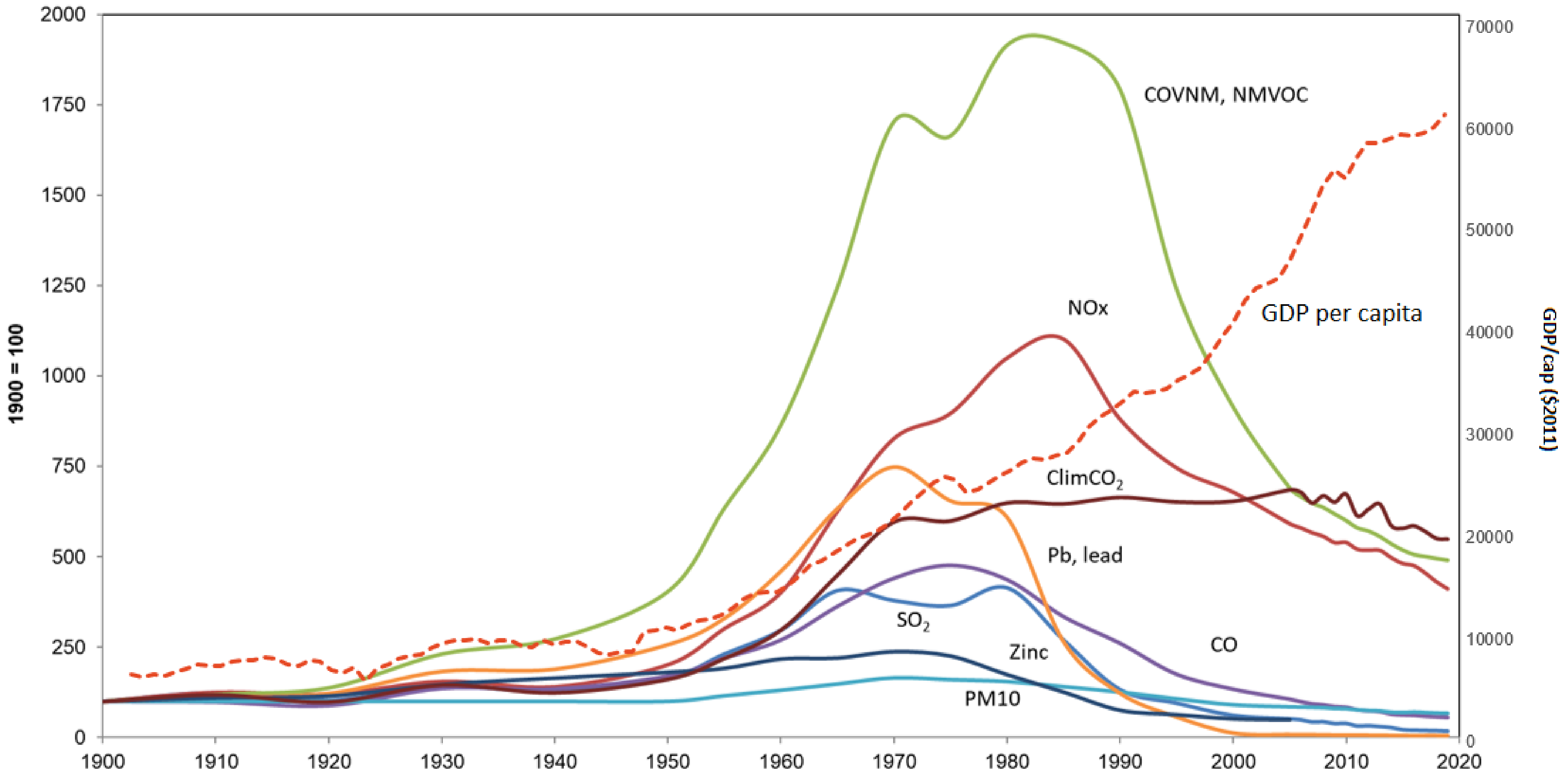
UKGDP = real GDP per capita in UK between 1751 and 2016

$UKCO_2E$ = CO_2 emissions **over real GDP**

Ben Amar, A. (2021), "Economic growth and environment in the United Kingdom: robust evidence using more than 250 years data", *Environmental Economics and Policy Studies* 23

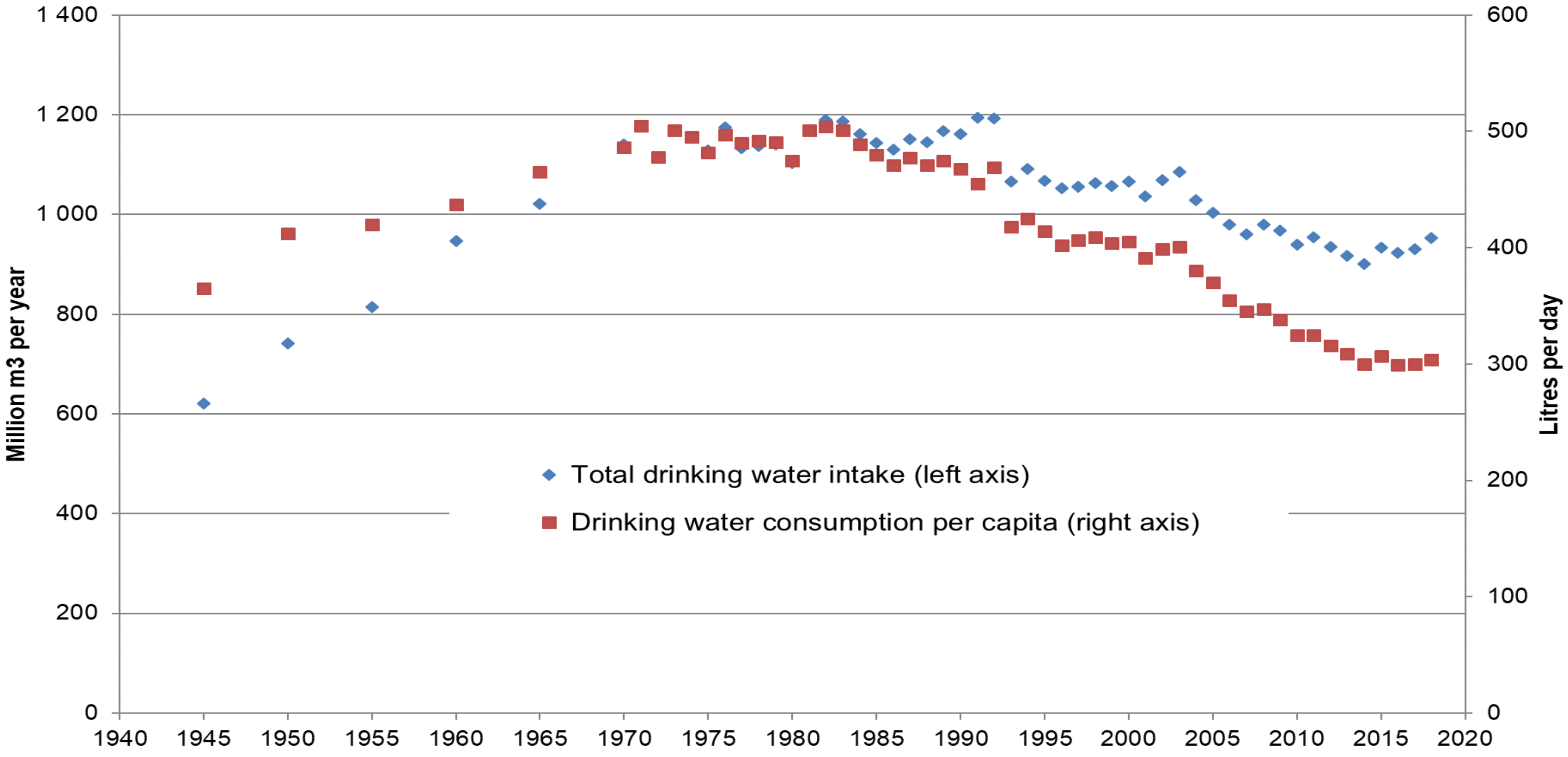
Empirical evidence of decoupling

Emissions of atmospheric pollutants in Switzerland (indices 1900=100)



Reference: Source of data: Federal office of the environment; Our World in data, World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD ; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Data: https://ourworldindata.org/economic-growth

Empirical evidence of decoupling
Extraction and consumption of drinking water in Switzerland

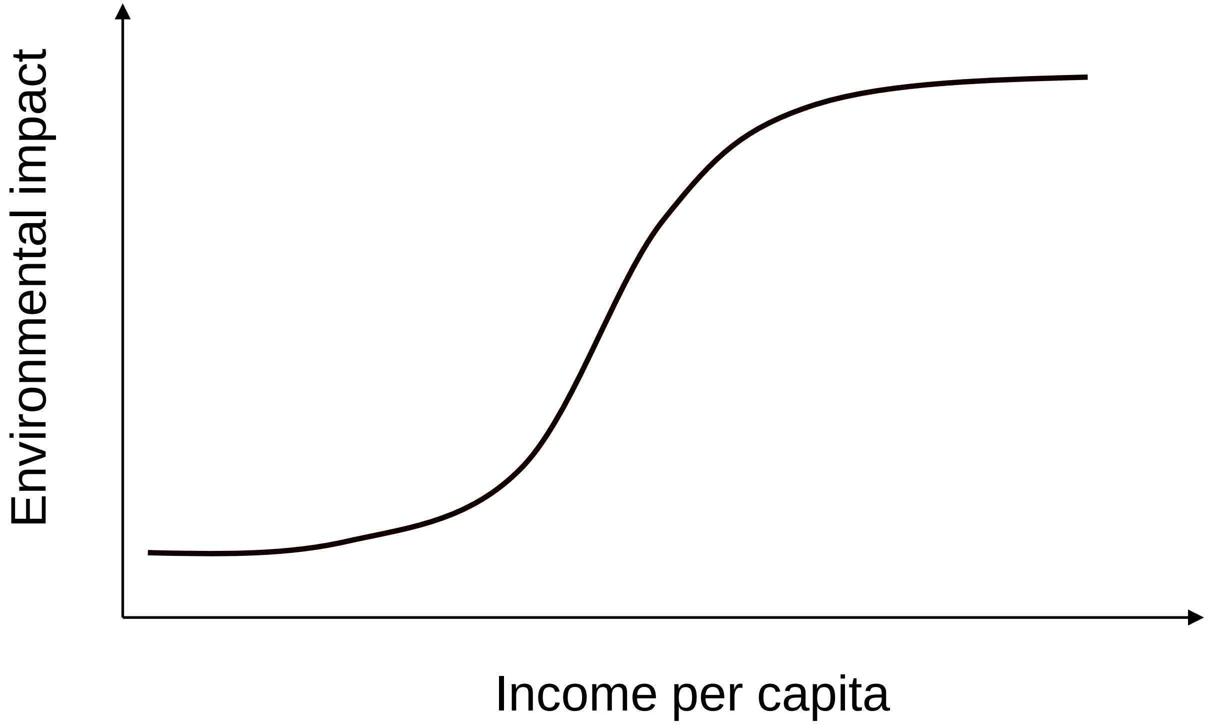


Source of data: Federal office of statistics

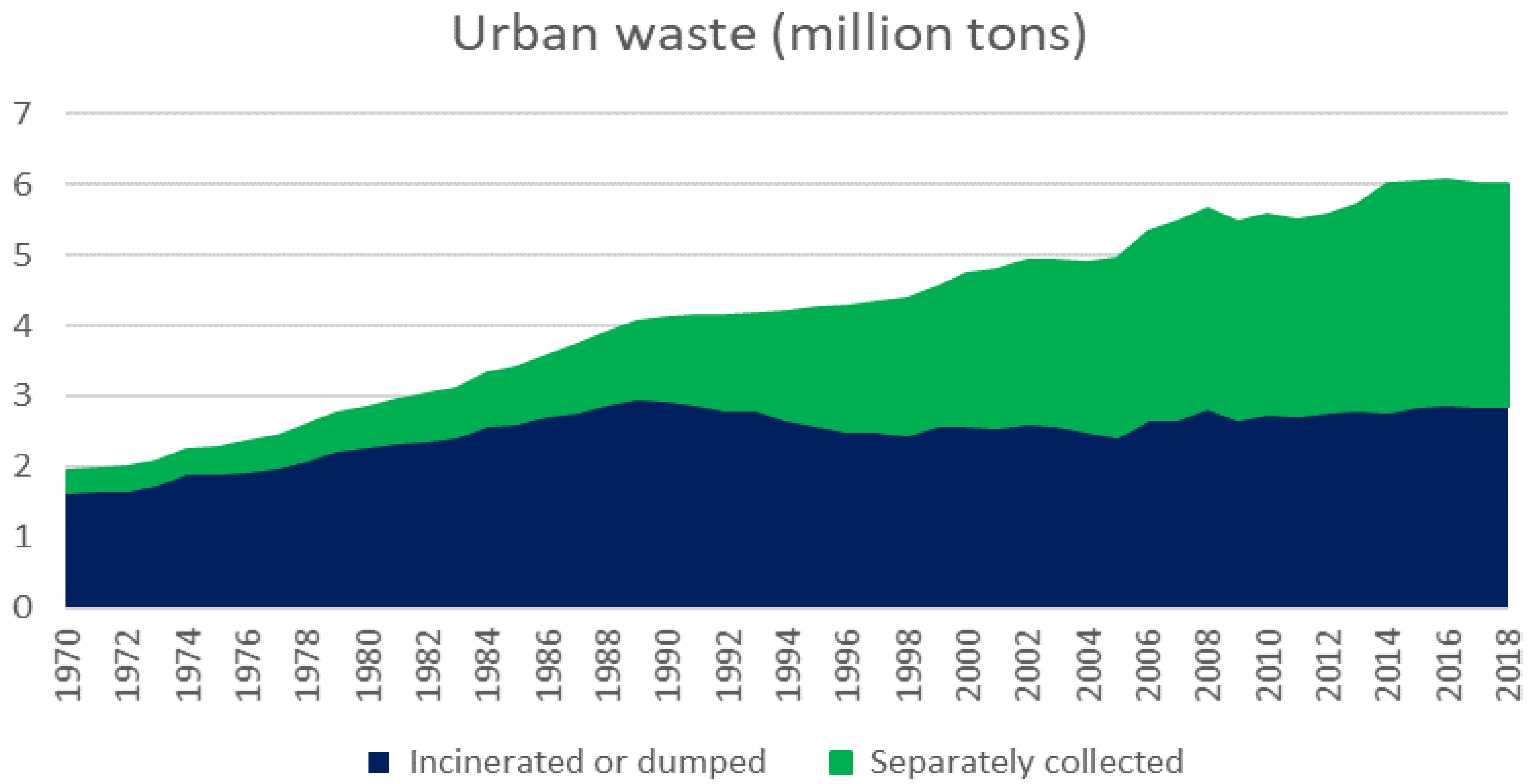
At home, water consumption = 142L, in hotels, businesses, fountains, etc.: 163L (2017)

New theory: S-shaped curve

- After industrialisation, the environmental impact stagnates at a high level
- This is called "saturation"
- As income per capita keeps rising, there is at least **relative decoupling**
- What if this high level is not sustainable?

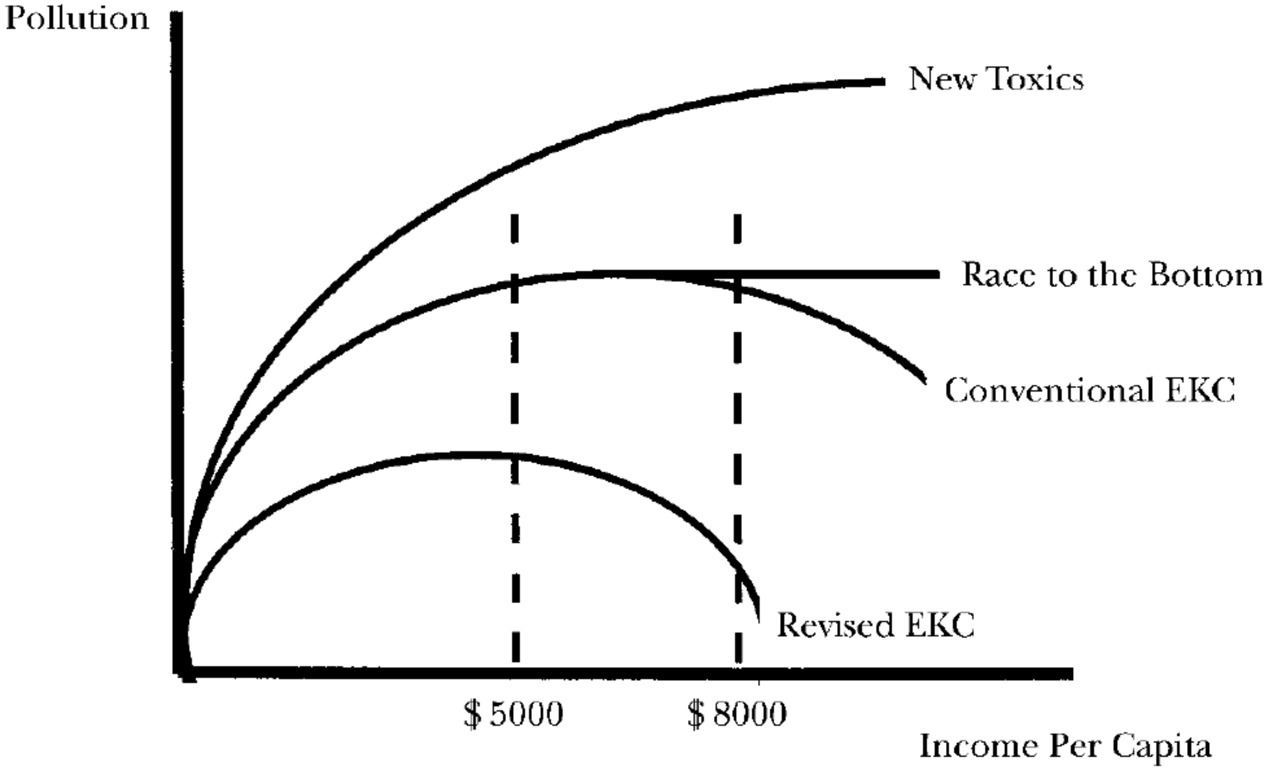


Urban waste in Switzerland – no turn-around yet



Source of data: Federal office of statistics

Variants of the EKC



- New toxics: They could appear as technologies are used to move down some EKC
- Race to the bottom: international competition hinders improvements
- Revised EKC: the diffusion of innovation could accelerate the transition for followers

Dasgupta, S., et al. (2002), "Confronting the Environmental Kuznets Curve", Journal of Economic Perspectives 16(1): 147-168

Conclusions on evidence on EKC

- Mixed evidence at best
- EKC was observed for some pollutants in some countries…

… but rarely for some important ones (CO_2) and not everywhere

- Many observed EKCs were achieved by externalizing the polluting activities (geographic scope)
- Many EKCs were achieved at the cost of more of some other pollution (impact scope)
- When all material flows are taken into account, what we really see is a saturation at a high level

Arguments against EKC

- The causality may go the other way: a sound environment and policies preserving lead to affluence
- Even if some EKCs were observed, nothing guarantees that they will 'automatically' replicate
- The turn-around may come too late for the planet limits
- The decrease of an environmental impact is of little help when it accumulates (e.g. CO_2 concentration, depletion of non-renewable resource) or when its effects are irreversible (e.g. species extinction)

Consequences of EKC for development

- Many poor countries stand at the bottom of the ascending phase of a bell-shaped or monotonically growing EKC
- Should they be deprived of economic growth? Or pushed forward so that they quickly reach the apex?
- Or is it possible to leap-frog the apex thanks to technology transfer?
- Instead of Kuznets curve and EKC, consider the relationship between inequality and pollution!

DECOUPLING

IPAT formula & Kaya Identity

Simple decomposition

$$\text{Impact} = \text{Impact}$$

$$\Leftrightarrow \text{Activity} * \text{Impact} = \text{Impact} * \text{Activity}$$

$$\Leftrightarrow \quad \boxed{\text{Impact} = \text{Activity} \times \frac{\text{Impact}}{\text{Activity}}}$$

With: Impact / Activity = resource efficiency

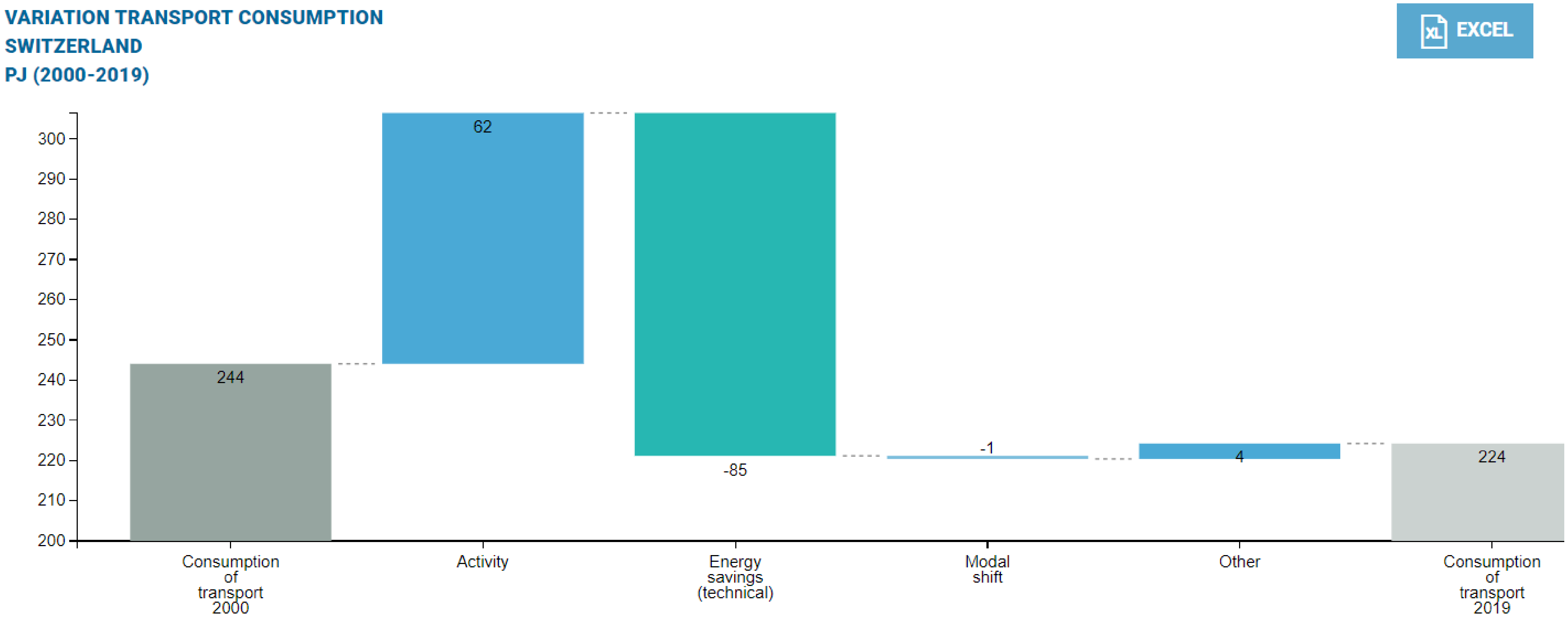
Decomposition of the growth rate of energy consumption for freight transportation in Switzerland, 2000-2019

		2000	2019	2019/2000
Activity	Freight transported (million t×km)	24 689	28 821	1.17
Efficiency	Energy per tkm of freight (TJ/tkm)	1.68	1.53	0.91
Impact	Energy consumption (TJ)	41 361	44 100	1.07

Data from Fed. off. of statistics & of energy

IPAT decomposition of Swiss energy consumption for transport

https://www.indicators.odyssee-mure.eu/decomposition.html, 19.11.2021

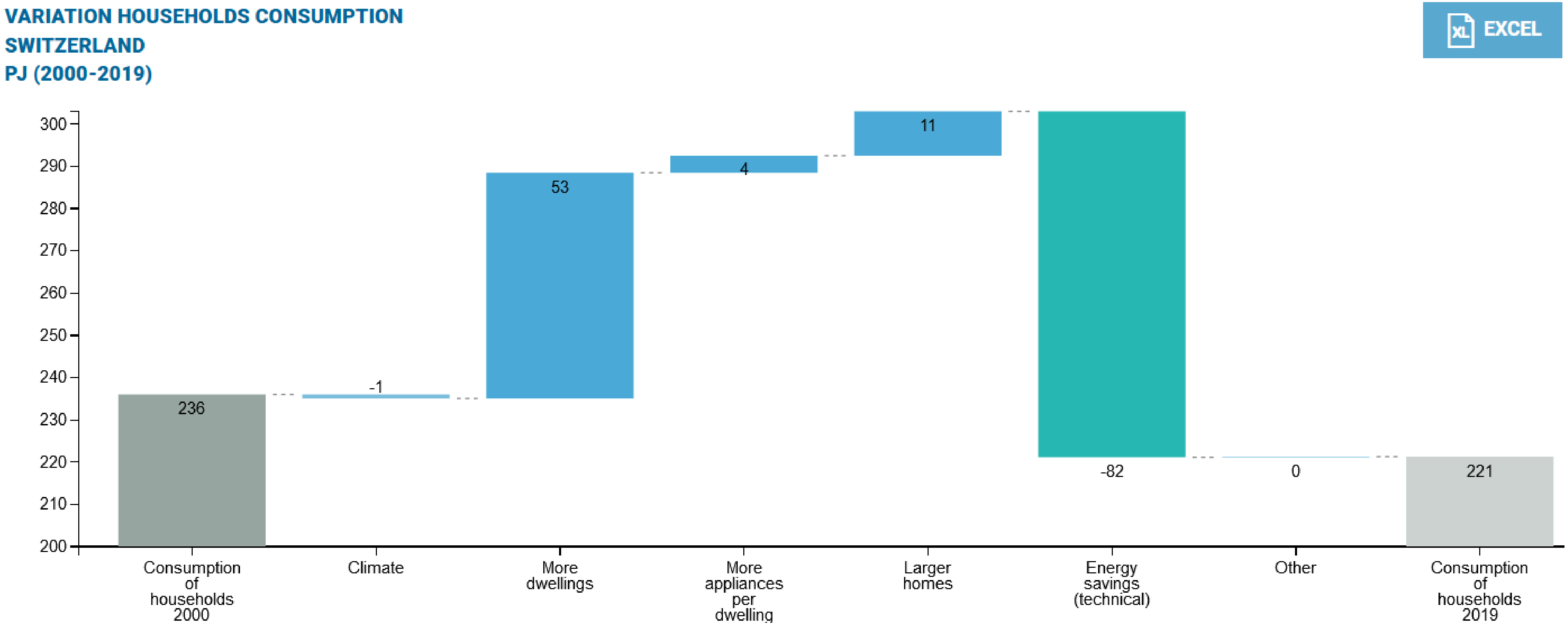


Source : ODYSSEE : based on national data

"Waterfall graph". Activity is measured in person×km and ton×km. Each component is expressed as the change in energy consumption it would have caused absent the other effects. Beware: the y-axis does not start from 0.

IPAT decomposition of Swiss energy consumption in housing

https://www.indicators.odyssee-mure.eu/decomposition.html, 19.11.2021



"Waterfall graph". Each component is expressed as the change in energy consumption it would have caused absent the other effects. Beware: the y-axis does not start from 0.

Efficiency vs intensity

$$\text{Impact} = \text{Activity} \times \frac{\text{Impact}}{\text{Activity}}$$

- Impact/Activity = resource intensity
- If Impact = CO_2 emissions, Activity/Impact = CO_2 intensity

Decomposition of the growth rate of energy consumption for freight transportation in Switzerland, 1990-2019

		1990	2019	2019/1990
Activity	Freight transported (million t×km)	20 569	28 821	1.40
Intensity	CO_2 per tkm of freight (kg/tkm)	0.118	0.103	0.87
Impact	CO_2 emissions (tons)	2.43	2.98	1.23

Data from Fed. off. of statistics & of the environment

IPAT formula

Origin:

Published in 1971/72 by Paul Ehrlich and John Holdren

Formula:

Environmental **I**mpact =
Population × **A**ffluence × **T**echnology

$$I = Pop \times \frac{GDP}{Pop} \times \frac{I}{GDP}$$

IPAT decomposition for Swiss motor fuel consumption

$$\text{Motor fuel consumption} = \text{Pop} \times \frac{\text{Households}}{\text{Pop}} \times \frac{\text{Cars}}{\text{Households}} \times \frac{\text{Km driven}}{\text{Cars}} \times \frac{\text{Fuel consumption}}{\text{Km}}$$

$$GF_{\text{Fuel cons.}} = GF_{\text{Pop.}} \times GF_{\text{1/Hh size}} \times GF_{\text{Car ownership}} \times GF_{\text{Km per car}} \times GF_{\text{1/Fuel efficiency}}$$

Decomposition of growth factors of motor fuel use in Switzerland, 1990-2015

Population	1.23
Households / population	× 1.04
Cars per household	× 1.17
Km driven per car	× 0.89
Fuel consumption per Km	× 0.80
Total fuel consumption	= 1.07

Data from Fed. off. of statistics & of energy

IPAT for CO_2: Kaya decomposition

$$CO_2 \text{ emissions} = CO_2 \text{ emissions}$$

$$\Leftrightarrow$$

$$\boxed{CO_2 \text{ emissions} = \text{Pop} \times \frac{\text{GDP}}{\text{Pop}} \times \frac{E}{\text{GDP}} \times \frac{CO_2}{E}}$$

E is energy consumption (primary or final)

Yiochi Kaya is a Japanese energy economist

He proposed this formula in 1993

Efficiency improvements cancelled by growth

$$CO_2 \text{ emissions} = \text{Pop} \times \frac{\text{GDP}}{\text{Pop}} \times \frac{\text{E}}{\text{GDP}} \times \frac{CO_2}{\text{E}}$$

$$\%CO_2 = \%\text{Pop} + \%(\text{GDP}/\text{Pop}) + \%(\text{E}/\text{GDP}) + \%(CO_2/\text{E})$$

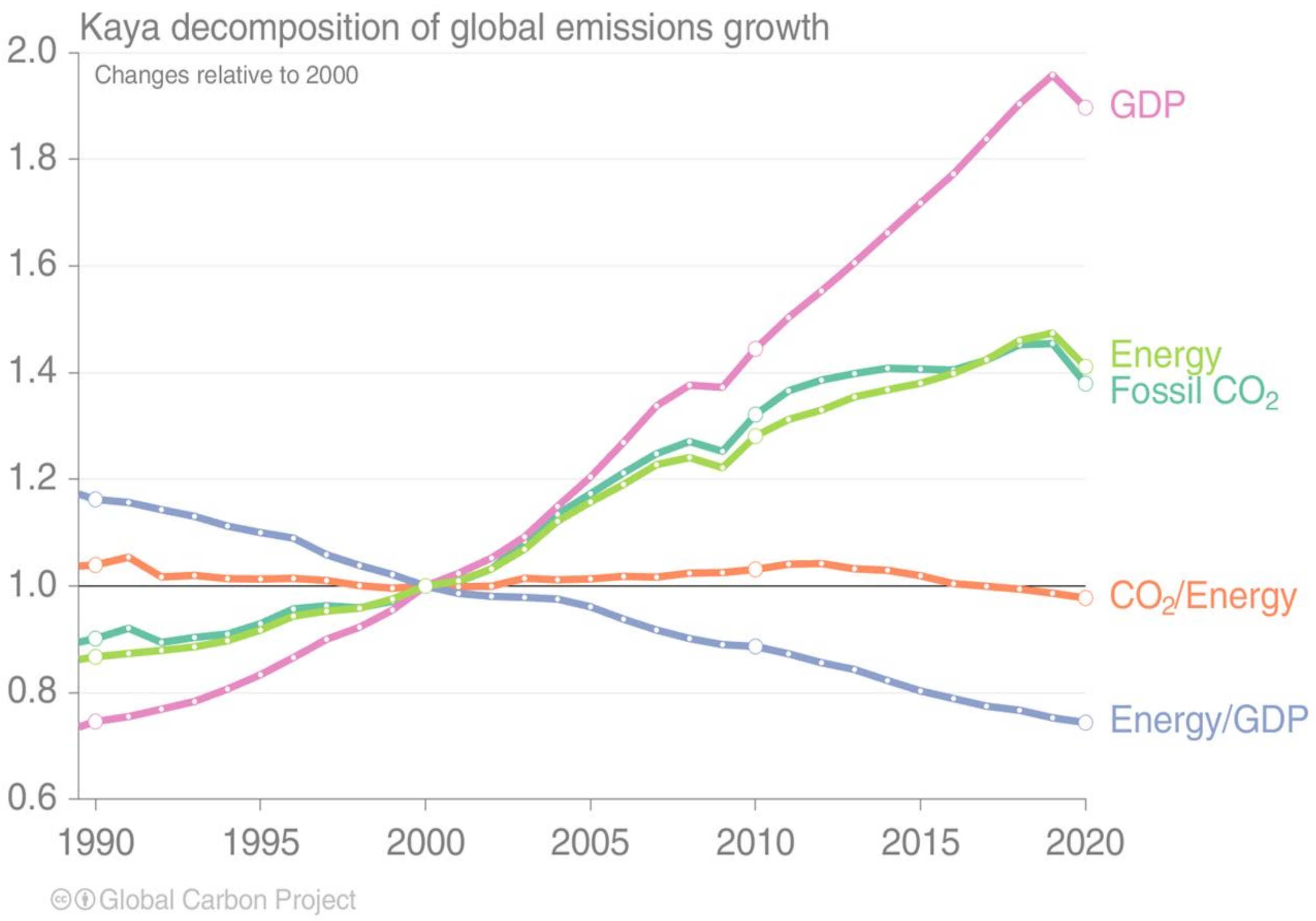
Decomposition of the average annual growth rate of global energy-related CO_2 emissions since the 1st oil price shock

	1973–1990	1990–2010	2010-2018
Population	1.8%	1.4%	1.2%
GDP/population	1.3%	1.4%	1.7%
Total primary energy supply/GDP	-0.9%	-0.9%	-1.5%
CO_2 emissions/TPES	-0.5%	0.1%	-0.2%
CO_2 emissions	1.7%	2.0%	1.2%

Sources: World Bank - World Data Bank, IEA

Kaya decomposition of global CO_2 emissions

This Kaya decomposition illustrates that relative decoupling of economic growth from CO_2 emissions is driven by reduced energy intensity (energy/GDP)



GLOBAL CARBON PROJECT

"Global carbon budget 2021" presentation

EPFL

LEURE

Kaya decomposition for Swiss aviation

$$\boxed{CO_2 \text{ emissions} = \text{Pop} \times \frac{\text{Flights}}{\text{Pop}} \times \frac{CO_2}{\text{Flights}}}$$

$$\%CO_2 = \%\text{Pop} + \%(\text{Flights}/\text{Pop}) + \%(CO_2/\text{Flights})$$

Decomposition of the average annual growth rate of CO_2 emissions from airplanes leaving Swiss airports, 2004-2019

Population	+1.0%
Flights per inhabitant	+4.0%
CO_2 emissions per flight	-1.6%
CO_2 emissions	+3.3%

Data from Fed. off. of statistics & of the environment

Kaya decomposition for CO_2 emission from heating in Switzerland

$$CO_2 \text{ emissions} = \text{Pop} \times \frac{\text{Heated housing surf.}}{\text{Pop}} \times \frac{\text{Energy for heating}}{\text{Heated housing surf.}} \times \frac{CO_2 \text{ emissions}}{\text{Energy for heating}}$$

$$GF_{CO_2} = GF_{\text{Pop.}} \times GF_{m^2\text{/inhabitant}} \times GF_{\text{Energy/}m^2} \times GF_{CO_2\text{/energy}}$$

Decomposition of growth factors of CO_2 emissions from heating in Switzerland, 1990-2019

Population	1.27	+ 27%
Heated m^2 per inhabitant	× 1.18	+ 18%
Energy per heated m^2	× 0.64	– 36%
CO_2 per MJ heating energy	× 0.69	– 31%
CO_2 emissions	= 0.66	– 34%

Data from Fed. off. of statistics & of energy

Limitations of IPAT (or Kaya) decomposition

The main limitation is the risk to consider each component independently when they are really connected

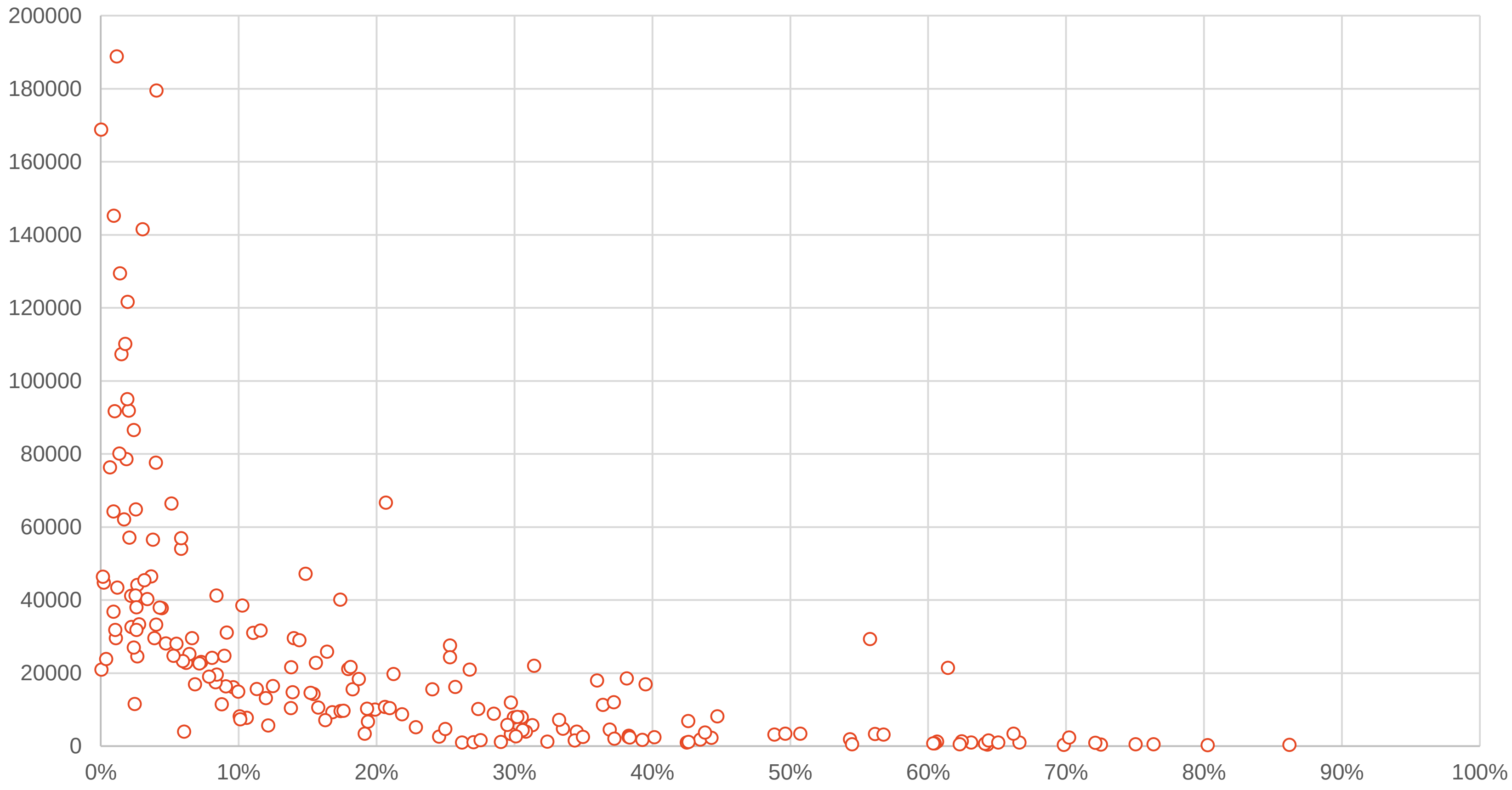
Examples:

- Distance travelled by bike = time × speed; you cannot increase time without loss of speed
- Greater affluence (higher A) generally leads to lower fertility (P slows down or even declines)
- More energy use may mean, in the short term, to have to use reserve coal or other fossil fuel power plants (worse T)
- Higher energy efficiency (better T) implies lower energy cost per unit of service, which leads generally to more use of service (worse A): **rebound effect**

LIMITS TO (GREEN) GROWTH ?

The energy dependency

GDP dependency to energy availability



Agriculture workforce (%, X-axis)
against energy-use per capita (kWh/cap/year, Y-axis)

Human energy eq.:
About 0.5 kWh/day
And 2.5 kWh/day

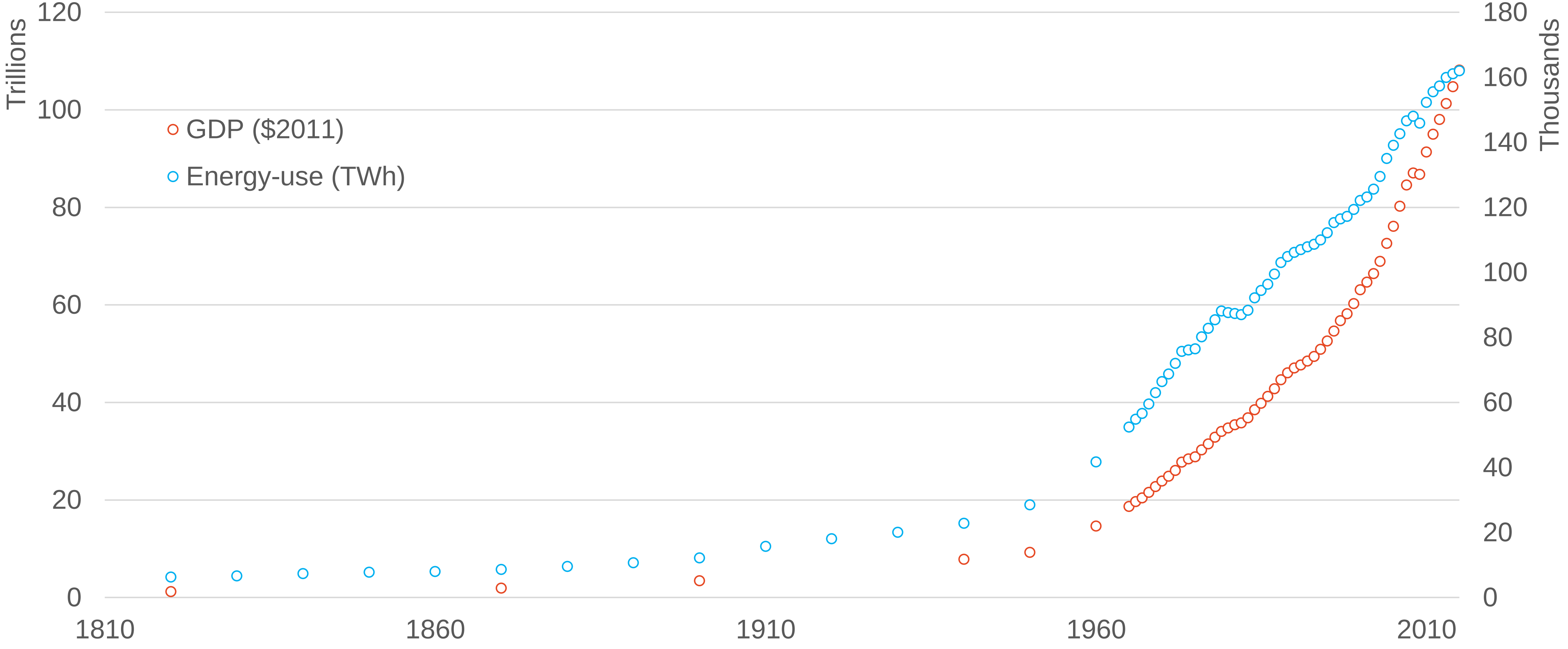
World energy-use:
About 21MWh/cap/year
Eq. 115 persons/day
27% agriculture workforce

Swiss:
About 38MWh/cap/year
Eq. 208 persons/day
2,5% agriculture workforce

Burundi:
About 0,32MWh/cap/year
Eq. 1,75 persons/day
86% agriculture workforce

Reference: Our World in Data based on International Labor Organization (via the World Bank) and historical sources: https://ourworldindata.org/employment-in-agriculture ; J. M. Jancovici, combien-suis-je-un-esclavagiste (2013): https://jancovici.com/transition-energetique/l-energie-et-nous/combien-suis-je-un-esclavagiste/;

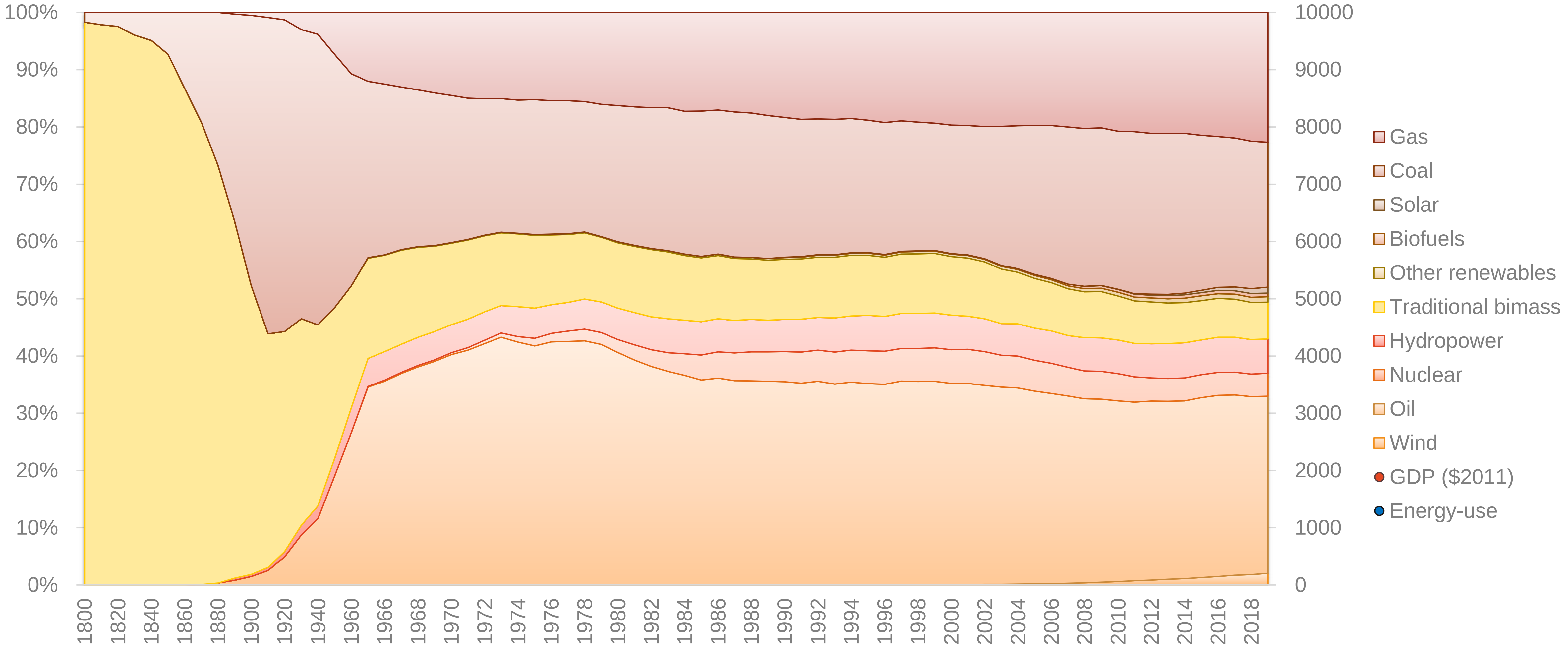
Gross Domestic Product & Energy use



GDP & energy since 1810

Reference: World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Our World in data, How much energy does the world consume? https://ourworldindata.org/energy-production-consumption (original data: Vaclav Smil (2017). Energy Transitions: Global and National Perspectives. & BP Statistical Review of World Energy)

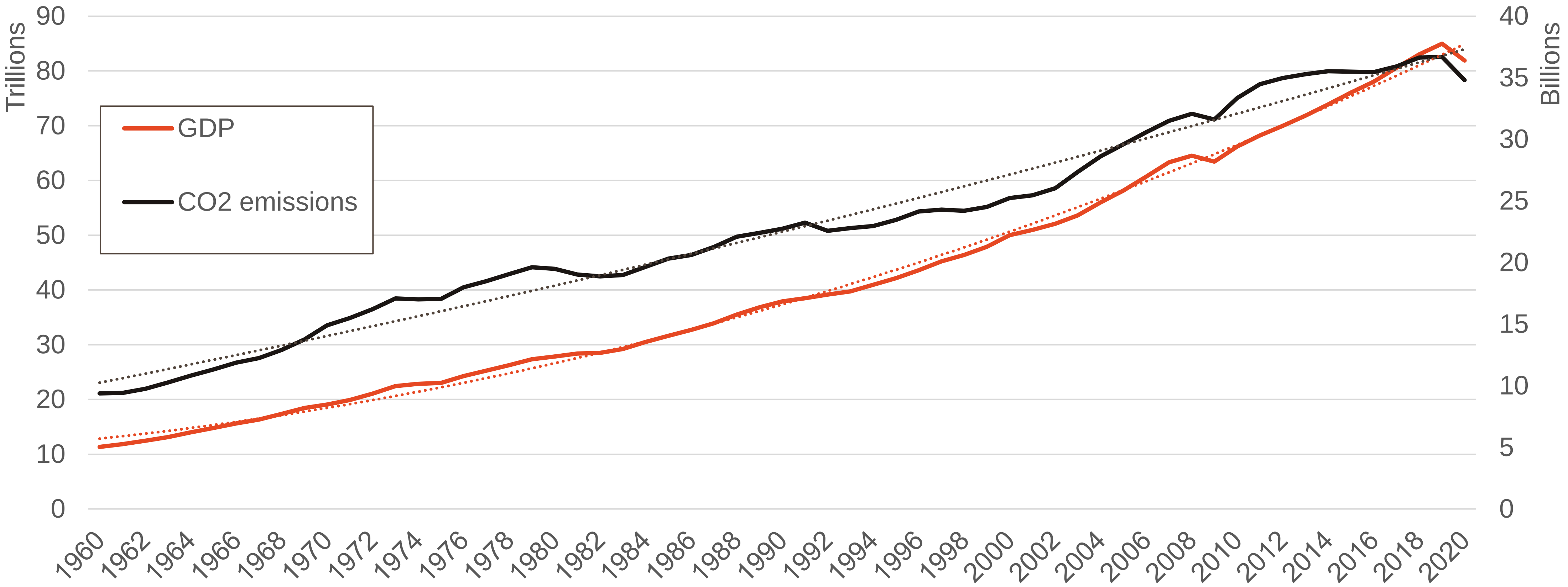
GDP & Energy use per source



Energy mix (%, left axis), energy use (base 100, right axis), GDP (base 100, right axis) since 1800

Reference: World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Our World in data, How much energy does the world consume? https://ourworldindata.org/energy-production-consumption (original data: Vaclav Smil (2017). Energy Transitions: Global and National Perspectives. & BP Statistical Review of World Energy)

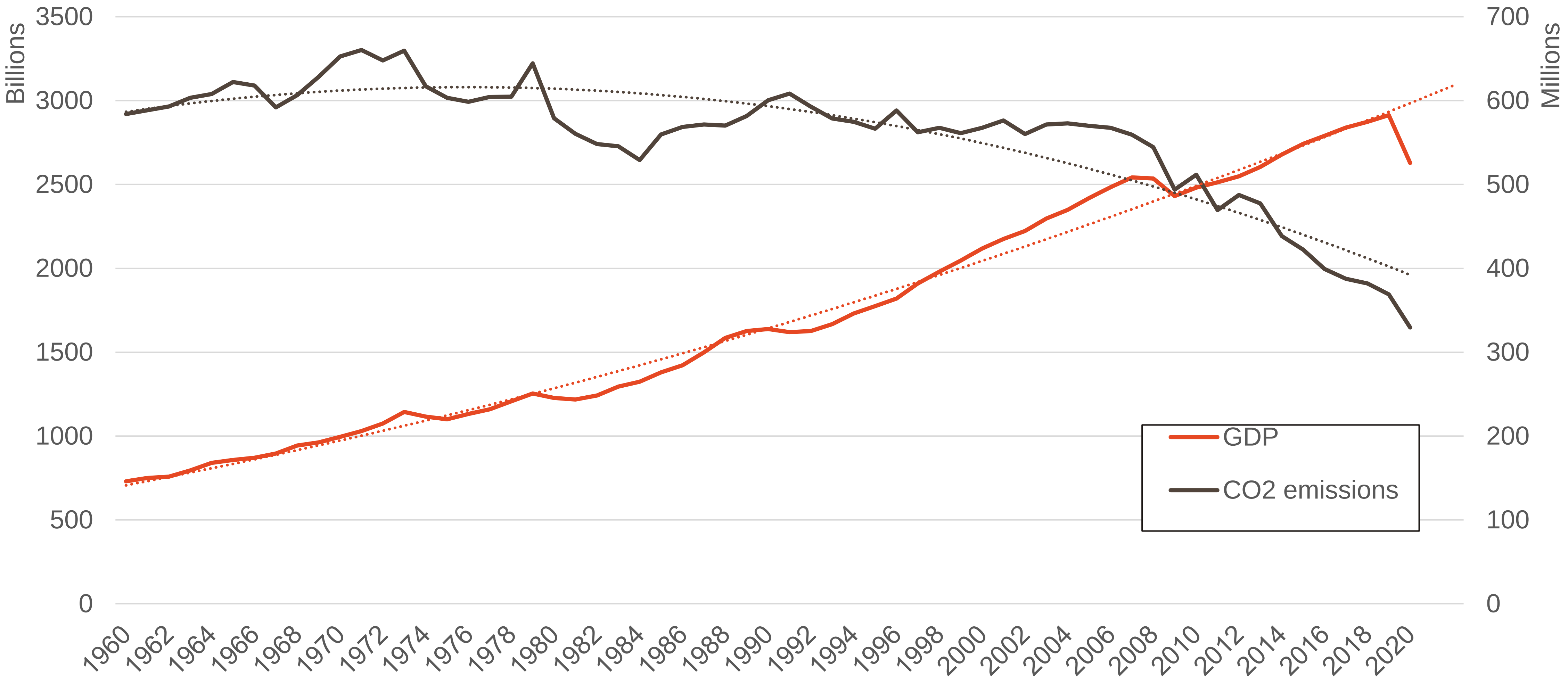
Decoupling proof at the global scale ?



Global GDP & CO_2 emissions since 1960: GDP displayed on primary axis Trillions $2010 (left axis), CO_2 are displayed on the secondary axis (right axis, Billions metric tons)

Reference: Jason Hickel (2021) What does degrowth mean? A few points of clarification, Globalizations, 18:7, 1105-1111, doi:10.1080/14747731.2020.1812222; World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Global Carbon Project 2021 (1.0) [Data set]: https://doi.org/10.18160/gcp-2021

Decoupling proof in the UK ?



GDP & CO_2 emissions in the UK since 1960: GDP displayed on primary axis Billions $2011, CO_2 are displayed on the secondary axis (Millions metric tons)

Reference: World Bank. global GDP in 2011 international-$: http://data.worldbank.org/indicator/NY.GDP.MKTP.PP.KD; Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm; Global Carbon Project 2021 (1.0) [Data set]: https://doi.org/10.18160/gcp-2021 ; *As defined by the OECD: What is green growth and how can it help deliver sustainable development?: https://www.oecd.org/greengrowth/whatisgreengrowthandhowcanithelpdeliversustainabledevelopment.htm

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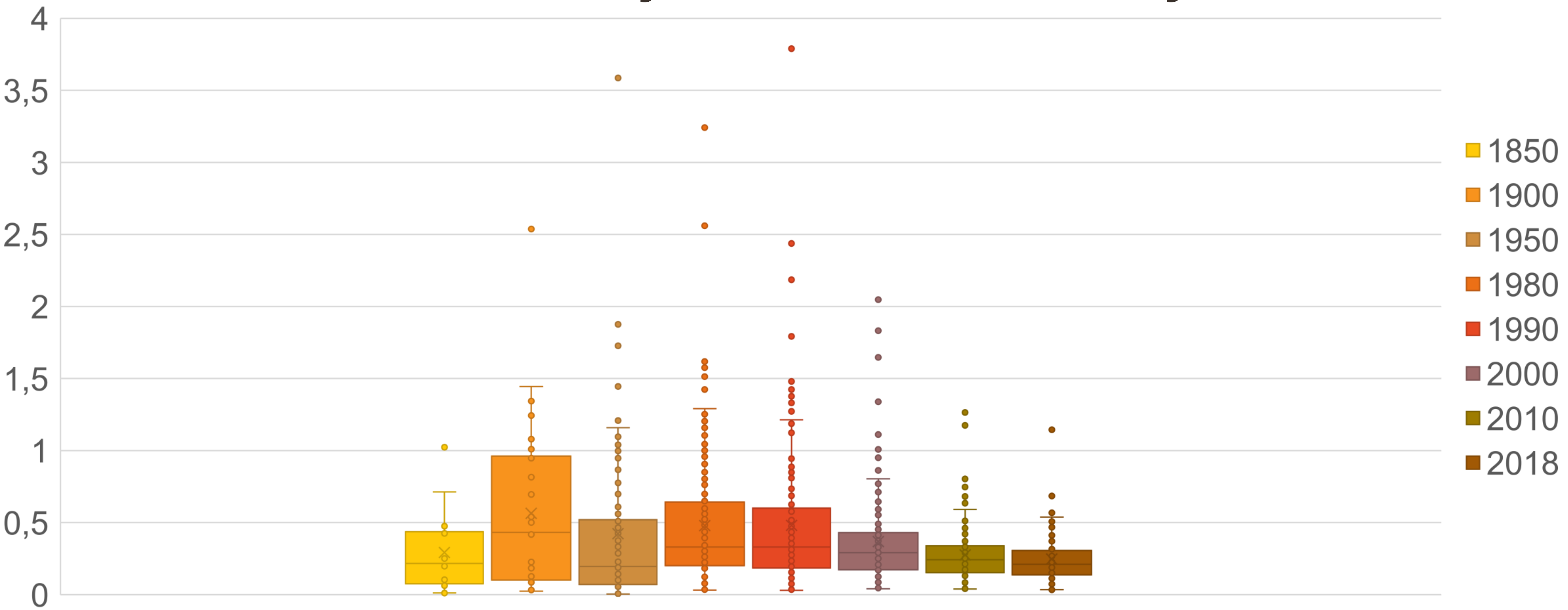
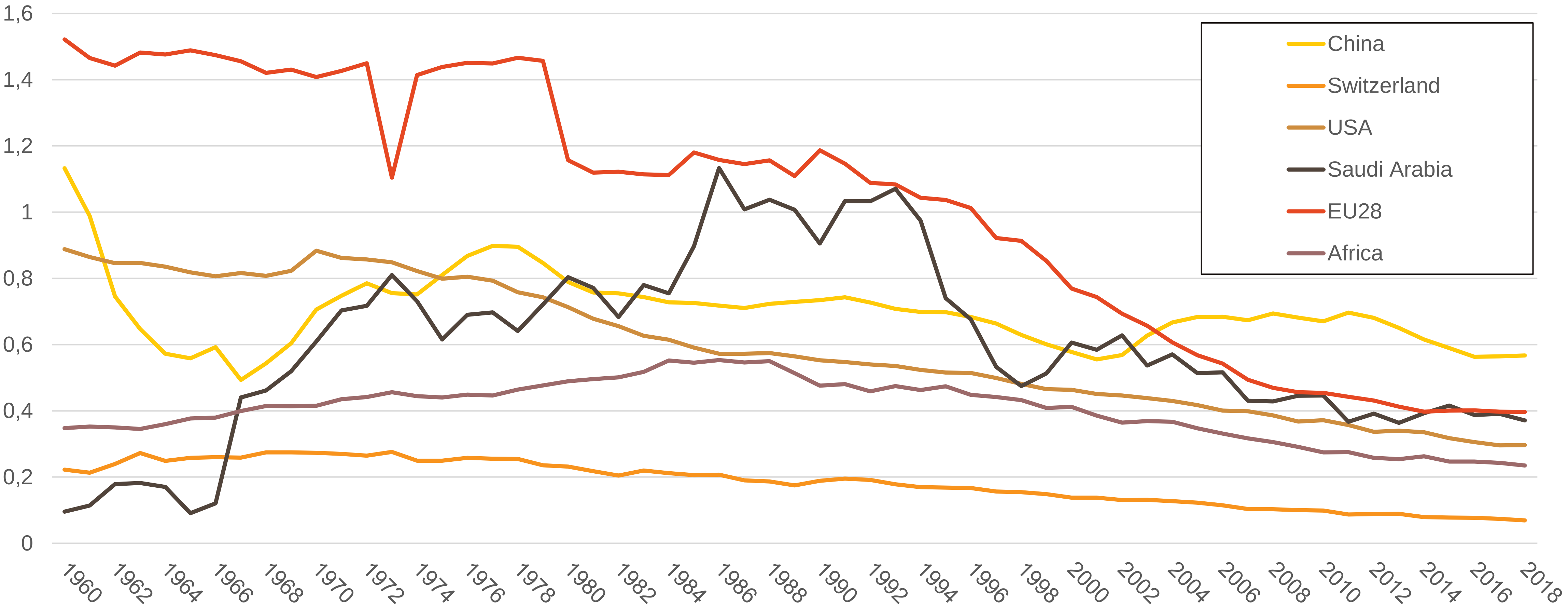
Carbon intensity of the Economy (historical)



Carbon intensity of the Economy (CI) since 1850: CI measures the CO_2 per $ of GDP in a given country in a given period of time.

Reference: Our World in Data based on the Global Carbon Project and Maddison Project Database 2020 (Bolt and van Zanden, 2020): OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/

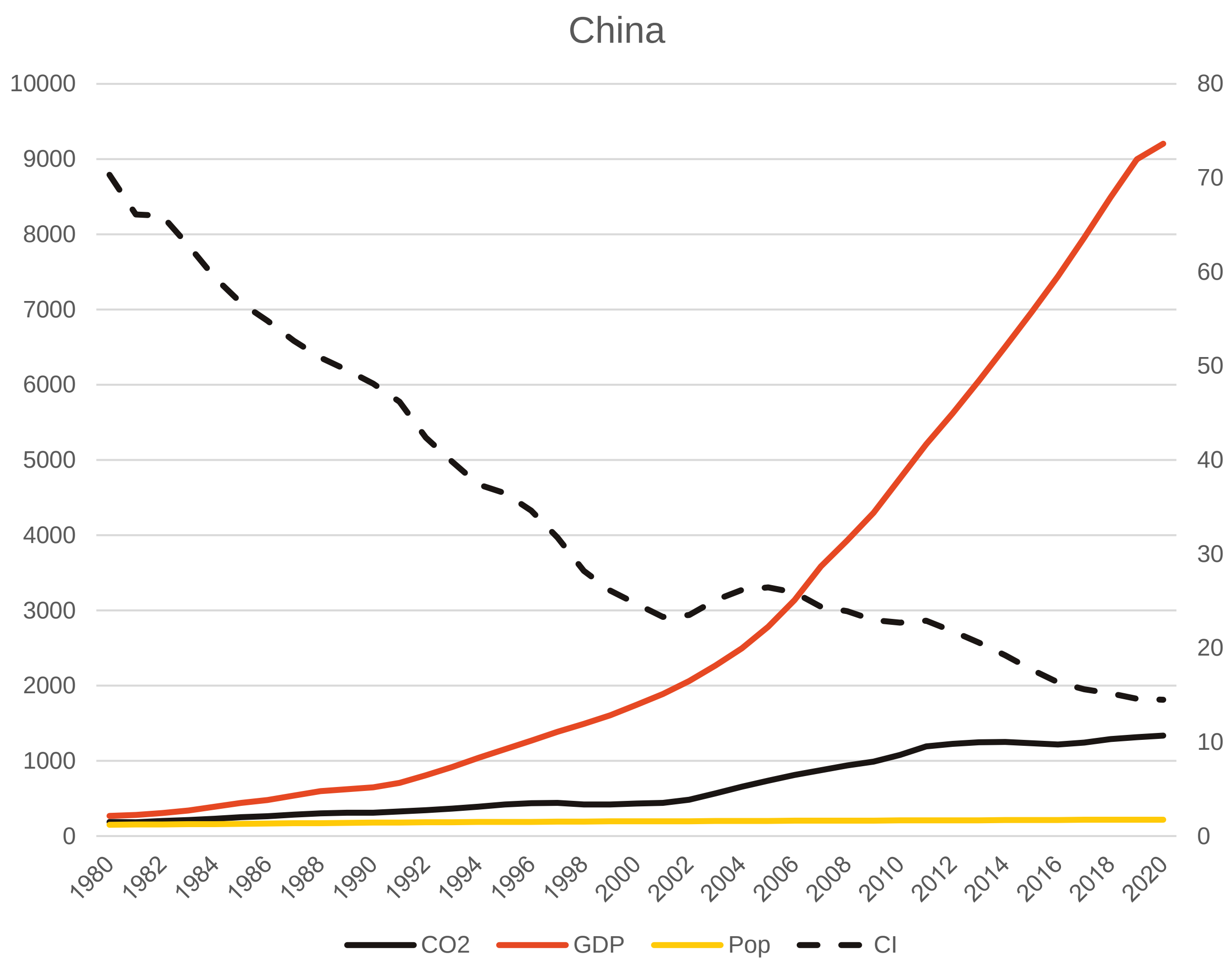
Carbon intensity per Country

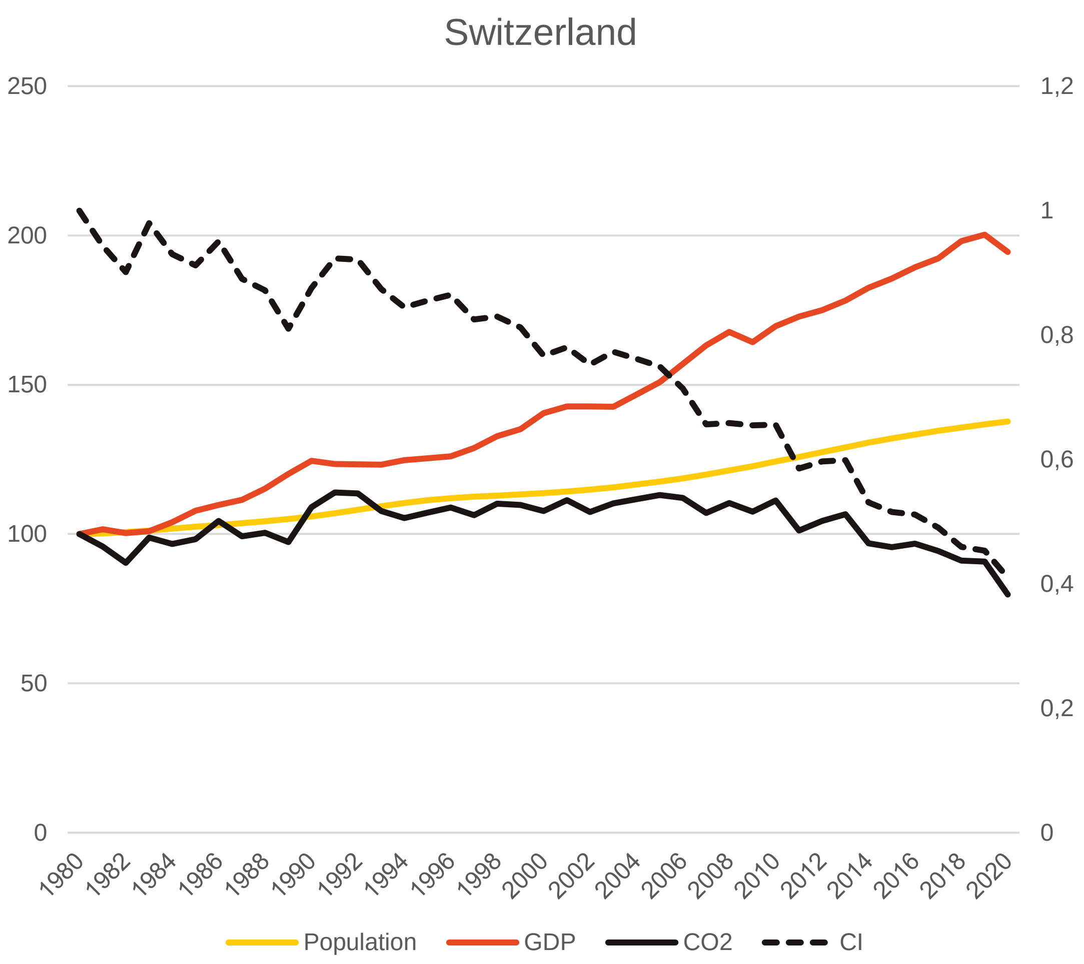


CI since 1960 (CO_2/$)

Reference: Our World in Data based on the Global Carbon Project and Maddison Project Database 2020 (Bolt and van Zanden, 2020): OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ •

Rebound effect

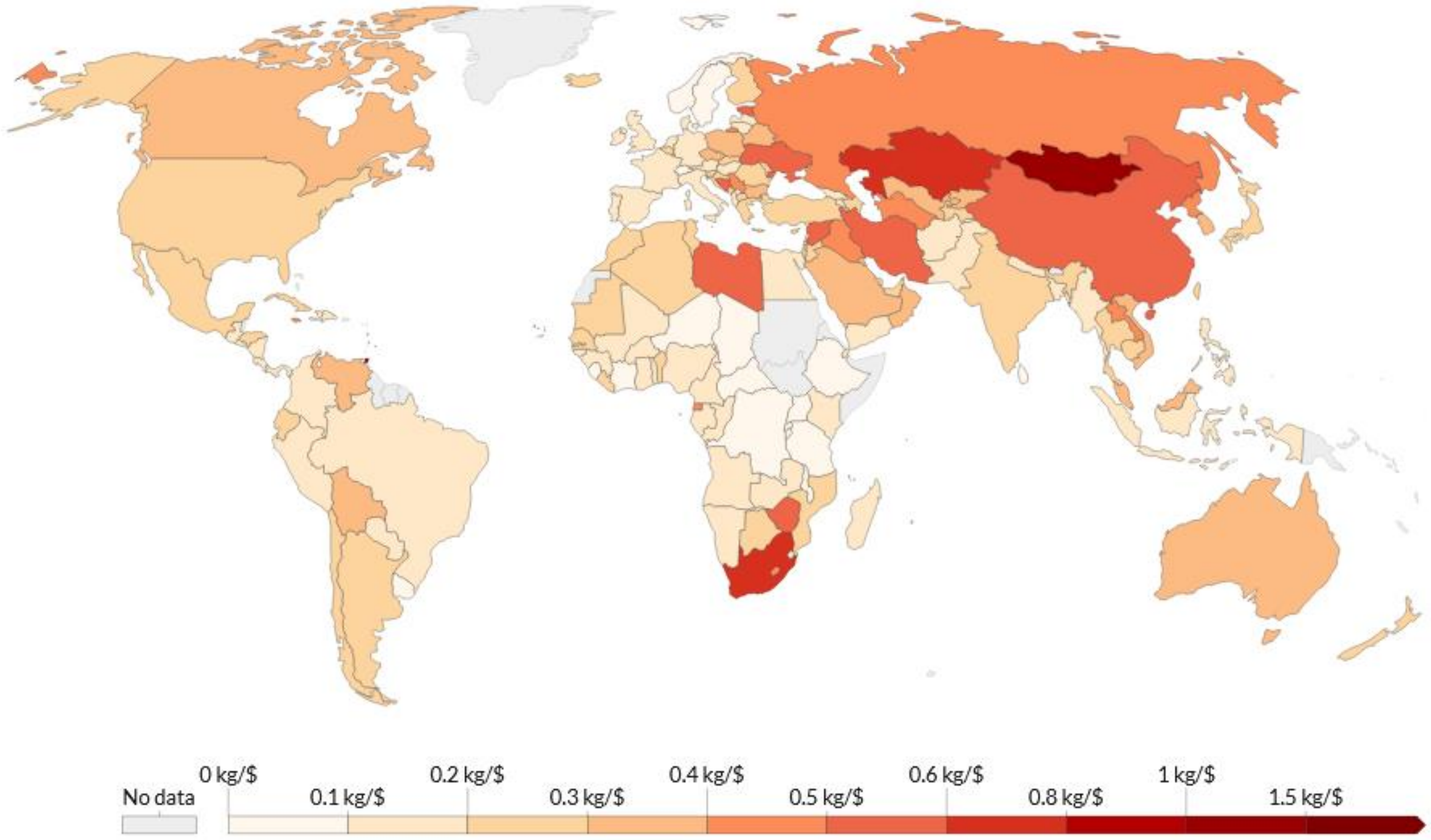




GDP, Population, CO2 and CI since 1980 (base 100)

Reference: Our World in Data based on the Global Carbon Project and Maddison Project Database 2020 (Bolt and van Zanden, 2020): OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

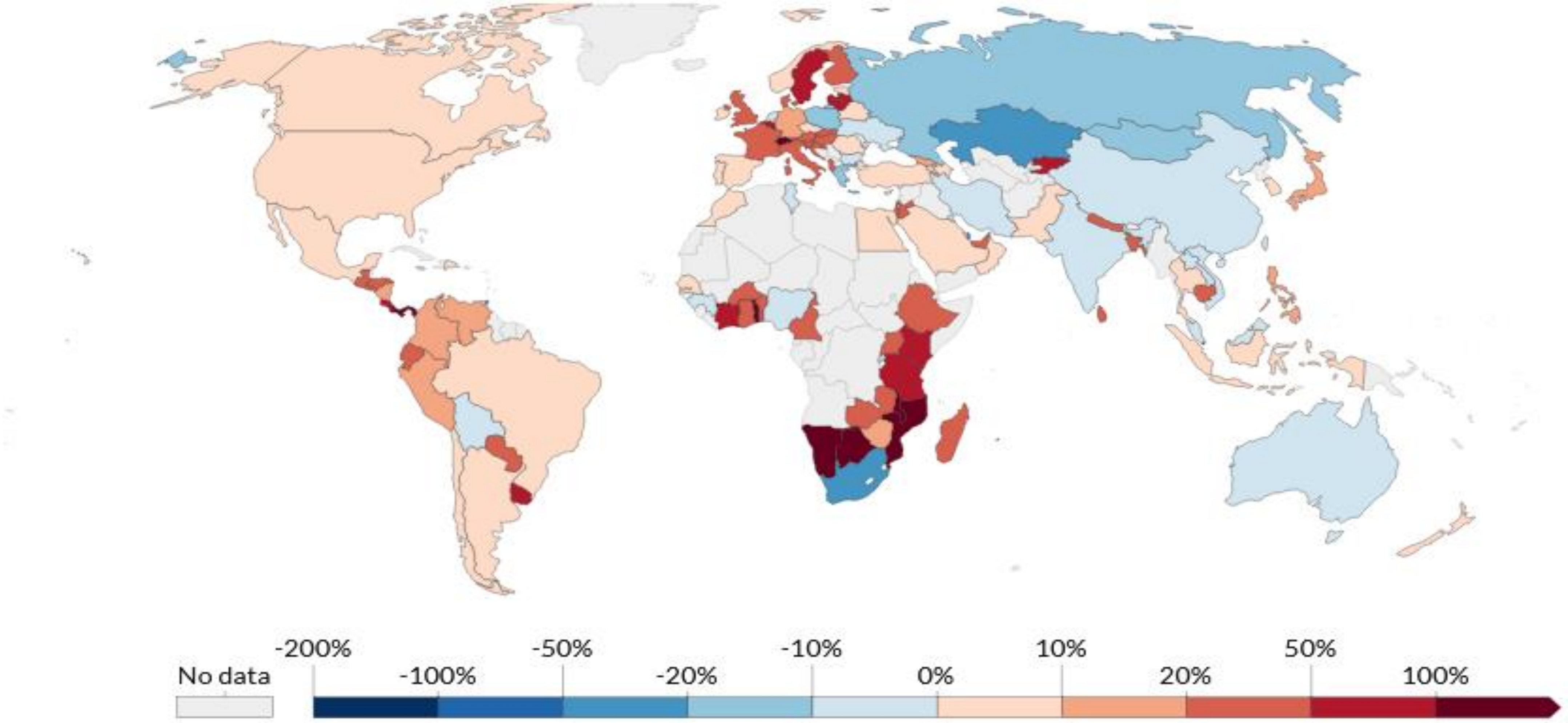
Carbon intensity of the Economy (current)



Map of the CI of the Economy (2018)

Reference: Our World in Data based on the Global Carbon Project and Maddison Project Database 2020 (Bolt and van Zanden, 2020): OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

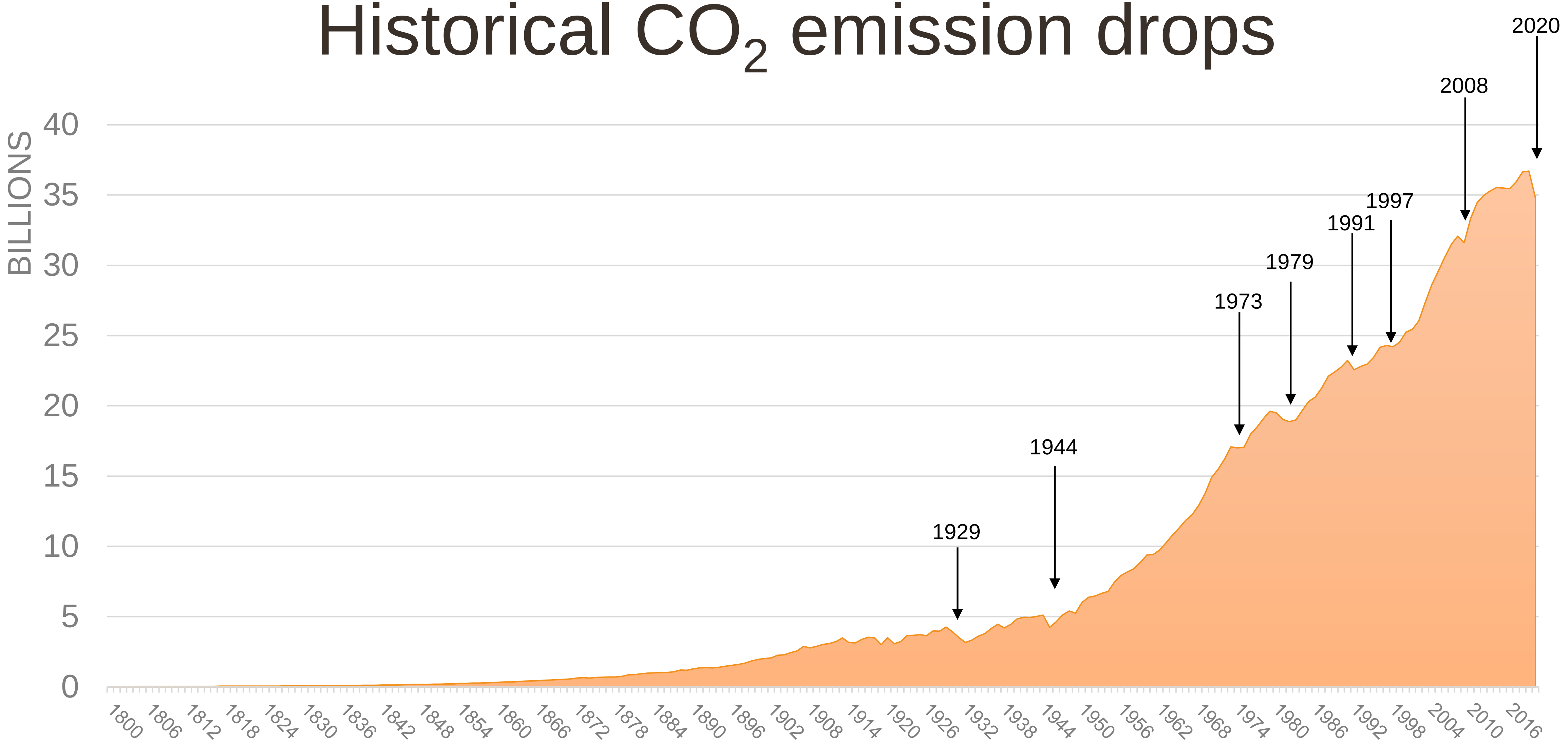
Carbon leakages



Map of the imported/exported CO_2 emissions (2018)

Reference: Our World in Data based on the Global Carbon Project and Maddison Project Database 2020 (Bolt and van Zanden, 2020): OurWorldInData.org/co2-and-other-greenhouse-gas-emissions/ • CC BY

Historical CO_2 emission drops



Key dates: Recessions or other economic shocks often caused the decrease in environmental impacts; this is not decoupling

Reference: Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm

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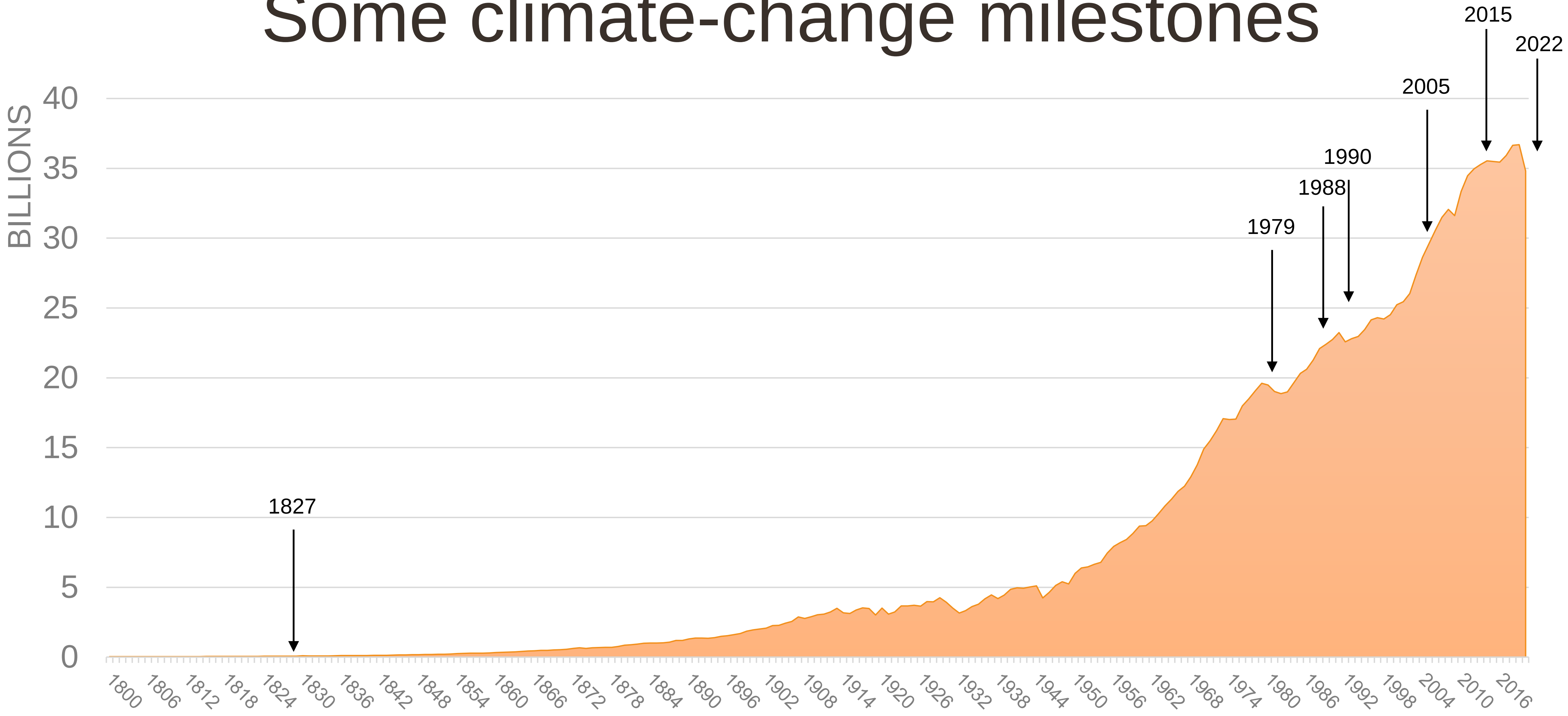
Some climate-change milestones



Reference: Maddison data. The Maddison data is published here: http://www.ggdc.net/maddison/oriindex.htm

Converging evidence on insufficient decoupling

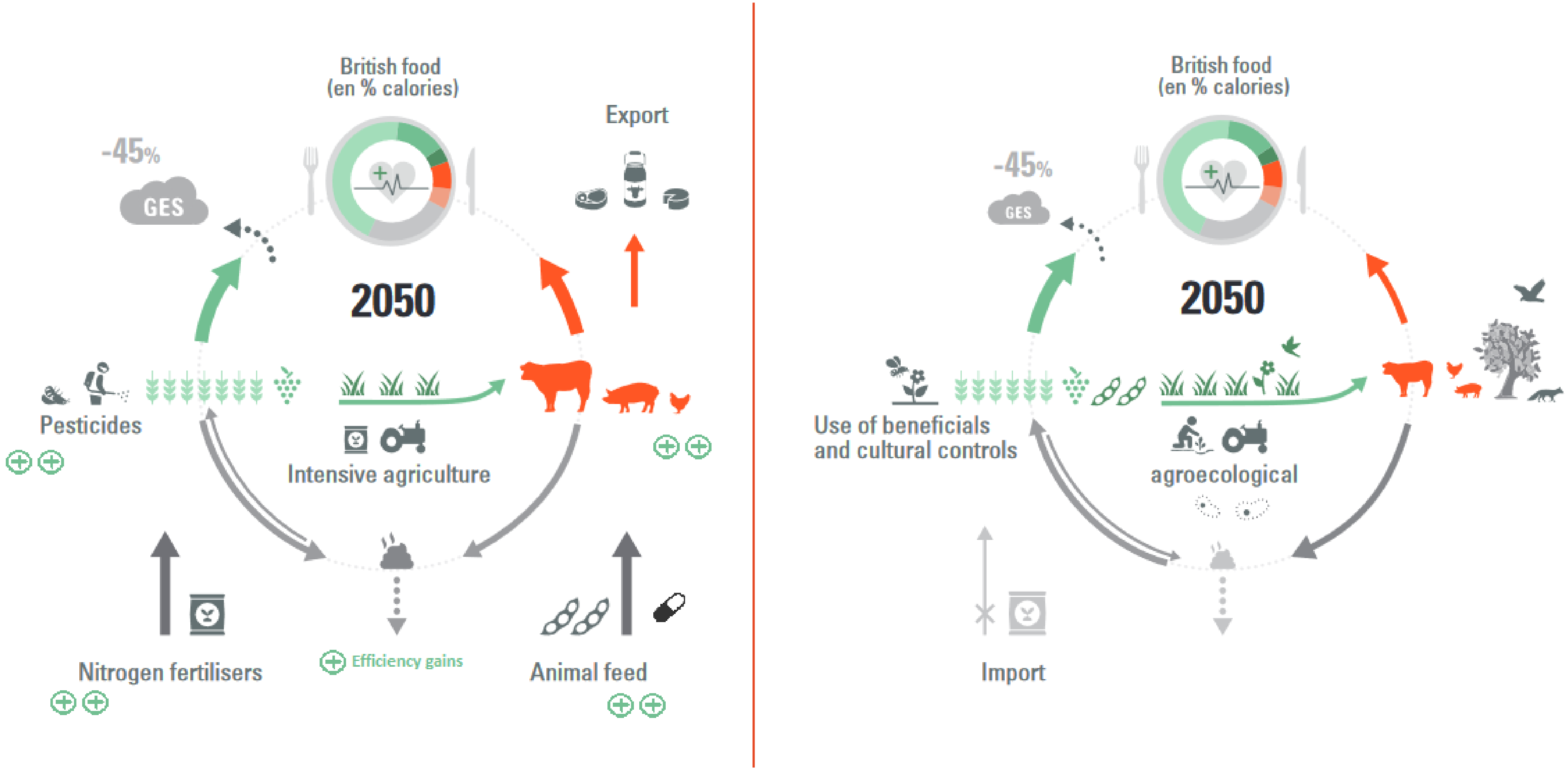
- A survey* of 835 peer-reviewed articles that test decoupling of primary or useful energy, CO_2 or greenhouse gas emissions, at global or national level, production or consumption-based
- It concludes that large rapid absolute reductions of resource use and greenhouse gas emissions cannot be achieved with the observed decoupling rates
- Hence decoupling needs to be complemented by sufficiency-oriented strategies and strict enforcement of absolute reduction targets

*Haberl, H. et al (2020). "A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights." Environmental Research Letters 15:065003

LIMITS TO (GREEN) GROWTH ?

Limits to efficiency

UK food and agriculture system by 2050



Sustainable intensification vs Agroecology (illustrative figure)

Reference/Figure adapted/extracted from: Poux, X., Schiavo, M. & Aubert, P.-M. Modelling an agroecological UK in 2050 – findings from TYFAREGIO. (2021);

Sustainable Intensification
(Climate Change Committee - UK 6th Carbon Budget)

Balanced pathway main assumptions

- Low-carbon farming practices and energy use: 50-75% deployment (e.g. cover crops, high sugar grasses and livestock health) and innovation (e.g. 3NOP, breeding and anaerobic digestion)
- Machinery: Biofuels and electrification options are taken-up from the mid-2020s and hydrogen fuel cells for larger applications from 2030 for mobile machinery. Building heating and cooling systems switch to low-carbon alternatives including heat pumps and hydrogen, with use of biomass phased-out by 2035.
- Agricultural productivity: Average crop yields increase to 11 tonnes/hectare by 2050 (wheat), driven by improvements in agronomy / Livestock stocking rates on lowland grassland increase by 10%. 10% of current horticultural production is moved indoors by 2050.
- Consumer behaviour change: There is a 35% shift away from all meat and dairy products by 2050. WRAP's UK Food Waste Reduction by 60% reduction by 2050
- Afforestation : Woodland area increases to 18% of UK land area by 2050 (about +1,2Mha)
- Bioenergy: 0,7Mha bioenergy crops by 2050

Reference: UK Climate Change Committee, The Sixth Carbon Budget - Agriculture and land use, land use change and forestry, 2020

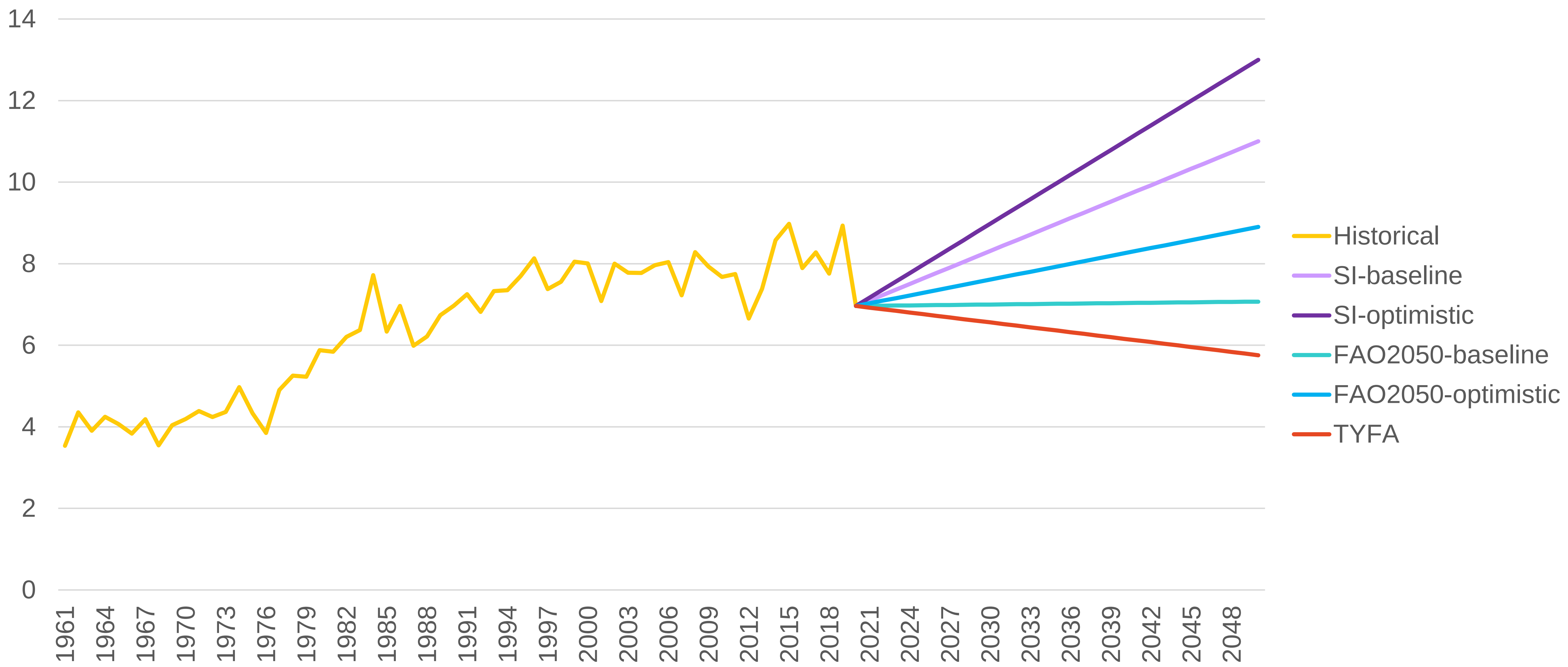
Agroecology
Ten Years For Agroecology (TYFA, IDDRI)

Main assumptions

- Low-carbon farming practices : phasing out pesticides and other synthetic fertilizers substituted by crop rotation, legumes covers, no-tillage, etc.
- Machinery: unchanged
- Agricultural productivity: Average crop yields decrease by 2050 (-45 to -15% compared with 2010).
- Consumer behaviour change: There is about 50% shift away from all meat and dairy products by 2050. Food waste reduction by 20% reduction by 2050
- Afforestation : Woodland area increases up to 1,1Mha by 2050
- Bioenergy: Phase out of biofuels
- Self-sufficiency: wide increase of self-sufficiency (e.g. from 49% to 129% for oilseeds, 81% to 124% Bee, etc.)

Reference: Poux, X. & Aubert, P.-M. An agroecological Europe in 2050: multifunctional agriculture for healthy eating. (2018); Poux, X., Schiavo, M. & Aubert, P.-M. Modelling an agroecological UK in 2050 – findings from TYFAREGIO. (2021); FAOSTAT: https://www.fao.org/faostat/en/#data.

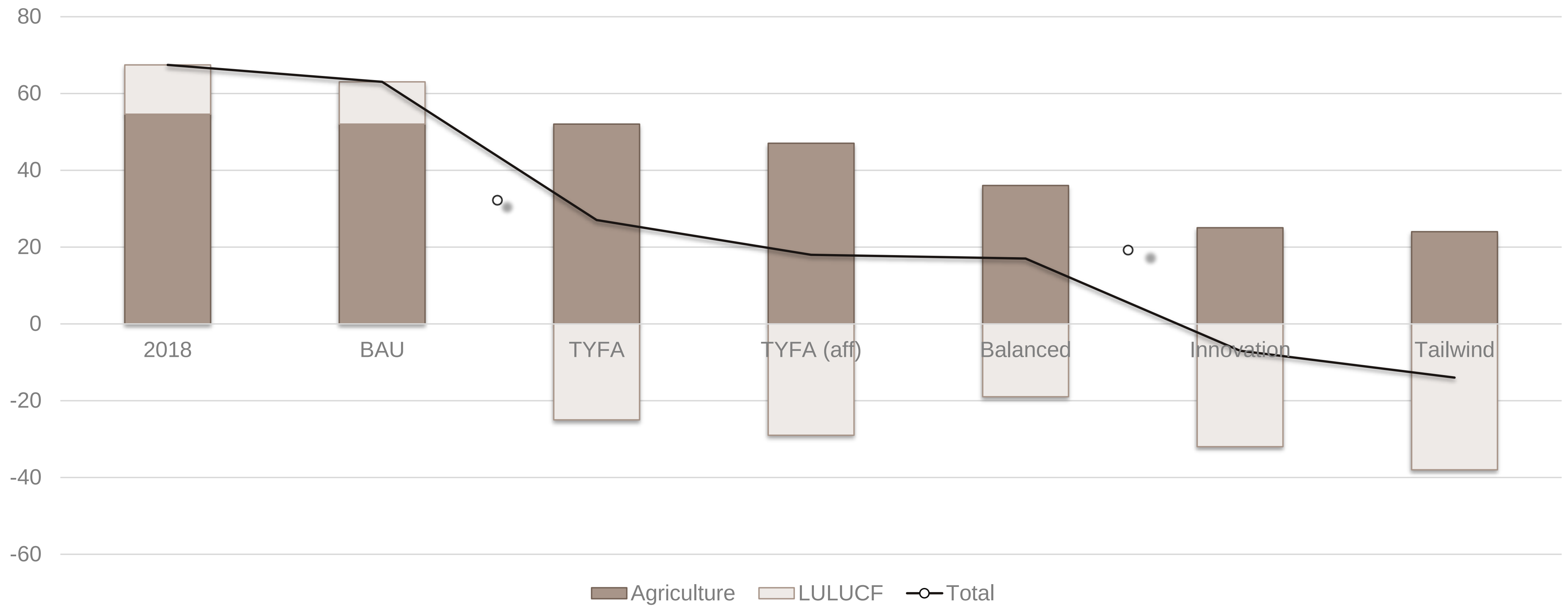
Yield assumptions focus



Wheat yields per scenario

Reference: UK Climate Change Committee, The Sixth Carbon Budget - Agriculture and land use, land use change and forestry, 2020; Poux, X. & Aubert, P.-M. An agroecological Europe in 2050: multifunctional agriculture for healthy eating. (2018); Poux, X., Schiavo, M. & Aubert, P.-M. Modelling an agroecological UK in 2050 – findings from TYFAREGIO. (2021); FAOSTAT: https://www.fao.org/faostat/en/#data.

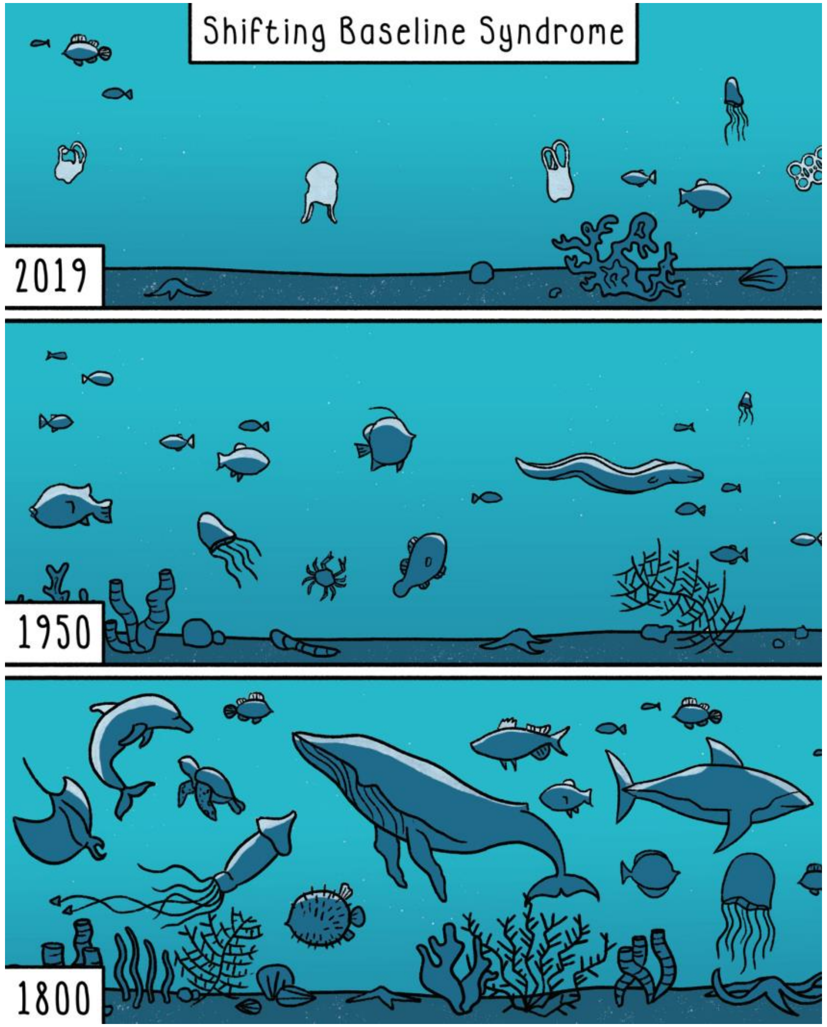
GHG balance



UK food and agriculture GHG emissions by 2050, a scenario comparison

Reference: UK Climate Change Committee, The Sixth Carbon Budget - Agriculture and land use, land use change and forestry, 2020; Poux, X. & Aubert, P.-M. An agroecological Europe in 2050: multifunctional agriculture for healthy eating. (2018); Poux, X., Schiavo, M. & Aubert, P.-M. Modelling an agroecological UK in 2050 – findings from TYFAREGIO. (2021);

Paradigm shift / Shifting baselines

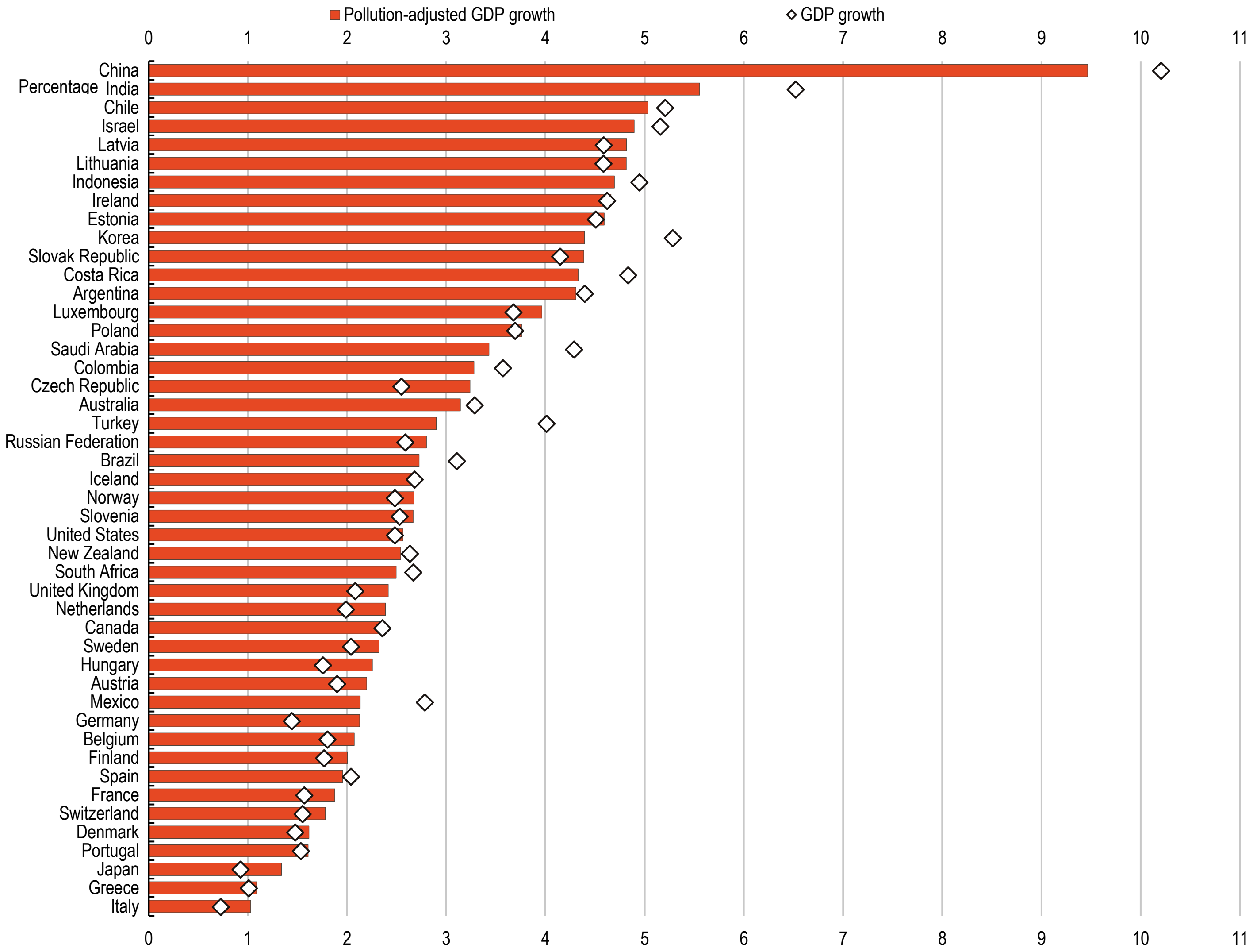


- 6th UK Carbon Budget: "The ability of *(…) agroecology farming measures to deliver deeper emissions reduction (…) and to deliver wider environmental benefits are not included in our scenarios due to the lack of robust evidence on the abatement potential*".
- Sustainable intensification is the dominant response to achieve net-zero paths by 2050, but according to Booth (2021), this techno-optimistic vision wrongly facilitates the move towards net zero paths and contributes to suppress the calls for a real transformative change.
- We change the world but we forget about it
- The reference level is continuously shifting and lowered, and previous losses are forgotten

BEYOND THE GDP

Some alternative indicators

Pollution adjusted GDP (by OECD)



Pollution adjusted GDP per country

Pollution adjusted GDP:

1. Labour contribution
2. Produced capital contribution
3. Natural capital contribution
4. EAMFP growth

Reference: OECD, Going for Growth 2018 - Going for greener growth - what can indicators tell us?, http://dx.doi.org/10.1787/888933680210

Green GDP (by OECD)

Set of 156 indicators including 4 main pillars

Environmental and resource productivity: "indicates whether economic growth is becoming more efficient through the use of natural capital.

The natural asset base: "indicates the risks to growth from a declining natural asset base;"

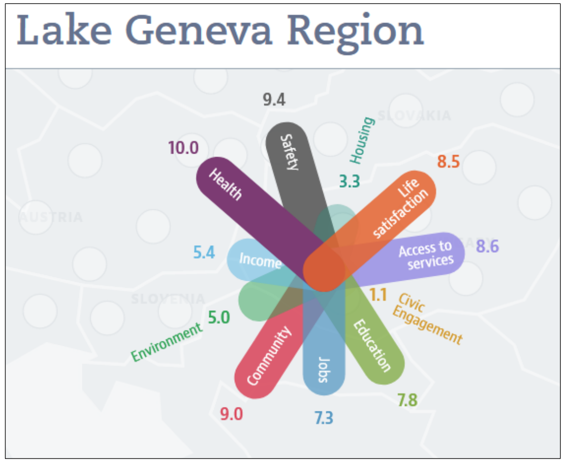
Environmental dimension of quality of life: "indicates how environmental conditions affect the quality of life and wellbeing of people;"

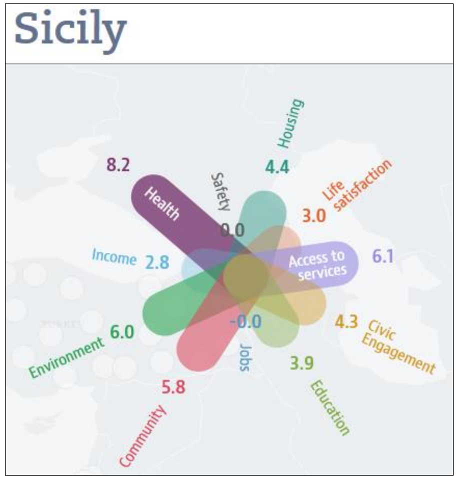
Economic opportunities and policy responses: "indicates the effectiveness of policies in delivering green growth and describes the societal responses needed to secure business and employment opportunities."

Reference: OECD, Green growth indicators, database: https://stats.oecd.org/Index.aspx?DataSetCode=GREEN_GROWTH

Regional well-being index (by OECD)

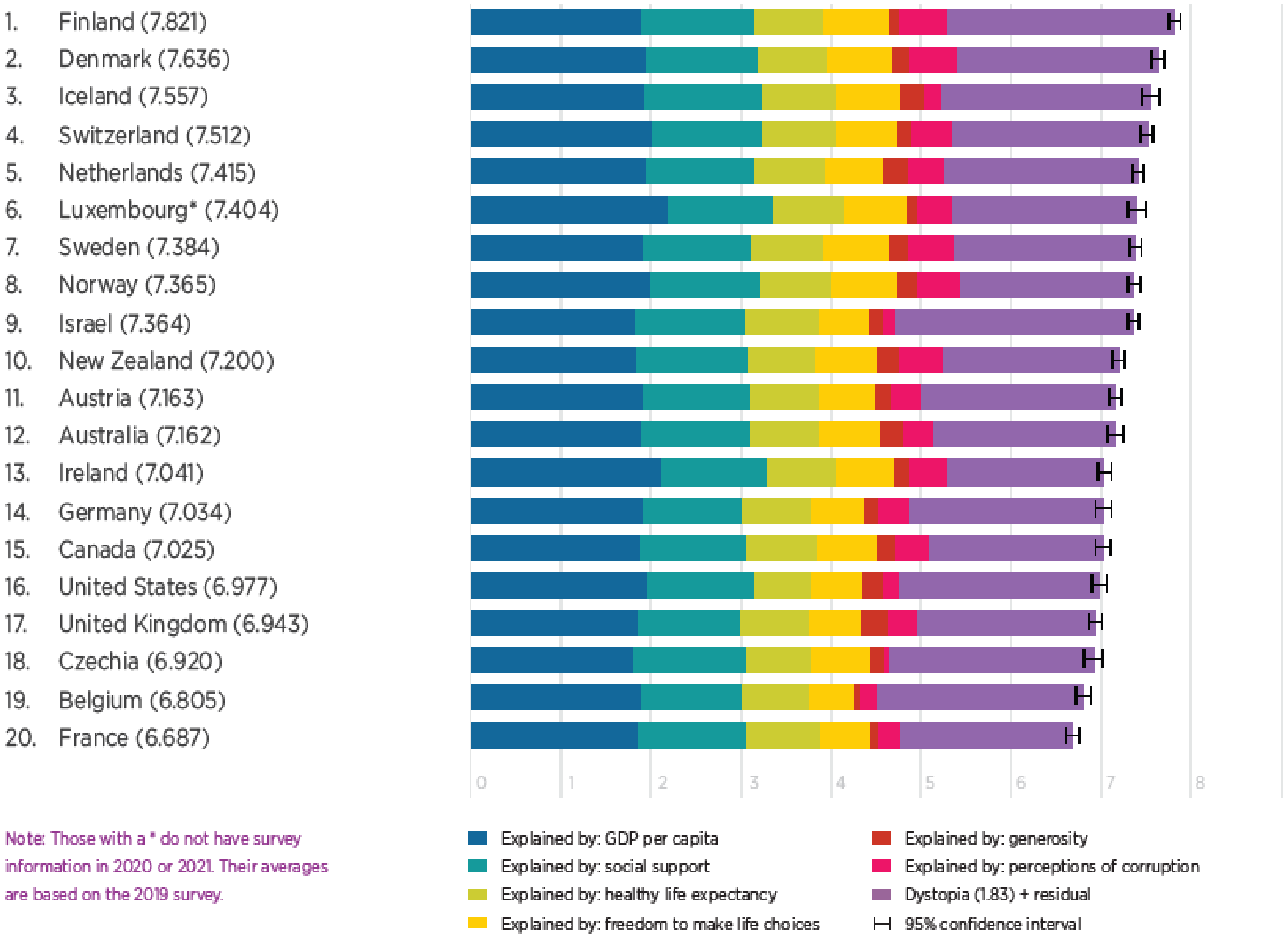
Indicators	Metrics
Income	Household disposable income per capita (in real USD PPP)
Jobs	Employment rate (%) & unemployment rate (%)
Housing	Number of rooms per person (ratio)
Health	Life expectancy at birth (years) & age adjusted mortality rate (per 1 000 people)
Education	Share of labour force with at least secondary education (%)
Environment	Estimated average exposure to air pollution in PM2.5 (µg/m³), based on satellite imagery data
Safety	Homicide rate (per 100 000 people)
Civic engagement	Voter turnout (%)
Accessibility of services	Share of households with broadband access (%)
Community	Percentage of people who have friends or relatives to rely on in case of need
Life satisfaction	Average self-evaluation of life satisfaction on a scale from 0 to 10





Reference: OECD, Regional well-being, database: https://www.oecdregionalwellbeing.org/index.html

Happiness index

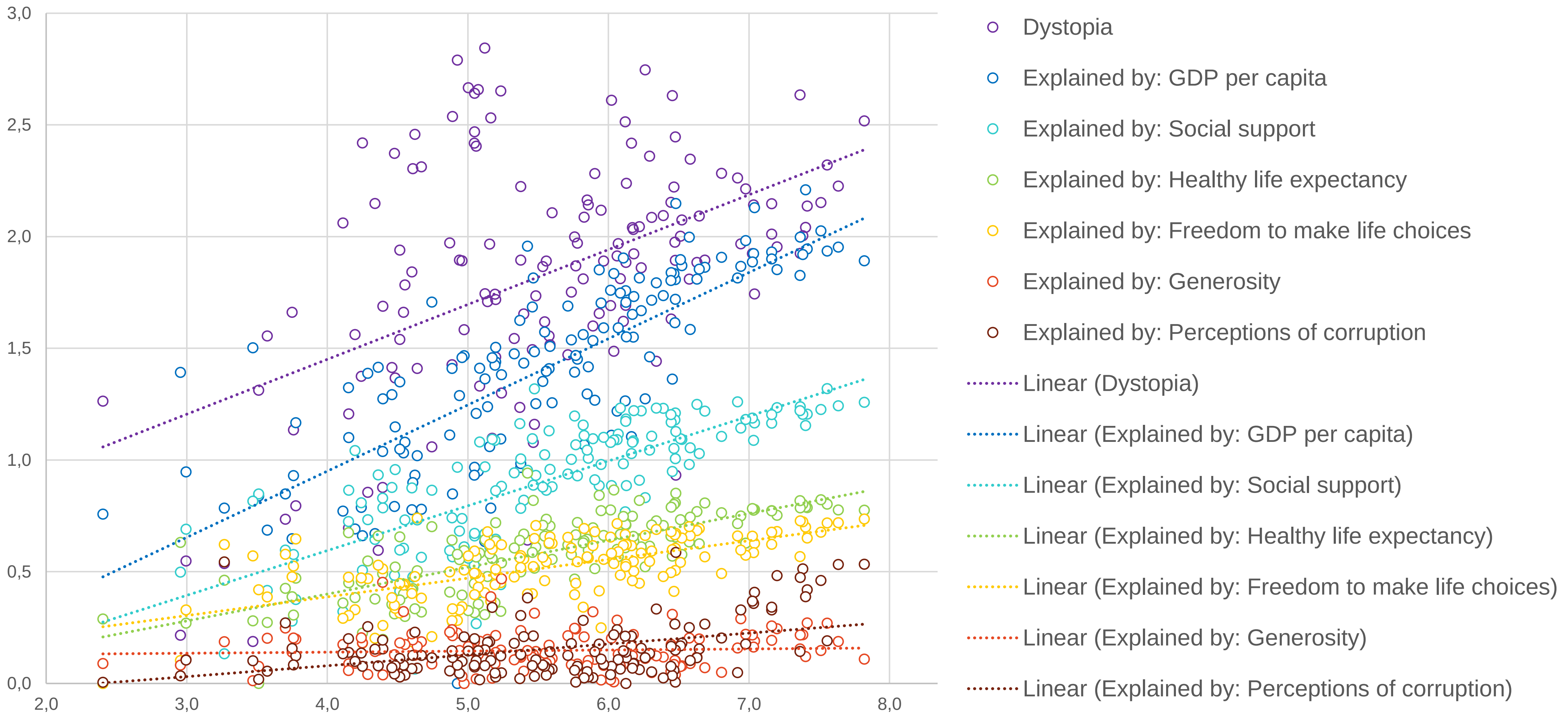


Note: Those with a * do not have survey information in 2020 or 2021. Their averages are based on the 2019 survey.

Happiness index per country and per source

Reference: Helliwell, J. F., Layard, R., Sachs, J. D., De Neve, J.-E., Aknin, L. B., & Wang, S. (Eds.). (2022). World Happiness Report 2022. New York: Sustainable Development Solutions Network.

Happiness Score per source



Estimated GDP over the last millennia (2011$):

Reference: Helliwell, J. F., Layard, R., Sachs, J. D., De Neve, J.-E., Aknin, L. B., & Wang, S. (Eds.). (2022). World Happiness Report 2022. New York: Sustainable Development Solutions Network.

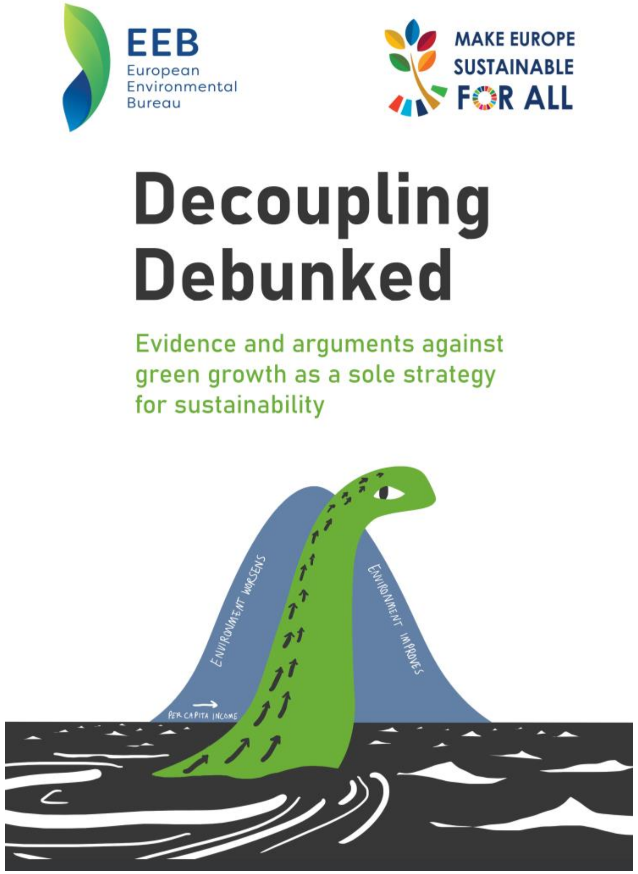
CONCLUSION

Some literature

Lessons learned

- Absolute decoupling would be nice: continued economic growth within the planetary boundaries (green growth)
- It is extremely difficult to obtain enough efficiency improvement and resource substitution to offset economic and population growth and reduce environmental impacts
- There is evidence of decoupling … but only in some sectors or countries, often with offsetting increases in environmental impacts in other sectors or countries, and almost never to the extent needed to preserve resources

Conclusion



Go for decoupling, but do not count on it to save the planet → the myth of economic growth needs to be addressed

Parrique T., Barth J., Briens F., C. Kerschner, Kraus-Polk A., Kuokkanen A., Spangenberg J.H., 2019. Decoupling debunked: Evidence and arguments against green growth as a sole strategy for sustainability. European Environmental Bureau, eeb.org/decoupling-debunked

Some reading suggestions

- Less is More: How Degrowth Will Save the World, Jason Hickel (2020)
- Comment tout peut s'effondrer, Pablo Servigne & Raphaël Stevens (2015)
- Limits to Growth, 30-year Update, Meadows et al. (2013)
- Climate wars, Harald Welzer (2012)
- Collapse: How Societies Choose to Fail or Succeed: Revised Edition, Jared Diamond (2011)

Etc.