Understanding and Preventing Climate Breakdown

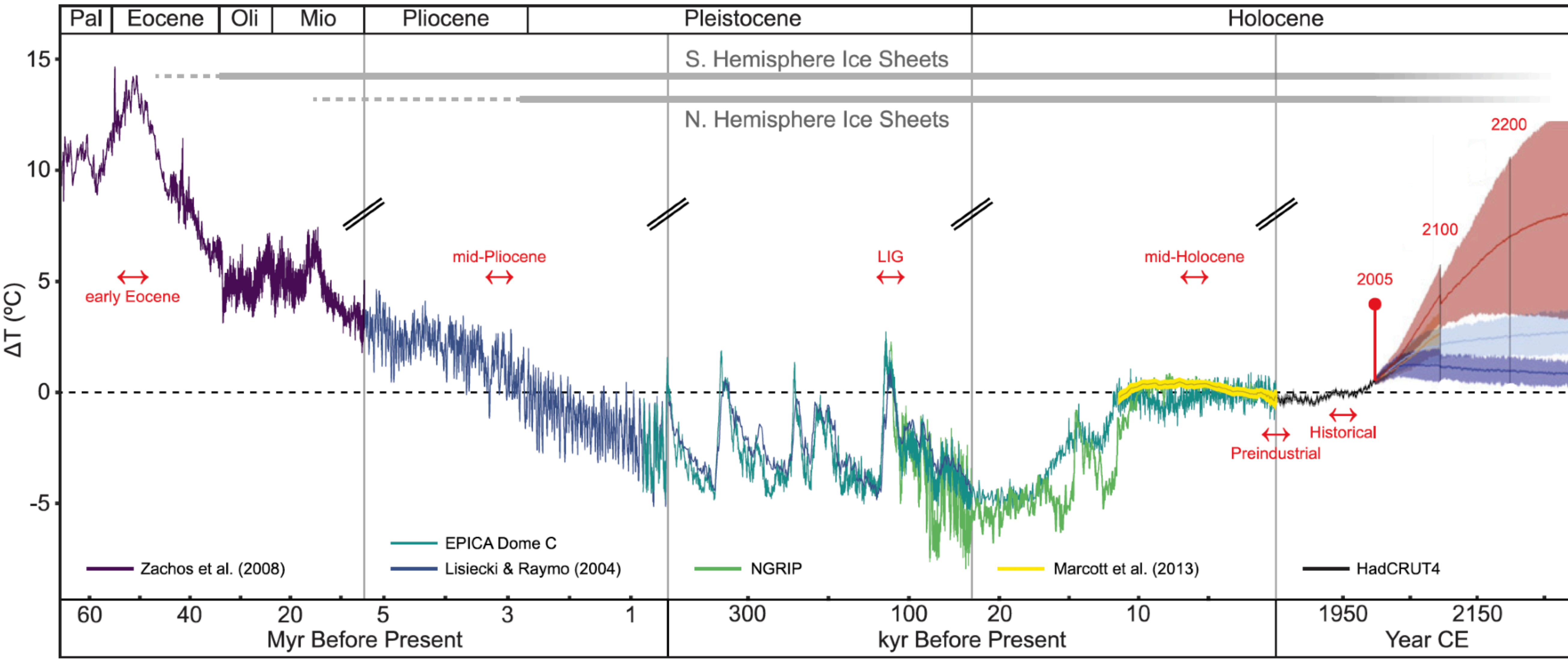
Fabian Dablander, PhD Candidate
Department of Psychological Methods, University of Amsterdam
CorrelAid Netherlands

27th November, 2021

Outline

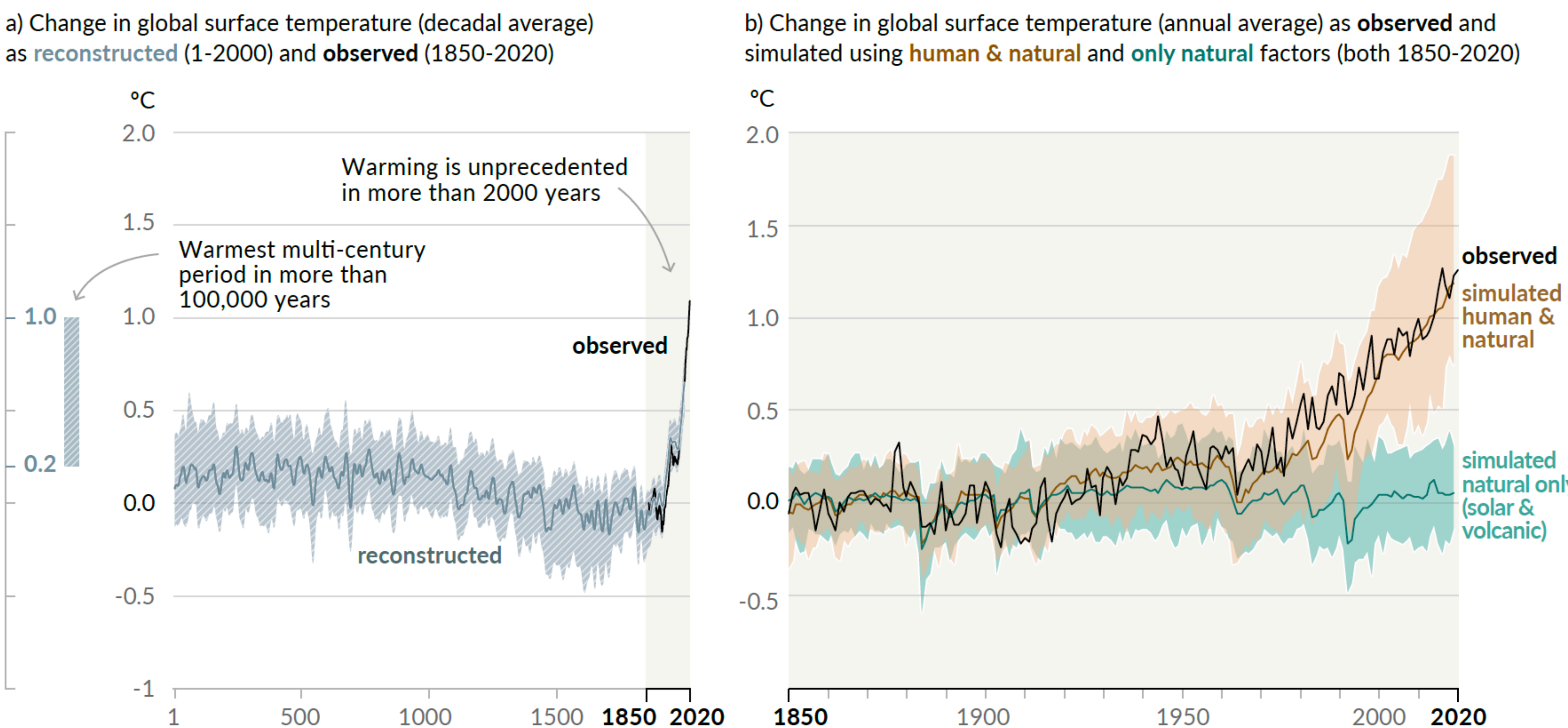
Part I:	The Bigger Picture	30 min
Part II:	Climate Impacts Today & Tomorrow	
Part III:	Why Have We Failed So Far?	30 min
Part IV:	What Can We Do Today?	
Part V:	Climate Action with En-ROADS	15 min

Part I:
The Bigger Picture



Burke et al. (2018); Brannen (2021); United Nations (2021)

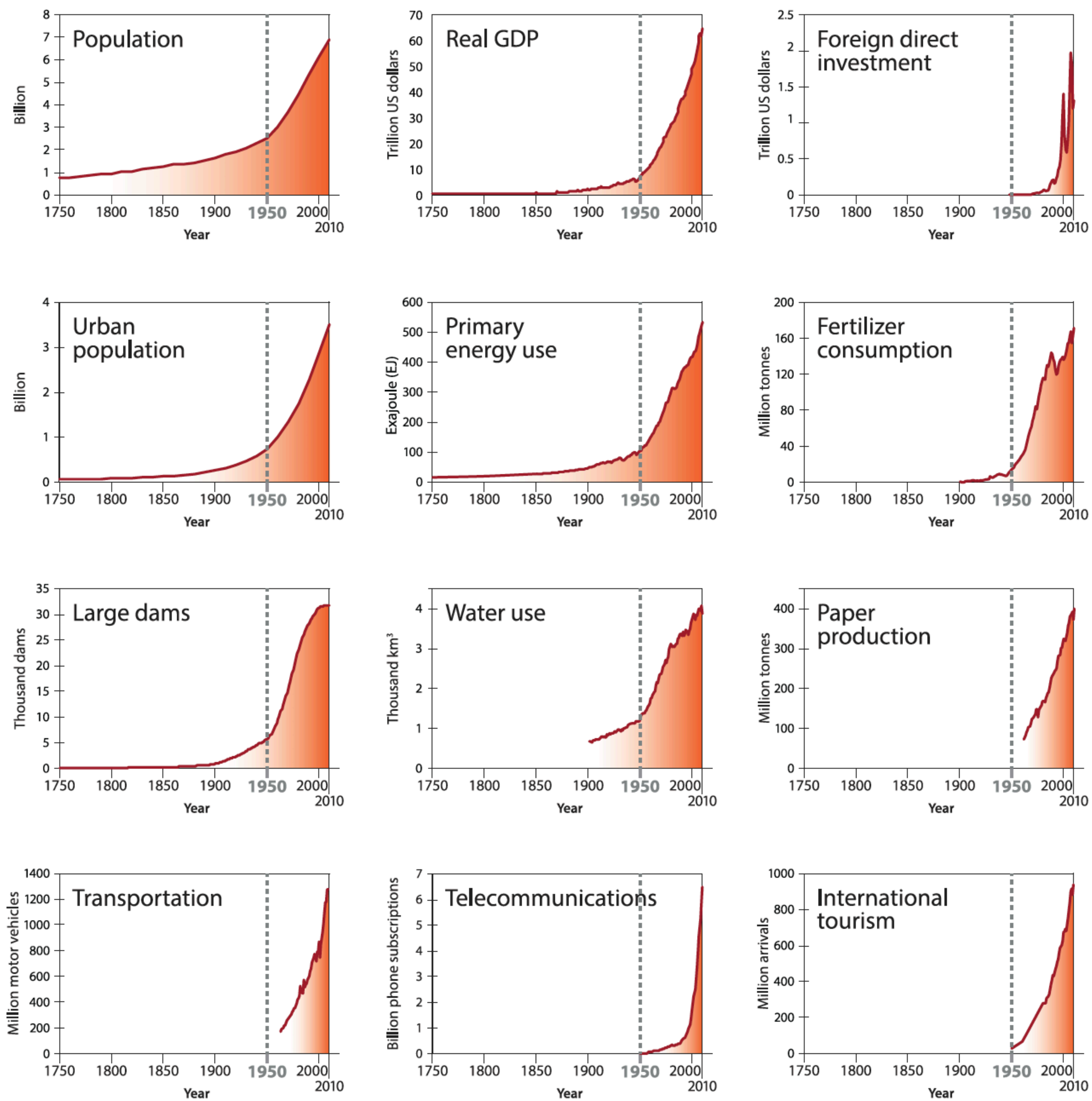
Changes in global surface temperature relative to 1850-1900



IPCC AR6 WGI SPM; Hausfather (2017)

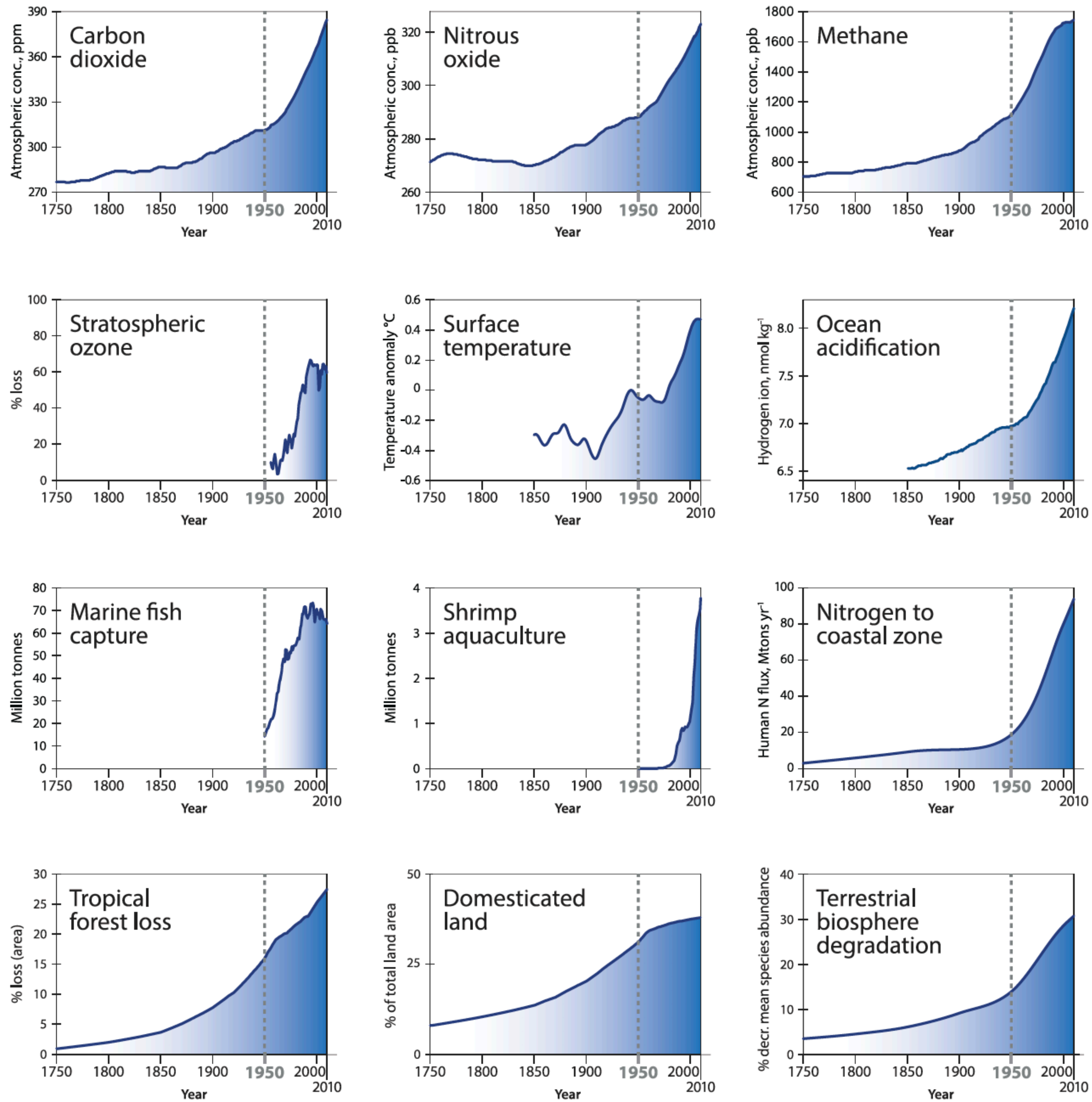
Evidence

Socio-economic trends

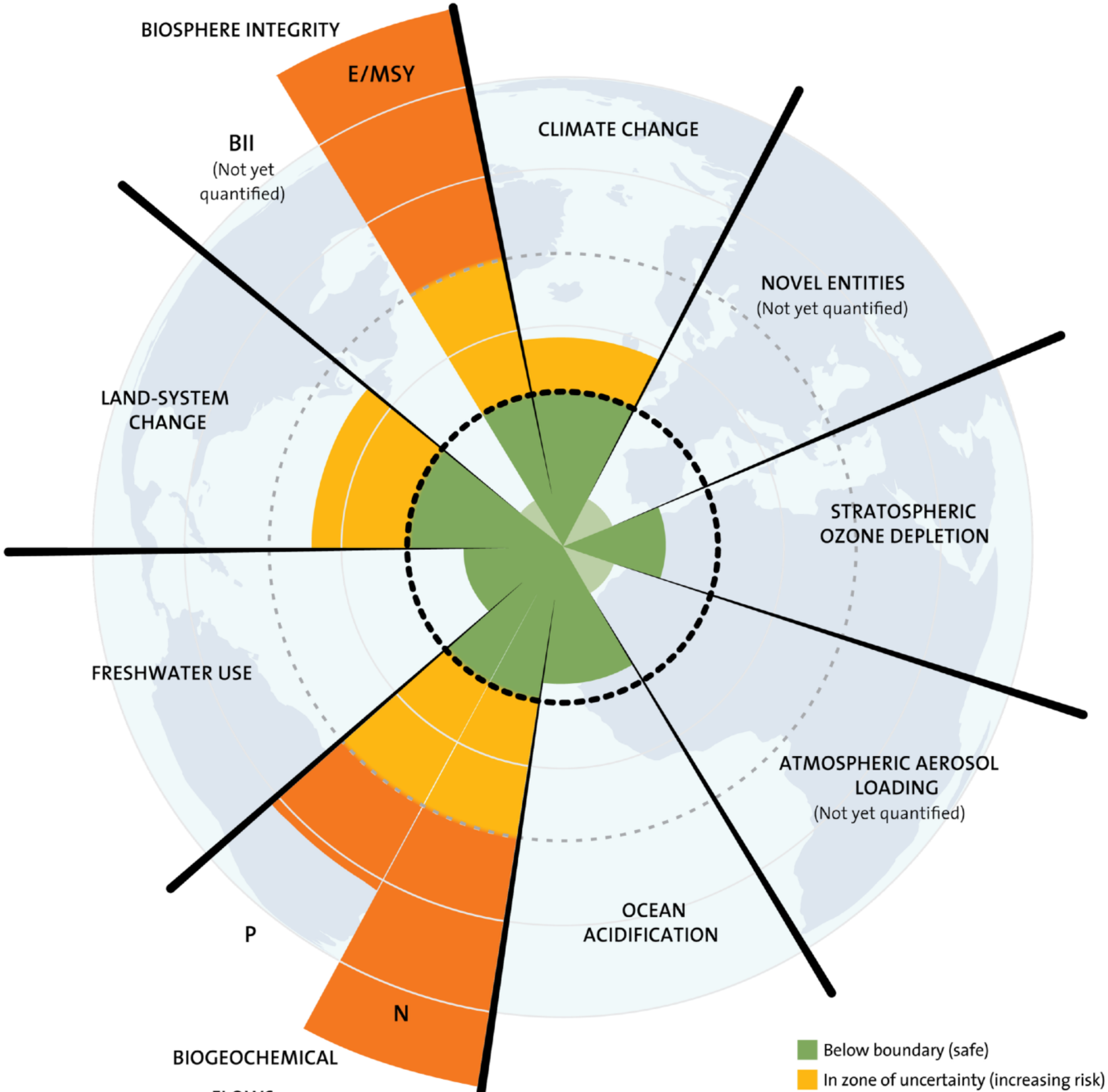


Steffen et al. (2015)

Earth system trends



Steffen et al. (2015)

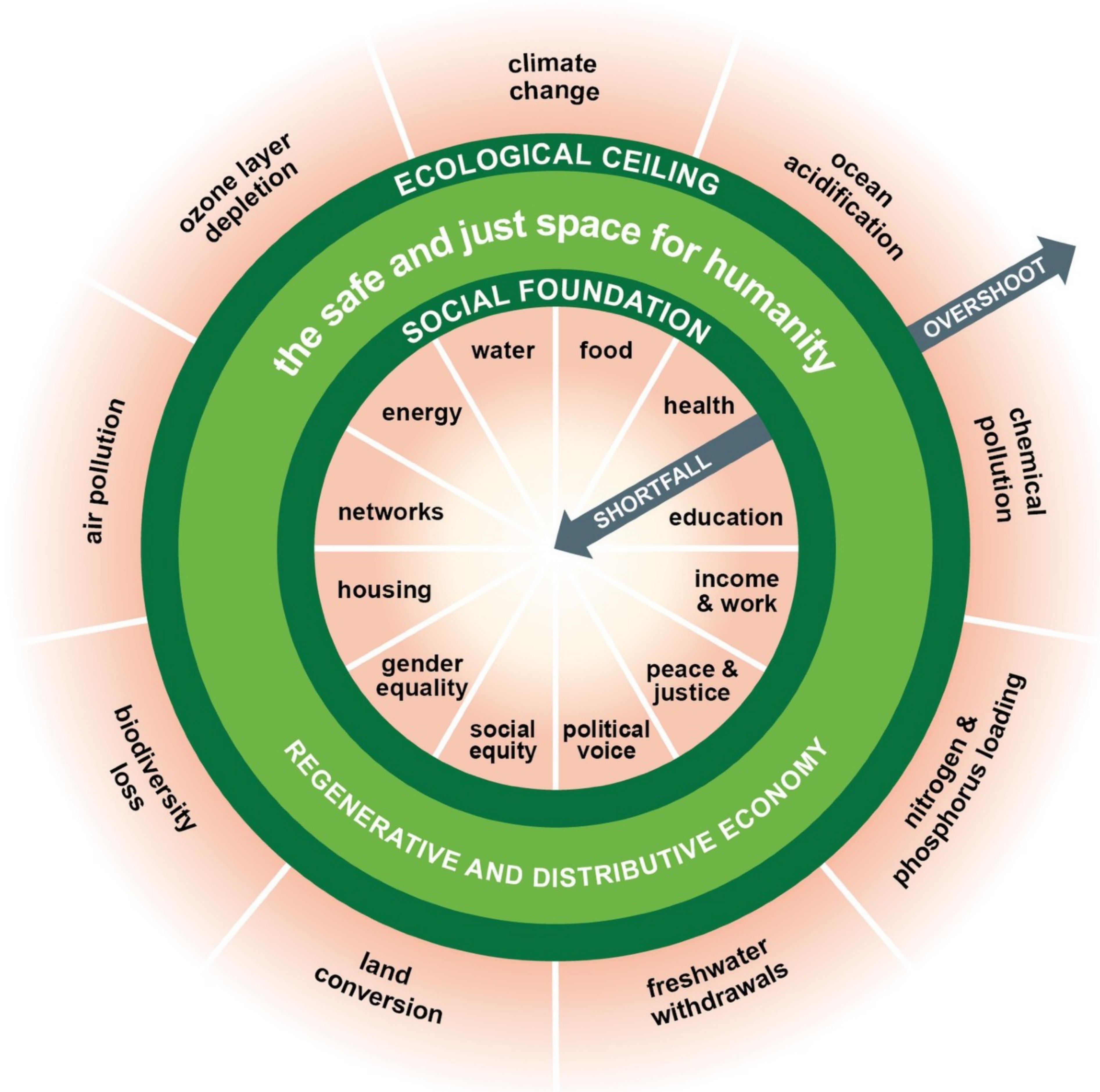


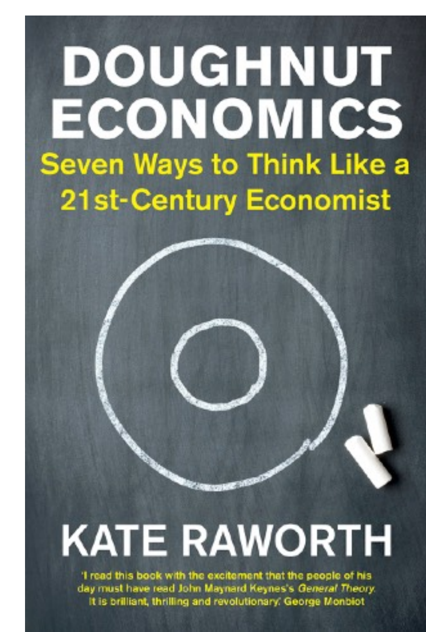
Rockström et al. (2009a,b); Steffen et al. (2015)

Breaking Boundaries

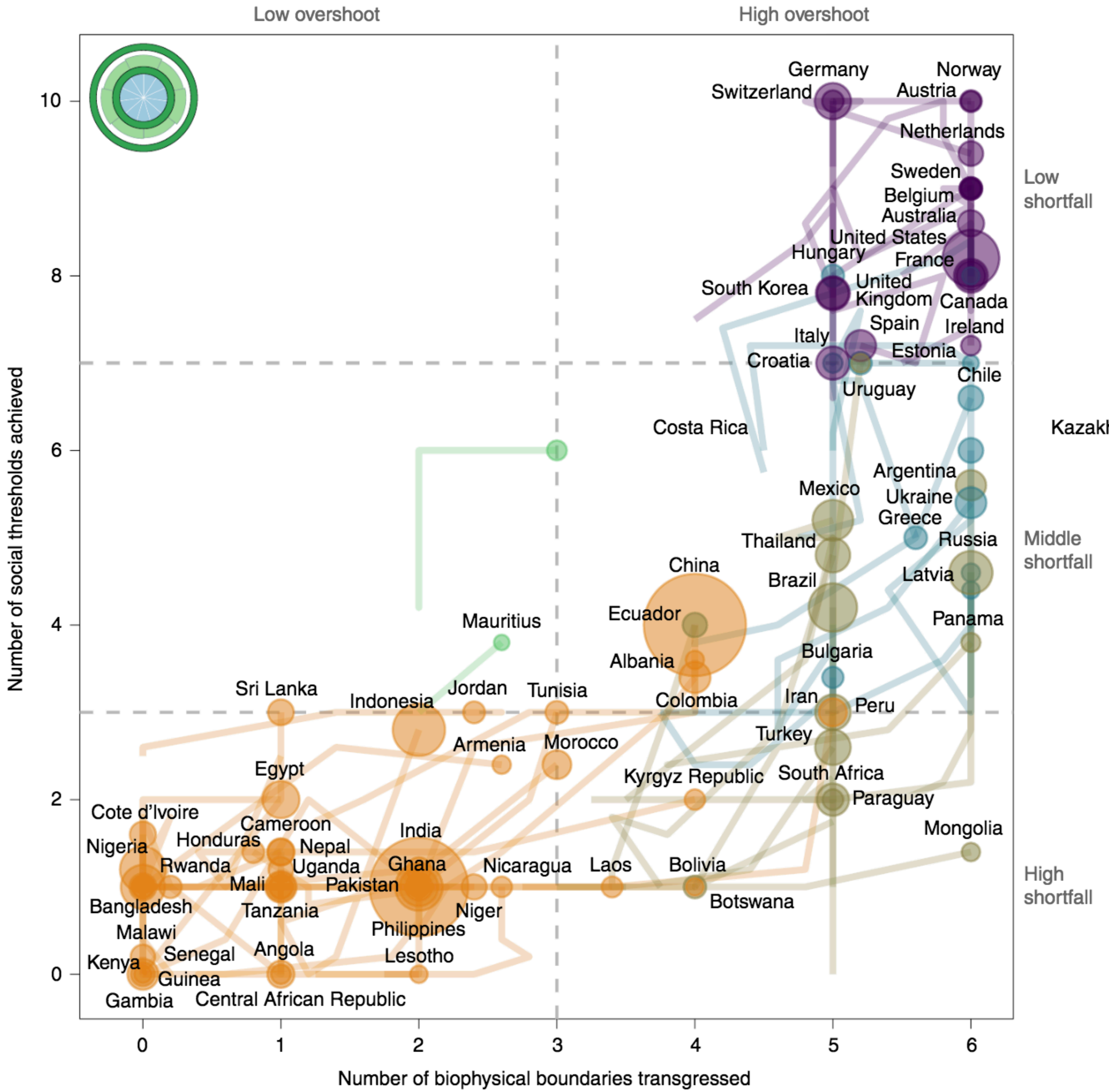
Rockström COP26

Raworth Talk





Raworth (2017)



Fanning et al. (2021); O'Neill et al. (2018)

https://goodlife.leeds.ac.uk/

Part II:

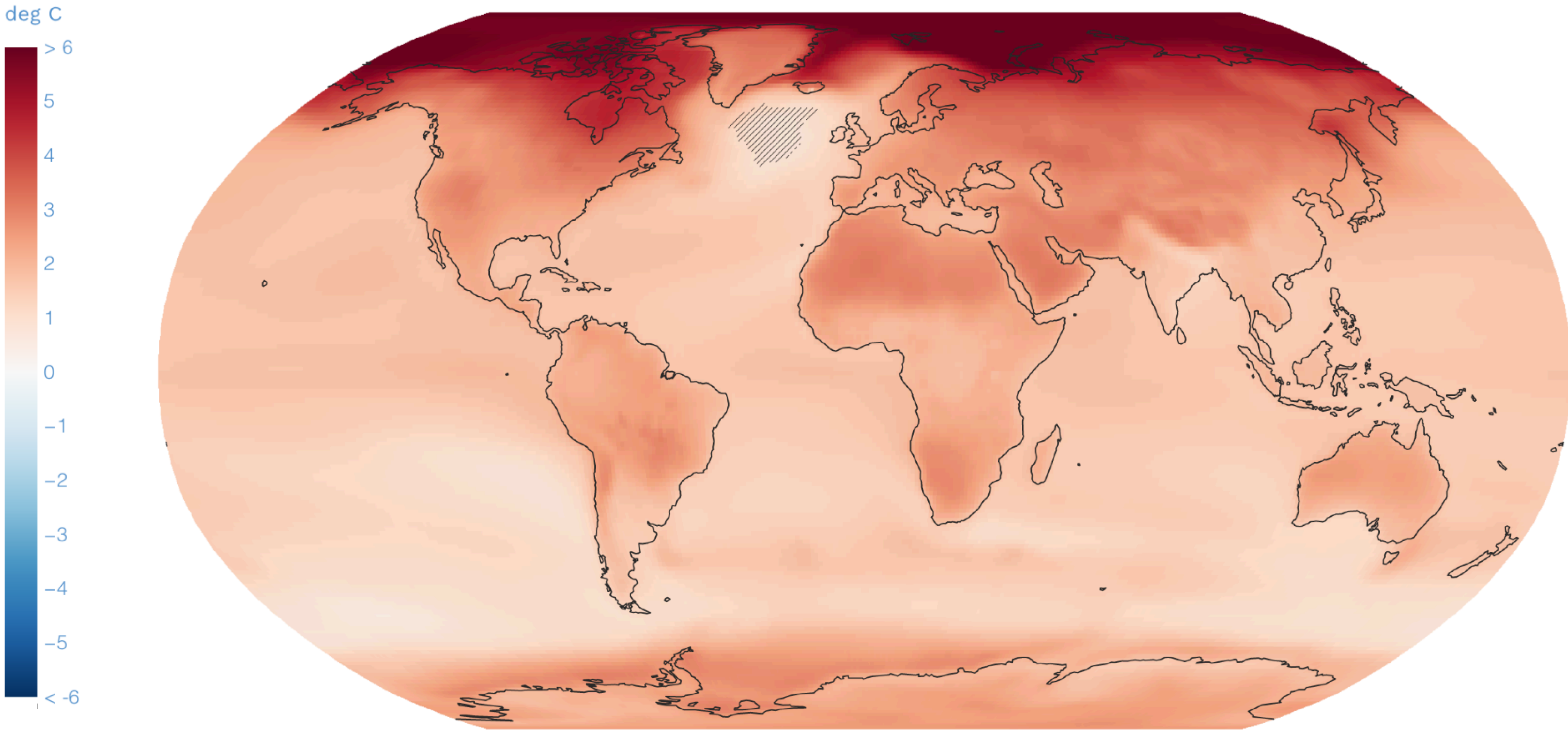
Climate Impacts Today & Tomorrow

Extreme Heat

Crop Failures

Source

Heat



CMIP6 - Mean temperature (T) Change deg C - Warming 2°C SSP2-4.5 (rel. to 1850-1900) - Annual (34 models)

Byrne (2020)

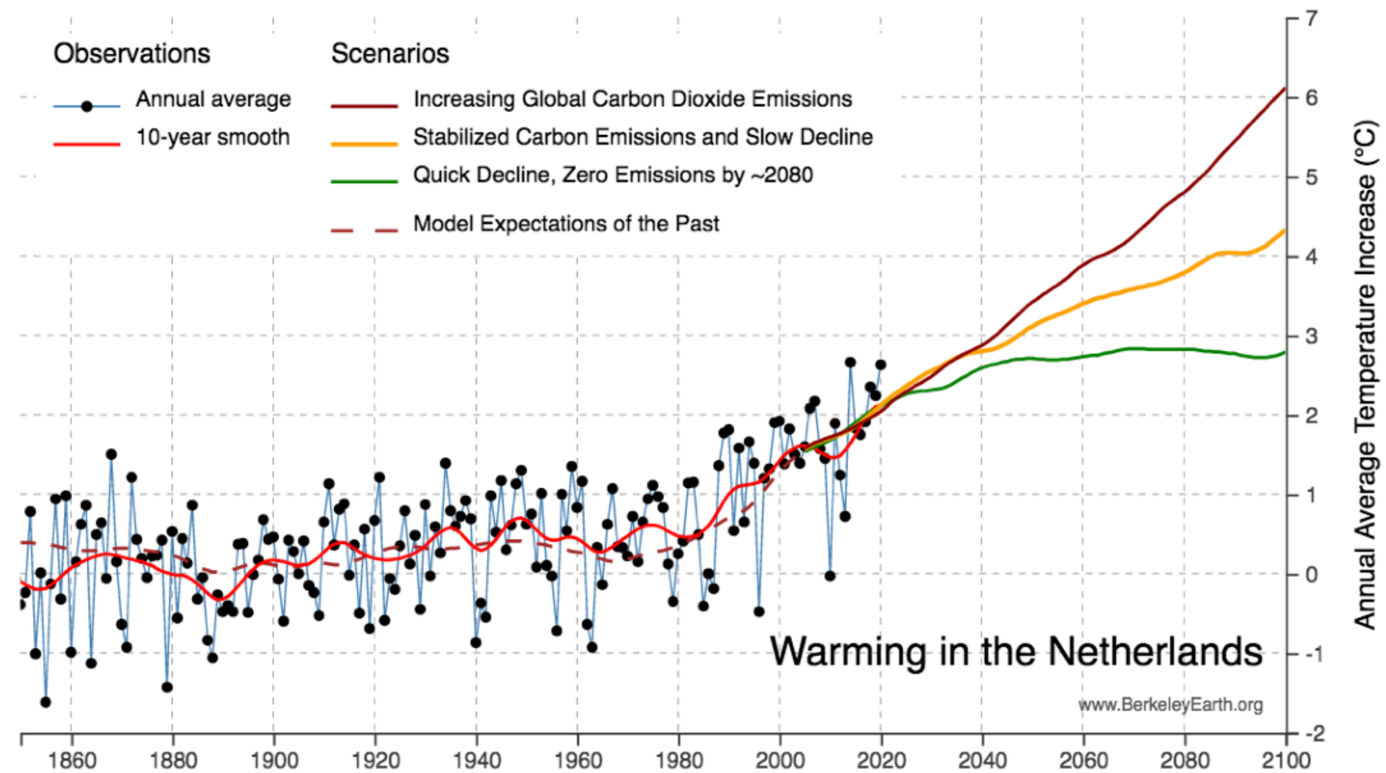
McSweeney (2019)

IPCC AR6 WGI Interactive Atlas

The Netherlands

Already +2.1 °C in 2020

Heading for around +4.3 °C in 2100

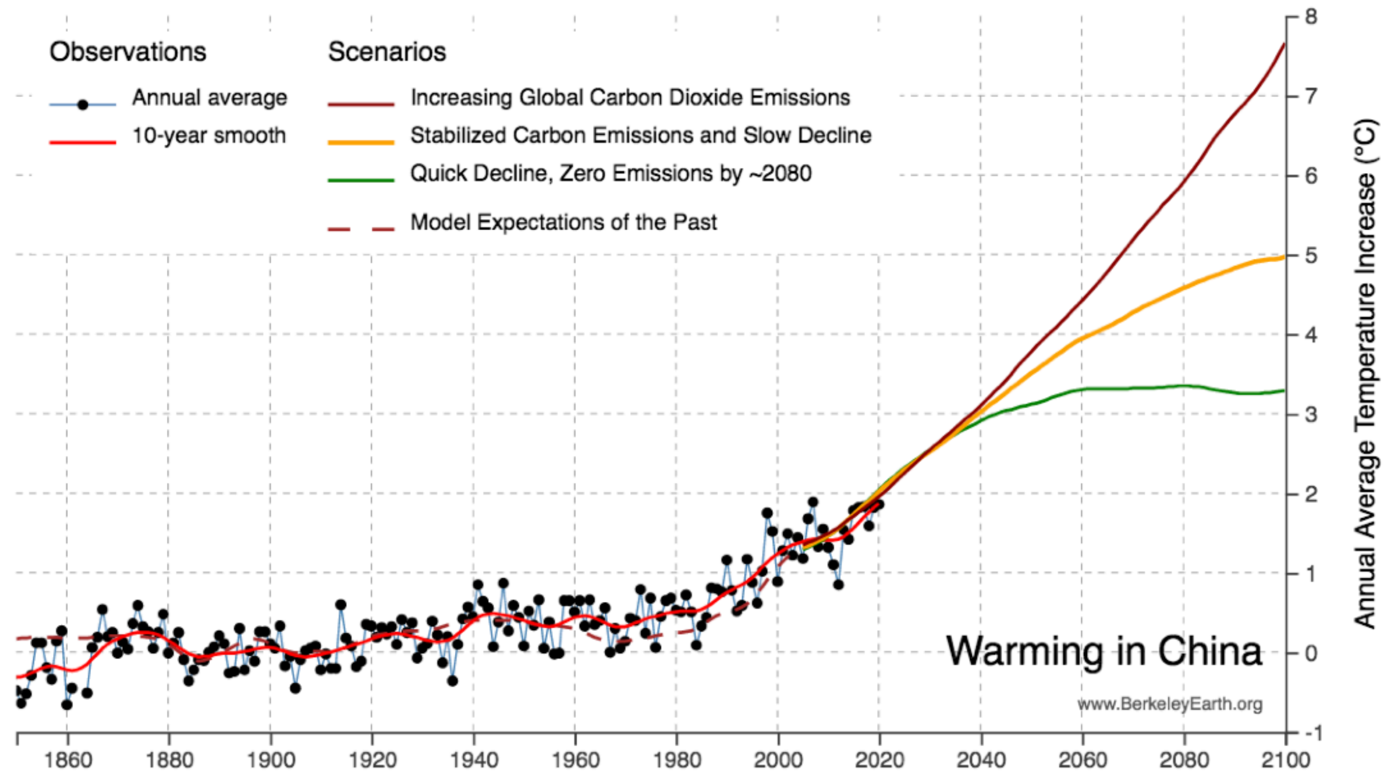


Berkeley Earth

China

Already +1.9 °C in 2020

Heading for around +5.0 °C in 2100

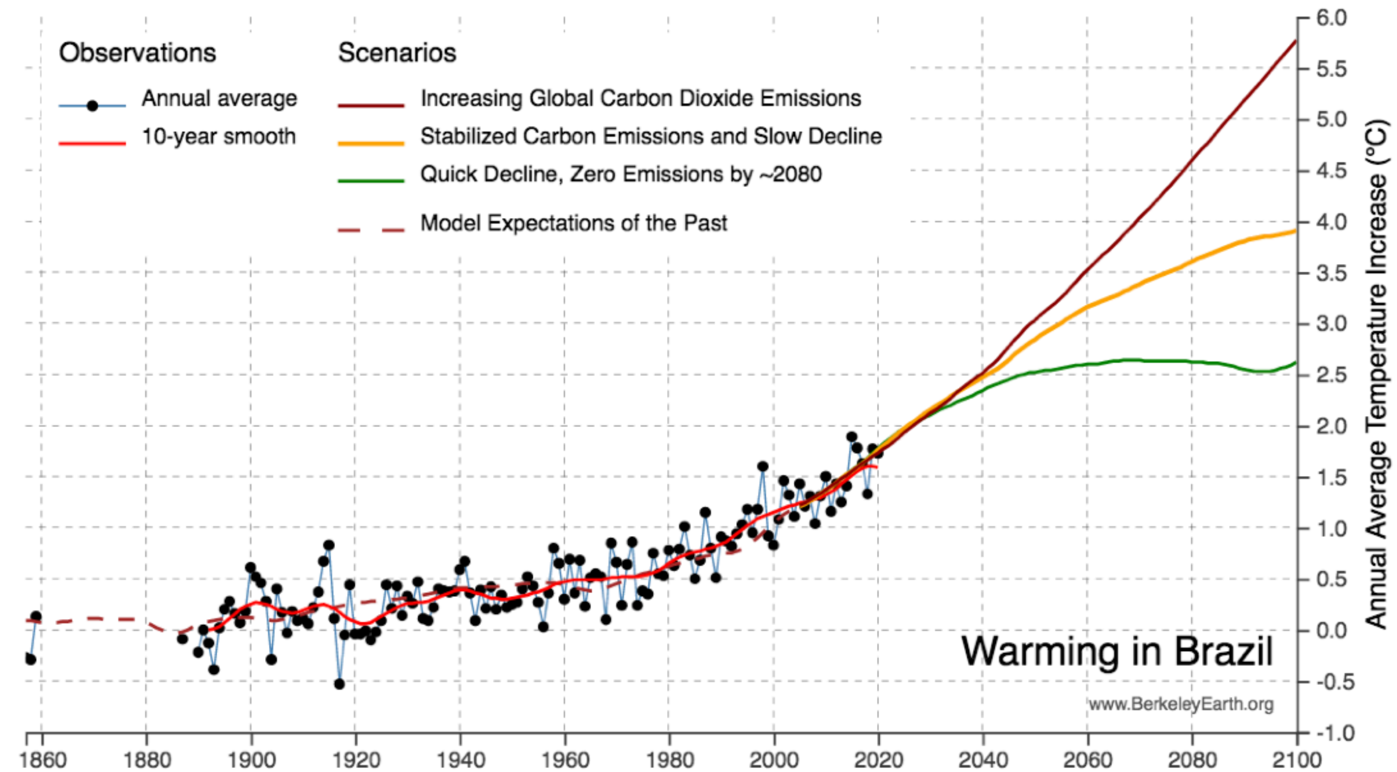


Berkeley Earth

Brazil

Already +1.6 °C in 2020

Heading for around +3.9 °C in 2100



Berkeley Earth

Article | Open Access | Published: 03 July 2020

Increasing trends in regional heatwaves

S. E. Perkins-Kirkpatrick & S. C. Lewis

Nature Communications 11, Article number: 3357 (2020) | Cite this article

Abstract

Heatwaves have increased in intensity, frequency and duration, with these trends projected to worsen under enhanced global warming. Understandi
critical implications for the biophysical and human syste
comprehensive assessment of regional observed change
metrics employed, underpinning datasets, and time peri
Berkeley Earth temperature dataset and key heatwave me
regional and global observed heatwave trends. In almost
demonstrates the most rapid and significant change. A m
significant increases almost everywhere since the 1950s,
Trends in heatwave frequency, duration and cumulative h
1950s, and due to the high influence of variability we reco
assessed over multiple decades. Our results provide com
heatwave trends, on spatial and temporal scales necessar

Article | Published: 31 May 2021

The burden of heat-related mortality attributable to recent human-induced climate change

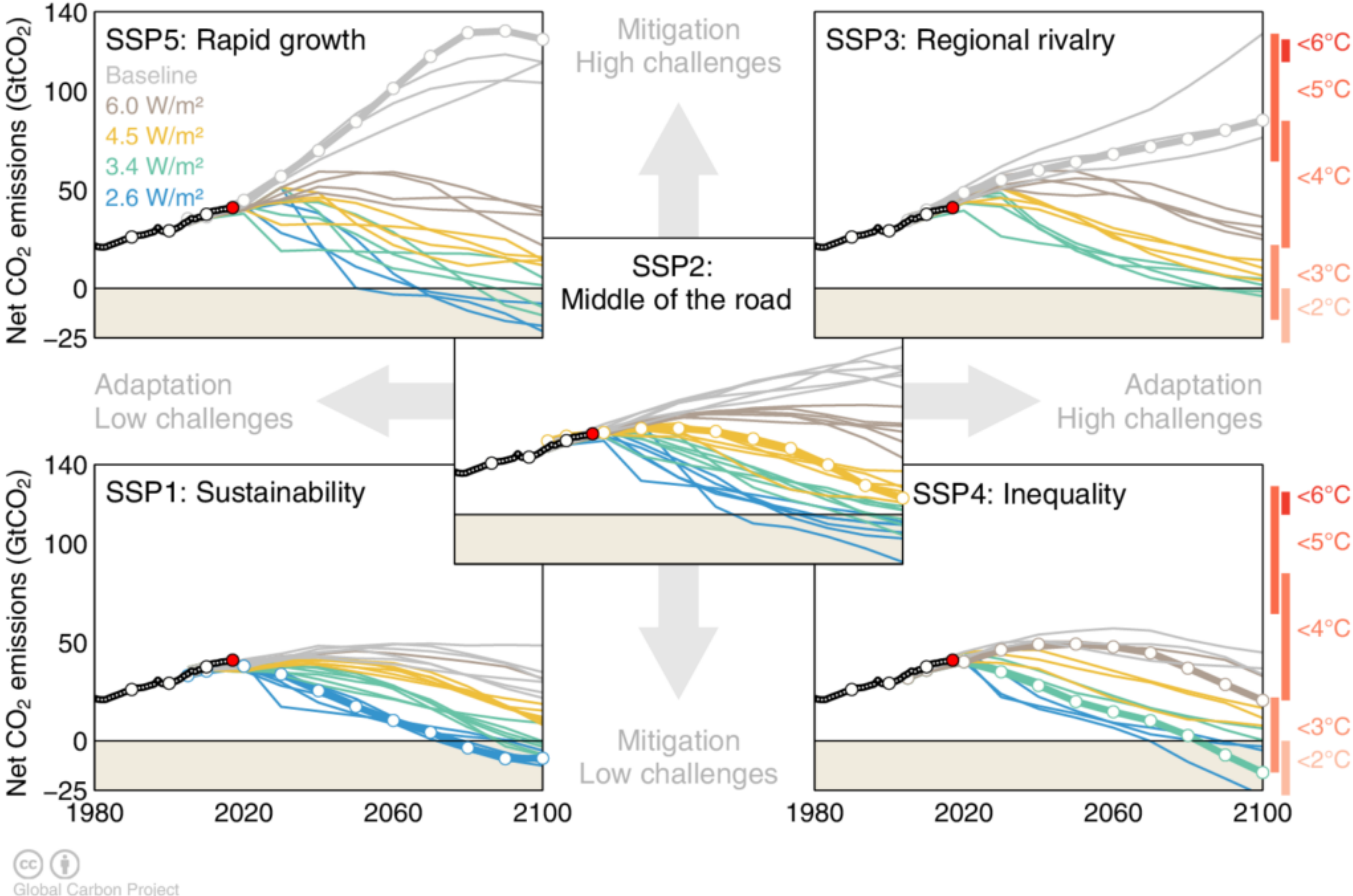
A. M. Vicedo-Cabrera, N. Scovronick, [...] A. Gasparrini

Nature Climate Change 11, 492–500 (2021) | Cite this article

Abstract

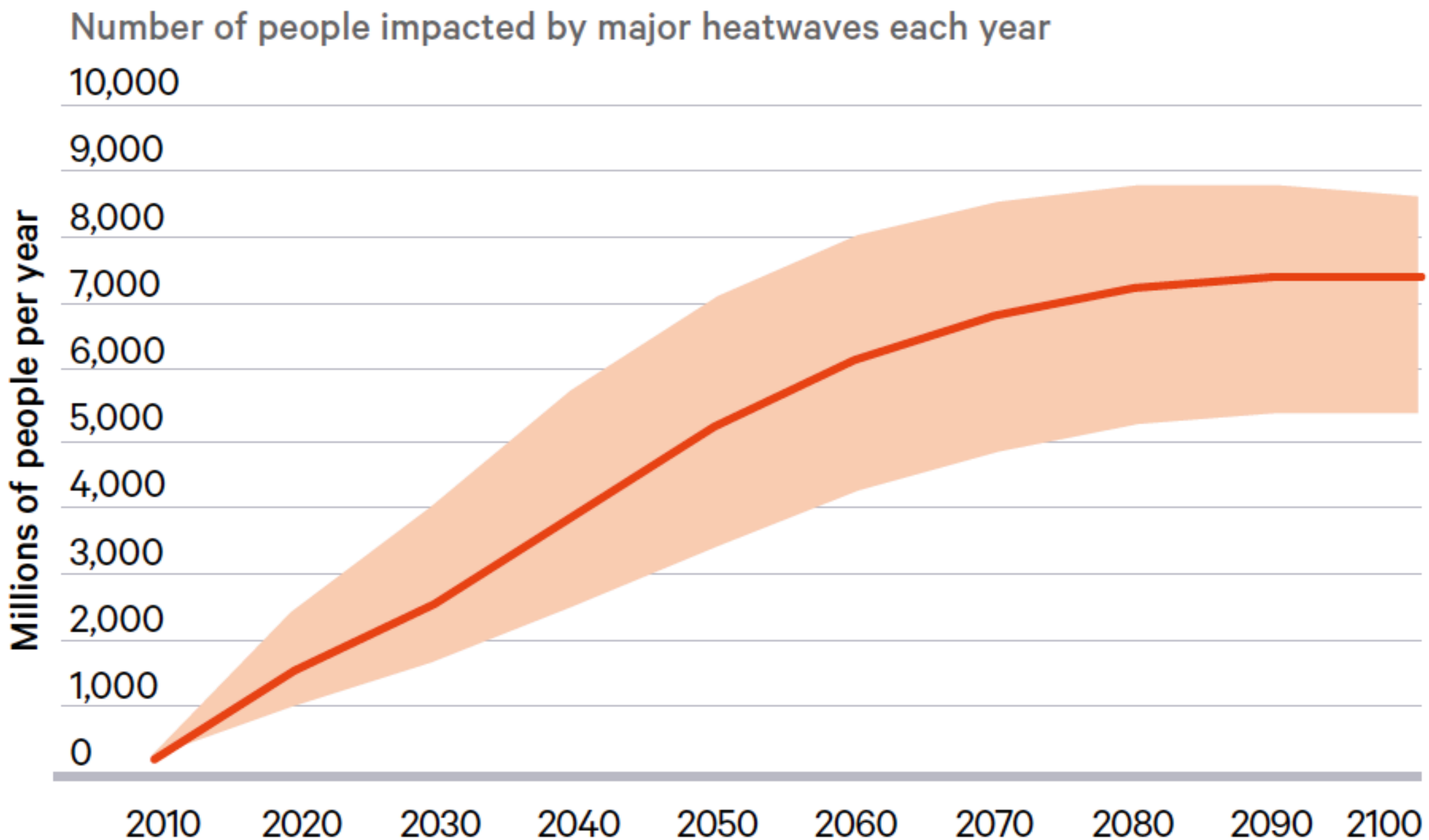
Climate change affects human health; however, there have been no large-scale, systematic efforts to quantify the heat-related human health impacts that have already occurred due to climate change. Here, we use empirical data from 732 locations in 43 countries to estimate the mortality burdens associated with the additional heat exposure that has resulted from recent human-induced warming, during the period 1991–2018. Across all study countries, we find that 37.0% (range 20.5–76.3%) of warm-season heat-related deaths can be attributed to anthropogenic climate change and that increased mortality is evident on every continent. Burdens varied geographically but were of the order of dozens to hundreds of deaths per year in many locations. Our findings support the urgent need for more ambitious mitigation and adaptation strategies to minimize the public health impacts of climate change.

Reporting here and here



Hausfather (2018); Evans & Hausfather (2018)

Extreme Heat - Current Trajectory



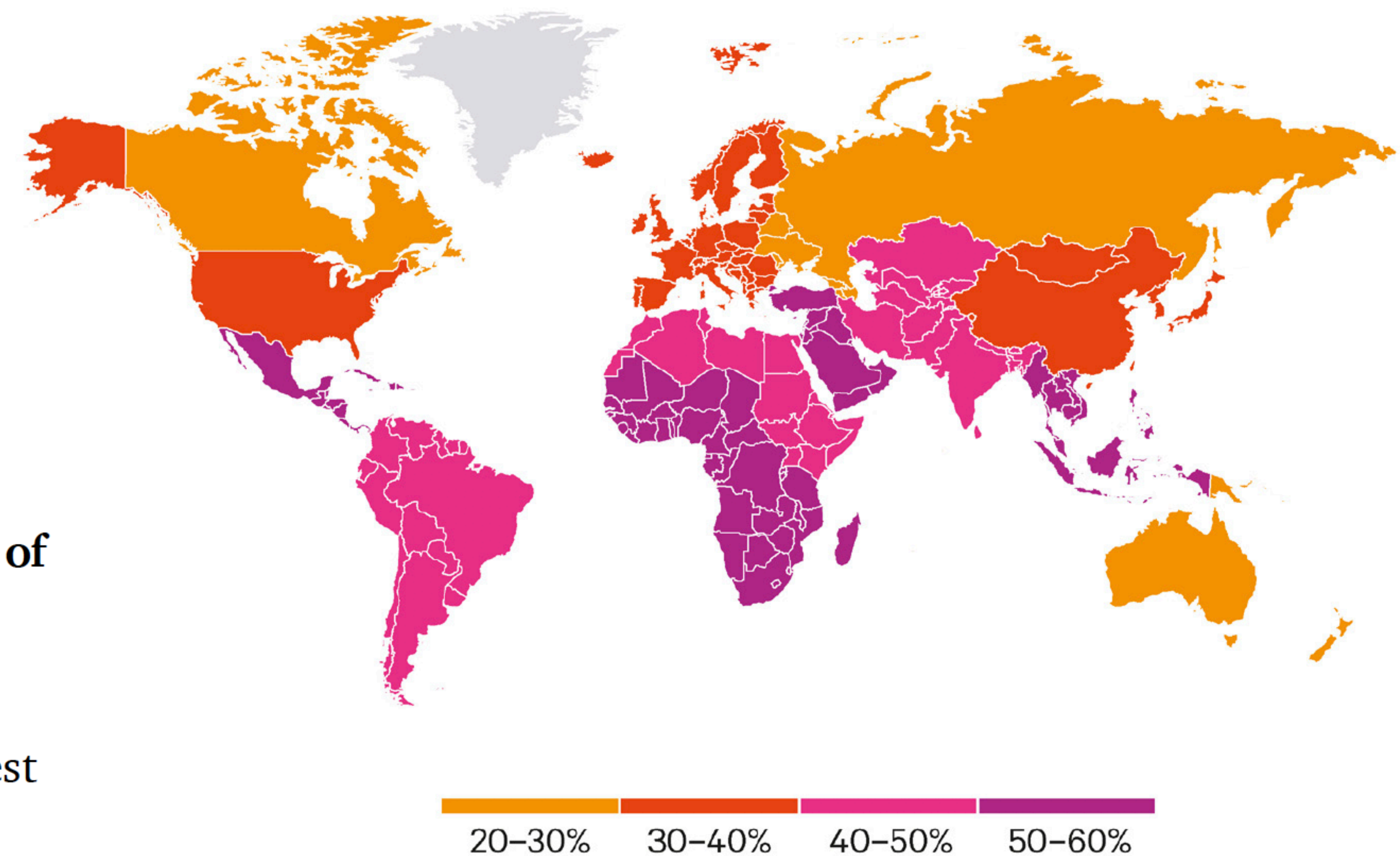
Shaded area represents the lower and upper estimates of the given impact.
Solid line represents the central estimate.

Quiggin et al. (2021)

Arnell et al. (2019)

Extreme Heat - Current Trajectory

Regional impacts, 2040: proportion of population experiencing major heatwaves each year
(Major heatwaves are comparable to the most extreme historic heatwaves)



By 2050, **more than 70 per cent of people in every region** will experience heatwaves each year.

Urban areas will suffer the greatest challenges of workability and survivability.

Quiggin et al. (2021)

Arnell et al. (2019)

SCIENCE ADVANCES | RESEARCH ARTICLE

CLIMATOLOGY

The emergence of heat and humidity too severe for human tolerance

Colin Raymond[1,2]*, Tom Matthews[3], Radley M. Horton[2,4]

Humans' ability to efficiently shed heat has enabled us to range over every continent, but a wet-bulb temperature (TW) of 35°C marks our upper physiological limit, and much lower values have serious health and productivity impacts. Climate models project the first 35°C TW occurrences by the mid-21st century. However, a comprehensive evaluation of weather station data shows that some coastal subtropical locations have already reported a TW of 35°C and that extreme humid heat overall has more than doubled in frequency since 1979. Recent exceedances of 35°C in global maximum sea surface temperature provide further support for the validity of these dangerously high TW values. We find the most extreme humid heat is highly localized in both space and time and is correspondingly substantially underestimated in reanalysis products. Our findings thus underscore the serious challenge posed by humid heat that is more intense than previously reported and increasingly severe.

nature geoscience

ARTICLES

https://doi.org/10.1038/s41561-021-00695-3

Check for updates

Projections of tropical heat stress constrained by atmospheric dynamics

Yi Zhang[1]✉, Isaac Held[1] and Stephan Fueglistaler[1,2]

Extreme heat under global warming is a concerning issue for the growing tropical population. However, model projections of extreme temperatures, a widely used metric for extreme heat, are uncertain on regional scales. In addition, humidity needs to be taken into account to estimate the health impact of extreme heat. Here we show that an integrated temperature–humidity metric for the health impact of heat, namely, the extreme wet-bulb temperature (TW), is controlled by established atmospheric dynamics and thus can be robustly projected on regional scales. For each 1 °C of tropical mean warming, global climate models project extreme TW (the annual maximum of daily mean or 3-hourly values) to increase roughly uniformly between 20° S and 20° N latitude by about 1 °C. This projection is consistent with theoretical expectation based on tropical atmospheric dynamics, and observations over the past 40 years, which gives confidence to the model projection. For a 1.5 °C warmer world, the probable (66% confidence interval) increase of regional extreme TW is projected to be 1.33–1.49 °C, whereas the uncertainty of projected extreme temperatures is 3.7 times as large. These results suggest that limiting global warming to 1.5 °C will prevent most of the tropics from reaching a TW of 35 °C, the limit of human adaptation.

Reporting here and here

One billion face heat-stress risk from 2°C rise

Author: Grahame Madge
00:01 (UTC) on Tue 9 Nov 2021

Areas where TW > 32°C for > 10 days per year at 4°C warming

Source

Canadian inferno: northern heat exceeds worst-case climate models

The Guardian

Source

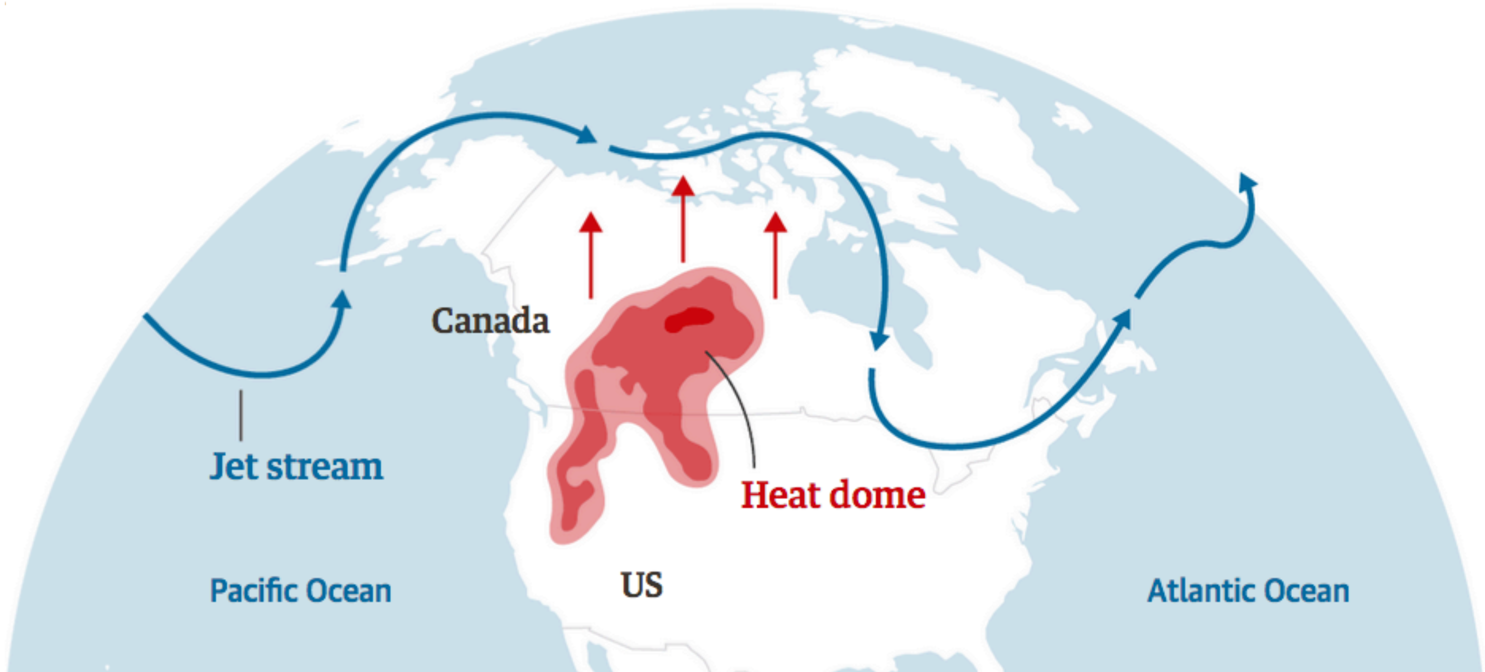
Mann Podcast

Scientists fear heat domes in North America and Siberia indicate a new dimension to the global crisis

Jonathan Watts

@jonathanwatts

Fri 2 Jul 2021 16.28 BST



"[T]here is something else going on with this heatwave, and indeed, with many of the very persistent weather extremes we've seen in recent years in the US, Europe, Asia and elsewhere, where the models aren't quite capturing the impact of climate change."

\- Michael Mann

"The recent extreme weather anomalies were not represented in global computer models that are used to project how the world might change with more emissions."

\- Johan Rockström

Fisher et al. (2021)

McSweeney (2019)

Contents lists available at SciVerse ScienceDirect

Global Environmental Change

journal homepage: www.elsevier.com/locate/gloenvcha

Climate change prediction: Erring on the side of least drama?

Keynyn Brysse[a,*], Naomi Oreskes[b], Jessica O'Reilly[c], Michael Oppenheimer[d]

[a] Program in Science, Technology and Society, Office of Interdisciplinary Studies, University of Alberta, Canada
[b] History and Science Studies, University of California, San Diego, United States
[c] Department of Sociology, College of St. Benedict/St. John's University, United States
[d] Department of Geosciences and Woodrow Wilson School of Public and International Affairs, Princeton University, United States

ARTICLE INFO

Article history:
Received 21 December 2011
Received in revised form 28 August 2012
Accepted 5 October 2012
Available online xxx

Keywords:
Climate change
Prediction
Scientific norms
Scientific assessment
Erring on the side of least drama

ABSTRACT

Over the past two decades, skeptics of the reality and significance of anthropogenic climate change have frequently accused climate scientists of "alarmism": of over-interpreting or overreacting to evidence of human impacts on the climate system. However, the available evidence suggests that scientists have in fact been conservative in their projections of the impacts of climate change. In particular, we discuss recent studies showing that at least some of the key attributes of global warming from increased atmospheric greenhouse gases have been under-predicted, particularly in IPCC assessments of the physical science, by Working Group I. We also note the less frequent manifestation of over-prediction of key characteristics of climate in such assessments. We suggest, therefore, that scientists are biased not toward alarmism but rather the reverse: toward cautious estimates, where we define caution as erring on the side of less rather than more alarming predictions. We call this tendency "erring on the side of least drama (ESLD)." We explore some cases of ESLD at work, including predictions of Arctic ozone depletion and the possible disintegration of the West Antarctic ice sheet, and suggest some possible causes of this directional bias, including adherence to the scientific norms of restraint, objectivity, skepticism, rationality, dispassion, and moderation. We conclude with suggestions for further work to identify and explore ESLD.

Brysse et al. (2012); Oppenheimer (2021)

Oreskes Podcast

Seville, Spain
August 2021: A billboard shows 47C (117F)

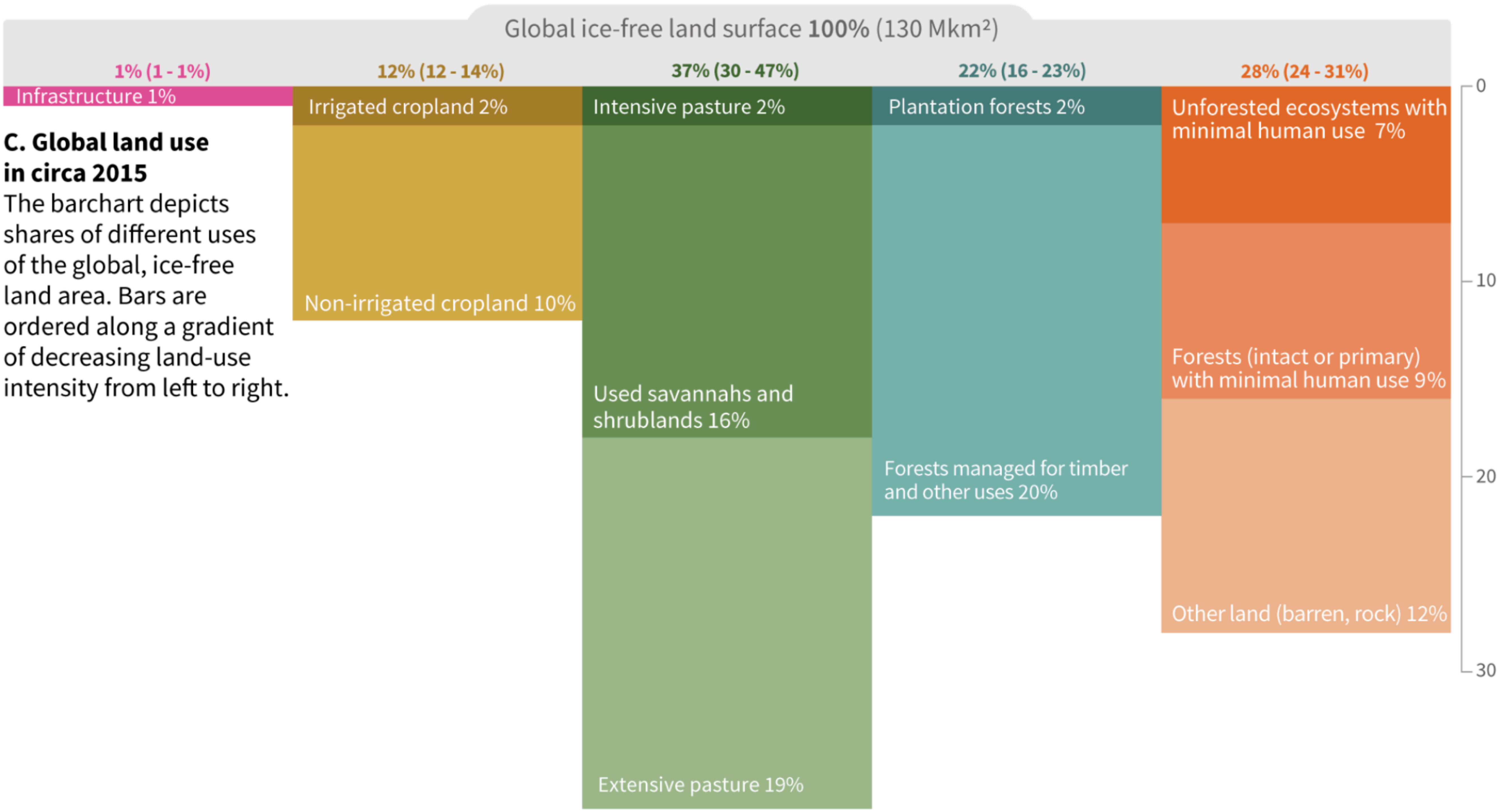
Extreme Heat

Badghis, Afghanistan
September 2021: A farmer holds a handful of failed wheat from his crop

Crop Failures

Source

Land Use



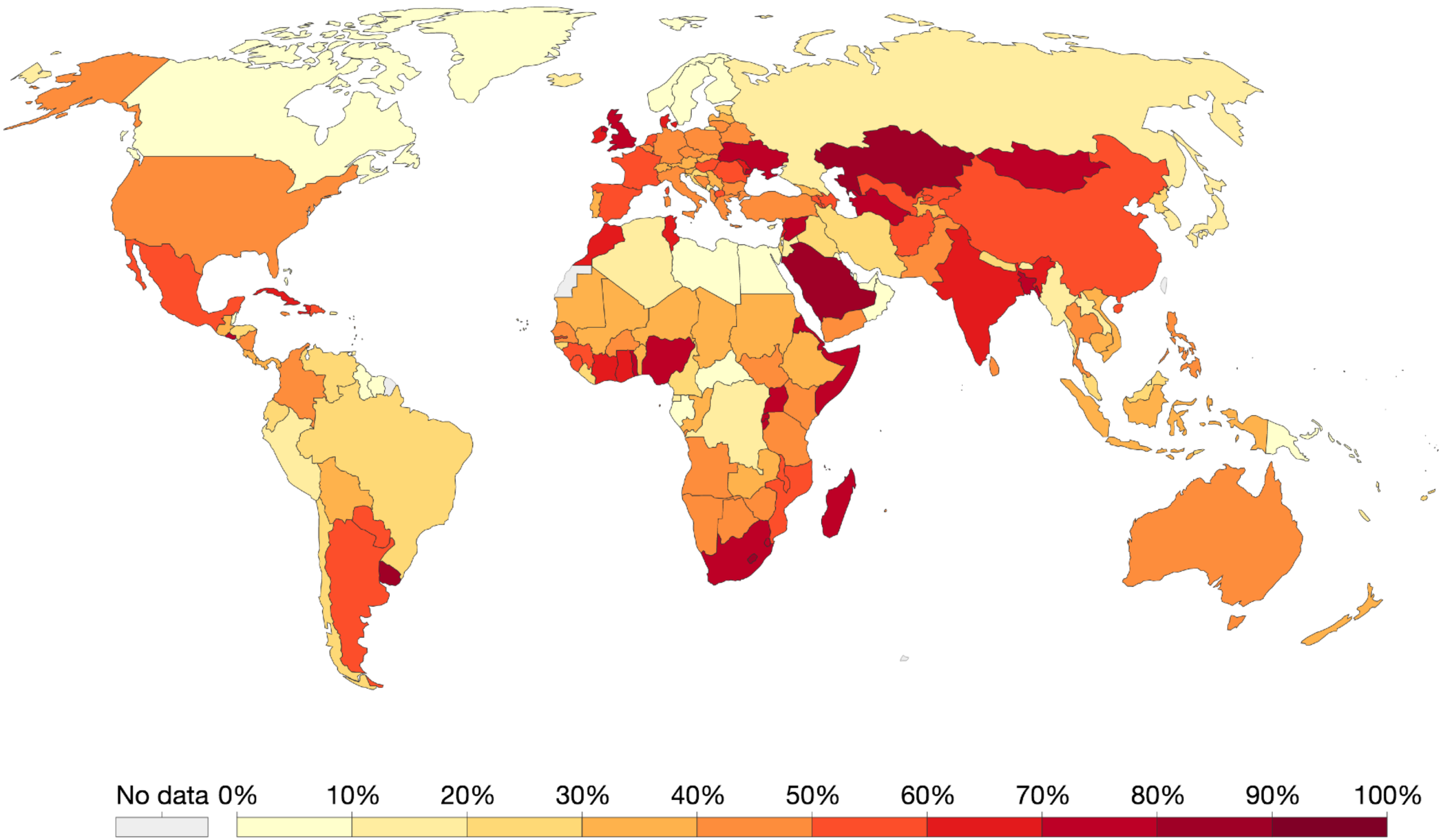
C. Global land use in circa 2015
The barchart depicts shares of different uses of the global, ice-free land area. Bars are ordered along a gradient of decreasing land-use intensity from left to right.

IPCC SRCCL SPM

Share of land area used for agriculture, 2018

The share of land area used for agriculture, measured as a percentage of total land area. Agricultural land refers to the share of land area that is arable, under permanent crops, and under permanent pastures.

Our World in Data



Source: Food and Agriculture Organization of the United Nations (via World Bank)
OurWorldInData.org/yields-and-land-use-in-agriculture/ • CC BY

Source

Severe drought devastates Washington state's wheat crop

abcNEWS

A drought in eastern Washington state that is the worst since 1977 has devastated what is normally the fourth largest U.S. wheat crop

By **NICHOLAS K. GERANIOS Associated Press**
11 August 2021, 20:46 • 4 min read

'Worst year I've ever witnessed': Drought withers Western Canada's spring wheat

'Some are harvesting about 25 per cent of what they would typically expect. The conditions are terrible'

Laura Brehaut
Aug 19, 2021 • August 19, 2021 • 8 minute read • 72 Comments

NATIONAL POST

News | Climate Change

Mexico water supply buckles on worsening drought, crops at risk

Weather forecasts warn of high temperatures portending crop damage and water supply shortages.

2 Jul 2021

ALJAZEERA

World / Americas

Record-breaking drought in Chile offers bountiful proof of climate change

- Science Minister Andres Couve said the steady decline in the country's water reserves because of climate change was now a 'national priority'
- 'The weather events are happening with a frequency and intensity that makes it very easy for people to see', he said

REUTERS
Reuters in Santiago + FOLLOW
Published: 3:46pm, 11 Aug, 2021

Brazil, Besieged by Covid, Now Faces a Severe Drought

Brazilians are paying more for electricity, dealing with the possibility of water rationing and expecting a destructive fire season in the Amazon in the worst dry spell in at least 90 years.

Published June 19, 2021 Updated June 21, 2021

The New York Times

Thursday, July 8, 2021

Record Droughts Plague Latin America

By Chase Harrison and Katie Hopkins

Abnormally dry conditions in Argentina, Brazil, Mexico, and Paraguay threaten water reserves and economic recovery.

AS/COA
AMERICAS SOCIETY
COUNCIL OF THE AMERICAS

Jordan facing 'one of the most severe' droughts in its history

ALJAZEERA

Experts say Jordan is now in the grip of one of the most severe droughts in its history, but many warn the worst is yet to come.

6 May 2021

COMMODITIES OCTOBER 13, 2021 / 1:59 PM / UPDATED 2 DAYS AGO

Iran buying record volume of wheat after worst drought in 50 years – sources

REUTERS

'The challenge for us now is drought, not war': livelihoods of millions of Afghans at risk

Tue 21 Sep 2021 10.36 BST

The Guardian

At least 1m people facing starvation as Madagascar's drought worsens

People eating termites and clay as UN says acute malnutrition has almost doubled this year in south

Mon 10 May 2021 06.00 BST

Drought puts 2.1 million Kenyans at risk of starvation

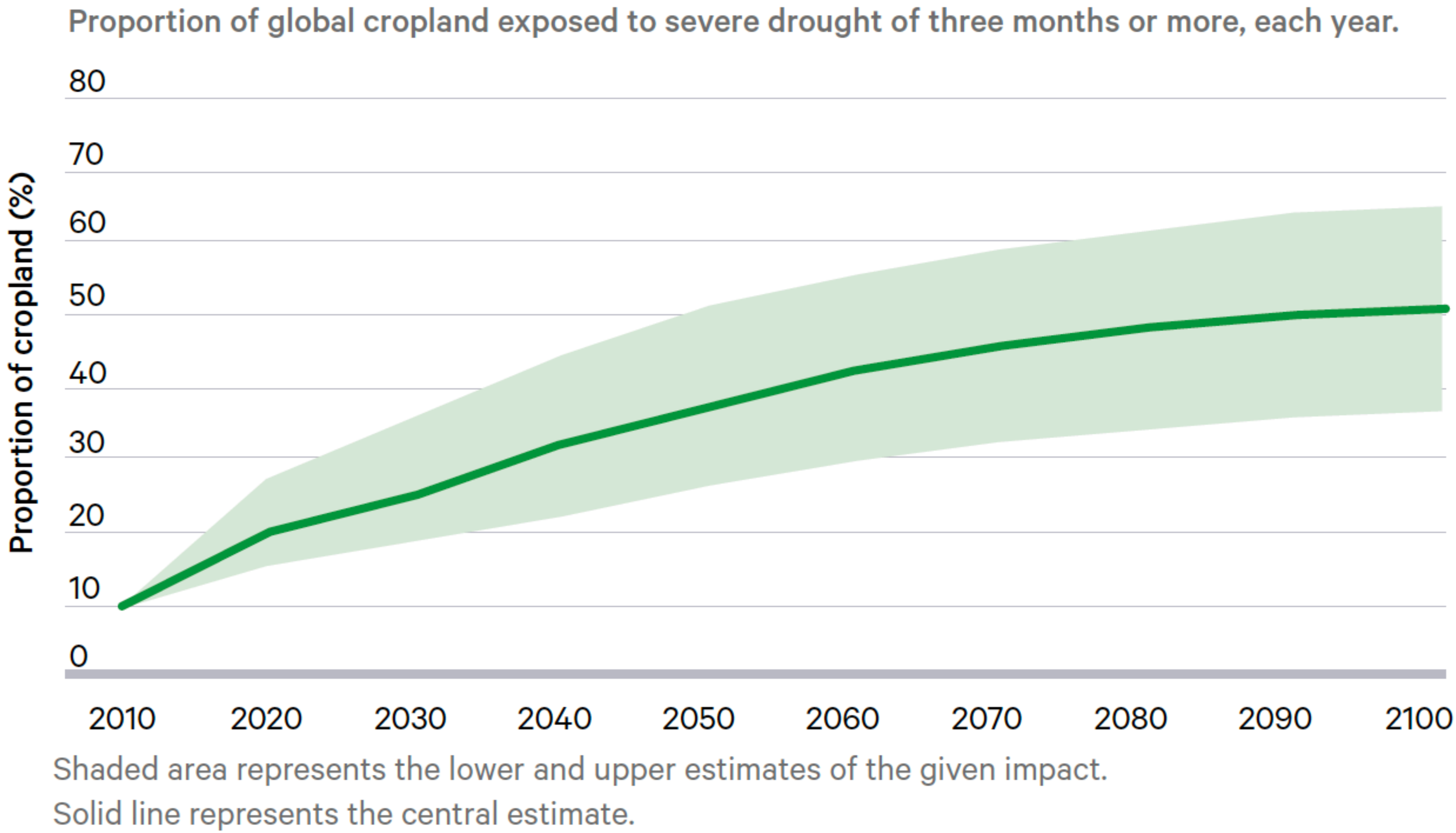
National disaster declared as crops fail after poor rains and locusts, while ethnic conflicts add to crisis

Wed 15 Sep 2021 07.00 BST

Angola: Millions facing hunger, as thousands flee their homes as drought ravages the south of Angola

July 22, 2021 2:00 am

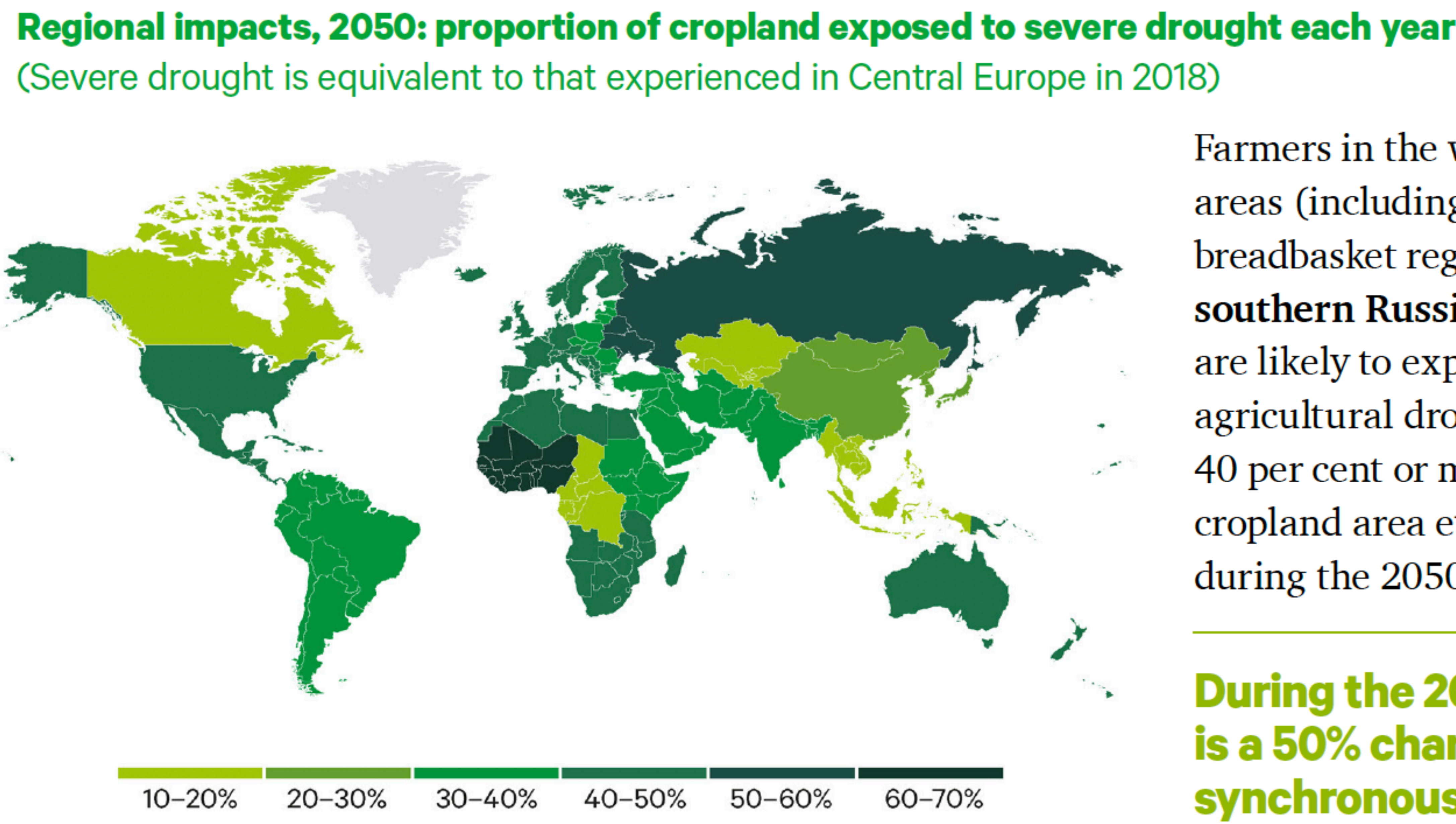
Agriculture - Current Trajectory



Quiggin et al. (2021)

Arnell et al. (2019)

Agriculture - Current Trajectory



Farmers in the worst-affected areas (including the critical breadbasket regions of **southern Russia** and the **US**) are likely to experience severe agricultural drought impacting 40 per cent or more of their cropland area every year during the 2050s.

During the 2040s there is a 50% chance of synchronous crop failure

Quiggin et al. (2021)

Baird (2021)

Arnell et al. (2019)

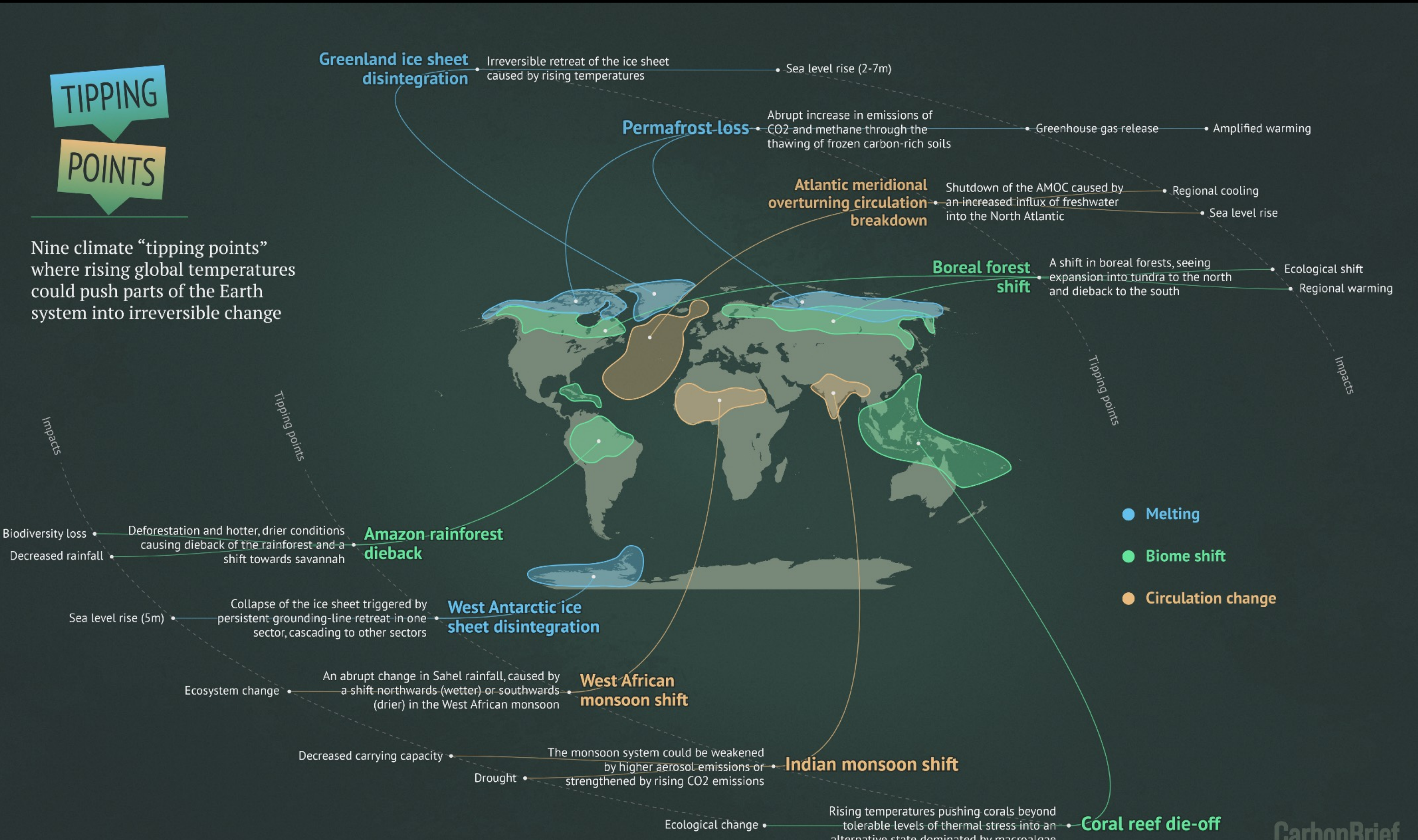
Seville, Spain
August 2021: A billboard shows 47C (117F)

Extreme Heat


Badghis, Afghanistan
September 2021: A farmer holds a handful of failed wheat from his crop

Crop Failures

Source



TIPPING
POINTS
Nine climate "tipping points" where rising global temperatures could push parts of the Earth system into irreversible change
Greenland ice sheet disintegration
Irreversible retreat of the ice sheet caused by rising temperatures
Sea level rise (2-7m)
Permafrost loss
Abrupt increase in emissions of CO2 and methane through the thawing of frozen carbon-rich soils
Greenhouse gas release
Amplified warming
Atlantic meridional overturning circulation breakdown
Shutdown of the AMOC caused by an increased influx of freshwater into the North Atlantic
Regional cooling
Sea level rise
Boreal forest shift
A shift in boreal forests, seeing expansion into tundra to the north and dieback to the south
Ecological shift
Regional warming
Tipping points
Impacts
Amazon rainforest dieback
Deforestation and hotter, drier conditions causing dieback of the rainforest and a shift towards savannah
Biodiversity loss
Decreased rainfall
West Antarctic ice sheet disintegration
Collapse of the ice sheet triggered by persistent grounding-line retreat in one sector, cascading to other sectors
Sea level rise (5m)
West African monsoon shift
An abrupt change in Sahel rainfall, caused by a shift northwards (wetter) or southwards (drier) in the West African monsoon
Ecosystem change
Indian monsoon shift
The monsoon system could be weakened by higher aerosol emissions or strengthened by rising CO2 emissions
Decreased carrying capacity
Drought
Coral reef die-off
Rising temperatures pushing corals beyond tolerable levels of thermal stress into an alternative state dominated by macroalgae
Ecological change
Melting
Biome shift
Circulation change
CarbonBrief

Source

REVIEW ARTICLE
https://doi.org/10.1038/s41561-021-00790-5

nature geoscience

Check for updates

Past abrupt changes, tipping points and cascading impacts in the Earth system

Victor Brovkin[1,2], Edward Brook[3], John W. Williams[4], Sebastian Bathiany[5], Timothy M. Lenton[6], Michael Barton[7], Robert M. DeConto[8], Jonathan F. Donges[9,10], Andrey Ganopolski[9], Jerry McManus[11], Summer Praetorius[12], Anne de Vernal[13], Ayako Abe-Ouchi[14], Hai Cheng[15], Martin Claussen[1,16], Michel Crucifix[17], Gilberto Gallopín[18], Virginia Iglesias[19], Darrell S. Kaufman[20], Thomas Kleinen[1], Fabrice Lambert[21], Sander van der Leeuw[22], Hannah Liddy[23], Marie-France Loutre[24], David McGee[25], Kira Rehfeld[26], Rachael Rhodes[27], Alistair W. R. Seddon[28], Martin H. Trauth[29], Lilian Vanderveken[17] and Zicheng Yu[30,31]

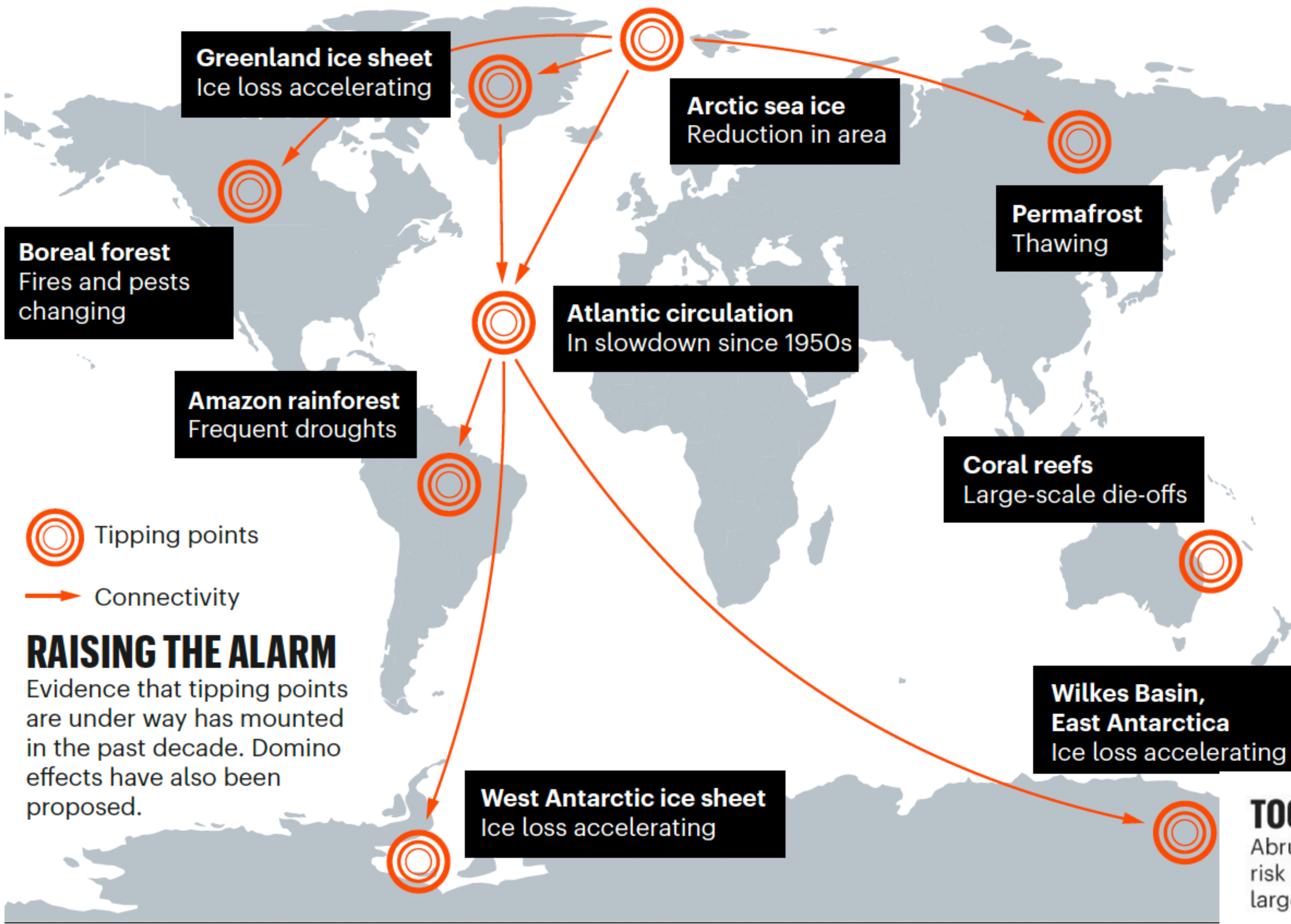
The geological record shows that abrupt changes in the Earth system can occur on timescales short enough to challenge the capacity of human societies to adapt to environmental pressures. In many cases, abrupt changes arise from slow changes in one component of the Earth system that eventually pass a critical threshold, or tipping point, after which impacts cascade through coupled climate–ecological–social systems. The chance of detecting abrupt changes and tipping points increases with the length of observations. The geological record provides the only long-term information we have on the conditions and processes that can drive physical, ecological and social systems into new states or organizational structures that may be irreversible within human time frames. Here, we use well-documented abrupt changes of the past 30 kyr to illustrate how their impacts cascade through the Earth system. We review useful indicators of upcoming abrupt changes, or early warning signals, and provide a perspective on the contributions of palaeoclimate science to the understanding of abrupt changes in the Earth system.

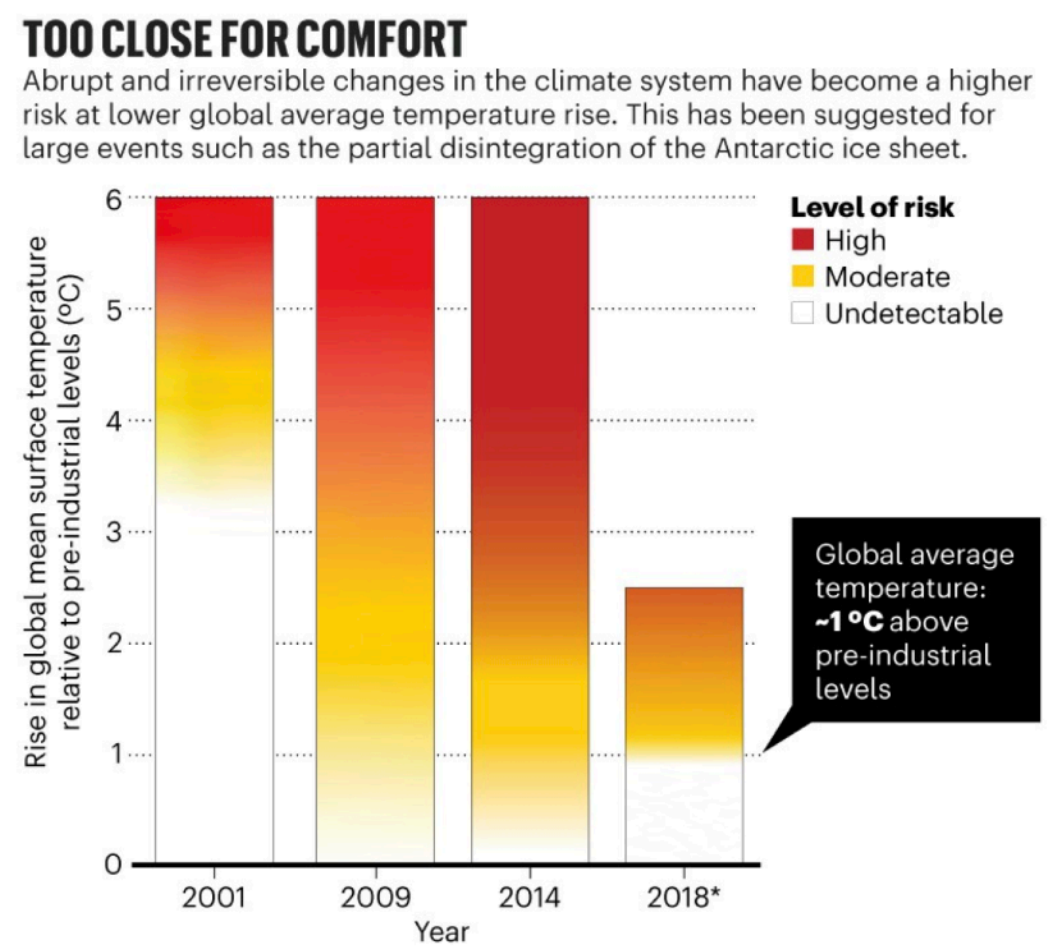
Tipping Point Panel

Brovkin et al. (2021)

Jonathan Donges Talk

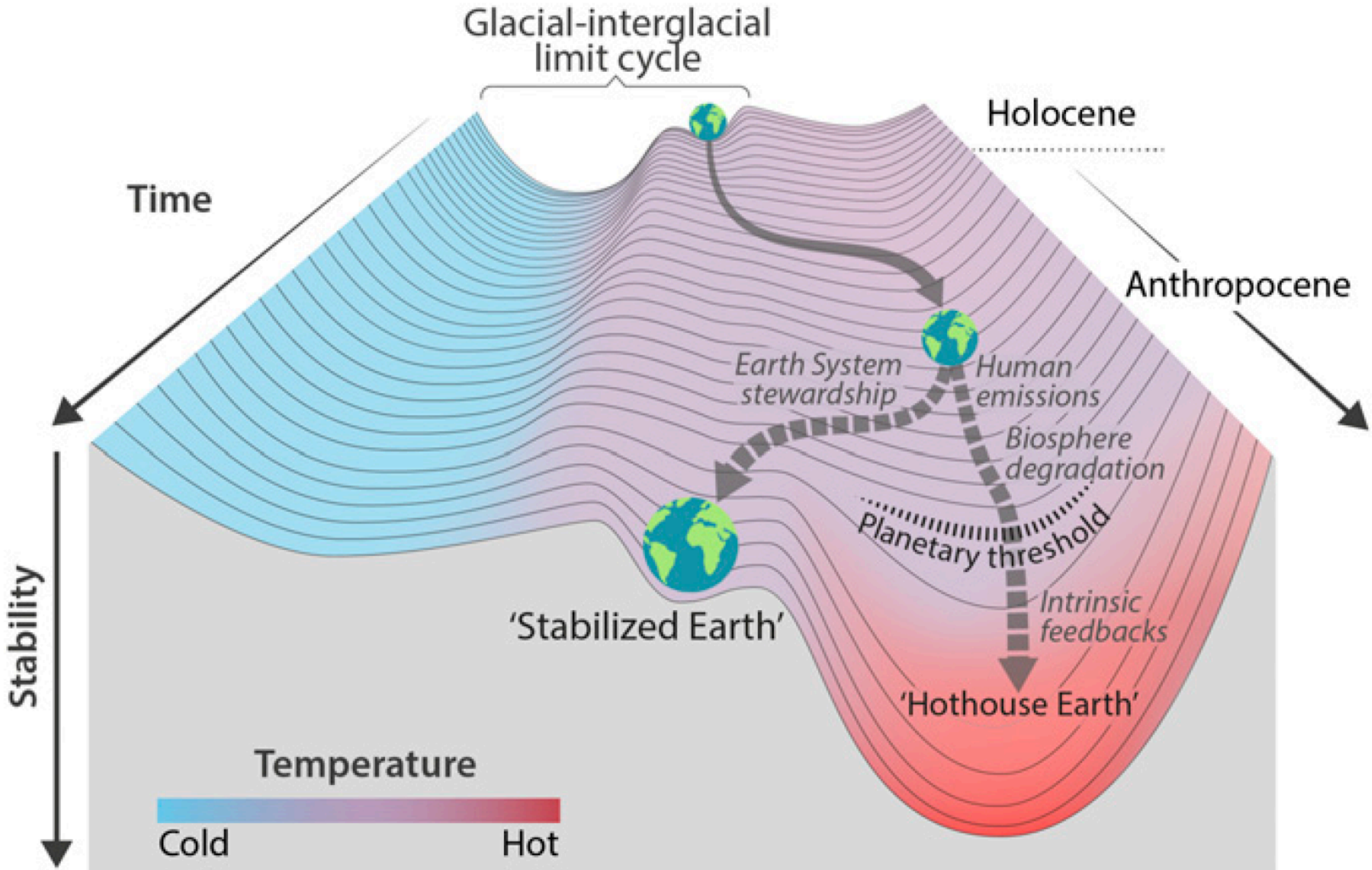
Lenton Podcast





Lenton et al. (2019)

Wunderling et al. (2021)



Steffen Podcast

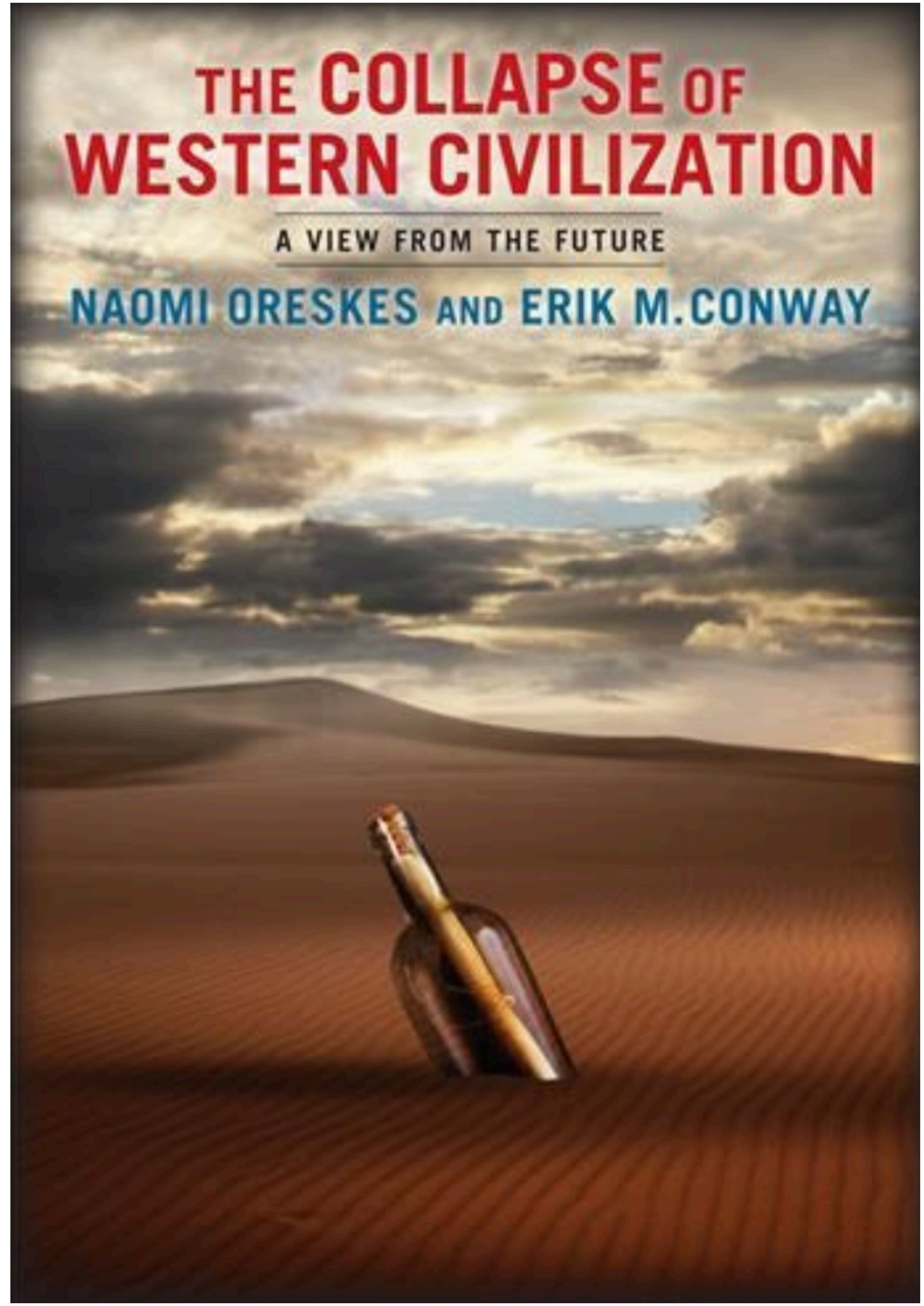
Rockström Podcast

Steffen et al. (2018)

"I think we have more than a 5% chance of succeeding but it is definitely less than 50%, in my view. But what is the option? If we have a final chance to save our culture and our civilisation, I am just compelled to do it."

John Schellnhuber

Founding Director
Potsdam Institute for Climate Impact Research



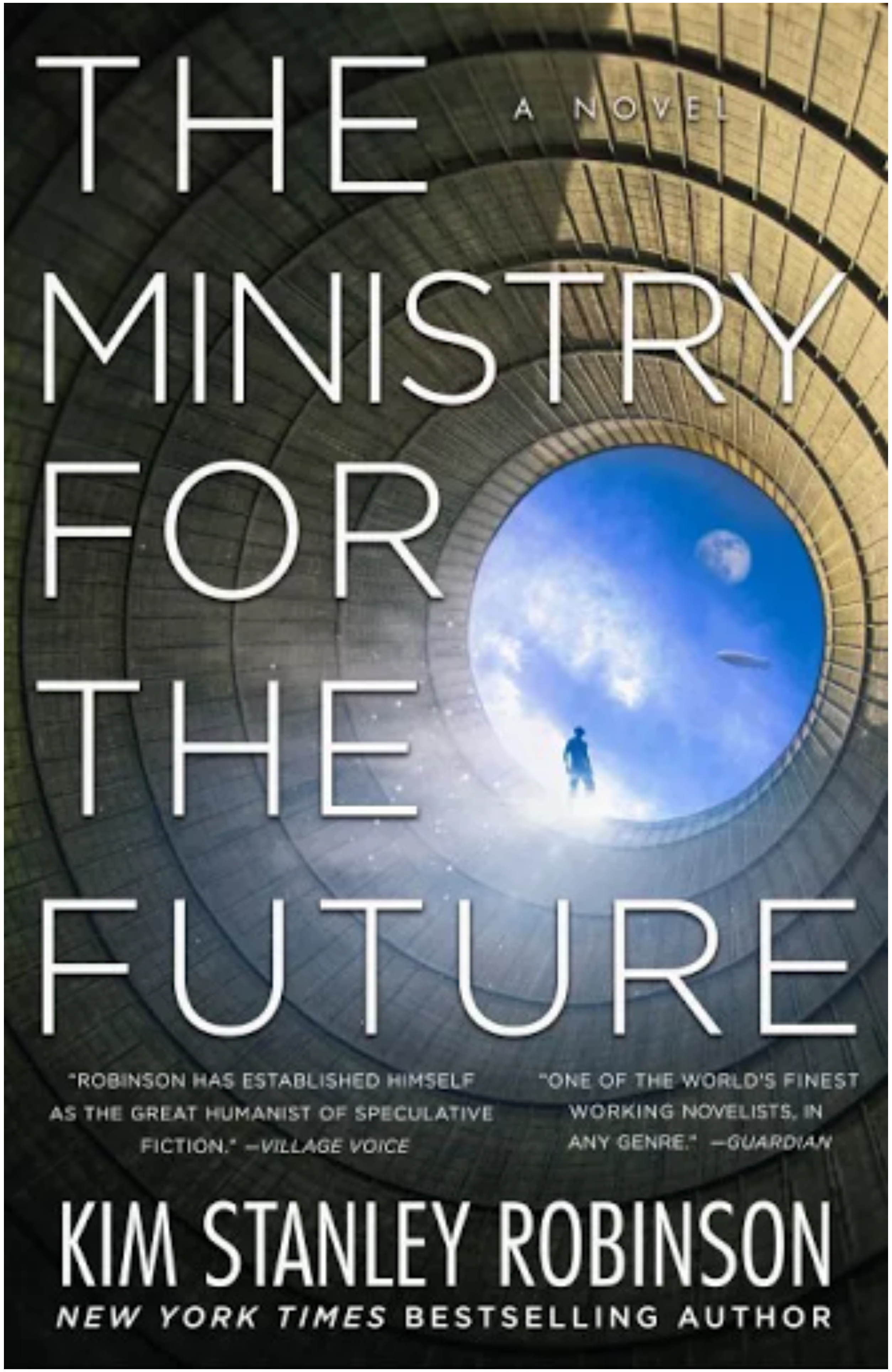
Source

Schellnhuber Talk

> "I think we have more than a 5% chance of succeeding but it is definitely less than 50%, in my view. But what is the option? If we have a final chance to save our culture and our civilisation, I am just compelled to do it."

John Schellnhuber

Founding Director
Potsdam Institute for Climate Impact Research



Source

Schellnhuber Talk

“I wish the Ring had never come to me. I wish none of this had happened.”

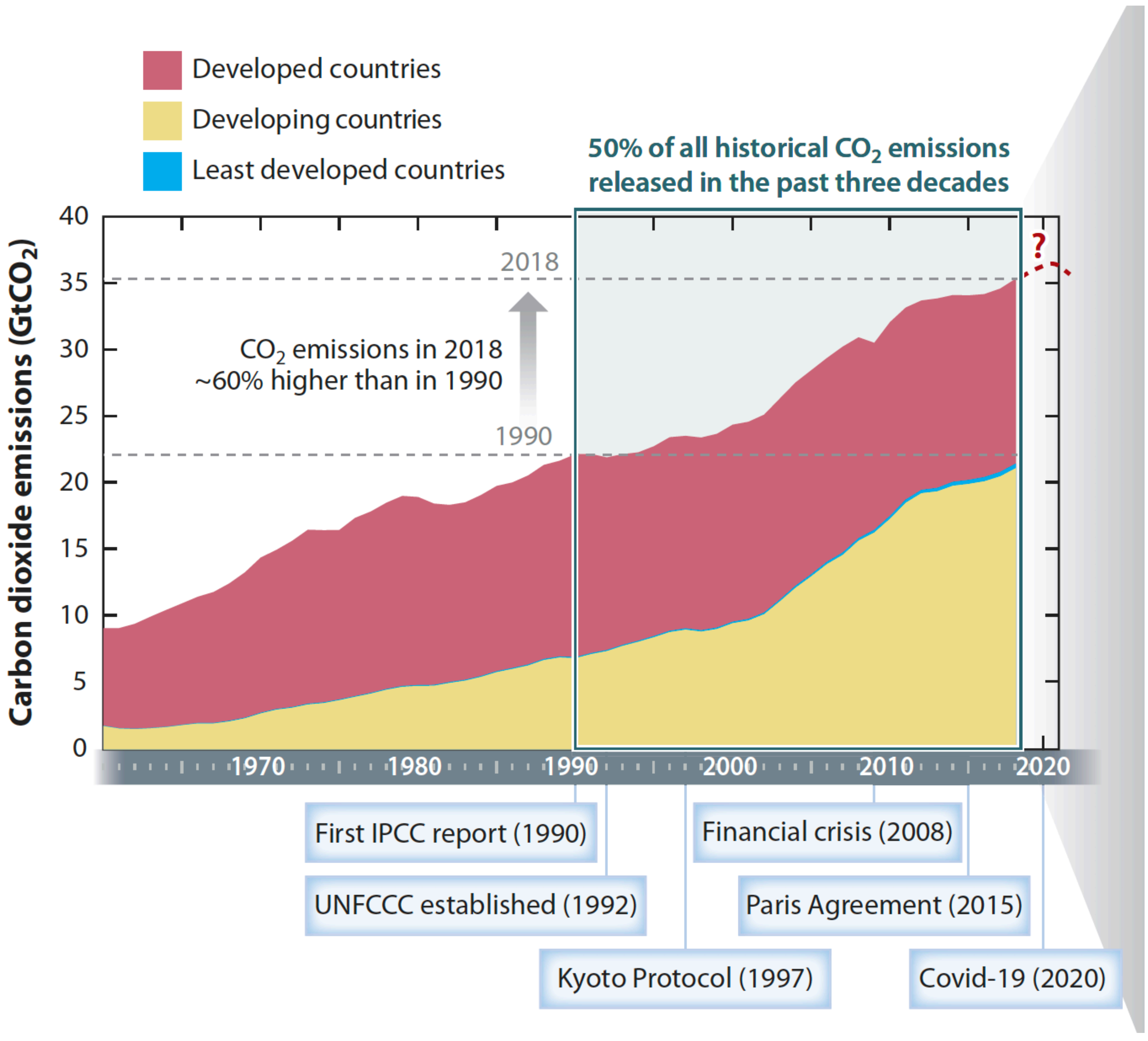
“So do all who live to see such times, but that is not for them to decide.

All we have to decide is what to do with the time that is given to us.”

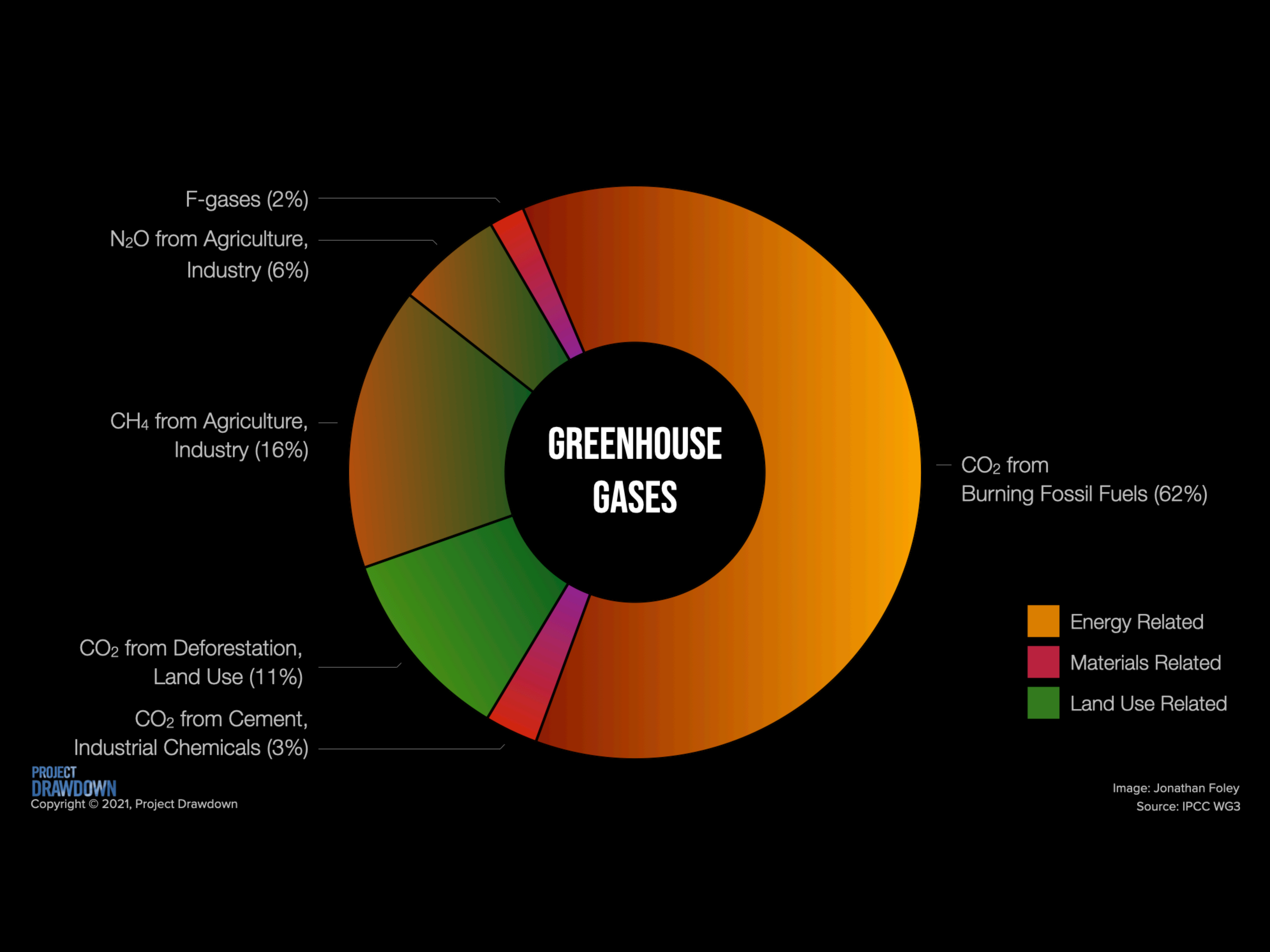
Scene

Pause

Part III:
Why Have We Failed So Far?

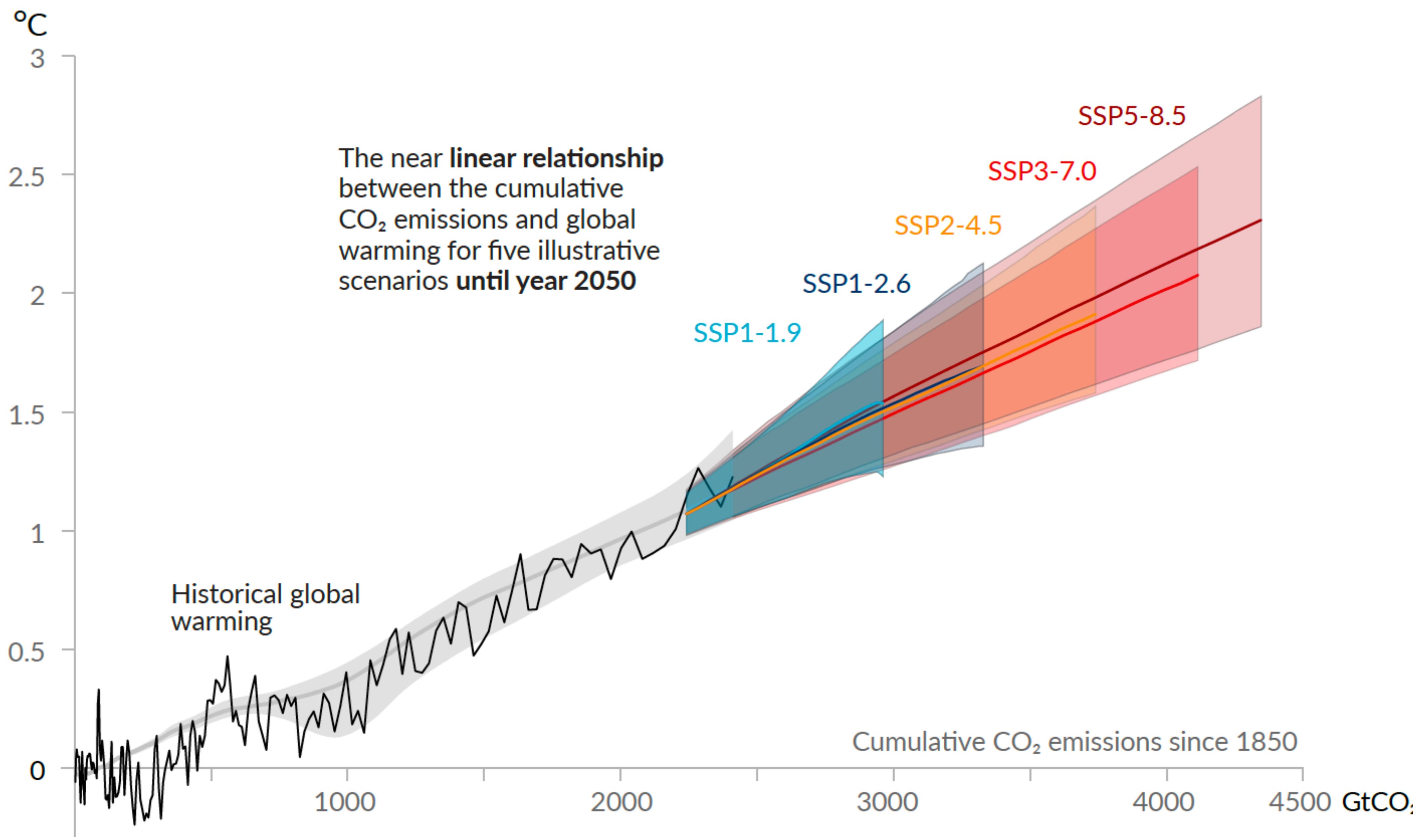


Stoddard et al. (2021)


F-gases (2%)
N_2O from Agriculture, Industry (6%)
CH_4 from Agriculture, Industry (16%)
GREENHOUSE GASES
CO_2 from Burning Fossil Fuels (62%)
CO_2 from Deforestation, Land Use (11%)
CO_2 from Cement, Industrial Chemicals (3%)
Energy Related
Materials Related
Land Use Related
PROJECT DRAWDOWN
Image: Jonathan Foley
Source: IPCC WG3

Every tonne of CO_2 emissions adds to global warming

Global surface temperature increase since 1850-1900 (°C) as a function of cumulative CO_2 emissions ($GtCO_2$)

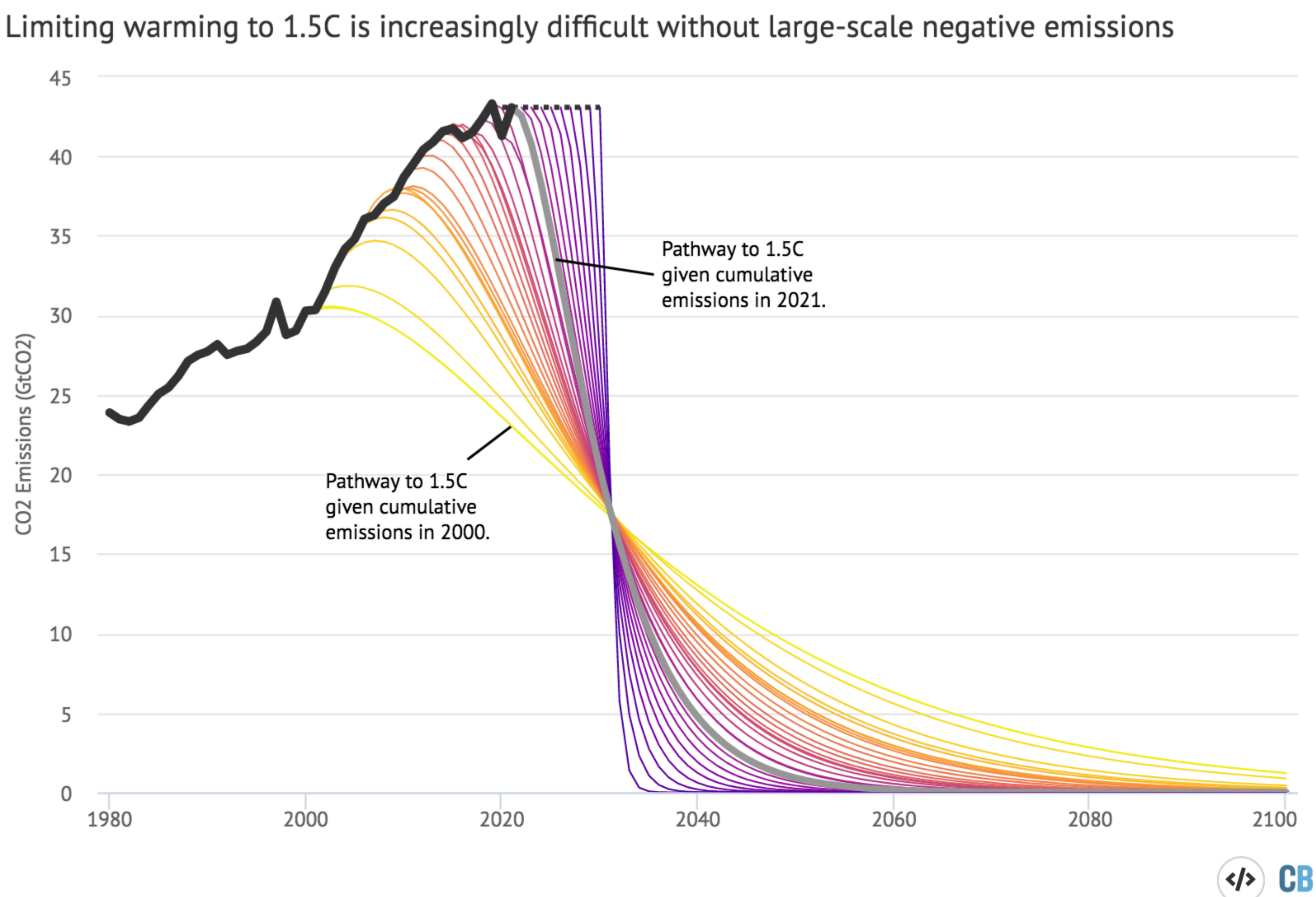


Global warming between 1850–1900 and 2010–2019 *(°C)*	Historical cumulative CO_2 emissions from 1850 to 2019 *($GtCO_2$)*
1.07 (0.8–1.3; *likely* range)	2390 (± 240; *likely* range)

Approximate global warming relative to 1850–1900 until temperature limit *(°C)**(1)	Additional global warming relative to 2010–2019 until temperature limit *(°C)*	Estimated remaining carbon budgets from the beginning of 2020 *($GtCO_2$)* *Likelihood of limiting global warming to temperature limit*(2)*					Variations in reductions in non-CO_2 emissions*(3)
		17%	*33%*	*50%*	*67%*	*83%*	
1.5	0.43	900	650	500	400	300	Higher or lower reductions in accompanying non-CO_2 emissions can increase or decrease the values on the left by 220 $GtCO_2$ or more
1.7	0.63	1450	1050	850	700	550	
2.0	0.93	2300	1700	1350	1150	900	

IPCC AR6 WGI SPM

Allen et al (2009); Peters (2019)



Hausfather (2021)

Rockström et al. (2017)

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

Davos Cluster

International Climate Governance

Vested Interests of the Fossil Fuel Industry

Geopolitics & Militarism

Enabler Cluster

Economics & Financialization

Mitigation Modelling

Energy Supply System

Ostrich Cluster

Inequity

High-Carbon Lifestyles

Social Imaginaries

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

Davos Cluster

International Climate Governance

Vested Interests of the Fossil Fuel Industry

Geopolitics & Militarism

Enabler Cluster

Economics & Financialization

Mitigation Modelling

Energy Supply System

Ostrich Cluster

Inequity

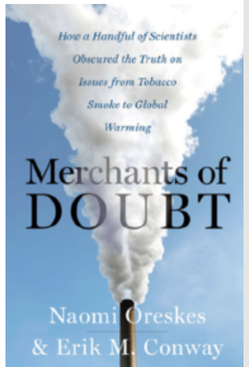
High-Carbon Lifestyles

Social Imaginaries

Fossil Fuelled Lies

Franta Talk
Franta Interview
The Corporation

Society's Understanding & Actions | **Big Oil's Understanding & Actions**



Franta (2018a,b); Franta (2021a,b); Farrell (2016); Supran & Oreskes (2017,2021a,b); McKibben (2015); Bonneuil et al. (2021); Franta & Supran (2017)

Fossil Fuelled Lies

Franta Talk
Franta Interview
The Corporation

Society's Understanding & Actions

- 1960: Keeling shows increase in CO_2
- 1965: Environmental Report Lyndon Johnson
- 1970s: Cooling or Warming? Warming!
- 1988: Hansen testifies before Congress
- 1988: IPCC forms
- 1992: UNFCCC
- 1997: Kyoto Protocol signed
- 2015: Paris Agreement

Big Oil's Understanding & Actions

Franta (2018a,b); Franta (2021a,b); Farrell (2016); Supran & Oreskes (2017,2021a,b); McKibben (2015); Bonneuil et al. (2021); Franta & Supran (2017)

Fossil Fuelled Lies

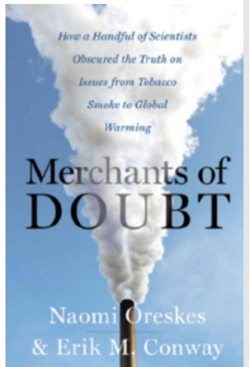
Franta Talk
Franta Interview
The Corporation

Society's Understanding & Actions

- 1960: Keeling shows increase in CO_2
- 1965: Environmental Report Lyndon Johnson
- 1970s: Cooling or Warming? Warming!
- 1988: Hansen testifies before Congress
- 1988: IPCC forms
- 1992: UNFCCC
- 1997: Kyoto Protocol signed
- 2015: Paris Agreement

Big Oil's Understanding & Actions

- 1959: Edward Teller warns Big Oil
- 1965: President of API warns Big Oil
- 1979-83: Exxon internal research programme
- 1980: API argues for tripling coal
- 1987: IPIECA Strategy meeting
  Emphasise uncertainties
  Stress the cost of action
  Focus on policies that do not threaten fossil fuels
  Insist on 'detection before action'
- 1989-2002: Global Climate Coalition
- 2000-now: Greenwashing



Franta (2018a,b); Franta (2021a,b); Farrell (2016); Supran & Oreskes (2017,2021a,b); McKibben (2015); Bonneuil et al. (2021); Franta & Supran (2017)

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

Davos Cluster

International Climate Governance

Vested Interests of the Fossil Fuel Industry ✓

Geopolitics & Militarism

Enabler Cluster

Economics & Financialization

Mitigation Modelling

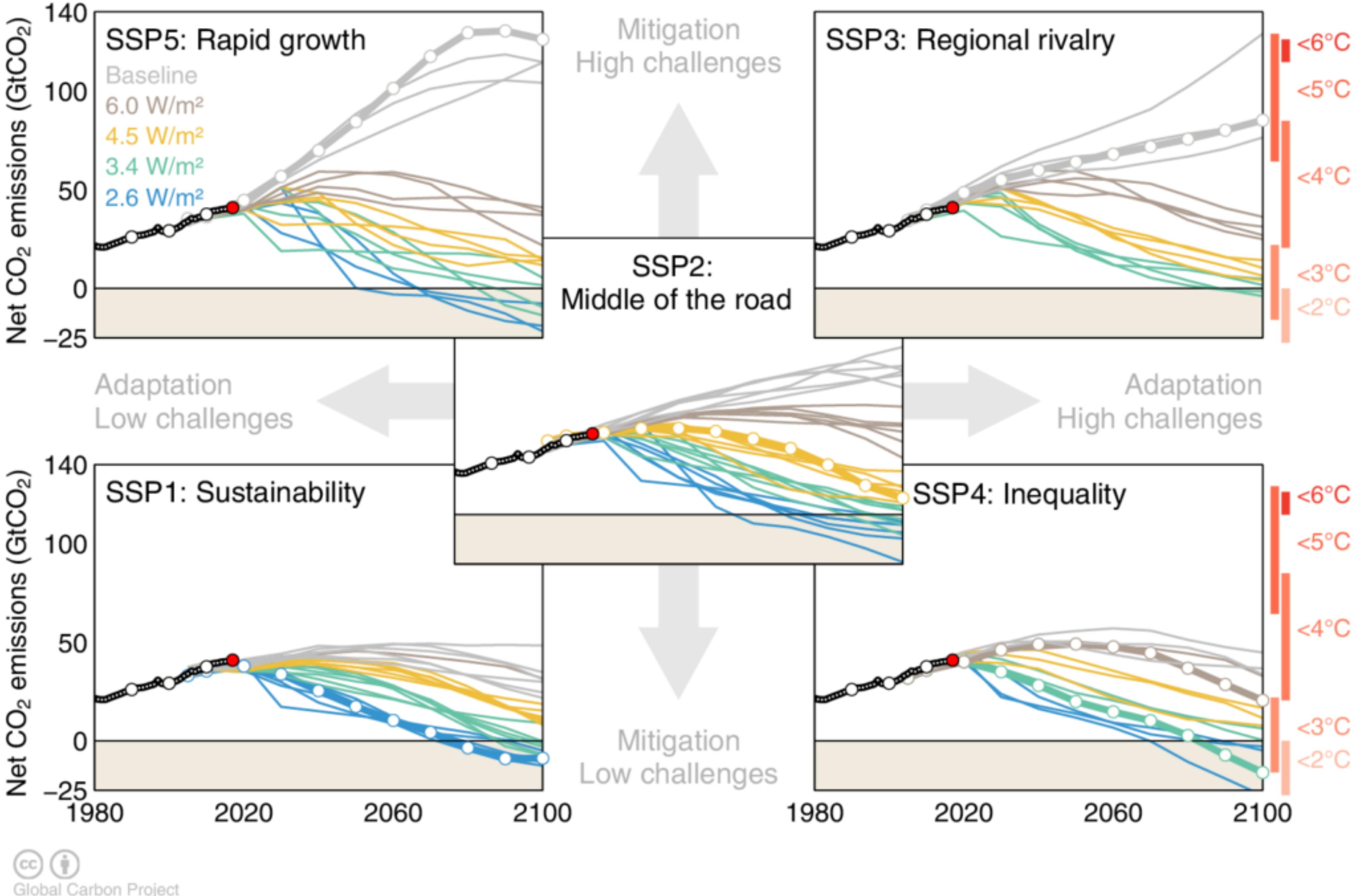
Energy Supply System

Ostrich Cluster

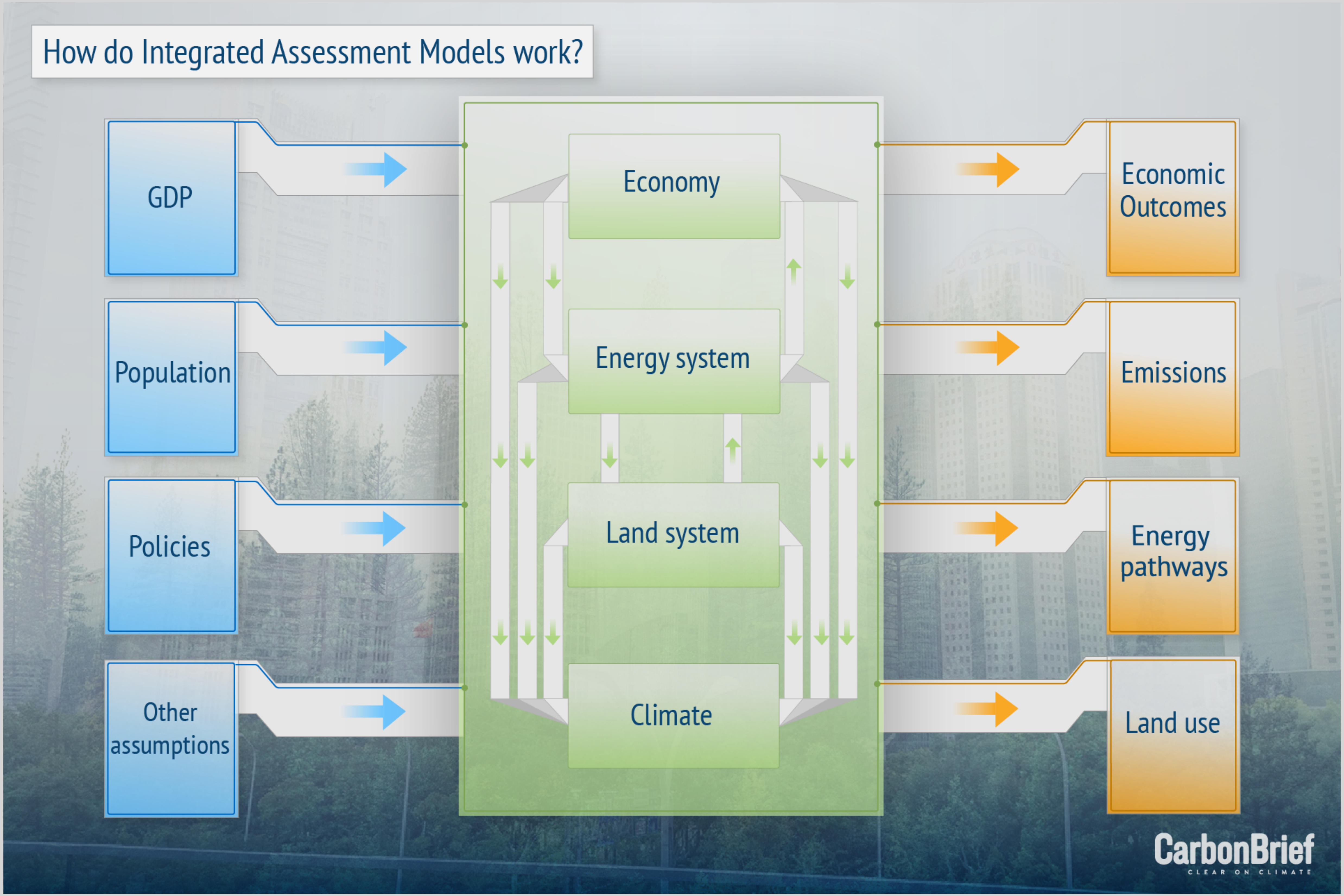
Inequity

High-Carbon Lifestyles

Social Imaginaries



Hausfather (2018); Evans & Hausfather (2018)



Hausfather (2018); Evans & Hausfather (2018); Pindyck (2013); Farmer et al. (2015); Creutzig et al. (2017); Anderson & Jewell (2019); Hickel et al. (2021)

Integrated Assessment Models

- Based on neoclassical economics
  - Rational agents, full information
  - Markets work, no wasted investments, no unemployment
  - Reduction in economic activity by definition a cost
  - Economic growth can be decoupled from emissions (“green growth”)

- Discount rate
  - Weigh near-time costs more heavily than those in the future
  - Action today is more costly than action tomorrow

- Under-predicted the fall in the cost of renewables
  - Overstated the cost of rapid decarbonisation

- Focus on market-based solutions (e.g., carbon price)
- Focus on technological innovation such as large-scale negative emissions technology

Hausfather (2018); Evans & Hausfather (2018); Pindyck (2013); Farmer et al. (2015); Creutzig et al. (2017); Anderson & Jewell (2019); Hickel et al. (2021)

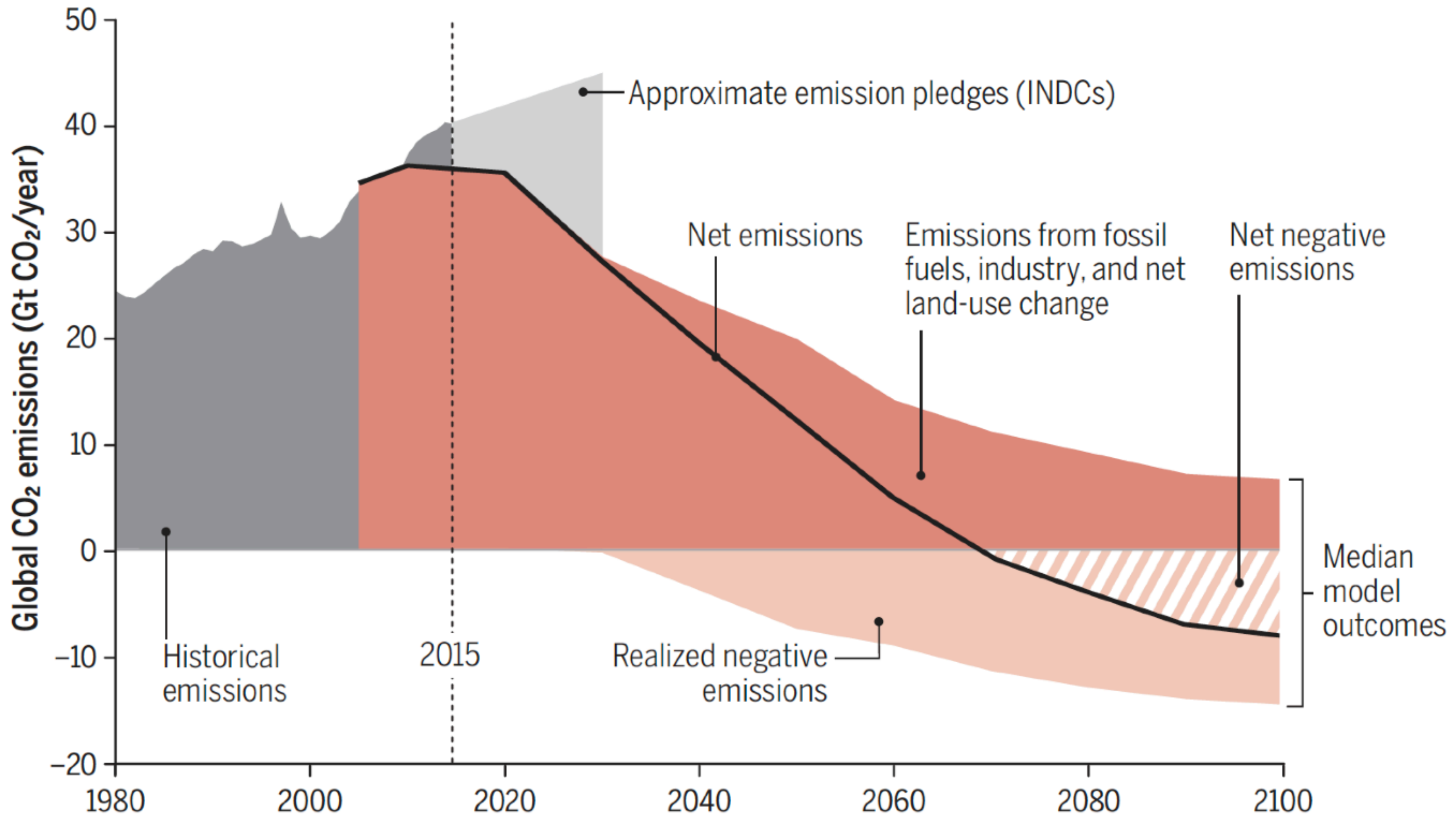
Peters Talk

Anderson Talk

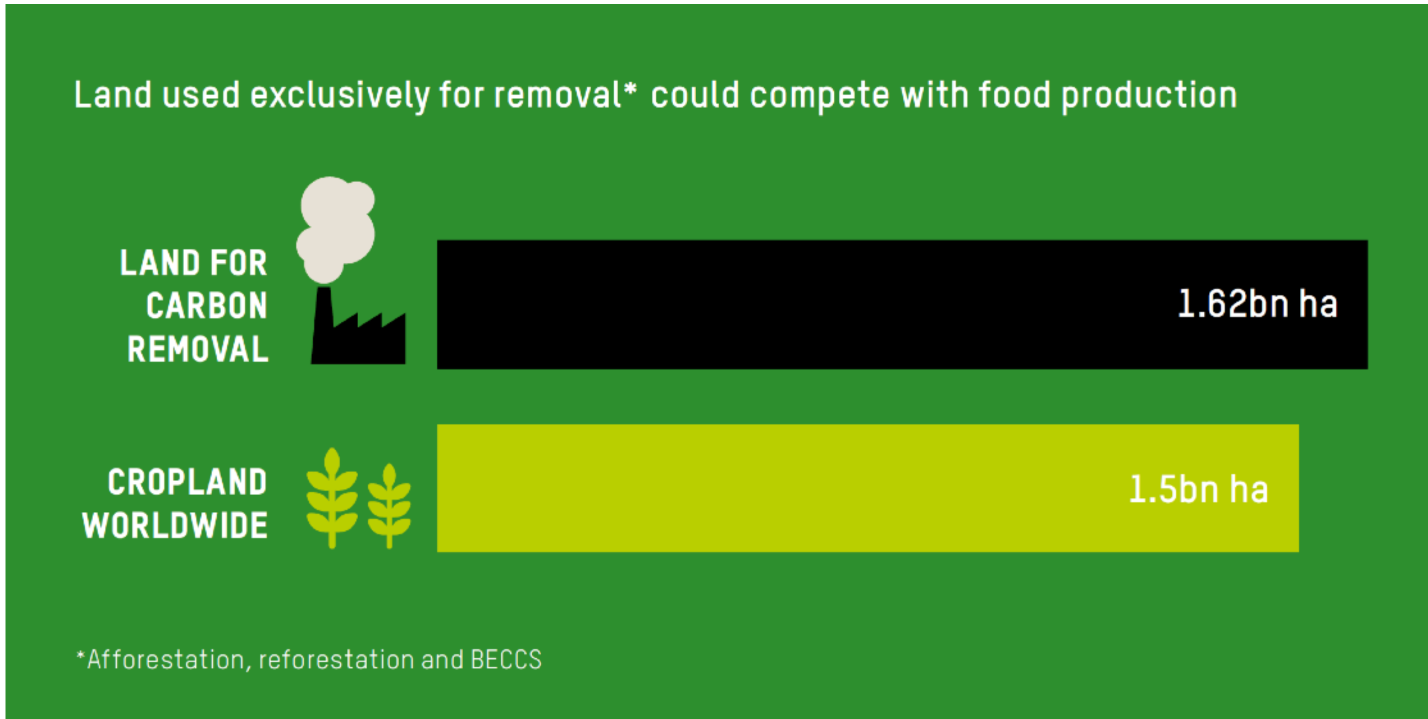
Anderson Interview

No quick fixes

Modelers generally report net carbon emissions, unintentionally hiding the scale of negative emissions. Separating out the positive CO_2 emissions from fossil fuel combustion, industry, and land-use change reveals the scale of negative CO_2 emissions in the model scenarios (*16*). INDCs, Intended Nationally Determined Contributions.



> ***"Negative-emission technologies are not an insurance policy, but rather an unjust and high-stakes gamble."***
>
> \- Anderson & Peters (2016)

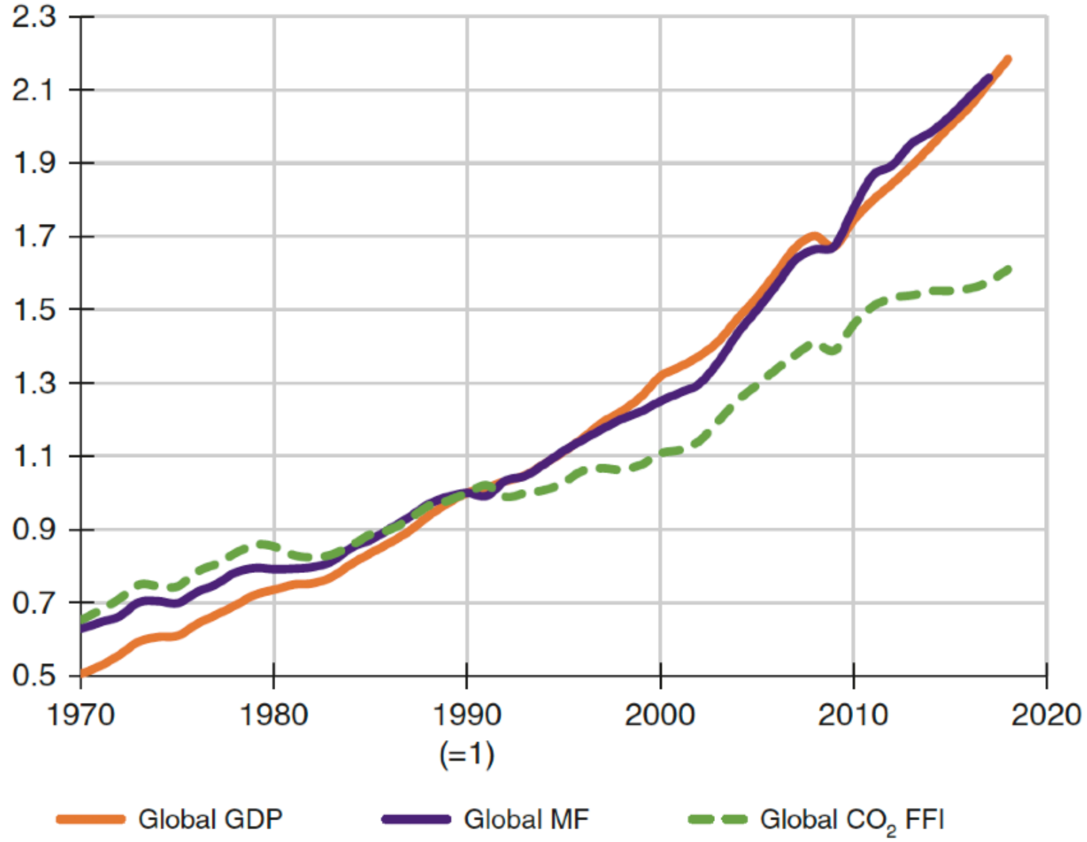


Hickman (2016)

Sen & Dabi (2021)

Carbon Brief

Hickel Podcast



PAPER • OPEN ACCESS

A systematic review of the evidence on decoupling of GDP, resource use and GHG emissions, part II: synthesizing the insights

Helmut Haberl[1], Dominik Wiedenhofer[1,9], Doris Virág[1,9], Gerald Kalt[1], Barbara Plank[1], Paul Brockway[2], Tomer Fishman[3], Daniel Hausknost[5], Fridolin Krausmann[1], Bartholomäus Leon-Gruchalski[4], Andreas Mayer[1], Melanie Pichler[1], Anke Schaffartzik[1,6], Tânia Sousa[7], Jan Streeck[1] and Felix Creutzig[8] − Hide full author list

Published 11 June 2020 • © 2020 The Author(s). Published by IOP Publishing Ltd

Environmental Research Letters, Volume 15, Number 6

Citation Helmut Haberl *et al* 2020 *Environ. Res. Lett.* **15** 065003

ECONOMICS

Unraveling the claims for (and against) green growth

Can the global economy grow indefinitely, decoupled from Earth's limitations?

By **Tim Jackson**[1] *and* **Peter A. Victor**[2]

Comment | Published: 04 August 2021

Urgent need for post-growth climate mitigation scenarios

Jason Hickel, Paul Brockway, Giorgos Kallis, Lorenz Keyßer, Manfred Lenzen, Aljoša Slameršak, Julia Steinberger & Diana Ürge-Vorsatz

Nature Energy **6**, 766–768 (2021) | Cite this article

2218 Accesses | **1476** Altmetric | Metrics

Is Green Growth Possible?

Jason Hickel[a] and Giorgos Kallis[b]

[a]Anthropology, Goldsmiths, University of London, London, UK; [b]ICREA and ICTA-UAB, Universitat Autonoma de Barcelona, Barcelona, Spain

ABSTRACT

The notion of green growth has emerged as a dominant policy response to climate change and ecological breakdown. Green growth theory asserts that continued economic expansion is compatible with our planet's ecology, as technological change and substitution will allow us to absolutely decouple GDP growth from resource use and carbon emissions. This claim is now assumed in national and international policy, including in the Sustainable Development Goals. But empirical evidence on resource use and carbon emissions does not support green growth theory. Examining relevant studies on historical trends and model-based projections, we find that: (1) there is no empirical evidence that absolute decoupling from resource use can be achieved on a global scale against a background of continued economic growth, and (2) absolute decoupling from carbon emissions is highly unlikely to be achieved at a rate rapid enough to prevent global warming over 1.5°C or 2°C, even under optimistic policy conditions. We conclude that green growth is likely to be a misguided objective, and that policymakers need to look toward alternative strategies.

KEYWORDS

Sustainable development; ecological economics; green growth; degrowth; decoupling

Wiedmann et al. (2020); Haberl et al. (2020); Jackson & Victor (2019); Hickel & Kallis (2019); Hickel et al. (2021); Hickel & Hallegatte (2021)

Keen Podcast

Climate Change Policy: What Do the Models Tell Us?

JOURNAL OF ECONOMIC LITERATURE
VOL. 51, NO. 3, SEPTEMBER 2013
(pp. 860-72)

Robert S. Pindyck

Abstract

Very little. A plethora of integrated assessment models (IAMs) have been constructed and used to estimate the social cost of carbon (SCC) and evaluate alternative abatement policies. These models have crucial flaws that make them close to useless as tools for policy analysis: certain inputs (e.g., the discount rate) are arbitrary, but have huge effects on the SCC estimates the models produce; the models' descriptions of the impact of climate change are completely ad hoc, with no theoretical or empirical foundation; and the models can tell us nothing about the most important driver of the SCC, the possibility of a catastrophic climate outcome. IAM-based analyses of climate policy create a perception of knowledge and precision, but that perception is illusory and misleading.

The appallingly bad neoclassical economics of climate change

Steve Keen

Institute for Strategy, Resilience and Security, University College London, London, UK

ABSTRACT
Forecasts by economists of the economic damage from climate change have been notably sanguine, compared to warnings by scientists about damage to the biosphere. This is because economists made their own predictions of damages, using three spurious methods: assuming that about 90% of GDP will be unaffected by climate change, because it happens indoors; using the relationship between temperature and GDP today as a proxy for the impact of global warming over time; and using surveys that diluted extreme warnings from scientists with optimistic expectations from economists. Nordhaus has misrepresented the scientific literature to justify the using a smooth function to describe the damage to GDP from climate change. Correcting for these errors makes it feasible that the economic damages from climate change are at least an order of magnitude worse than forecast by economists, and may be so great as to threaten the survival of human civilization.

KEYWORDS
Climate change; neoclassical economics; William Nordhaus

Keen (2020)
Pindyck (2013)
Evans, Pidcock, & Yeo (2017)

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

Davos Cluster

International Climate Governance

Vested Interests of the Fossil Fuel Industry

Geopolitics & Militarism

Enabler Cluster

Economics & Financialization

Mitigation Modelling

Energy Supply System

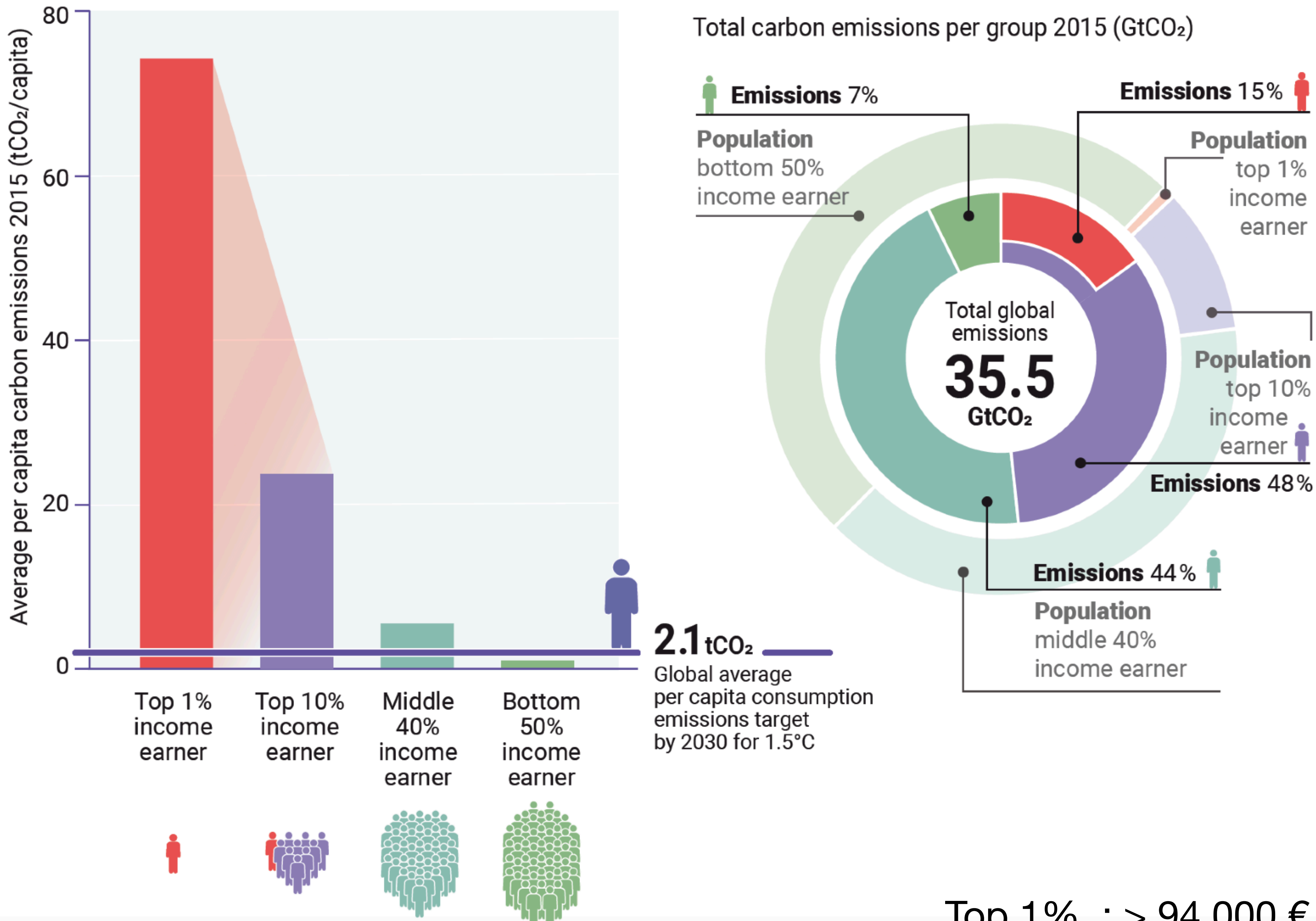
Ostrich Cluster

Inequity

High-Carbon Lifestyles

Social Imaginaries

Carbon Inequality

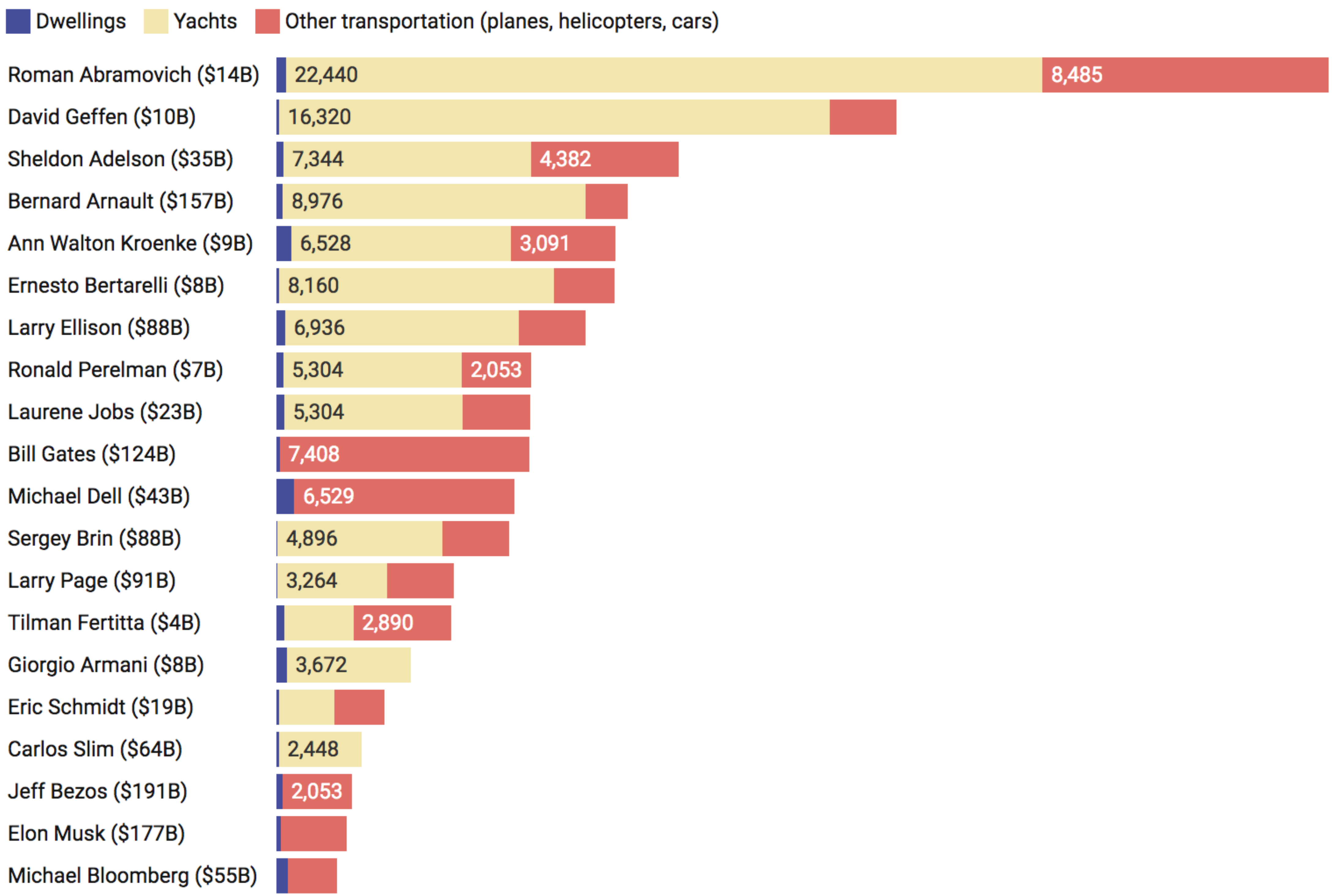


Top 1% : > 94,000 € / year
Top 10%: > 32,800 € / year

Capstick et al. (2020)

Billionaire Emissions

Monbiot rant



Estimates of wealth are based on Feb. 15 data, according to Forbes, except for Sheldon Adelson, who died in January.

Chart: The Conversation, CC-BY-ND • Source: Forbes, Carbon Footprint, US US Energy Information Administration, Carbon Independent, "The Yacht of 2030"

Barros & Wilk (2021a,b)

Monbiot column

New Zealand Escape

Comment | Published: 28 January 2019

Shift the focus from the super-poor to the super-rich

Ilona M. Otto, Kyoung Mi Kim, Nika Dubrovsky & Wolfgang Lucht

Nature Climate Change **9**, 82–84 (2019) | Cite this article

4864 Accesses | **28** Citations | **1921** Altmetric | Metrics

Perspective | Open Access | Published: 19 June 2020

Scientists' warning on affluence

Thomas Wiedmann, Manfred Lenzen, Lorenz T. Keyßer & Julia K. Steinberger

Nature Communications **11**, Article number: 3107 (2020) | Cite this article

171k Accesses | **107** Citations | **4550** Altmetric | Metrics

Perspective | Published: 30 September 2021

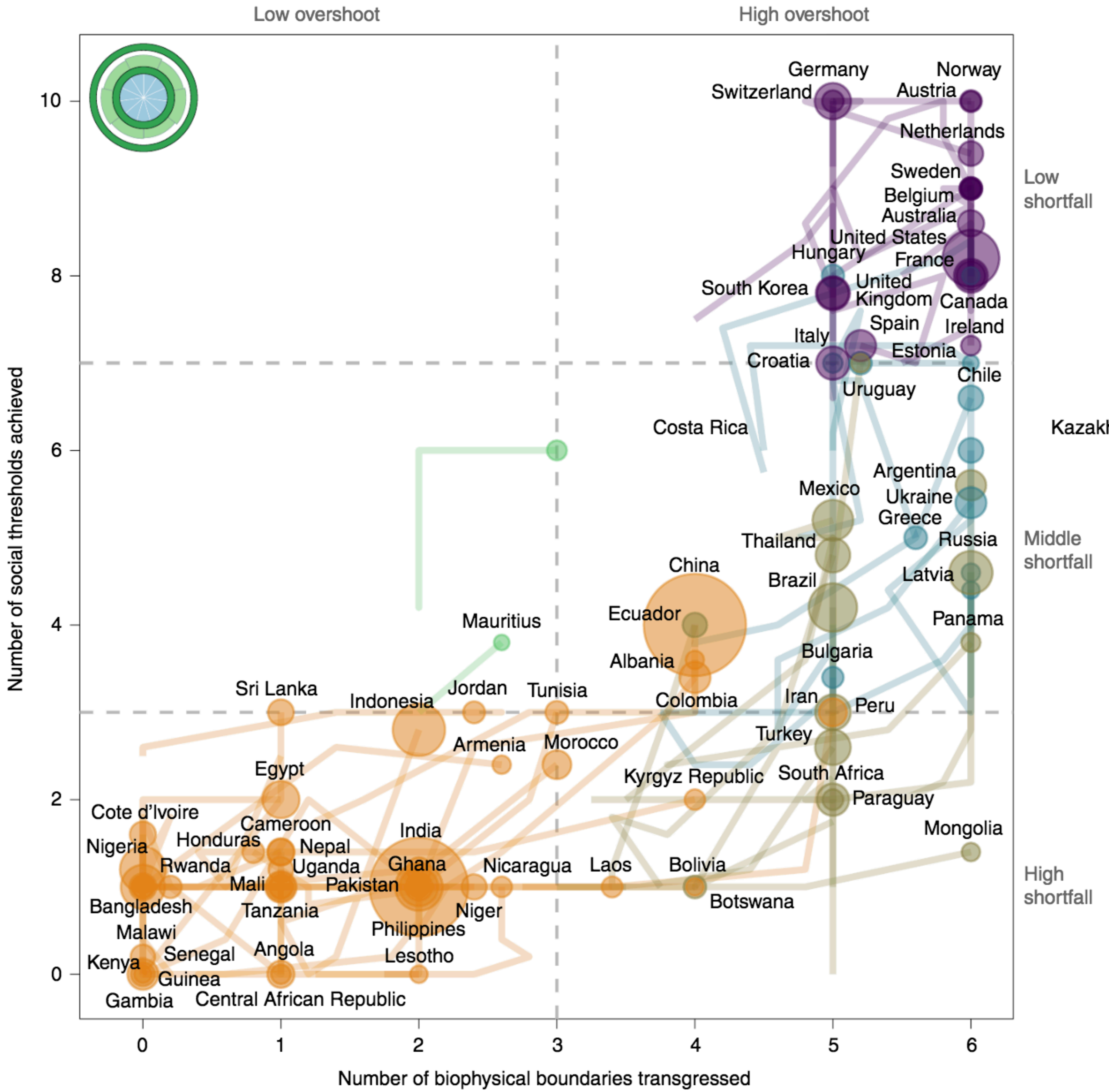
The role of high-socioeconomic-status people in locking in or rapidly reducing energy-driven greenhouse gas emissions

Kristian S. Nielsen, Kimberly A. Nicholas, Felix Creutzig, Thomas Dietz & Paul C. Stern

Nature Energy **6**, 1011–1016 (2021) | Cite this article

12k Accesses | **671** Altmetric | Metrics

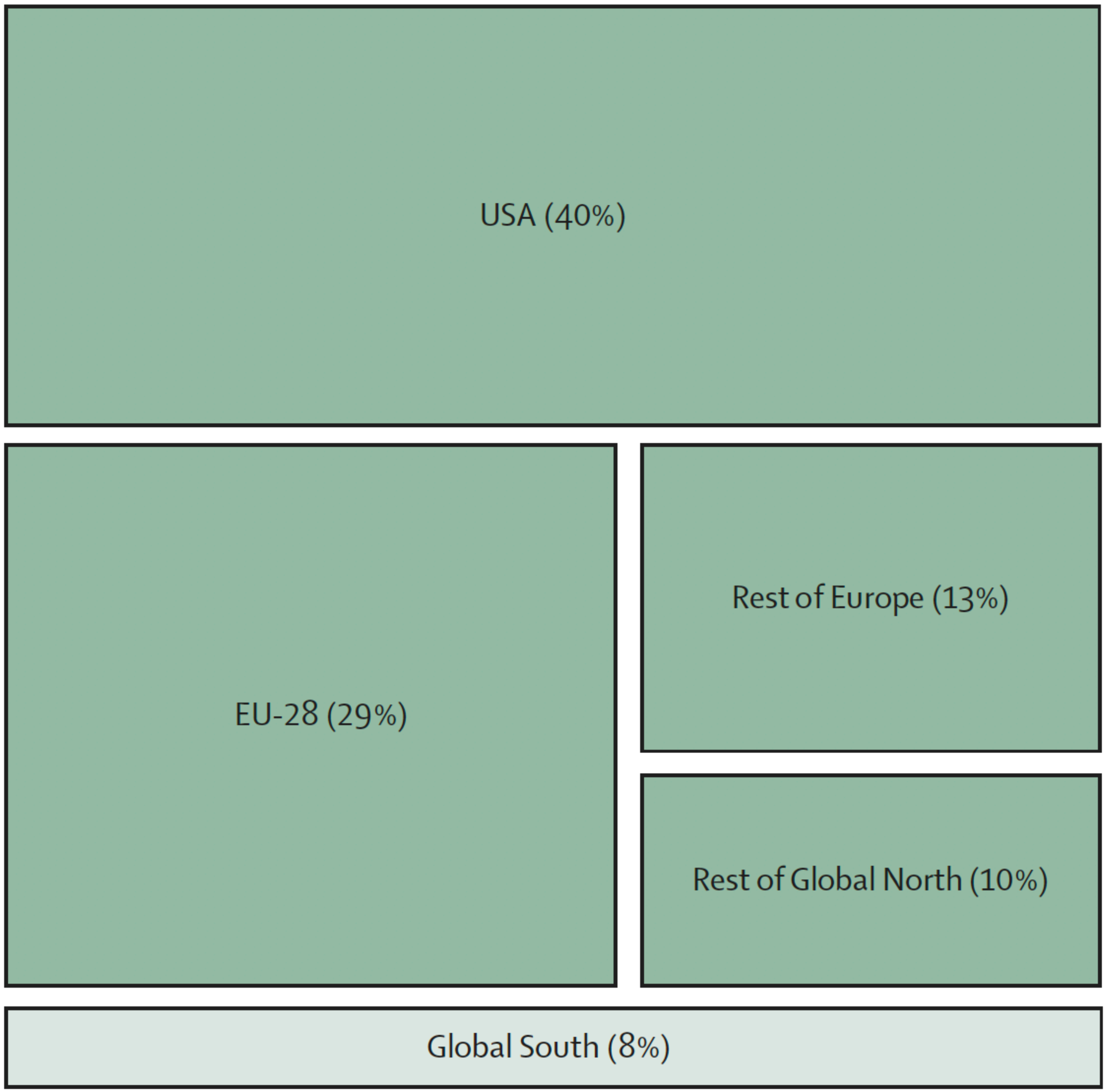
Otto et al. (2019); Wiedmann et al. (2020); Nielsen et al. (2021)

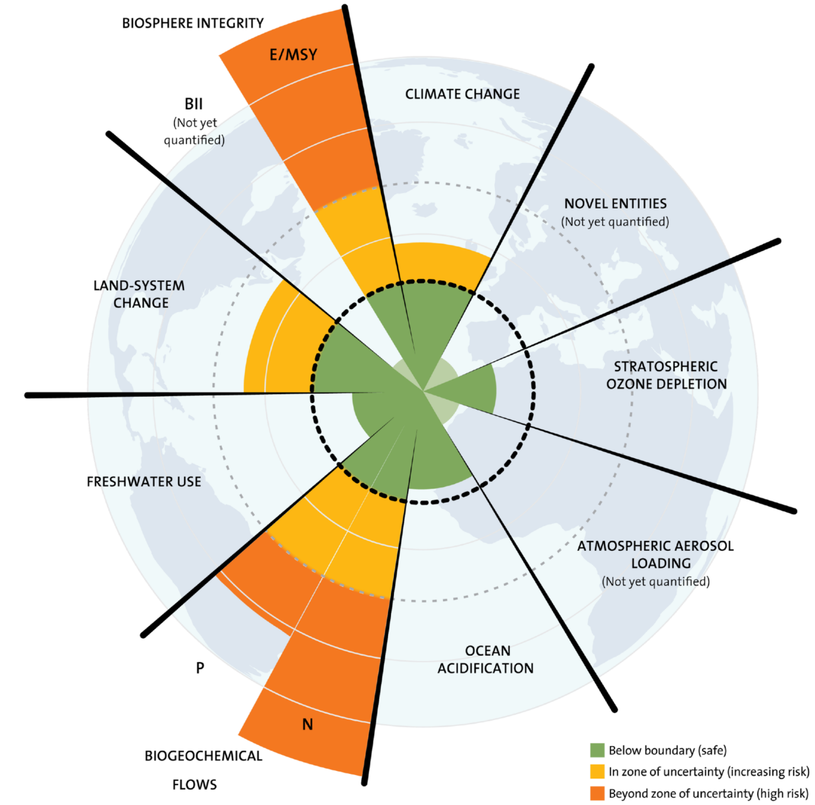


Fanning et al. (2021); O'Neill et al. (2018)

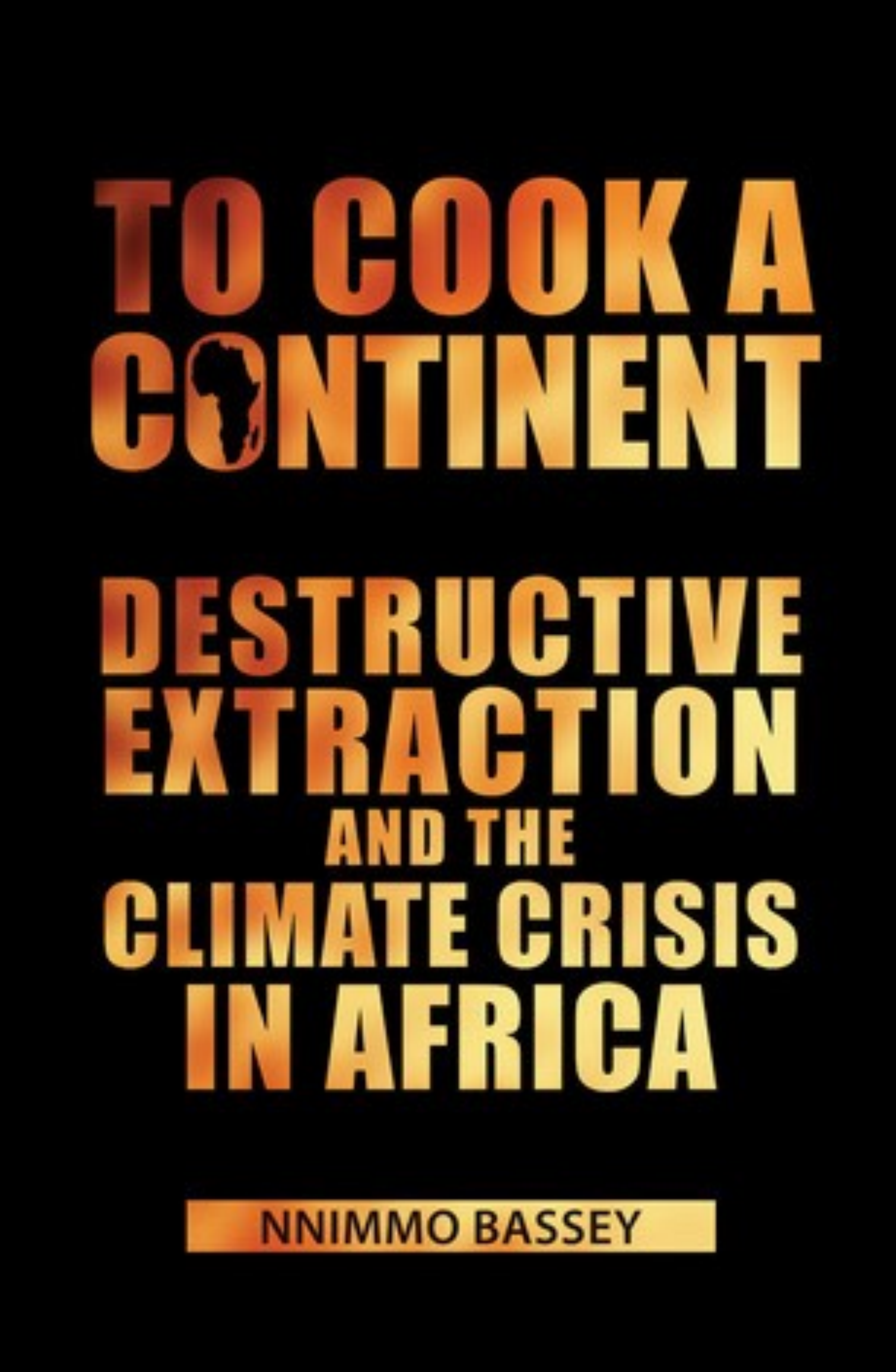
https://goodlife.leeds.ac.uk/

Responsibility for climate breakdown





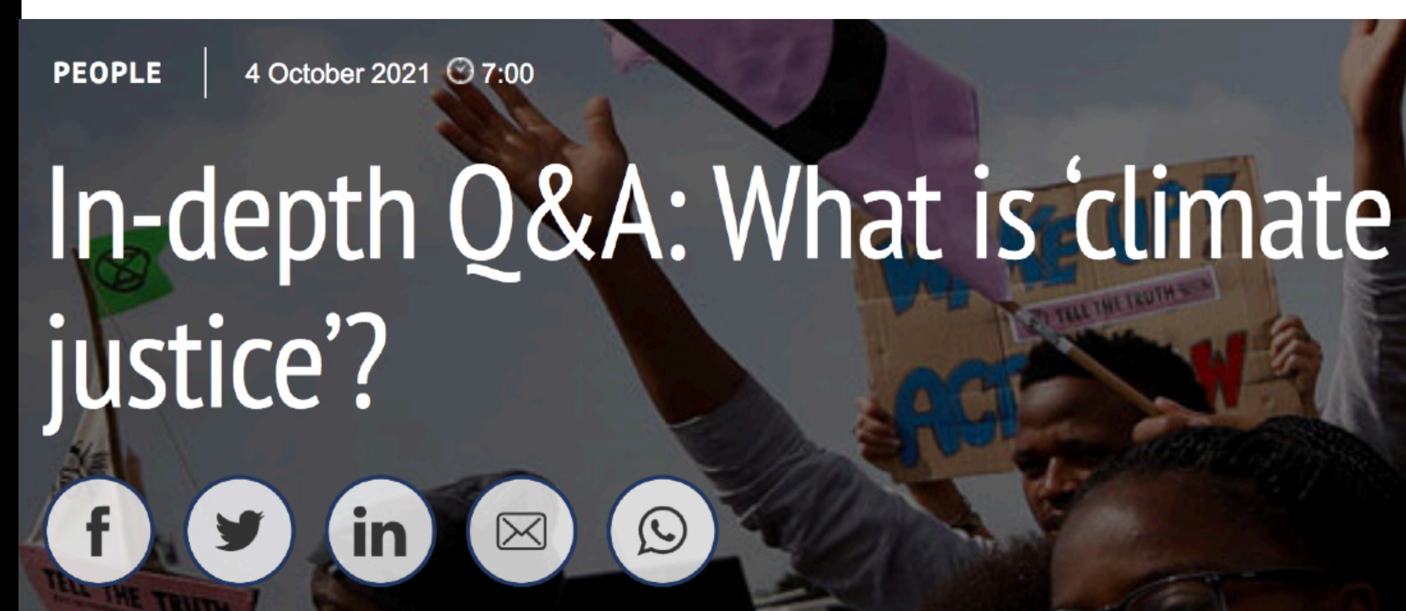
Hickel (2020) Anderson et al. (2020)



Mittal & Bassey Event

Climate Reparations

Learning From Ladakh



Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

Davos Cluster

International Climate Governance

Vested Interests of the Fossil Fuel Industry

Geopolitics & Militarism

Enabler Cluster

Economics & Financialization

Mitigation Modelling

Energy Supply System

Ostrich Cluster

Inequity

High-Carbon Lifestyles

Social Imaginaries

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

"I've been there all along, and it had taken me too long to figure out what was happening. I wrote the first book about [climate change] and I kept writing more books, articles, and having symposiums on the theory that if we kept piling up enough data and reason eventually the powers that be would get to work — why wouldn't they?

- Bill McKibben

Anderson Interview

Power

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

"I've been there all along, and it had taken me too long to figure out what was happening. I wrote the first book about [climate change] and I kept writing more books, articles, and having symposiums on the theory that if we kept piling up enough data and reason eventually the powers that be would get to work — why wouldn't they?

I thought that we were in an argument. And it took me too long to figure out that we won the argument, but that that didn't mean anything. We won the argument — the science was entirely robust and clear. We were just losing the fight.

\- Bill McKibben

Anderson Interview

Power

Three Decades of Climate Mitigation: Why Haven't We Bent the Global Emissions Curve?

Annual Review of Environment and Resources
Vol. 46:653-689 (Volume publication date October 2021)
First published as a Review in Advance on June 29, 2021
https://doi.org/10.1146/annurev-environ-012220-011104

Isak Stoddard,[1] Kevin Anderson,[1,2] Stuart Capstick,[3] Wim Carton,[4] Joanna Depledge,[5] Keri Facer,[1,6] Clair Gough,[2] Frederic Hache,[7] Claire Hoolohan,[2,3] Martin Hultman,[8] Niclas Hällström,[9] Sivan Kartha,[10] Sonja Klinsky,[11] Magdalena Kuchler,[1] Eva Lövbrand,[12] Naghmeh Nasiritousi,[13,14] Peter Newell,[15] Glen P. Peters,[16] Youba Sokona,[17] Andy Stirling,[18] Matthew Stilwell,[19] Clive L. Spash,[20] and Mariama Williams[17]

"I've been there all along, and it had taken me too long to figure out what was happening. I wrote the first book about [climate change] and I kept writing more books, articles, and having symposiums on the theory that if we kept piling up enough data and reason eventually the powers that be would get to work — why wouldn't they?

I thought that we were in an argument. And it took me too long to figure out that we won the argument, but that that didn't mean anything. We won the argument — the science was entirely robust and clear. We were just losing the fight.

Because the fight wasn't about data and reason, the fight was about money and power, which is what fights are always about."

- Bill McKibben

Anderson Interview

Power

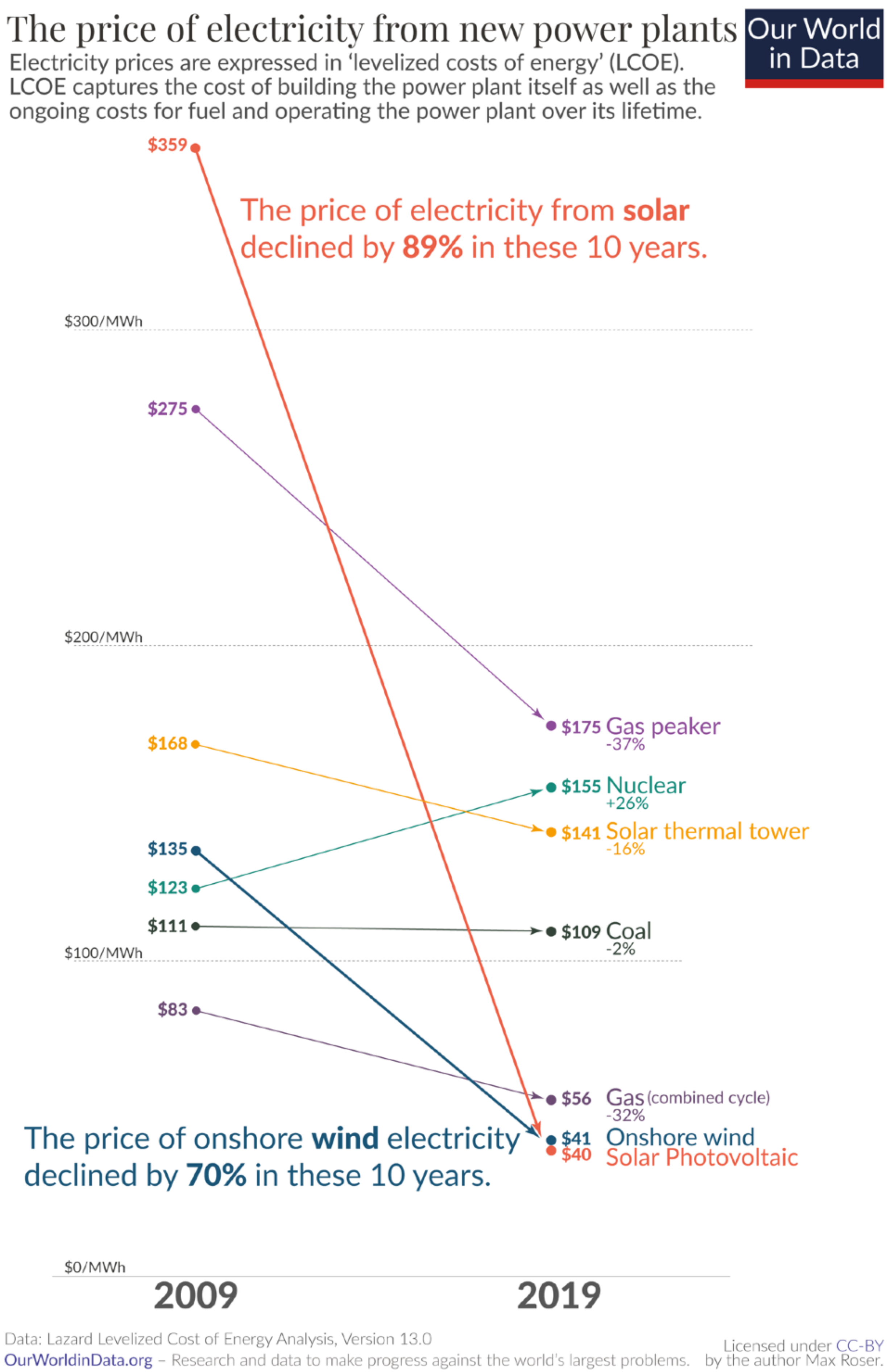
Pause

Part IV:
What Can We Do Today?

It's easy to feel pessimistic about the climate. But we've got two big things on our side

Bill McKibben

McKibben (2021)



Report I; Report II

Campanale Interview

Way et al. (2021); Roser (2020)


CLIMATE
SYSTEM CHANGE
SKOLSTREJK FÖR KLIMATET
NOT

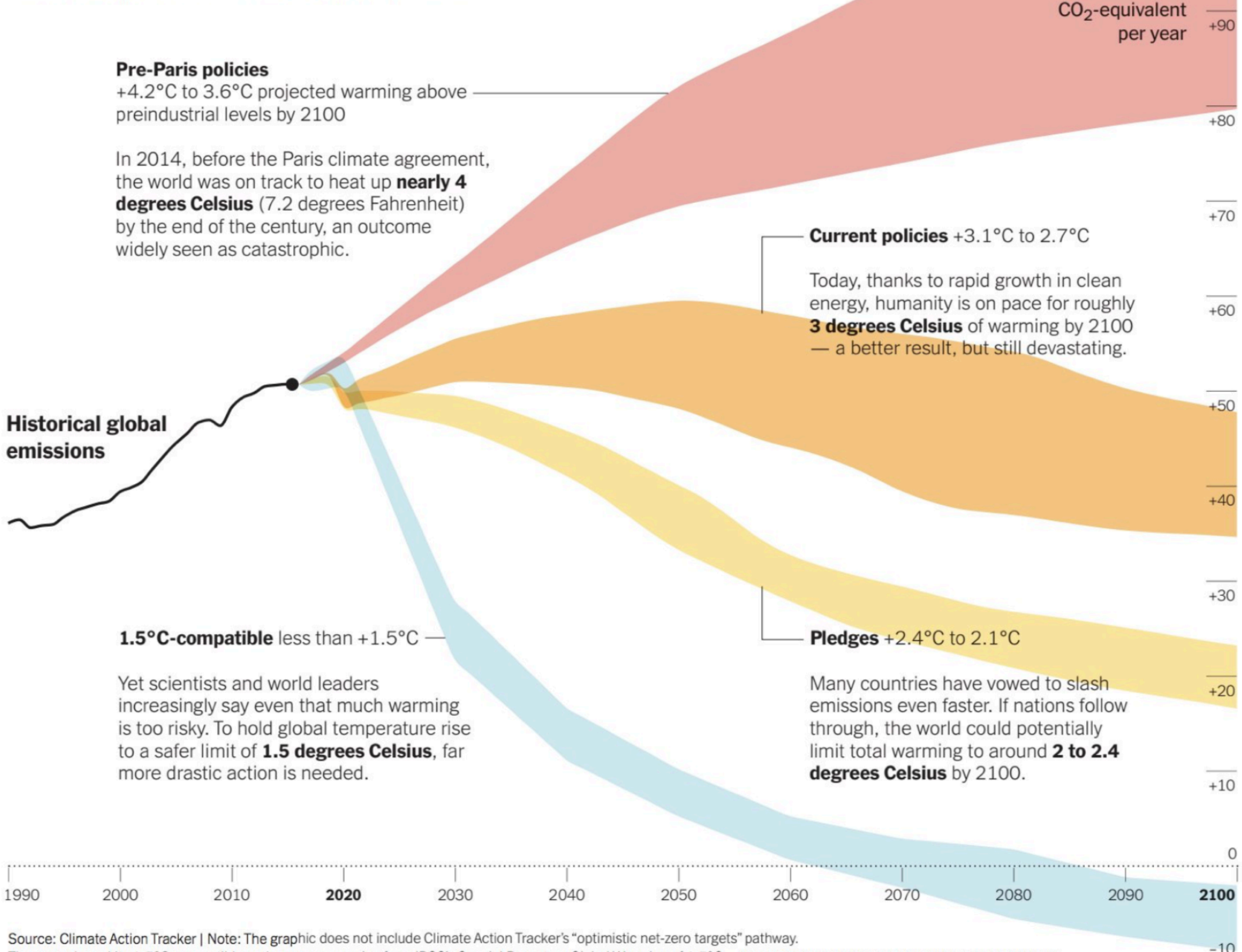

Climate Emergency
RISE UP
ACT NOW
REBEL FOR LIFE


DENIAL IS NOT A POLICY!
DENIAL GETS US NOWHERE

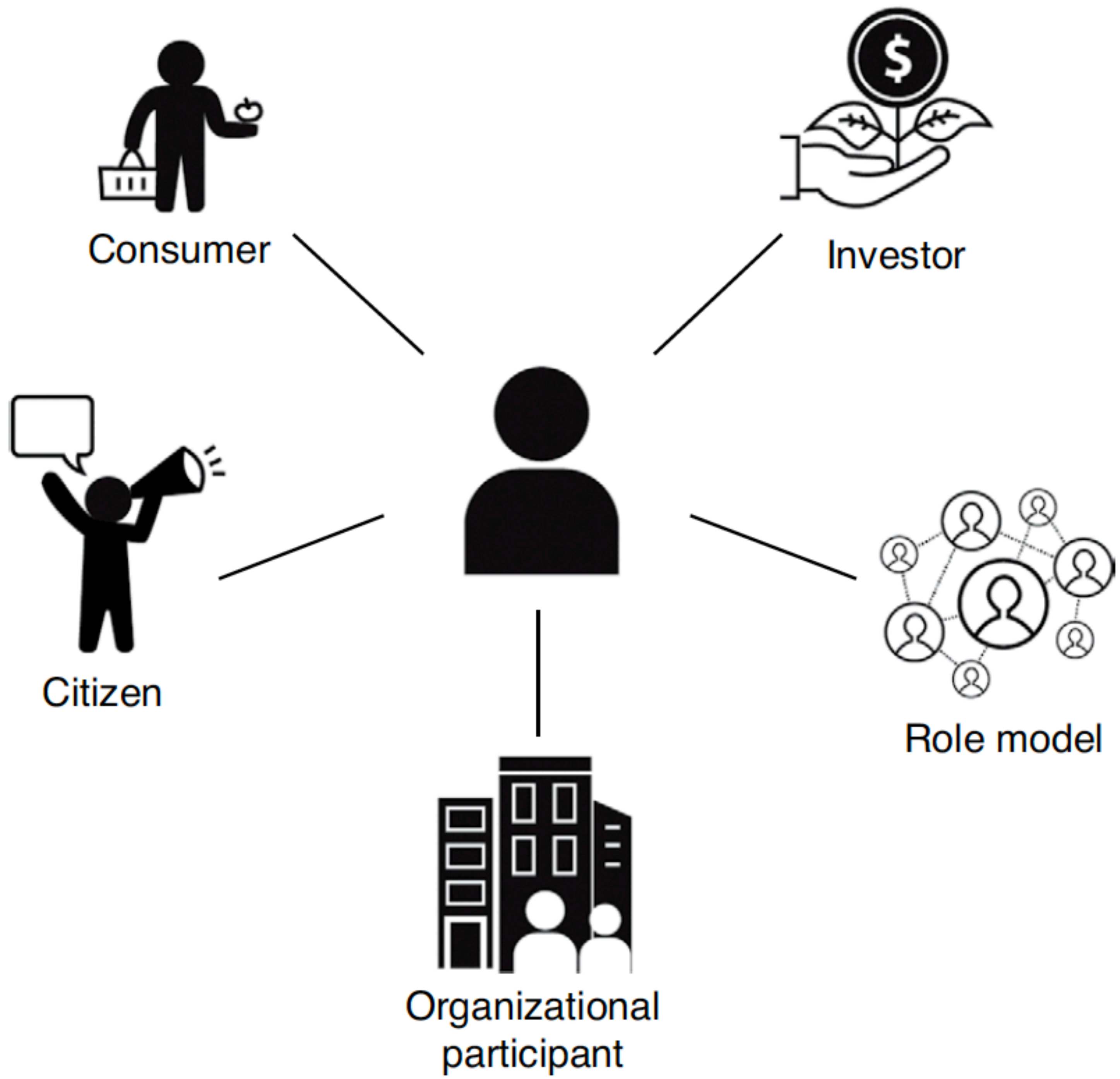

WE ARE THE MAJORITY
THE PEOPLE HAVE SPOKEN
OUR TIME
THIS IS A DEMOCRACY
ACT LIKE IT
OUR TIME TO RISE

The World Has Bent the Emissions Curve. But Not Nearly Enough.

Ahead of next week's United Nations climate summit, the focus is on one crucial question: How many degrees hotter will the Earth get? Page A10.



Source: Climate Action Tracker | Note: The graphic does not include Climate Action Tracker's "optimistic net-zero targets" pathway.
The group based its 1.5°C-compatible pathway on scenarios from IPCC's Special Report on Global Warming of 1.5°C. NADJA POPOVICH AND BILL MARSH/THE NEW YORK TIMES



Nielsen et al. (2021a,b,c,d)

Carbon Footprint Reduction

- Stop or lower air travel
- Stop driving petrol cars
- Reduce your meat consumption, especially beef
- Talk about it!

An Audacious Toolkit: Actions Against Climate Breakdown (Part 3: I is for Individual)

Julia Steinberger Nov 26, 2018 · 15 min read

Your Personal Action Guide for the Environment

Solving our biggest environmental problems will require huge changes in policy and business practice. But it turns out that our personal actions can help too, if we focus on the right things. Here are some places to start.

Dr. Jonathan Foley Follow
Apr 22, 2020 · 14 min read ★

Ivanova et al. (2020); Steinberger (2018); Foley (2020)

Investor

Organizational participant

- Divestment (Personal & Organizational)
- Donations to environmental organizations
- Influence through position / status

Organize lectures / workshops
High-level interventions
(Reduce meat in cafeteria, at parties, disincentivize flights, etc.)
....

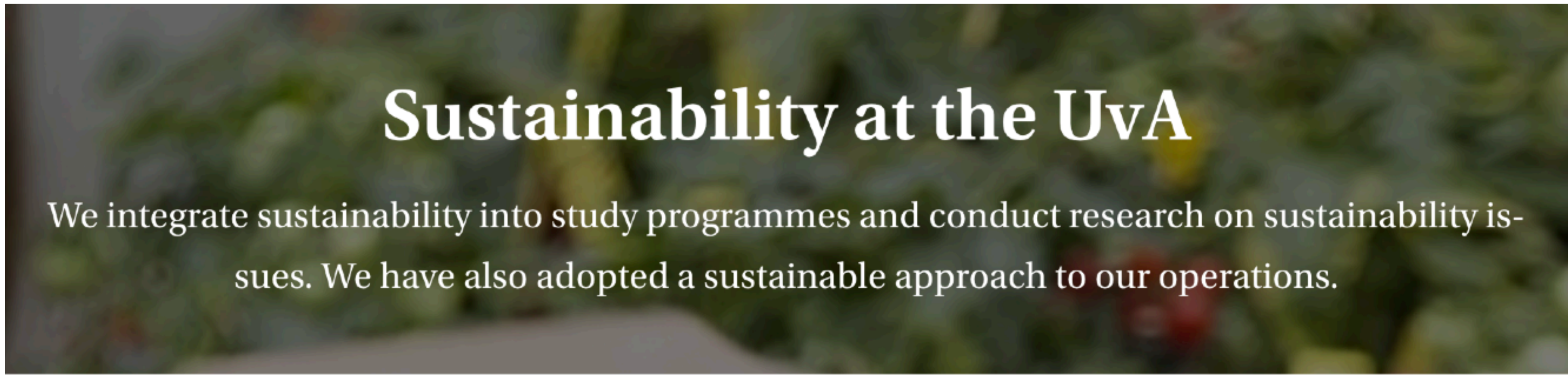
Comment | Published: 15 March 2021

Changing scientific meetings for the better

Sarvenaz Sarabipour, Aziz Khan, Yu Fen Samantha Seah, Aneth D. Mwakilili, Fiona N. Mumoki, Pablo J. Sáez, Benjamin Schwessinger, Humberto J. Debat & Tomislav Mestrovic

Nature Human Behaviour **5**, 296–300 (2021) | Cite this article

7822 Accesses | **4** Citations | **249** Altmetric | Metrics

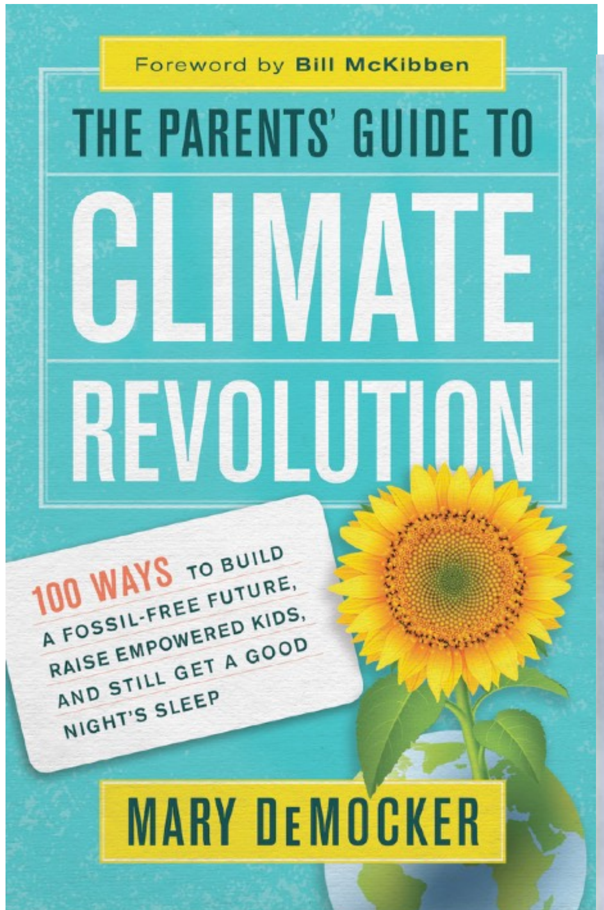


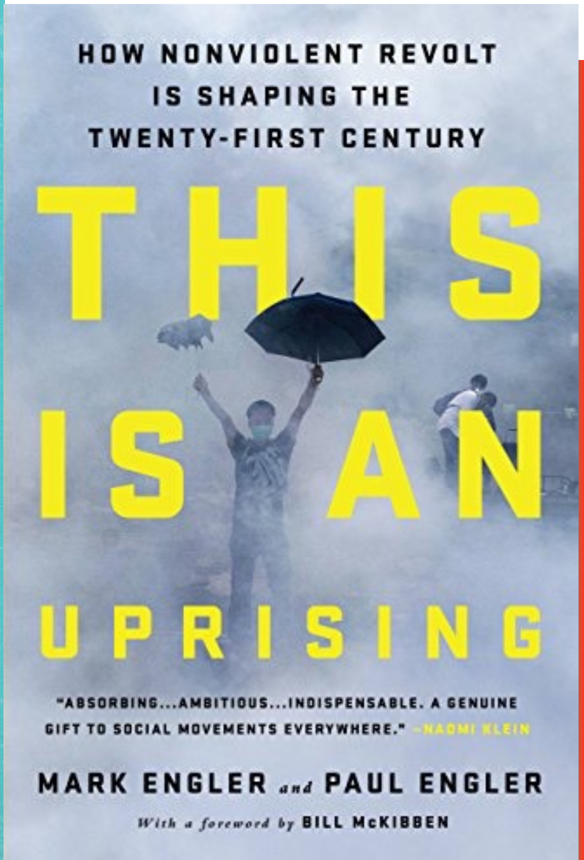
Sarabipour et al. (2021)

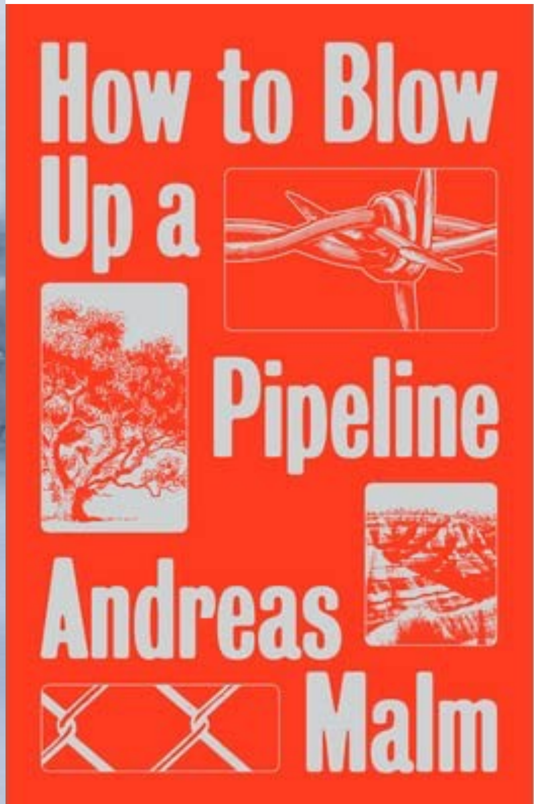
Citizen

Role model

- Vote
- Talk about the climate crisis (urgency **and** agency)
- Contagion of low-carbon lifestyle (social norm shift)







Monbiot Podcast
Monbiot Interview
Stop Line 3 Documentary

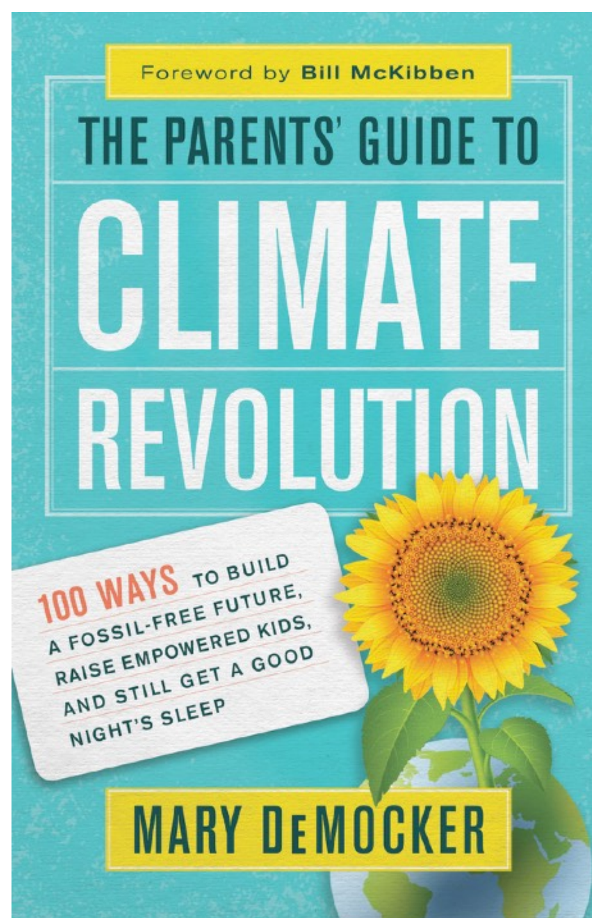
Citizen

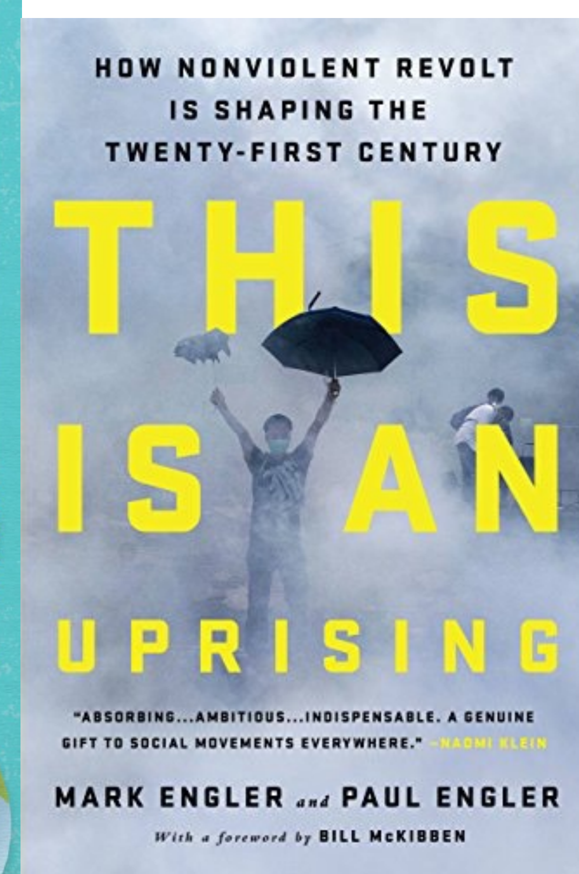
Role model

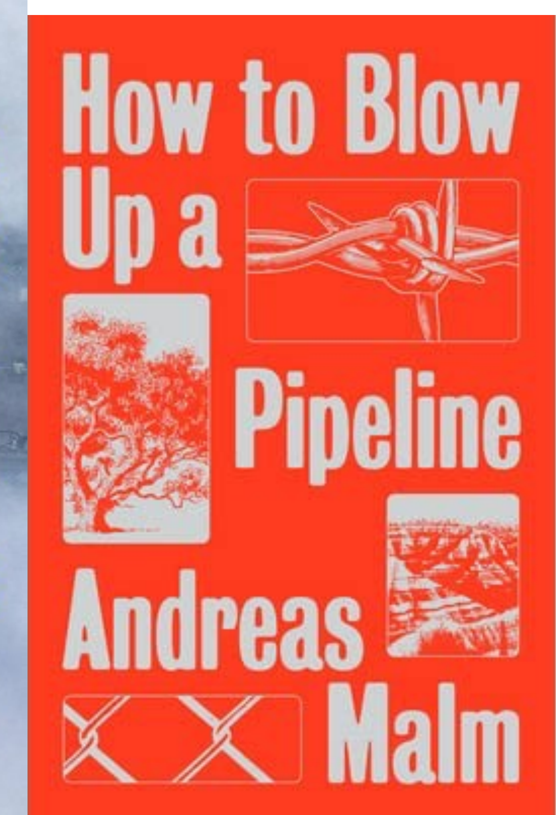
- Vote
- Talk about the climate crisis (urgency **and** agency)
- Contagion of low-carbon lifestyle (social norm shift)

- Mobilize, mobilize, and mobilize
- Get together with other people and mobilize

Monbiot Podcast
Monbiot Interview
Stop Line 3 Documentary





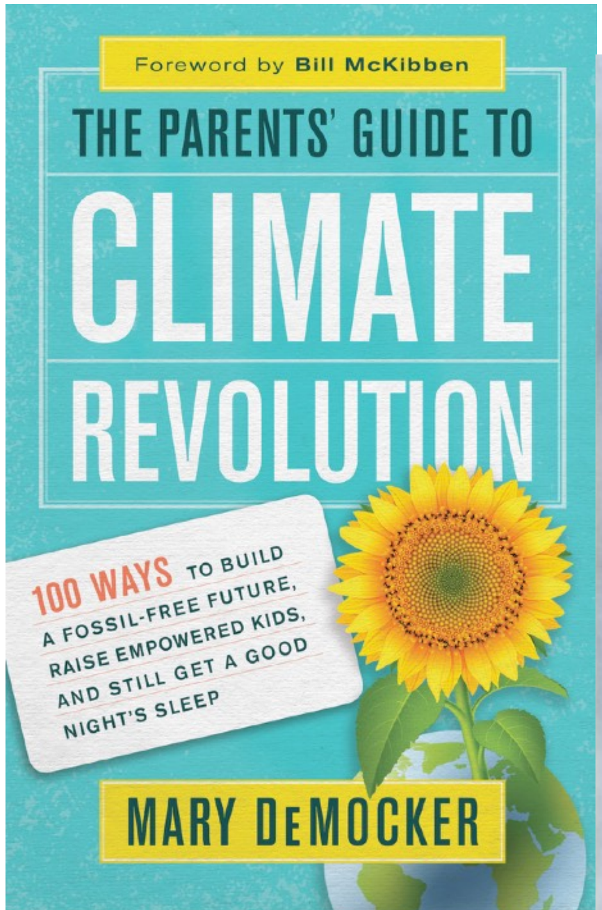


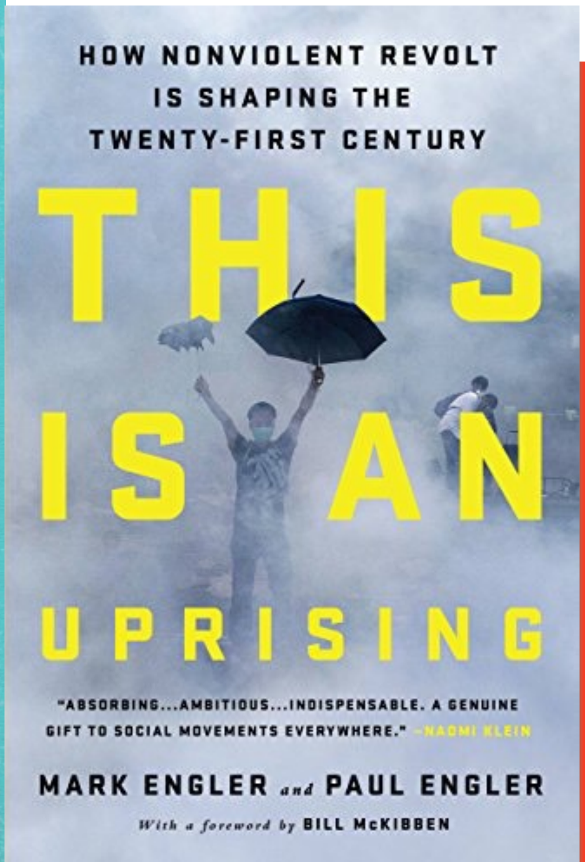
Citizen

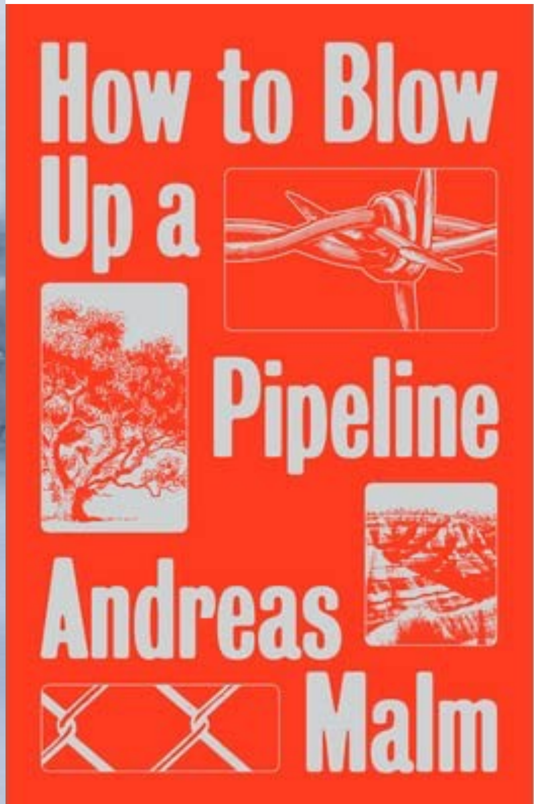
Role model

- Vote
- Talk about the climate crisis (urgency **and** agency)
- Contagion of low-carbon lifestyle (social norm shift)

- Dedicate some time to change the world







Monbiot Podcast

Monbiot Interview

Stop Line 3 Documentary

Tipping positive change

Timothy M. Lenton

Sensitive intervention points in the post-carbon transition

We must exploit socioeconomic tipping points and amplifiers

By **J. D. Farmer[1,2,3], C. Hepburn[1,4], M. C. Ives[1,4], T. Hale[5], T. Wetzer[1,6,7], P. Mealy[1,4,8], R. Rafaty[1], S. Srivastav[1,4], R. Way[1,4]**

points") (*3*), such that a relatively small change can trigger a larger change that becomes irreversible (*4*), where nonlinear

Social tipping dynamics for stabilizing Earth's climate by 2050

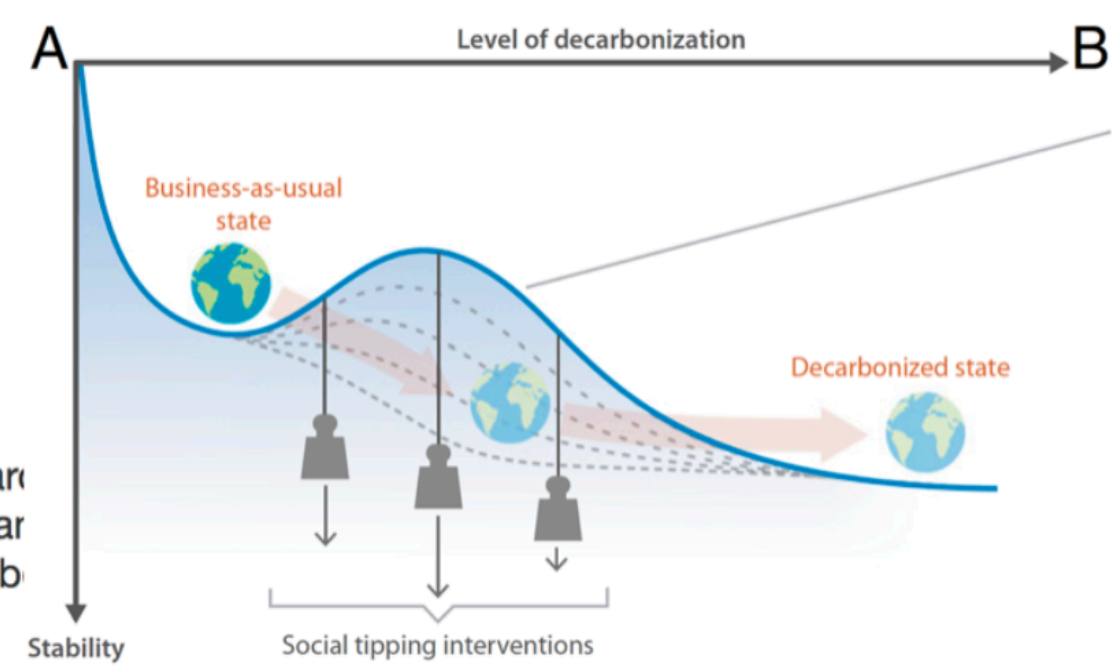
Ilona M. Otto, Jonathan F. Donges, Roger Cremades, Avit Bhowmik, Richar
Wolfgang Lucht, Johan Rockström, Franziska Allerberger, Mark McCaffrey, Sylvar
Alex Lenferna, Nerea Morán, Detlef P. van Vuuren, and Hans Joachim Schellnhub

Sensitive intervention points to achieve net-zero emissions

Report of the Policy Advisory Group* of the Committee on Climate Change

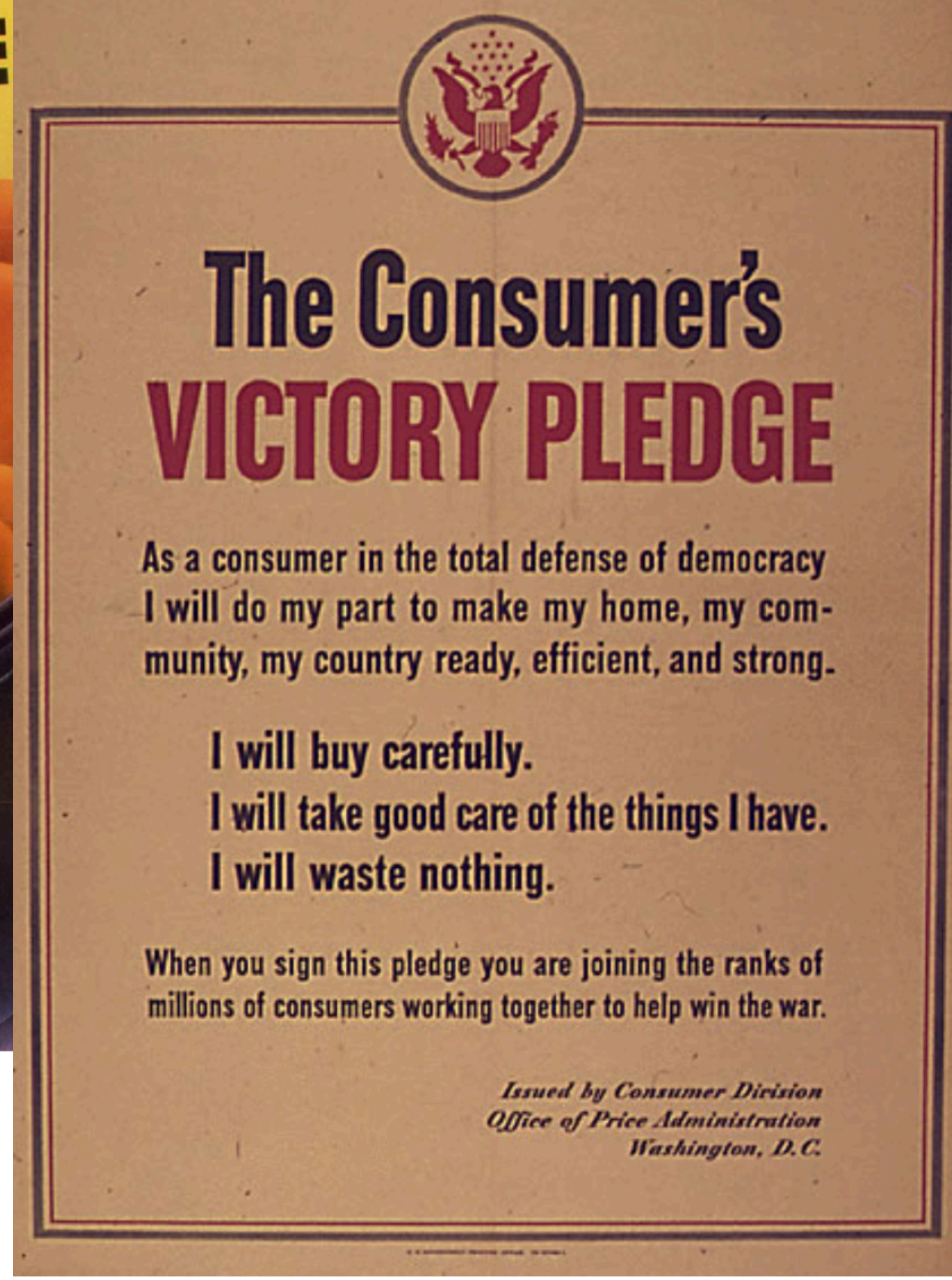
9 December 2020

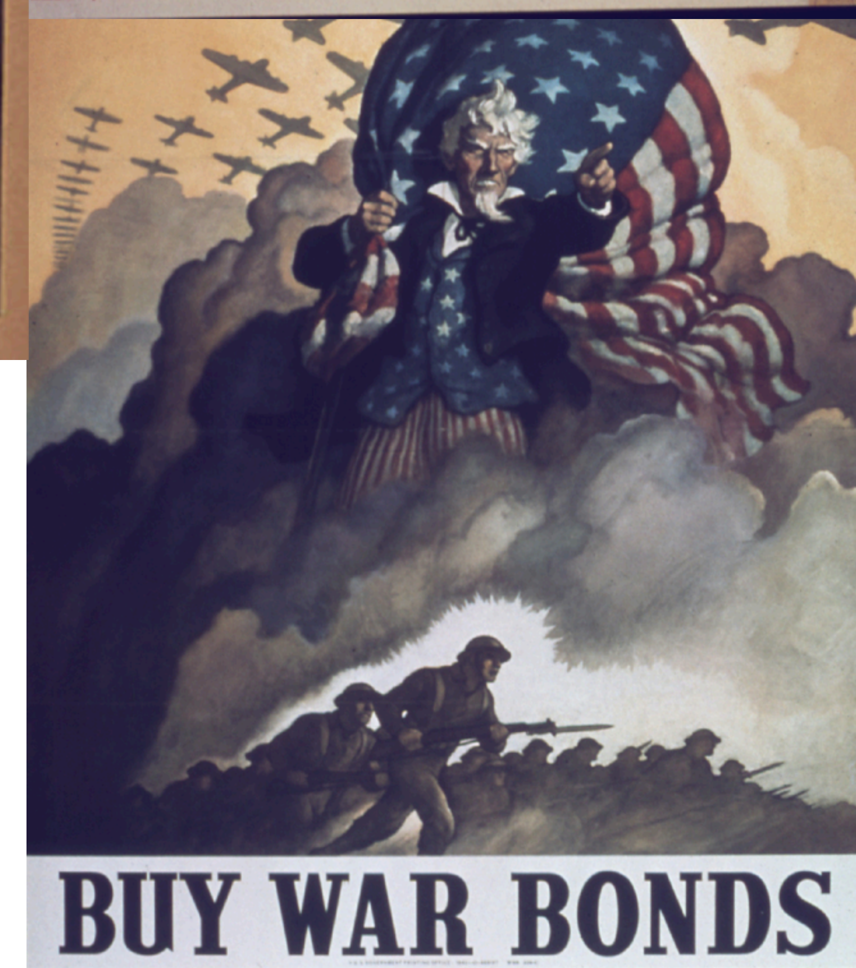
Cameron Hepburn, Tera Allas, Laura Cozzi, Michael Liebreich, Jim Skea, Lorraine Whitmarsh, Giles Wilkes and Bryony Worthington



Lenton (2019); Farmer et al. (2019); Otto et al. (2020); Hepburn et al. (2020); Winkelmann et al. (2020)

Source





Government spending rose 10 fold from 1940 to 1945

National speed limit of 35 mph to conserve fuel, car sharing

Manufacturing of cars, construction of new homes banned

Rationing of gasoline, meat, butter, sugar etc.

Income taxes of up to 94%

“We need a billion climate activists.”

- Peter Kalmus

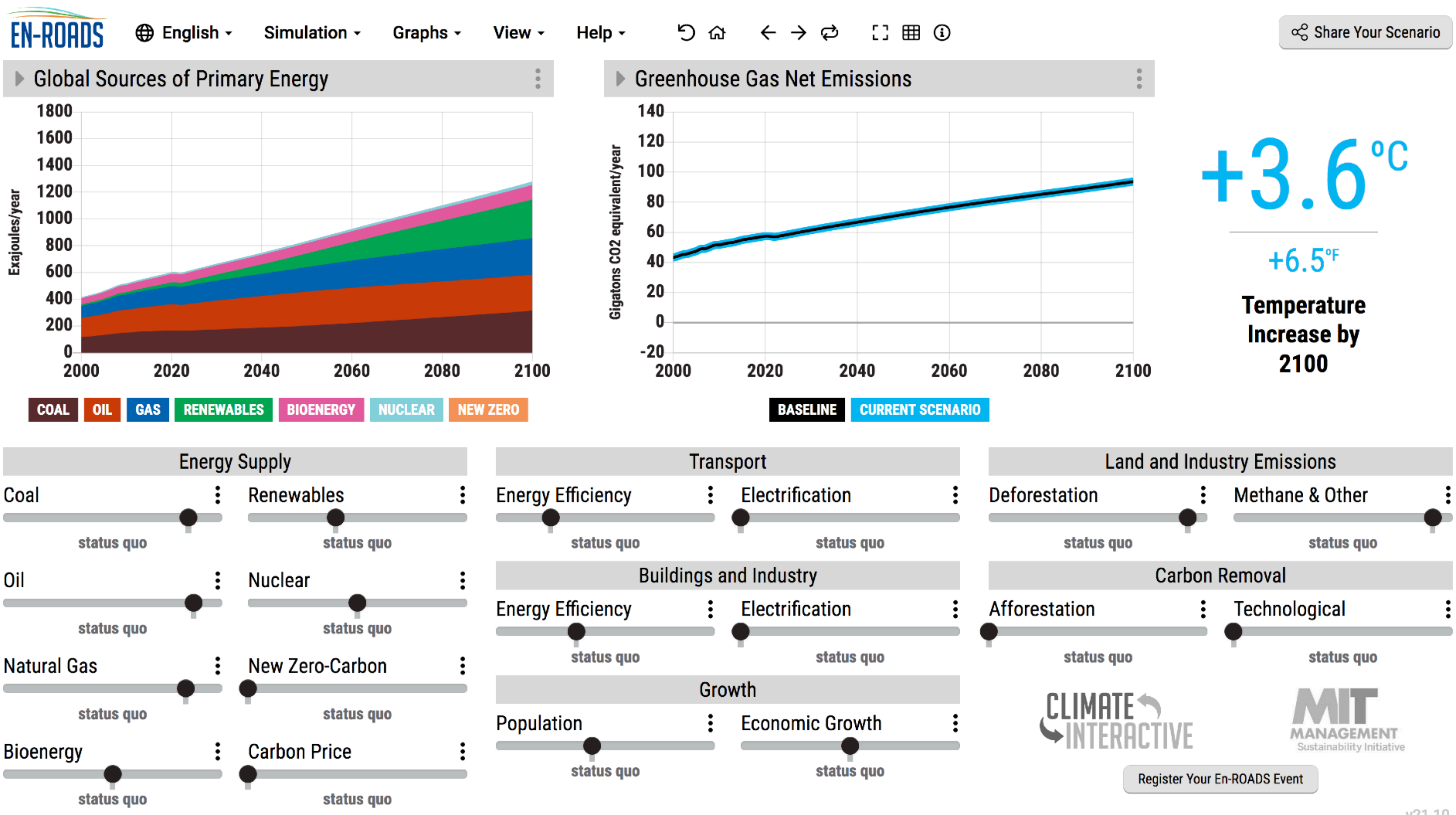
We can despair and plunge into paralysis or we can become stubborn optimists with a fierce conviction that no matter how difficult, we must and we can rise to the challenge.

– Christiana Figueres

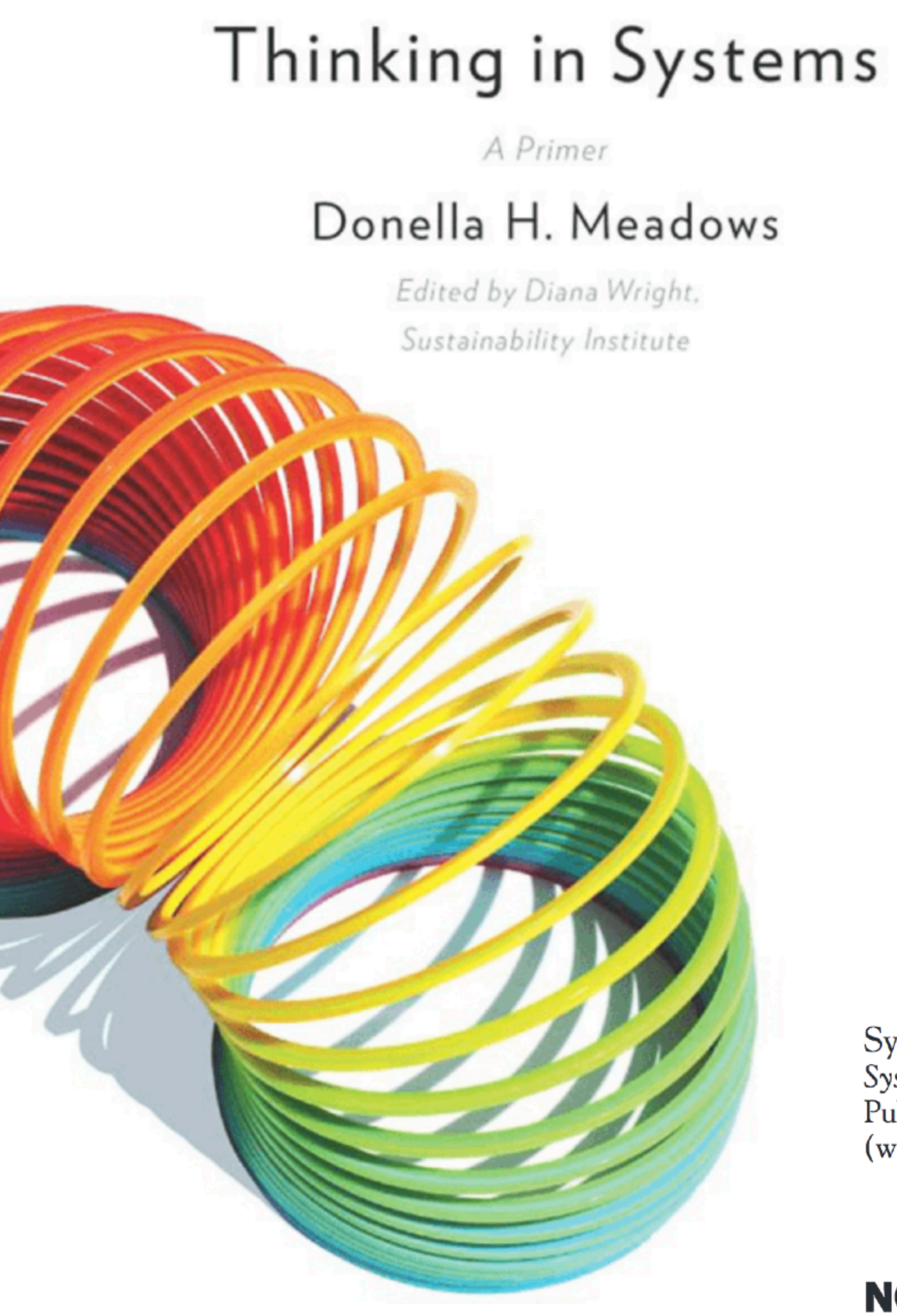
Pause

Part V:
Climate Action with En-ROADS

Interactive Part


EN-ROADS
English
Simulation
Graphs
View
Help
Share Your Scenario
Global Sources of Primary Energy
Exajoules/year
1800
1600
1400
1200
1000
800
600
400
200
0
2000
2020
2040
2060
2080
2100
COAL
OIL
GAS
RENEWABLES
BIOENERGY
NUCLEAR
NEW ZERO
Greenhouse Gas Net Emissions
Gigatons CO2 equivalent/year
140
120
100
80
60
40
20
0
-20
BASELINE
CURRENT SCENARIO
+3.6°C
+6.5°F
Temperature Increase by 2100
Energy Supply
Coal
status quo
Renewables
status quo
Oil
status quo
Nuclear
status quo
Natural Gas
status quo
New Zero-Carbon
status quo
Bioenergy
status quo
Carbon Price
status quo
Transport
Energy Efficiency
status quo
Electrification
status quo
Buildings and Industry
Energy Efficiency
status quo
Electrification
status quo
Growth
Population
status quo
Economic Growth
status quo
Land and Industry Emissions
Deforestation
status quo
Methane & Other
status quo
Carbon Removal
Afforestation
status quo
Technological
status quo
CLIMATE INTERACTIVE
MIT MANAGEMENT
Sustainability Initiative
Register Your En-ROADS Event
v21.10

Link



The Donella Meadows Project
Academy for Systems Change

CLIMATE INTERACTIVE
tools for a thriving future

MIT MANAGEMENT
SLOAN SCHOOL

Online Course

System Dynamics Review
System Dynamics Review (2012)
Published online in Wiley Online Library
(wileyonlinelibrary.com) **DOI**: 10.1002/sdr.1474

NOTES AND INSIGHTS

Climate interactive: the C-ROADS climate policy model

John Sterman,[a,b*] Thomas Fiddaman,[b,c] Travis Franck,[b,d] Andrew Jones,[b]
Stephanie McCauley,[b] Philip Rice,[b] Elizabeth Sawin[b] and Lori Siegel[b]

Syst. Dyn. Rev. (2012)

Appendix

Miscellaneous

Link

Sustainability Resources

Fabian Dablander & Andrea Bacilieri

We recently started to curate a list of resources that we found useful and that we can recommend to others (including those outside the climate bubble). Note that the items are in no particular order, and that they need not necessarily express our views.

Online courses / Lecture series

- *Mastering En-ROADS by Climate Interactive*
- *Climate Solutions 101 by Project Drawdown*
- *Oxford School of Climate Change*
- *Oxford Climate Society YouTube Channel*
    - Especially the talks by Noam Chomsky as well as by Nnimmo Bassey and Anuradha Mittal.

Books

- *Thinking in Systems*
- *The Future We Choose*
- *The New Climate War*
- *Merchants of Doubt*
- *Doughnut Economics*
- *This Changes Everything*
- *Designing Regenerative Cultures*
- *Think Like a Commoner*
- *Less is More*
- *The Divide*
- *To Cook a Continent*
- *Revolutions That Made the Earth*
- *Earth System Science: A Very Short Introduction*
- *Climate Change: A Very Short Introduction*
- *This Is an Uprising*
- *How to Blow Up a Pipeline*
- *The Ministry for the Future*
- *The Great Derangement*
- *The Collapse of Western Civilization*

Podcasts

- *Drilled*
- *The Climate Pod*
- *Sustain Ability - The Potsdam Dialogues*
- *The Sustainability Agenda*
    - Especially the episodes with Daniel Wahl, Rupert Read, Will Steffen, John Foley, Tim Lenton, Jason Hickel, Naomi Klein, Mark Campanale.

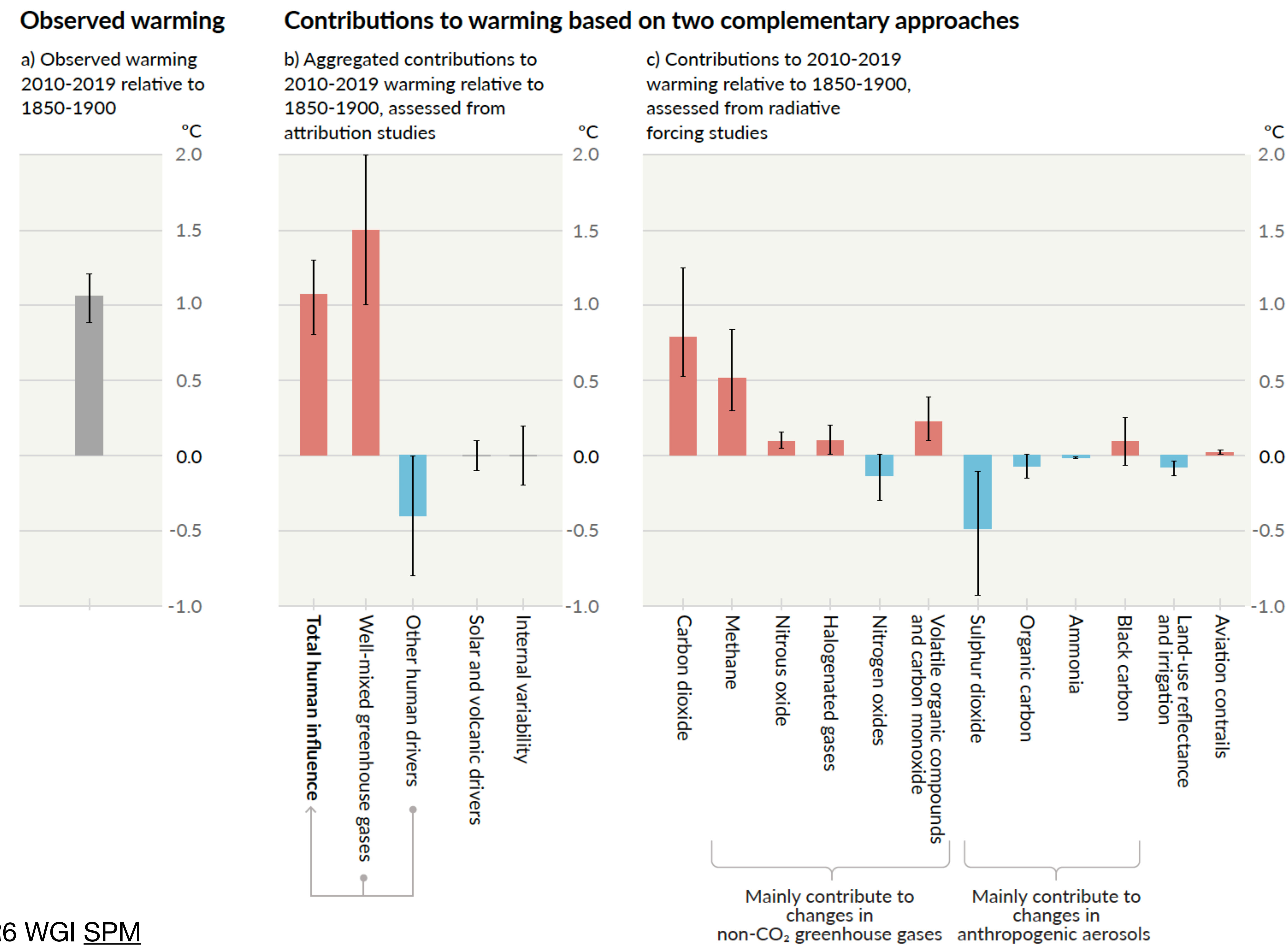
News / Newsletters

- *Carbon Brief*
- *Mongabay*
- *Inside Climate News*
- *Bill McKibben's Newsletter* *[Superseded by his Substack]*
- *George Monbiot's weekly columns at The Guardian*

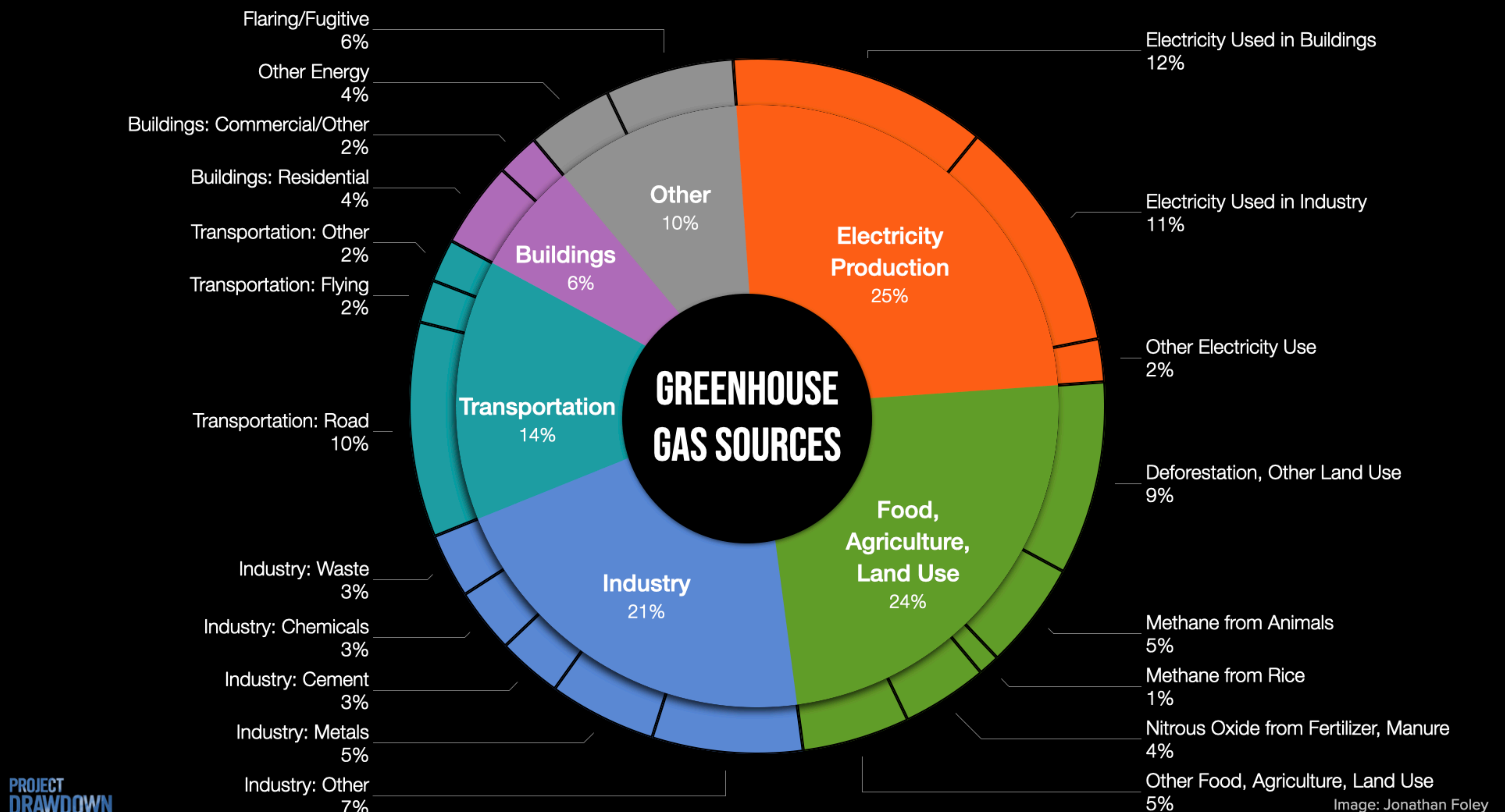
Documentaries

- *Breaking Boundaries*
- *David Attenborough: A Life on Our Planet*
- *Chasing Ice*
- *Chasing Coral*
- *Tomorrow*
- *How To Change the World*
- *The End of the Line*
- *Seaspiracy*
- *Cowspiracy*
- *Kiss the Ground*
- *The True Cost*
- *The End of Poverty?*
- *The Four Horsemen*
- *The Corporation*
- *Gasland*
- *The Prize: The Epic Quest for Oil, Money, and Power*
- *Ancient Futures: Learning from Ladakh*
- *LN3: Teachings of the Anishinaabe Resistance*

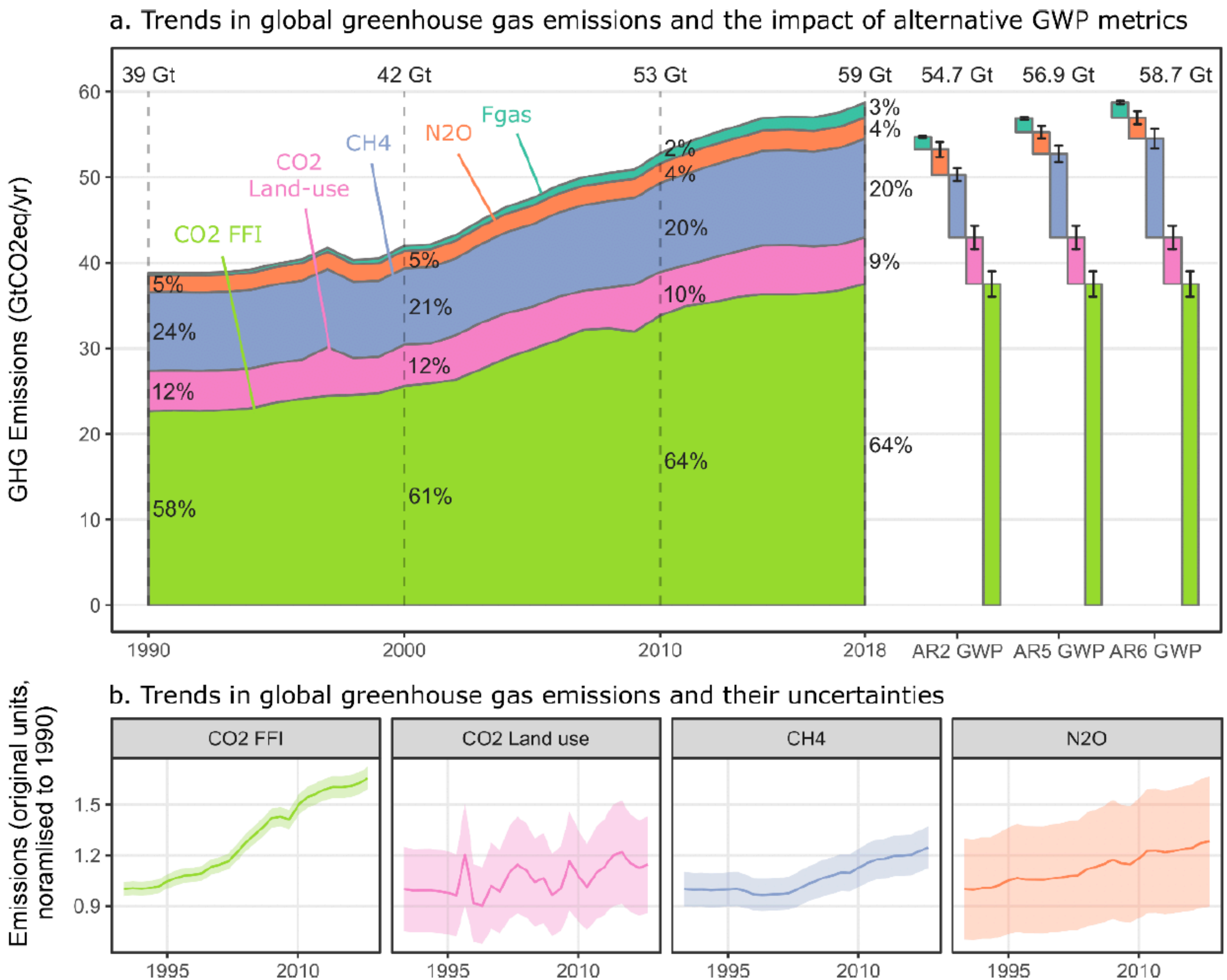
Observed warming is driven by emissions from human activities, with greenhouse gas warming partly masked by aerosol cooling



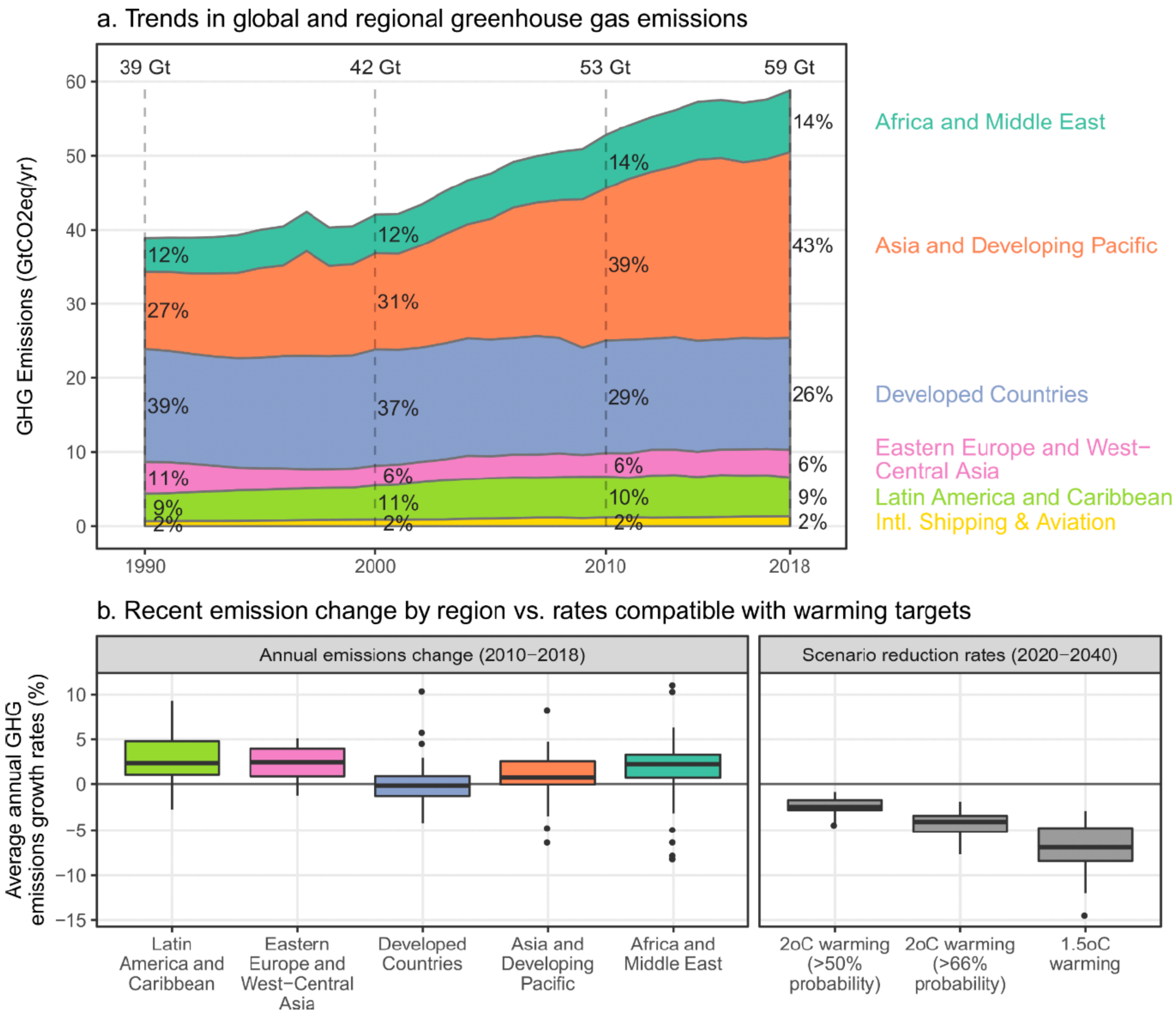
IPCC AR6 WGI SPM



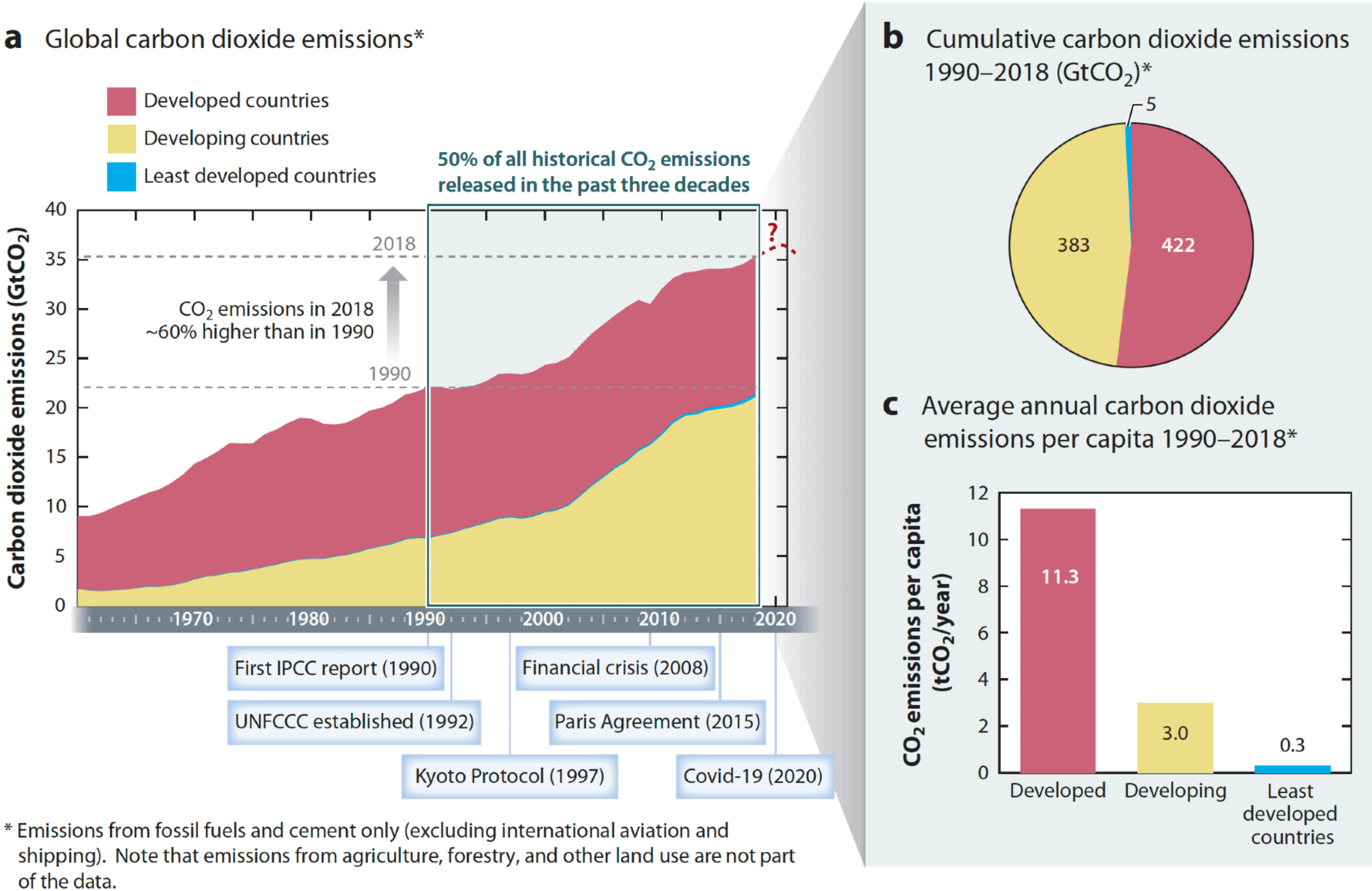
GREENHOUSE GAS SOURCES
Electricity Production 25%
Food, Agriculture, Land Use 24%
Industry 21%
Transportation 14%
Buildings 6%
Other 10%
Flaring/Fugitive 6%
Other Energy 4%
Buildings: Commercial/Other 2%
Buildings: Residential 4%
Transportation: Other 2%
Transportation: Flying 2%
Transportation: Road 10%
Industry: Waste 3%
Industry: Chemicals 3%
Industry: Cement 3%
Industry: Metals 5%
Industry: Other 7%
Electricity Used in Buildings 12%
Electricity Used in Industry 11%
Other Electricity Use 2%
Deforestation, Other Land Use 9%
Methane from Animals 5%
Methane from Rice 1%
Nitrous Oxide from Fertilizer, Manure 4%
Other Food, Agriculture, Land Use 5%
PROJECT DRAWDOWN
Image: Jonathan Foley
Source: IPCC WG3 AR5



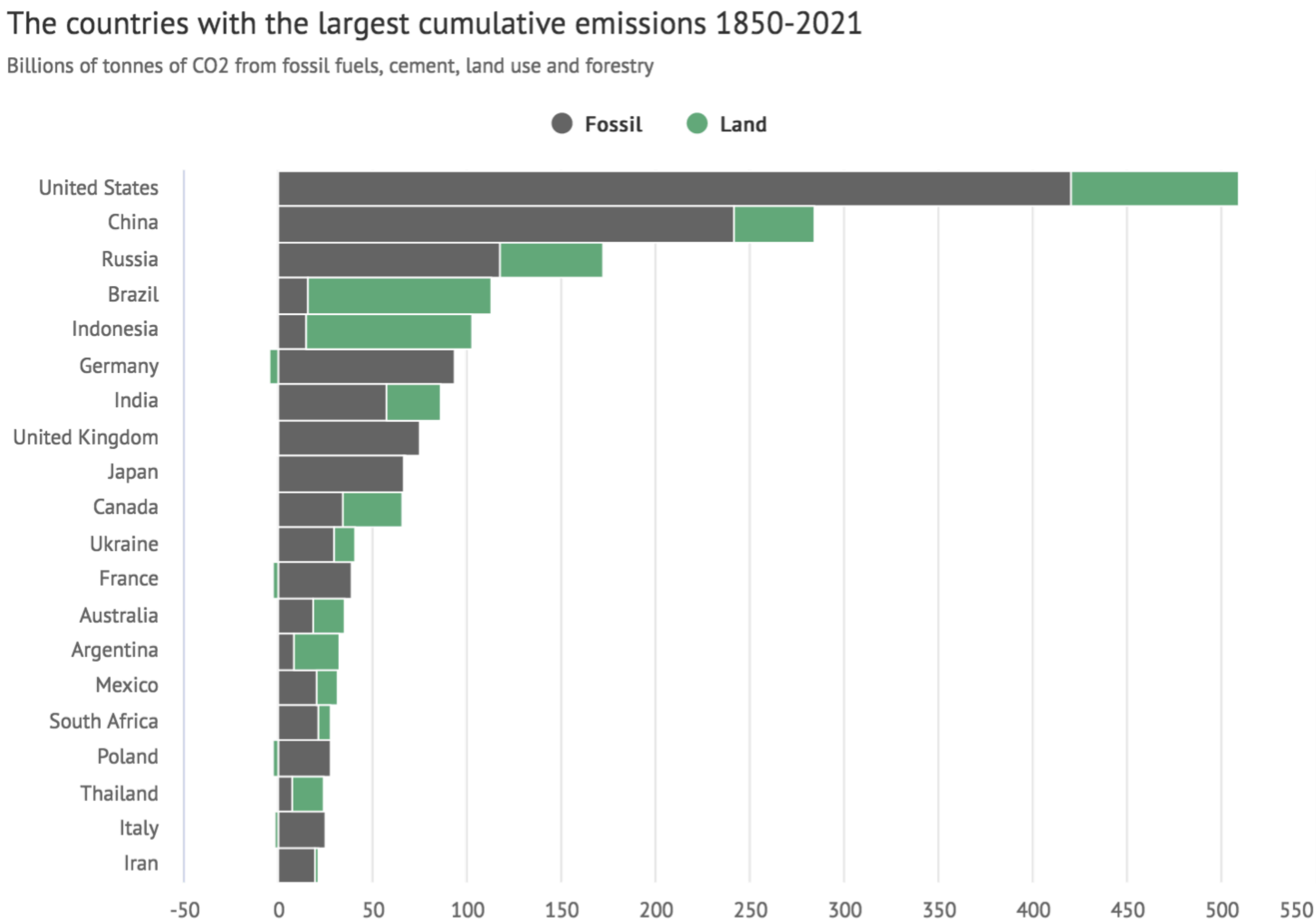
Leaked IPCC AR6 WGIII SPM



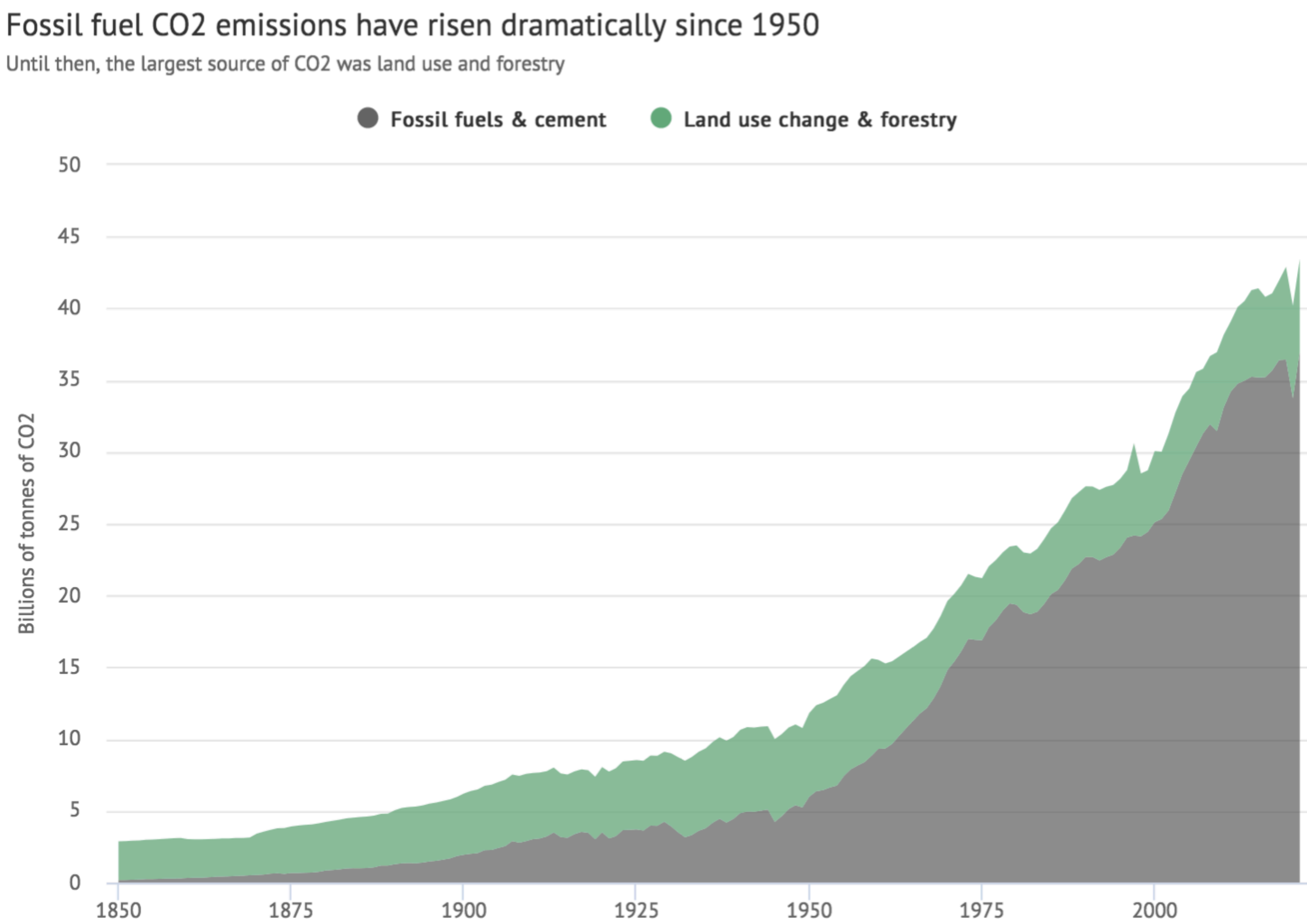
Leaked IPCC AR6 WGIII SPM



Stoddard et al. (2021)

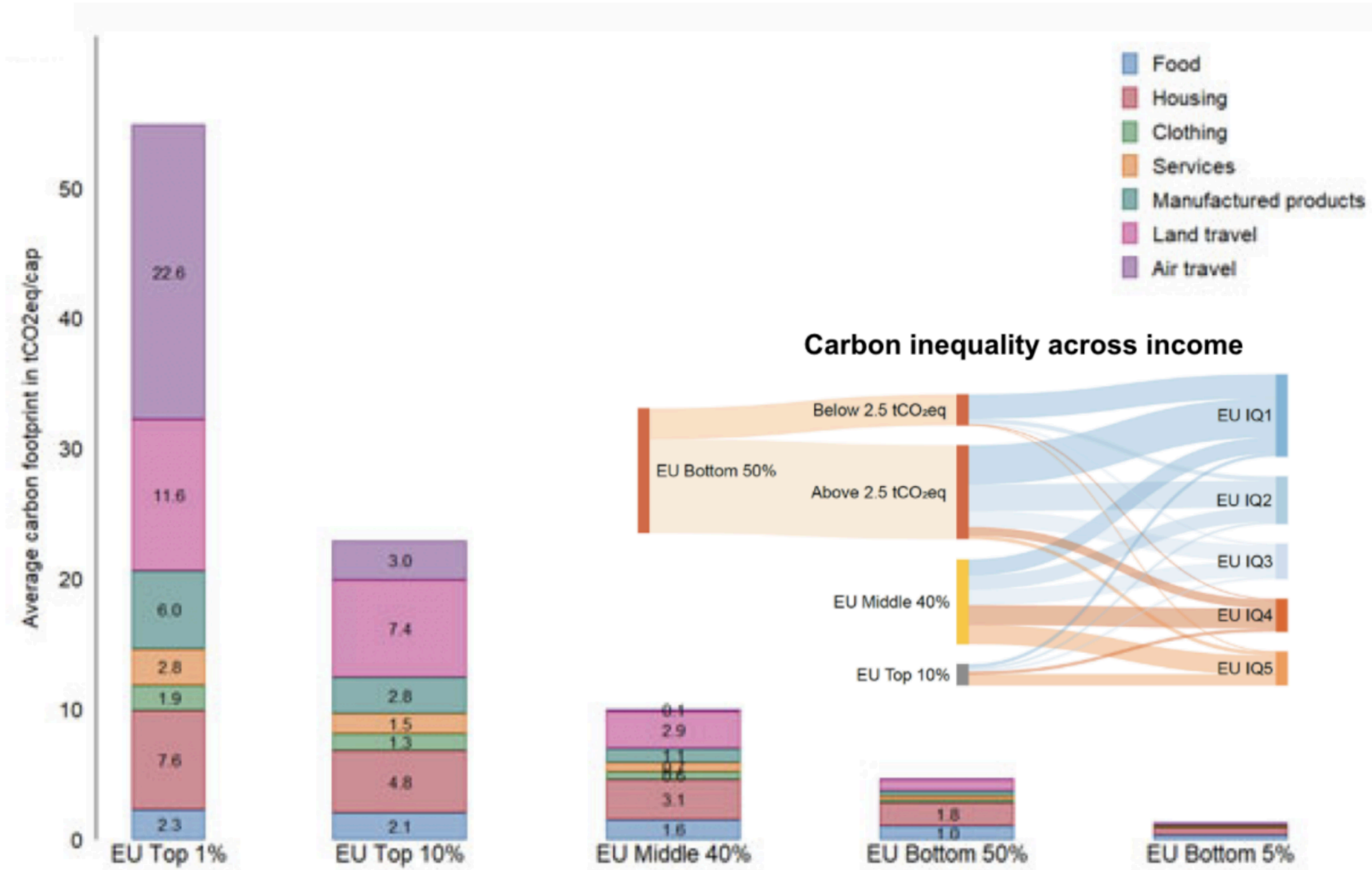

The countries with the largest cumulative emissions 1850-2021
Billions of tonnes of CO2 from fossil fuels, cement, land use and forestry
Fossil
Land
United States
China
Russia
Brazil
Indonesia
Germany
India
United Kingdom
Japan
Canada
Ukraine
France
Australia
Argentina
Mexico
South Africa
Poland
Thailand
Italy
Iran
-50
0
50
100
150
200
250
300
350
400
450
500
550

Evans (2021)


Fossil fuel CO2 emissions have risen dramatically since 1950
Until then, the largest source of CO2 was land use and forestry
Fossil fuels & cement
Land use change & forestry
Billions of tonnes of CO2
50
45
40
35
30
25
20
15
10
5
0
1850
1875
1900
1925
1950
1975
2000

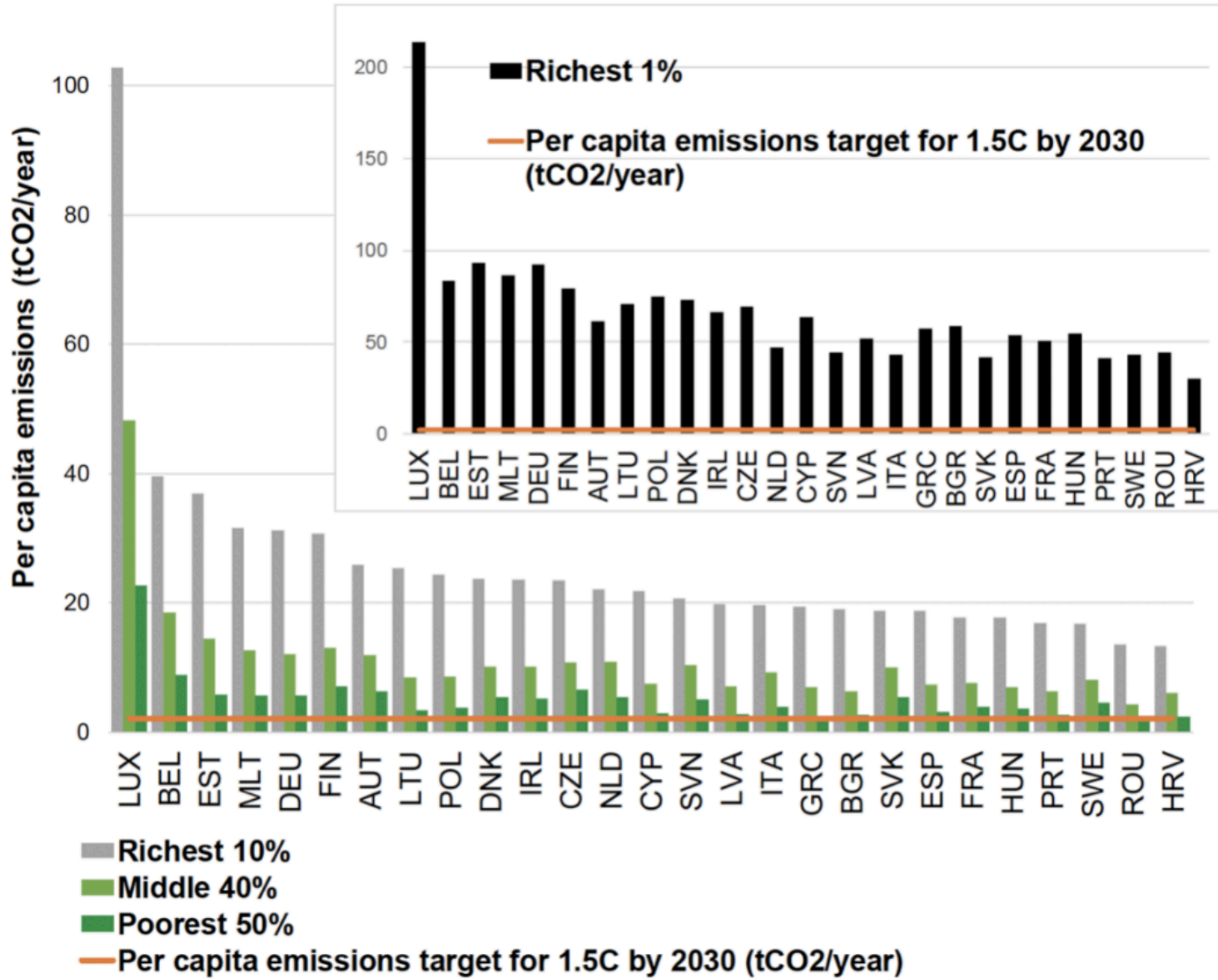
Evans (2021)

Carbon inequality across EU households

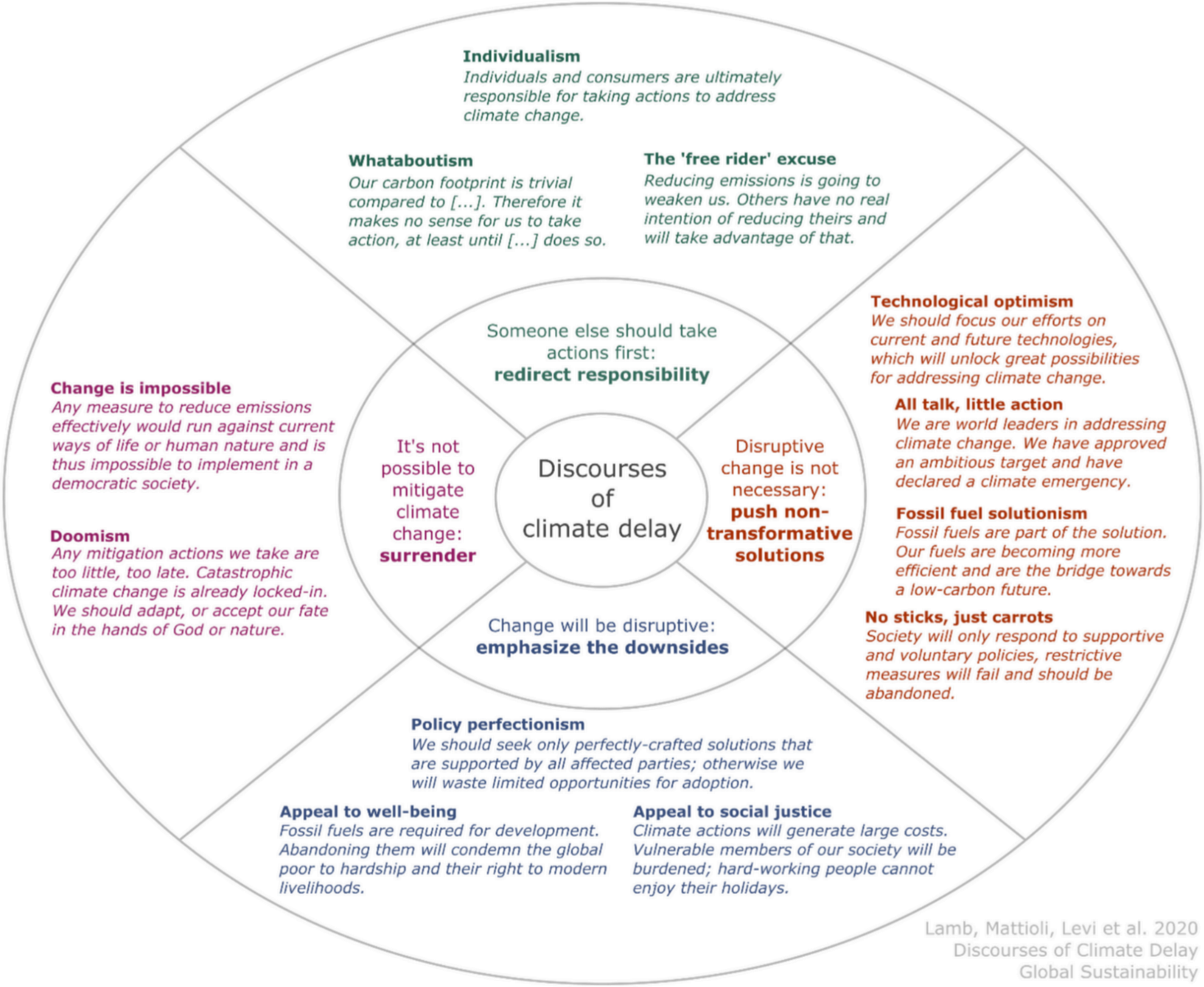


Ivanova & Wood (2020)

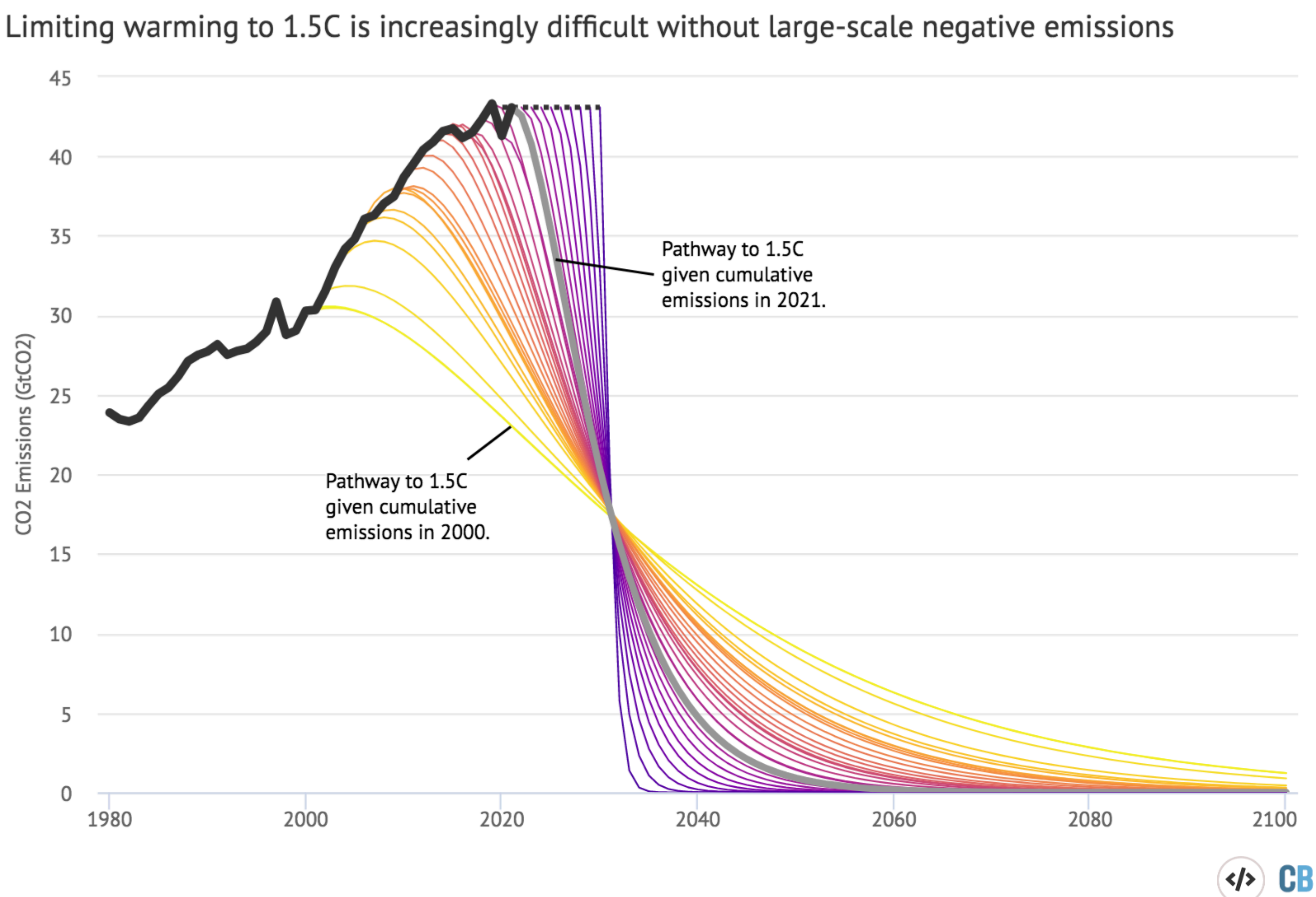
Carbon inequality across EU member states



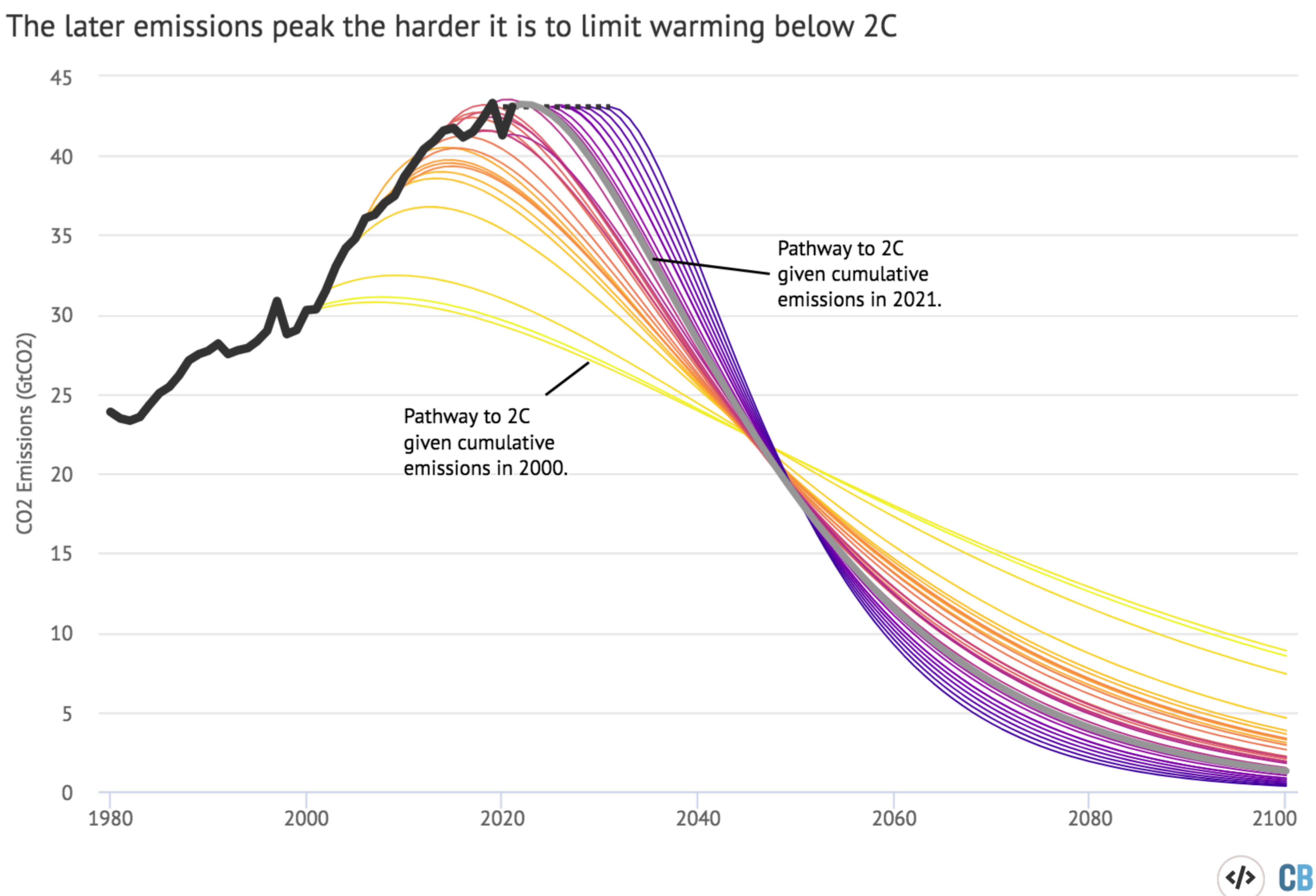
Gore & Alestig (2020)


Individualism
Individuals and consumers are ultimately responsible for taking actions to address climate change.
Whataboutism
Our carbon footprint is trivial compared to […]. Therefore it makes no sense for us to take action, at least until […] does so.
The 'free rider' excuse
Reducing emissions is going to weaken us. Others have no real intention of reducing theirs and will take advantage of that.
Someone else should take actions first:
redirect responsibility
Technological optimism
We should focus our efforts on current and future technologies, which will unlock great possibilities for addressing climate change.
All talk, little action
We are world leaders in addressing climate change. We have approved an ambitious target and have declared a climate emergency.
Fossil fuel solutionism
Fossil fuels are part of the solution. Our fuels are becoming more efficient and are the bridge towards a low-carbon future.
No sticks, just carrots
Society will only respond to supportive and voluntary policies, restrictive measures will fail and should be abandoned.
Disruptive change is not necessary:
push non-transformative solutions
Discourses of climate delay
It's not possible to mitigate climate change:
surrender
Change is impossible
Any measure to reduce emissions effectively would run against current ways of life or human nature and is thus impossible to implement in a democratic society.
Doomism
Any mitigation actions we take are too little, too late. Catastrophic climate change is already locked-in. We should adapt, or accept our fate in the hands of God or nature.
Change will be disruptive:
emphasize the downsides
Policy perfectionism
We should seek only perfectly-crafted solutions that are supported by all affected parties; otherwise we will waste limited opportunities for adoption.
Appeal to well-being
Fossil fuels are required for development. Abandoning them will condemn the global poor to hardship and their right to modern livelihoods.
Appeal to social justice
Climate actions will generate large costs. Vulnerable members of our society will be burdened; hard-working people cannot enjoy their holidays.
Lamb, Mattioli, Levi et al. 2020
Discourses of Climate Delay
Global Sustainability

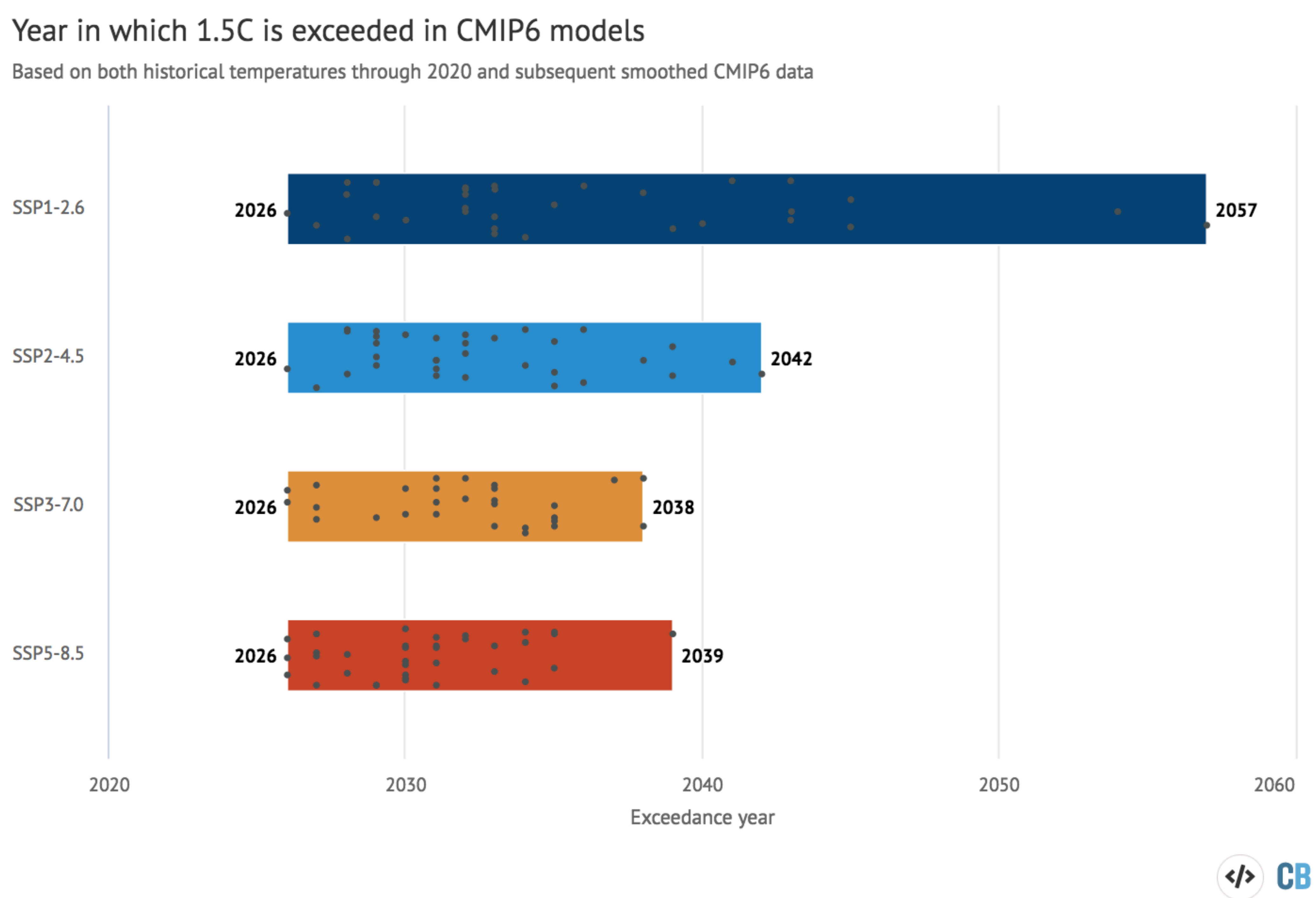
Lamb (2020)



Hausfather (2021)



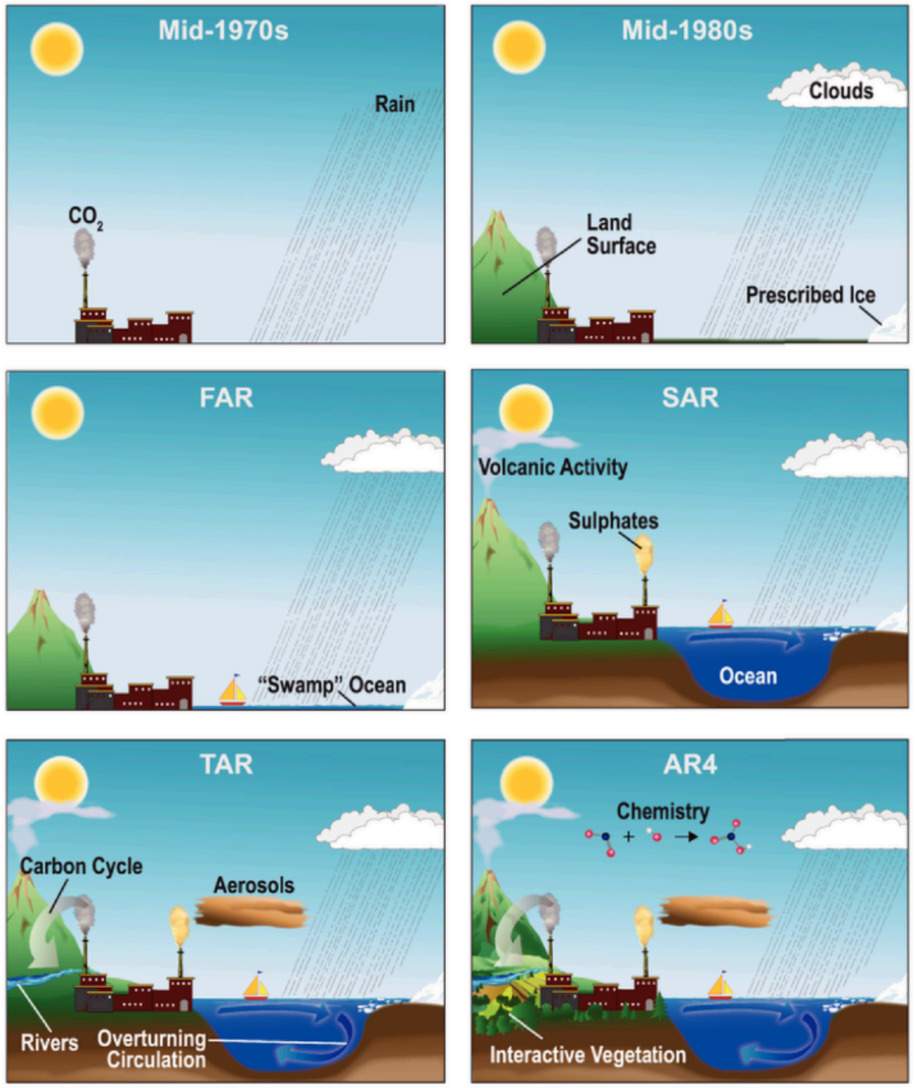
Hausfather (2021)

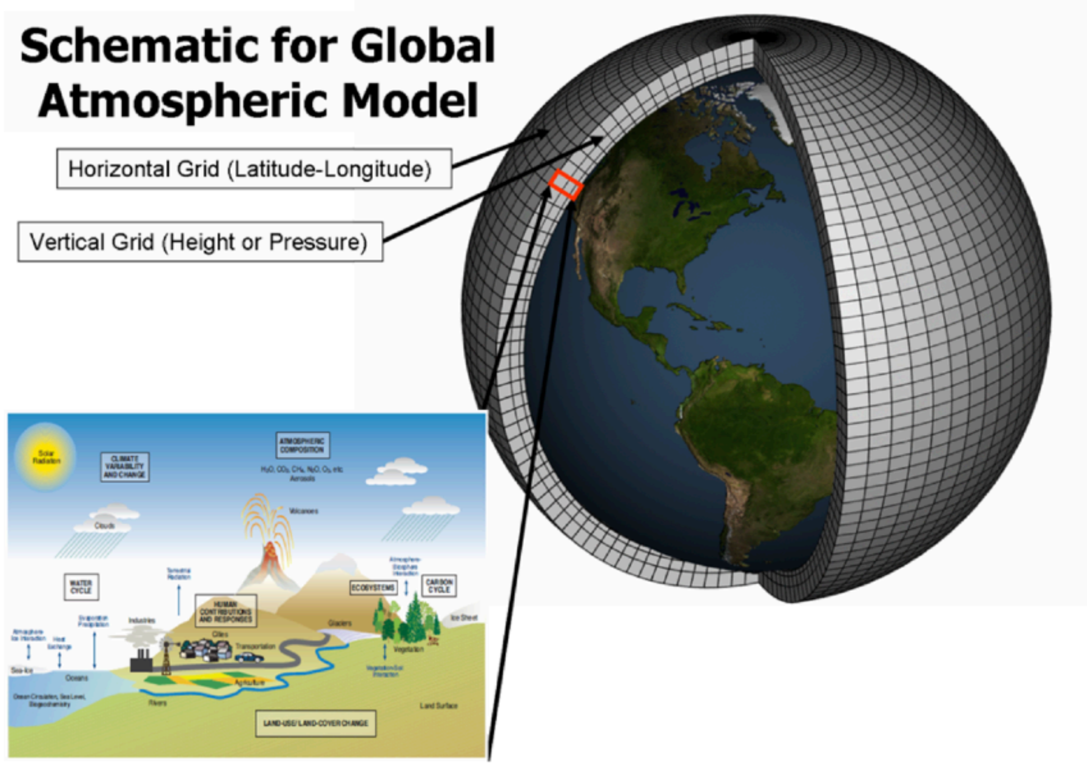


Hausfather (2020)

Hausfather (2020)

The World in Global Climate Models





PERSPECTIVE

The scientific challenge of understanding and estimating climate change

Tim Palmer and Bjorn Stevens
+ See all authors and affiliations

PNAS December 3, 2019 116 (49) 24390-24395; first published December 2, 2019; https://doi.org/10.1073/pnas.1906691116

GLOBAL WARMING

Climate panel confronts implausibly hot models

Major IPCC report likely to curb near-term projections with measured warming trend

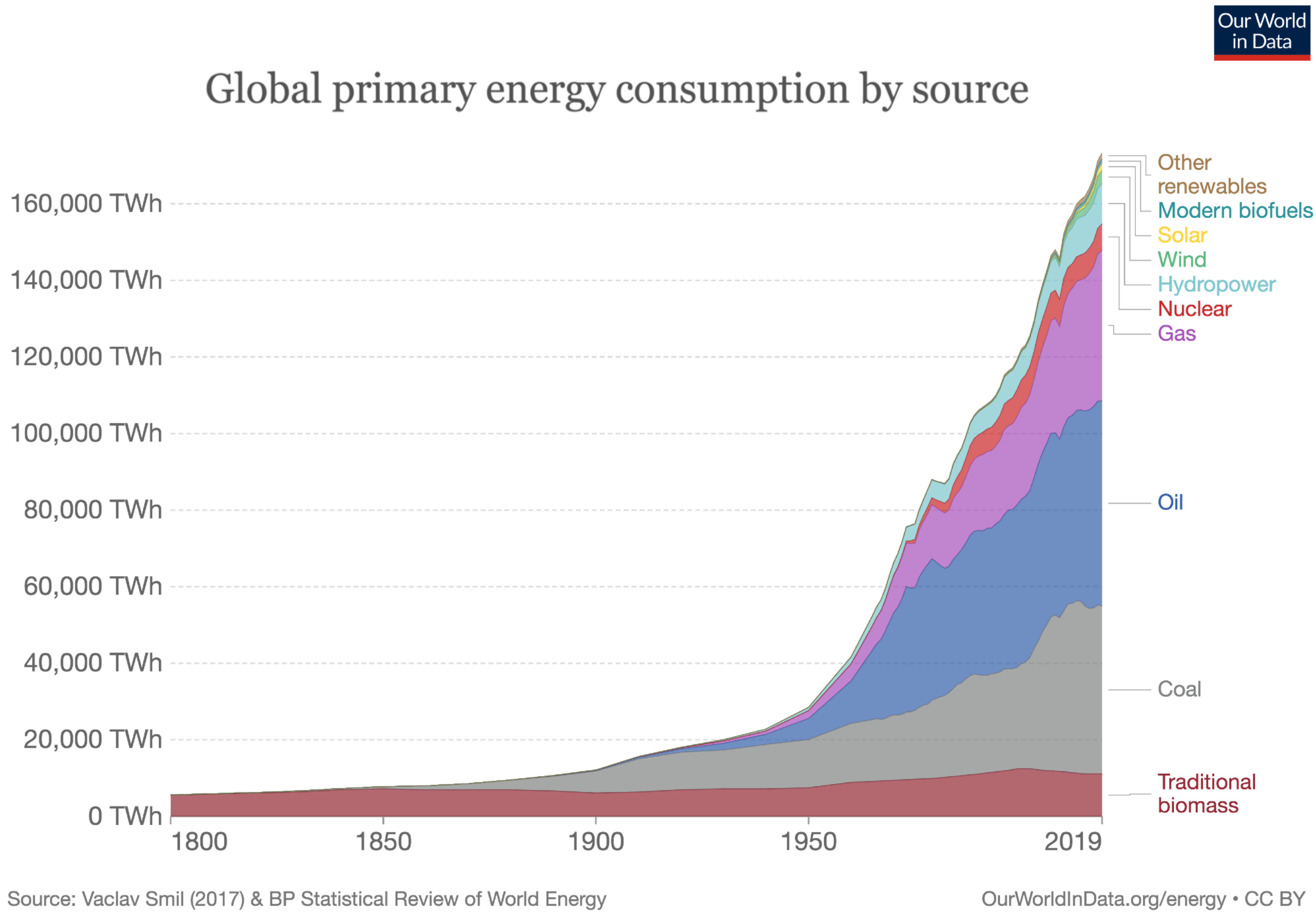
Voosen (2021)

Palmer & Stevens (2019)

Philip Stier Talk

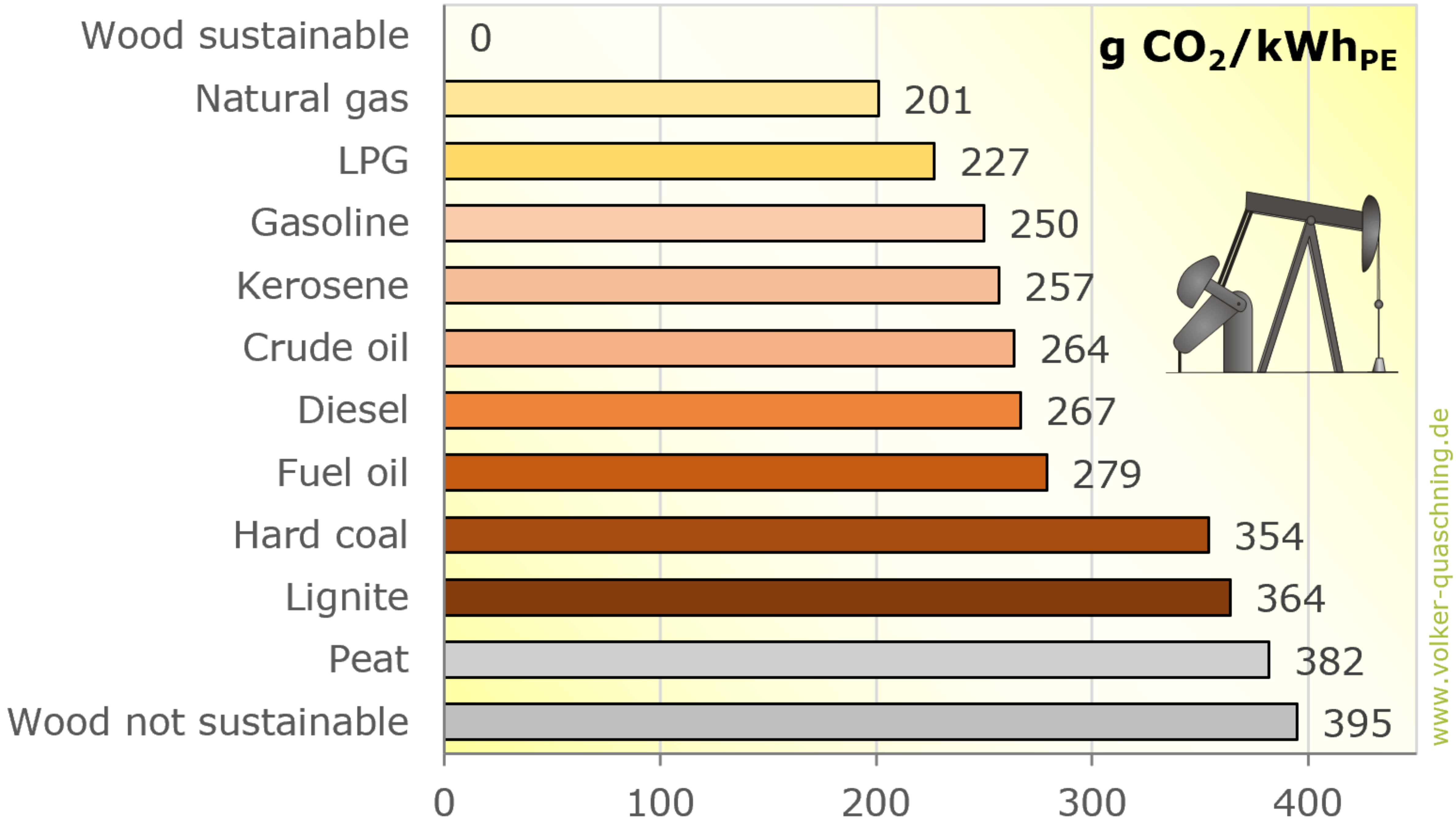
McSweeney & Hausfather (2018)

Energy Supply



Source

York & Bell (2019)



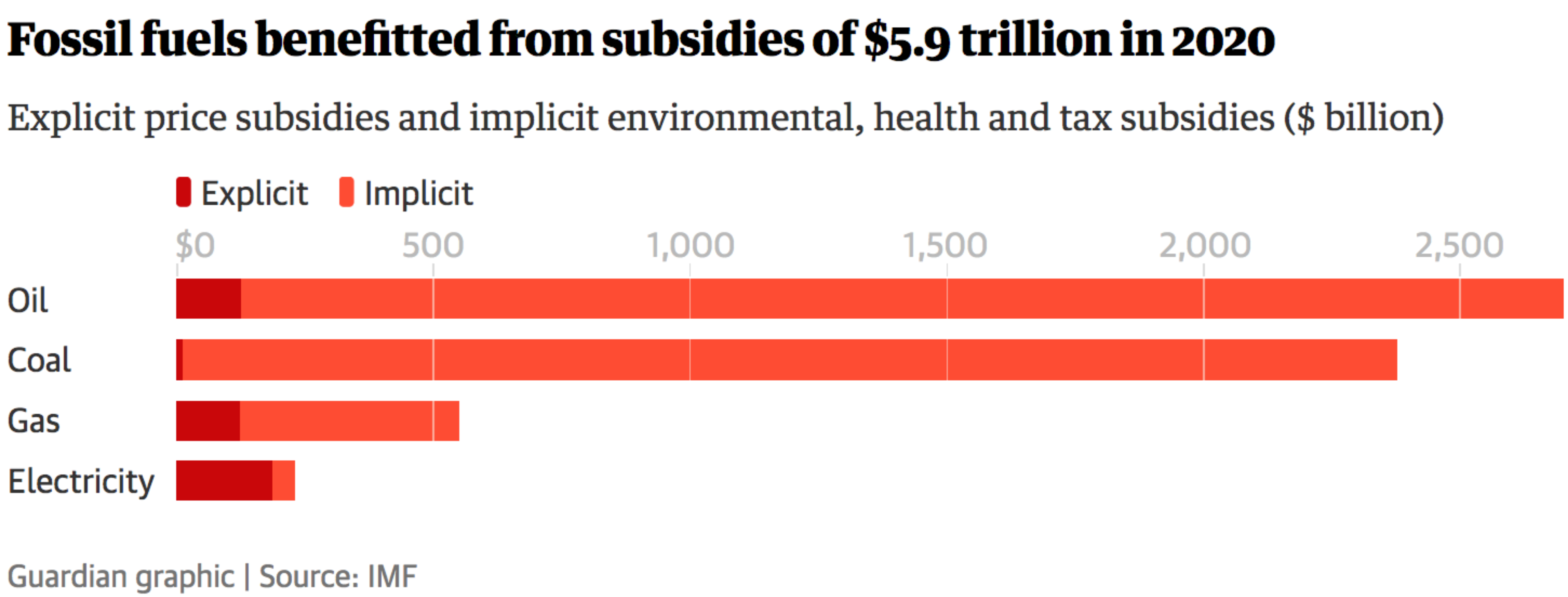
Source

On Biofuels

Fossil fuel industry gets subsidies of $11m a minute, IMF finds

The Guardian

Trillions of dollars a year are 'adding fuel to the fire' of the climate crisis, experts say



Source

In the **5 years** since the Paris Agreement, the world's **60 biggest banks** have financed fossil fuels to the tune of **$3.8 trillion**. Runaway funding for fossil fuel extraction and infrastructure **fuels climate chaos** and threatens the lives and livelihoods of millions.

Source

US auctions off oil and gas drilling leases in Gulf of Mexico after climate talks

Biden administration launching auction of more than 80m acres for fossil fuel extraction that experts call 'incredibly reckless'

The Guardian

Source

XR Cambridge
@xr_cambridge

Emissions must fall 60% in 9 years & the IEA says zero new oil & gas projects for a hope of even 'net' zero. So it would be reasonable to assume laws are being passed to end exploration right? In fact, the world is on an oil & gas binge. A shocking, terrifying, revolutionary 🧵

10:38 AM · Jun 13, 2021 · Twitter Web App

Source

988 Retweets **306** Quote Tweets **1,629** Likes

Article | Published: 08 September 2021

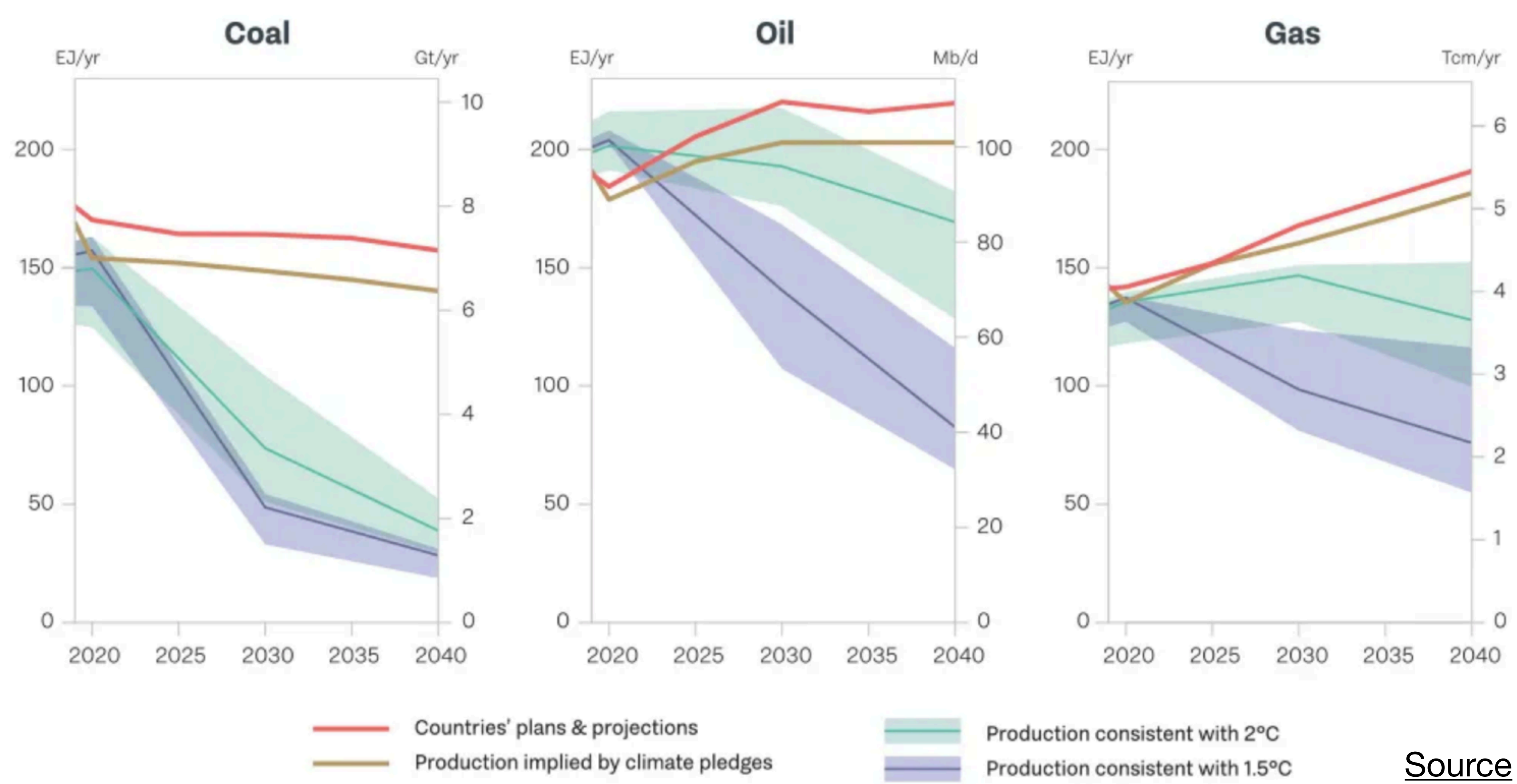
Unextractable fossil fuels in a 1.5 °C world

Dan Welsby, James Price, Steve Pye & Paul Ekins

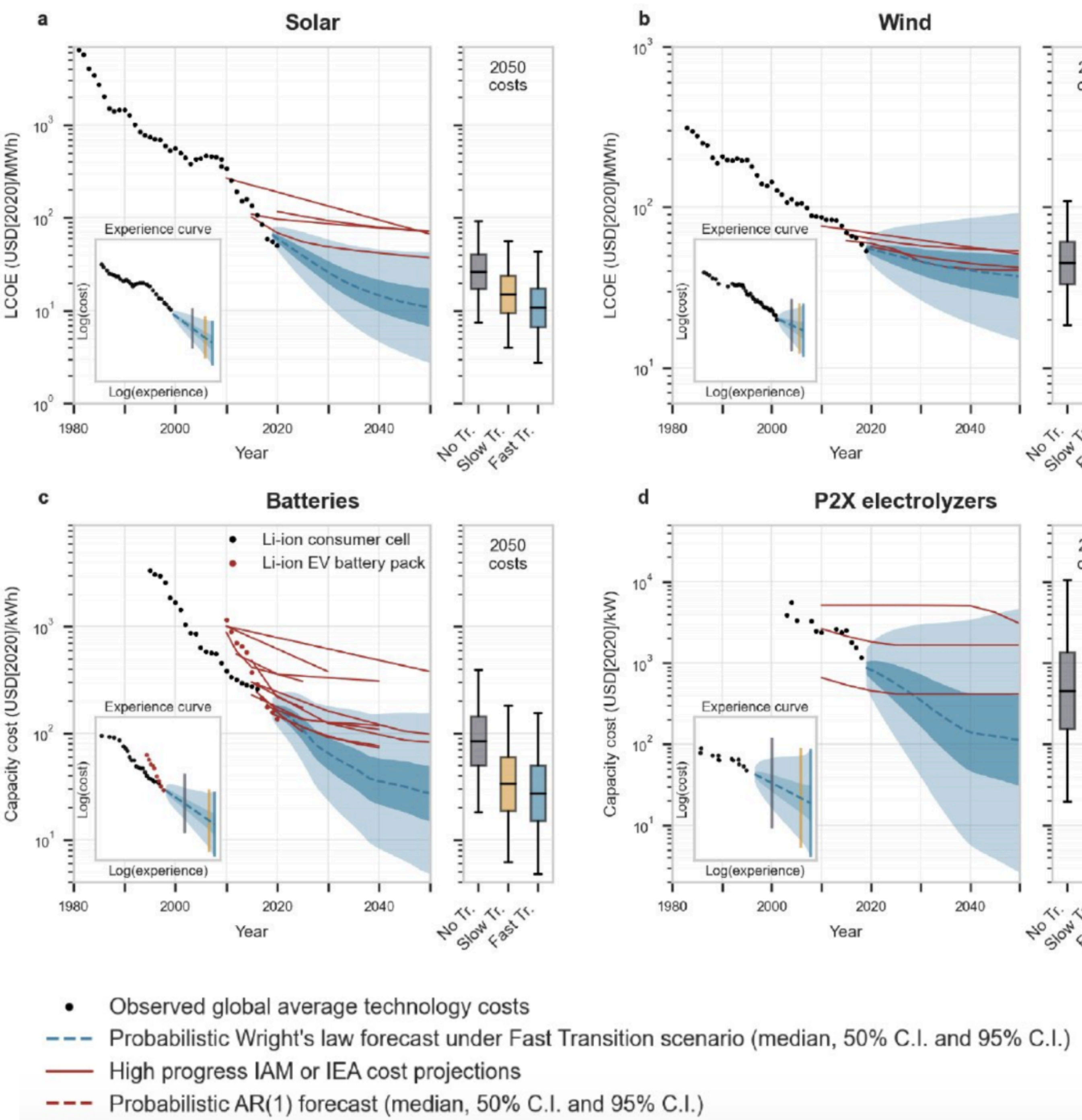
Nature **597**, 230–234 (2021) | Cite this article

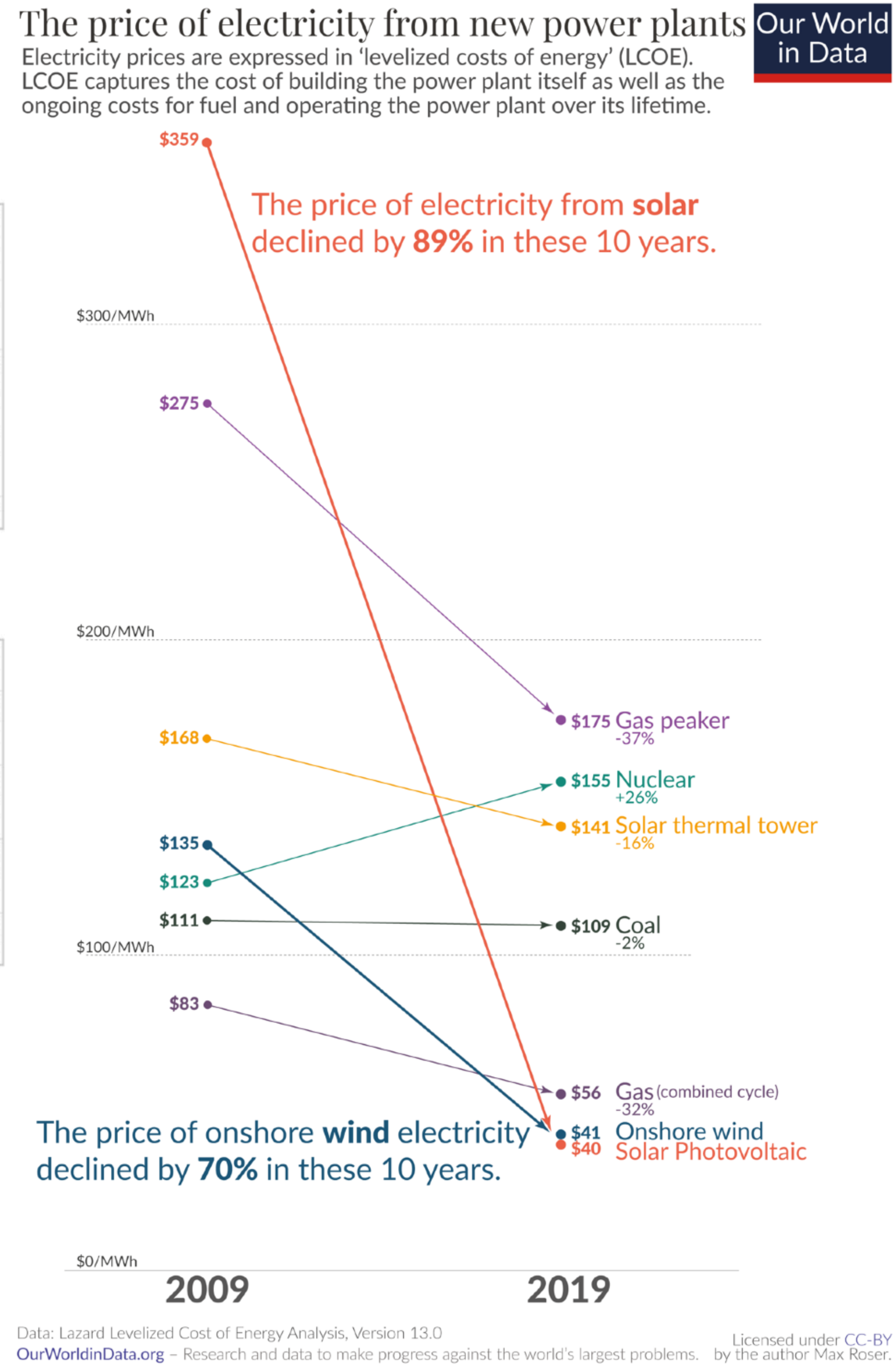
52k Accesses | **7** Citations | **4550** Altmetric | M

Source

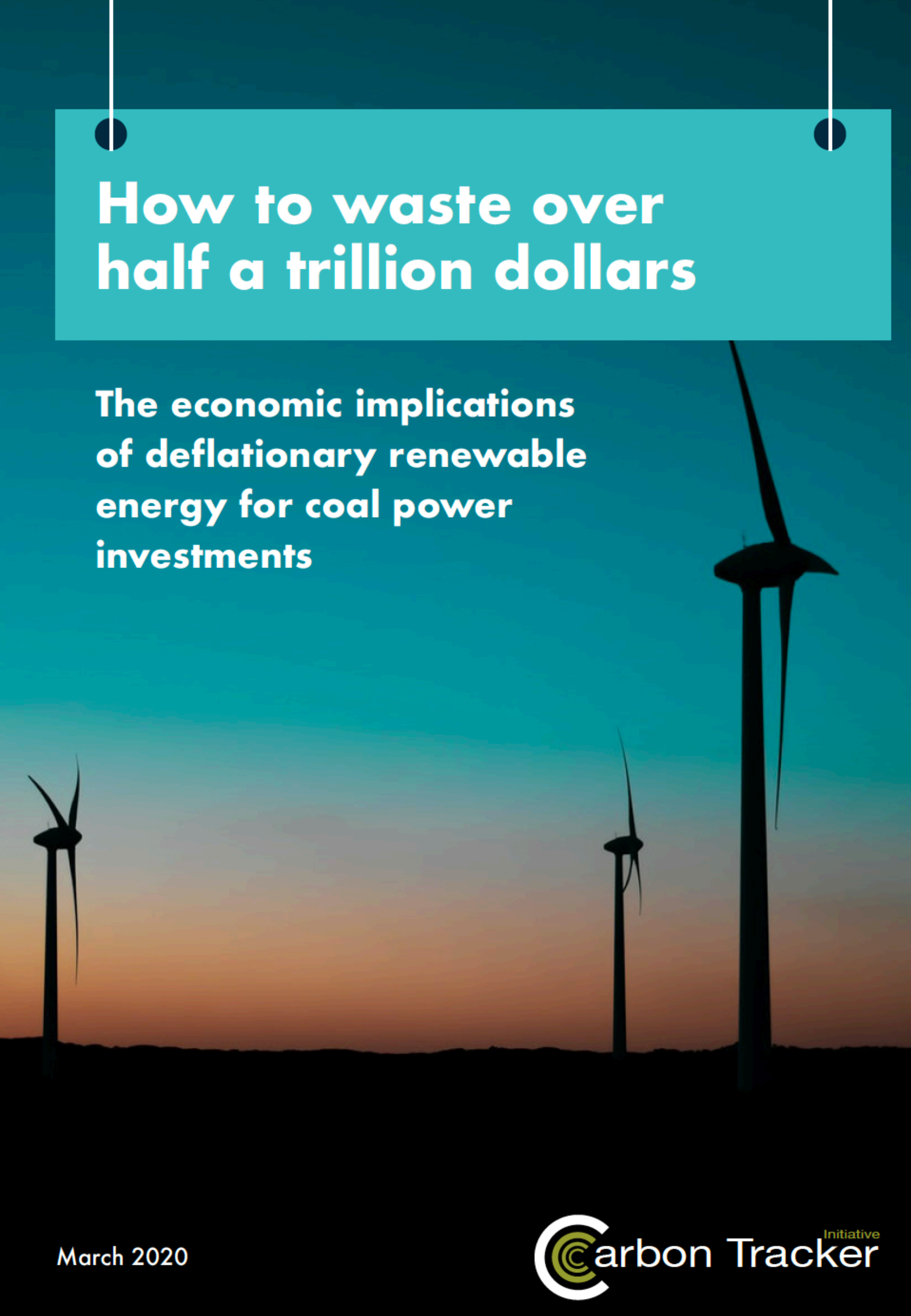


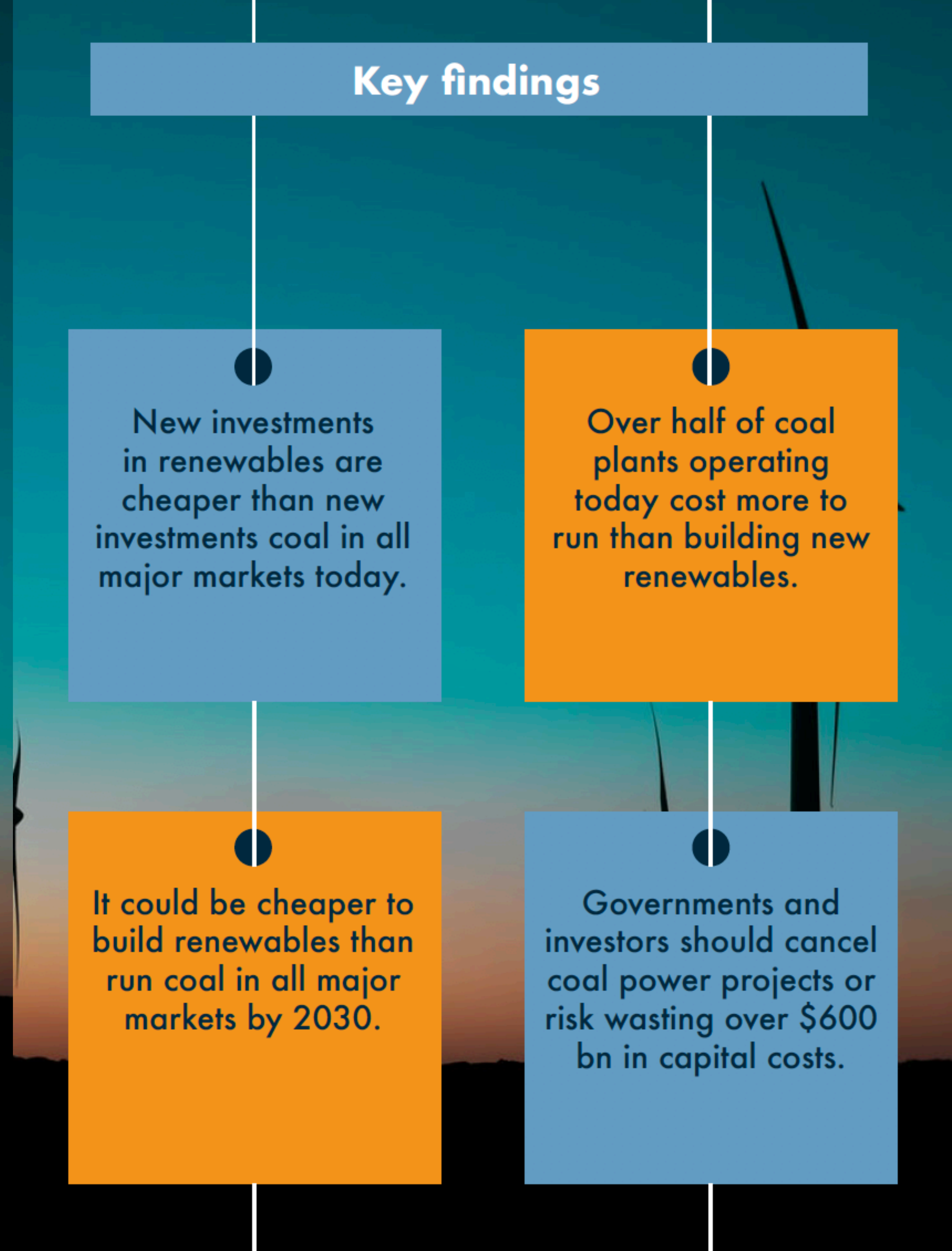
Source





Way et al. (2021); Roser (2020)





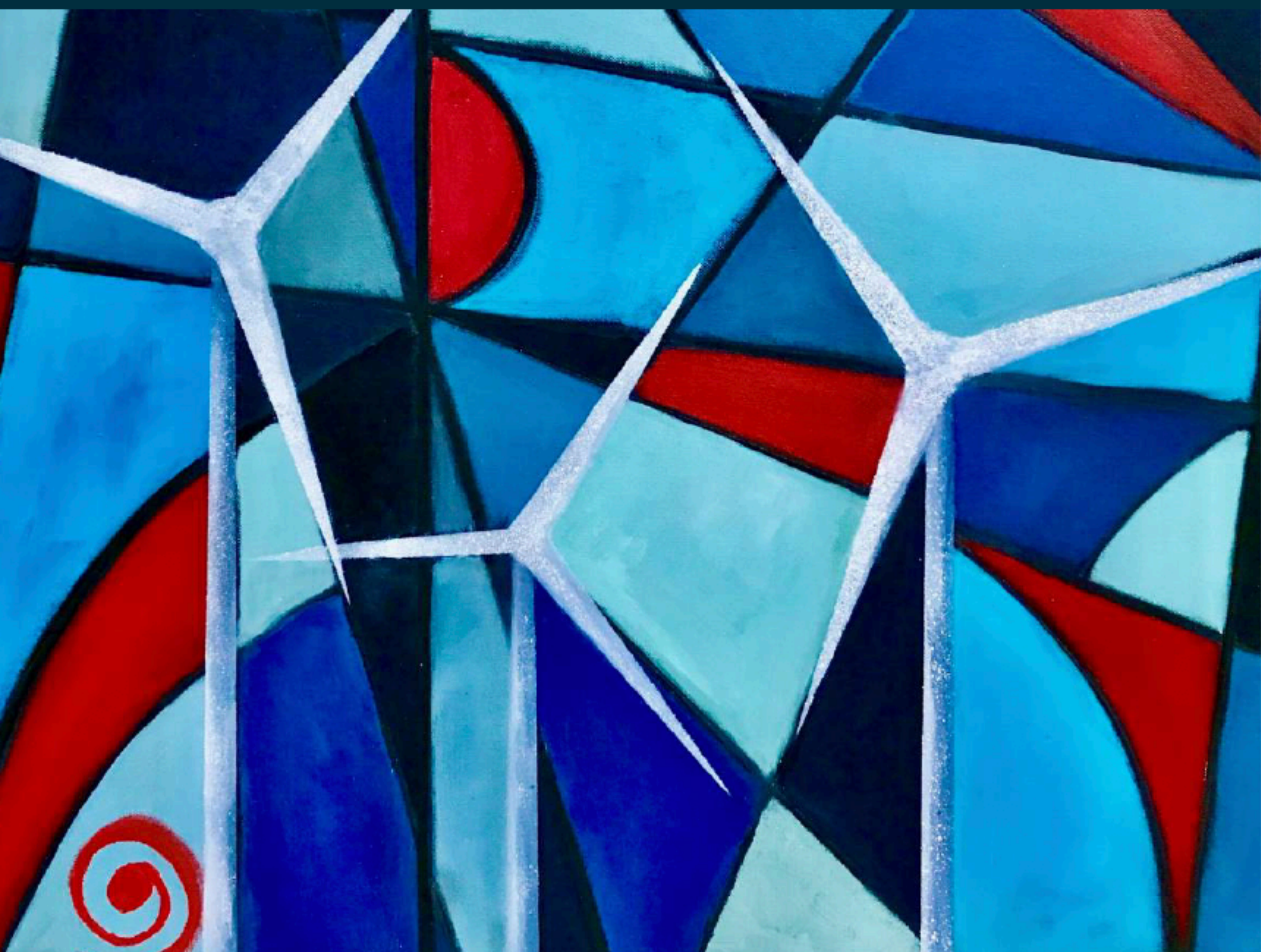
Source; Report on Gas

Campanale Interview

Carbon Tracker Initiative

The sky's the limit

Solar and wind energy potential is 100 times as much as global energy demand



Report

April 2021

1 Key findings

There is a huge new cheap energy resource available. With current technology and in a subset of available locations we can capture at least 6,700 PWh p.a. from solar and wind, which is more than 100 times global energy demand.

The opportunity has only just been unlocked. The collapse in renewable costs in the last three years means that half of this solar and wind technical potential now has economic potential, and by the end of the decade it will be over 90% of it.

Land is no constraint. The land required for solar panels alone to provide all global energy is 450,000 km2, 0.3% of the global land area of 149 million km2. That is less than the land required for fossil fuels today, which in the US alone is 126,000 km2, 1.3% of the country.

People will take advantage of the cheap energy. Humans specialise in extracting cheap energy, and fast, as witnessed by the rapid development of shale gas. Now the opportunity has been unlocked, ***expect continued exponential growth of solar and wind deployment***.

The tide is coming in fast. The technical and economic barriers have been crossed and the only impediment to change is political. Sector by sector and country by country the fossil fuel incumbency is being swamped by the rapidly rising tide of new energy technologies.

The fossil fuel era is over. The fossil fuel industry cannot compete with the technology learning curves of renewables, so demand will inevitably fall as solar and wind continue to grow. At the current 15-20% growth rates of solar and wind, ***fossil fuels will be pushed out of the electricity sector by the mid 2030s and out of total energy supply by 2050.***

There are four key groups of countries. They range from those with superabundant renewables potential, more than 1,000 times their energy demand like Namibia, all the way down to those with stretched potential of less than 10 times their demand like South Korea.

Poor countries are the greatest beneficiaries. They have the largest ratio of solar and wind potential to energy demand, and stand to unlock huge domestic benefits. The continent of ***Africa for example is a renewables superpower, with 39% of global potential***.

Germany is a special case. Germany has the third lowest solar and wind technical potential in the world relative to its energy demand. The troubles faced by Germany are therefore highly unusual, and if they can solve them then so can everyone else.

We enter a new era. The unlocking of energy reserves 100 times our current demand creates new possibilities for cheaper energy and more local jobs in a more equitable world with far less environmental stress.

Source

Campanale Interview

Carbon Pricing

World Bank Dashboard

ENVIRONMENTAL RESEARCH
LETTERS

CrossMark

OPEN ACCESS

RECEIVED
30 October 2020

REVISED
4 January 2021

ACCEPTED FOR PUBLICATION
12 January 2021

PUBLISHED
24 March 2021

TOPICAL REVIEW

Does carbon pricing reduce emissions? A review of ex-post analyses

Jessica F Green

Political Science, University of Toronto, Toronto, Canada

E-mail: Jf.green@utoronto.ca

Keywords: carbon markets, carbon pricing, climate change, cap and trade, carbon tax

Abstract

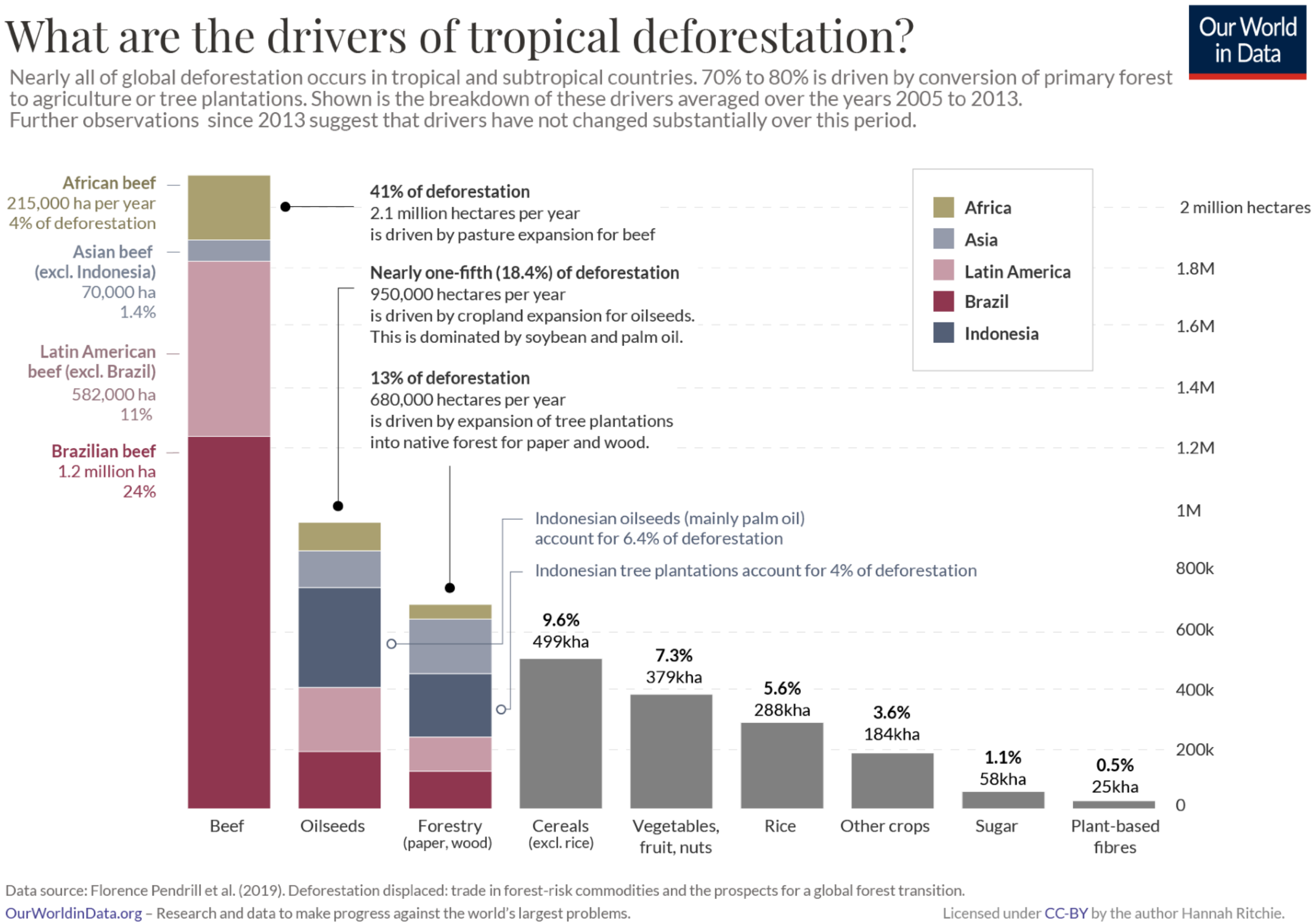
Carbon pricing has been hailed as an essential component of any sensible climate policy. Internalize the externalities, the logic goes, and polluters will change their behavior. The theory is elegant, but has carbon pricing worked in practice? Despite a voluminous literature on the topic, there are surprisingly few works that conduct an *ex-post* analysis, examining how carbon pricing has actually performed. This paper provides a meta-review of ex-post quantitative evaluations of carbon pricing policies around the world since 1990. Four findings stand out. First, though carbon pricing has dominated many political discussions of climate change, only 37 studies assess the actual effects of the policy on emissions reductions, and the vast majority of these are focused on Europe. Second, the majority of studies suggest that the aggregate reductions from carbon pricing on emissions are limited—generally between 0% and 2% per year. However, there is considerable variation across sectors. Third, in general, carbon taxes perform better than emissions trading schemes (ETSs). Finally, studies of the EU-ETS, the oldest ETS, indicate limited average annual reductions—ranging from 0% to 1.5% per annum. For comparison, the IPCC states that emissions must fall by 45% below 2010 levels by 2030 in order to limit warming to 1.5 °C—the goal set by the Paris Agreement (Intergovernmental Panel on Climate Change 2018). Overall, the evidence indicates that carbon pricing has a limited impact on emissions.

Green (2019, 2021)

Stokes & Mildenberger (2020)

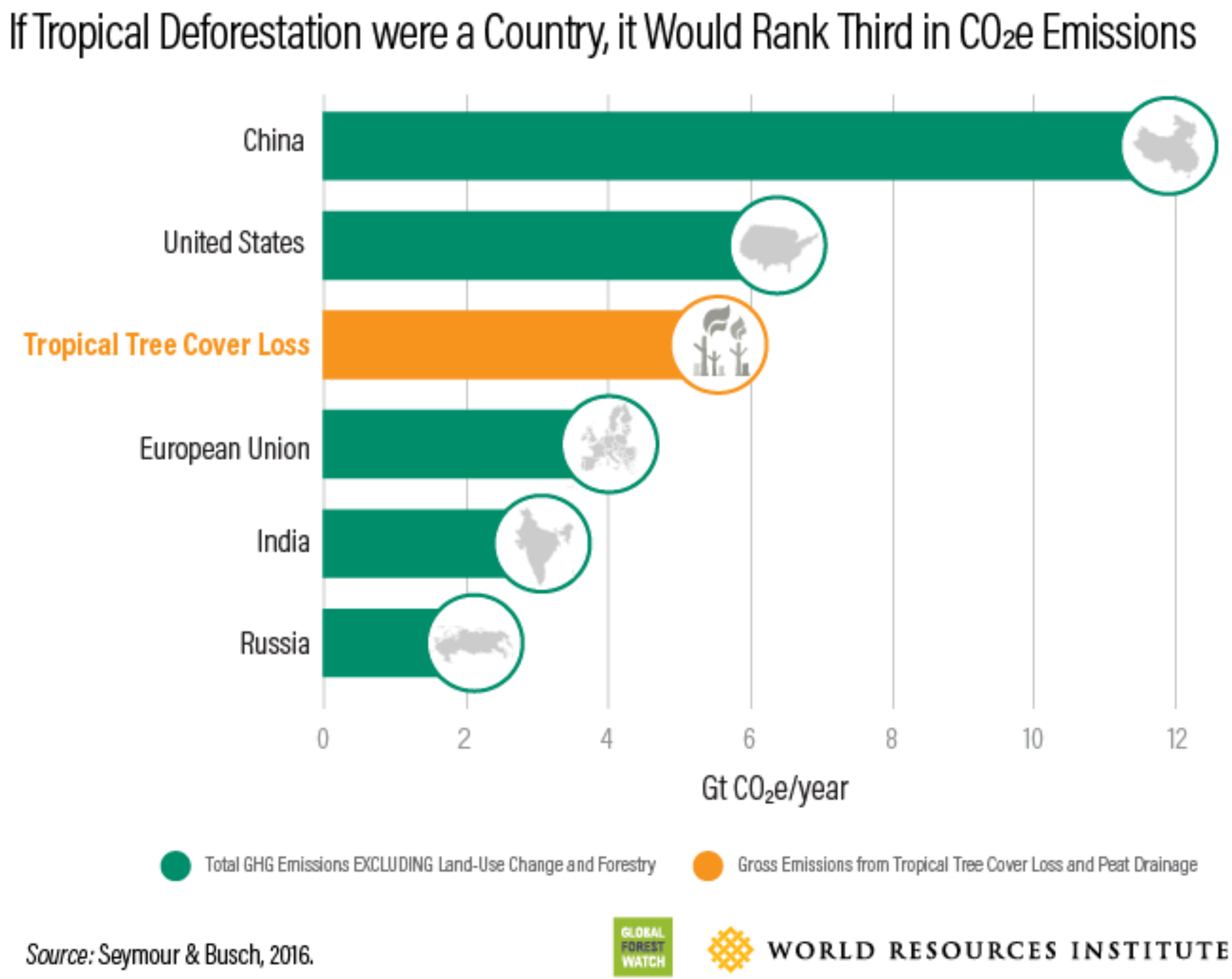
Deforestation and Afforestation

Deforestation



Source

Deforestation in Brazil 22% increase


If Tropical Deforestation were a Country, it Would Rank Third in CO_2e Emissions
China
United States
Tropical Tree Cover Loss
European Union
India
Russia
0
2
4
6
8
10
12
Gt CO_2e/year
Total GHG Emissions EXCLUDING Land-Use Change and Forestry
Gross Emissions from Tropical Tree Cover Loss and Peat Drainage
Source: Seymour & Busch, 2016.
GLOBAL FOREST WATCH
WORLD RESOURCES INSTITUTE

Source

Afforestation

Pitfalls of Tree Planting Show Why We Need People-Centered Natural Climate Solutions FREE

Forrest Fleischman, Shishir Basant, Ashwini Chhatre, Eric A Coleman, Harry W Fischer, Divya Gupta, Burak Güneralp, Prakash Kashwan, Dil Khatri, Robert Muscarella ... Show more

BioScience, Volume 70, Issue 11, November 2020, Pages 947–950, https://doi.org/10.1093/biosci/biaa094

Published: 16 September 2020

(1) Ecosystems, not tree planting campaigns, capture and store carbon

(2) Preventing ecosystem destruction is the most cost-effective natural climate solution

(3) Forests can regrow on deforested land without tree planting

(4) Tree plantations sequester less carbon, less securely, than naturally regenerated forests

(5) Tree plantations in grasslands, shrublands, and peatlands destroy biodiversity

(6) Trees can reduce water availability

(7) Trees can warm the atmosphere

(8) Perverse financial incentives lead to rushed planting and high tree mortality

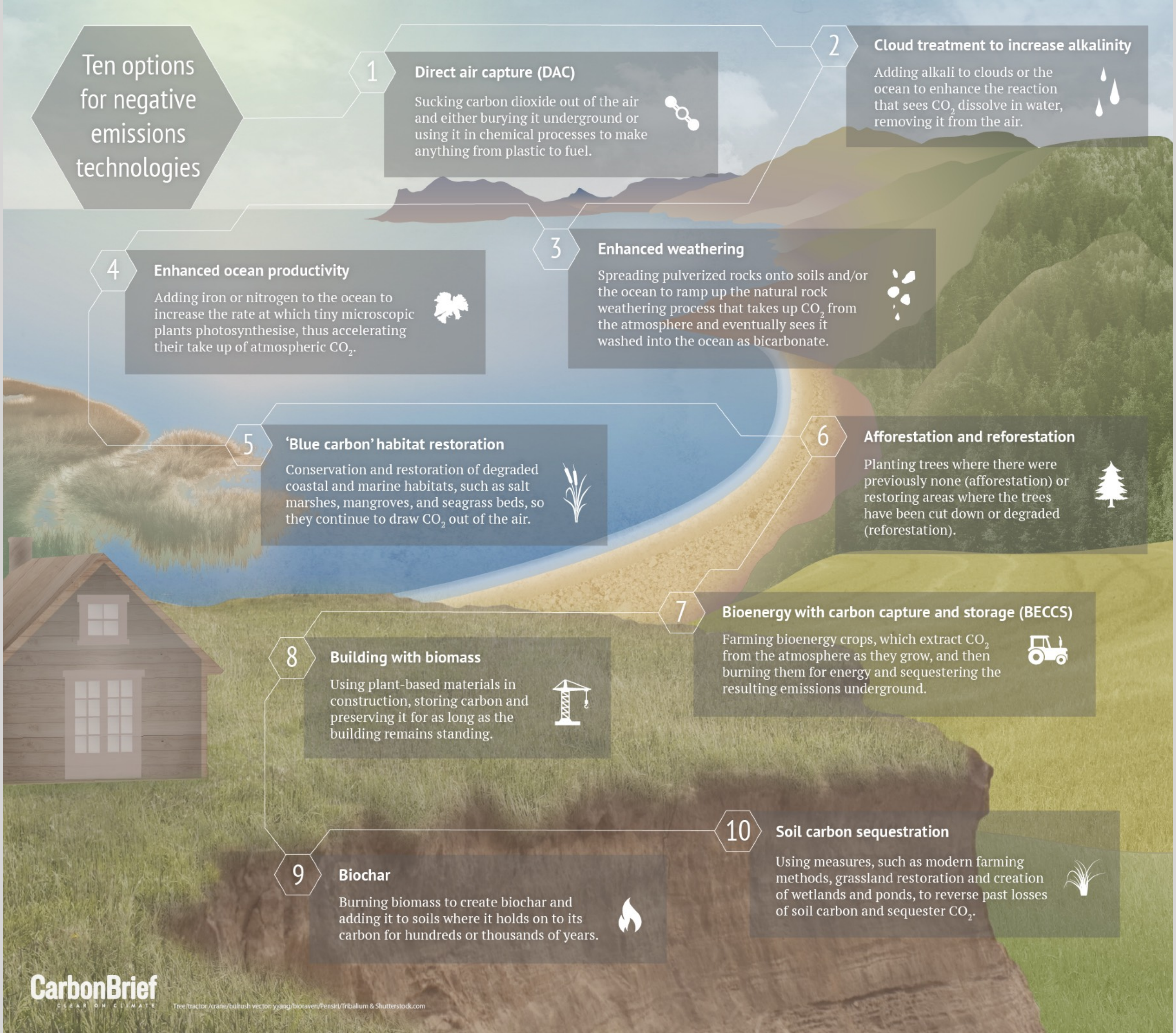
(9) Tree planting threatens rural livelihoods

(10) Tree planting targets the Global South to capture emissions from the Global North

Fleischman et al. (2021)

Jones (2021); Marshall (2020); Koberstein & Applegate (2019)

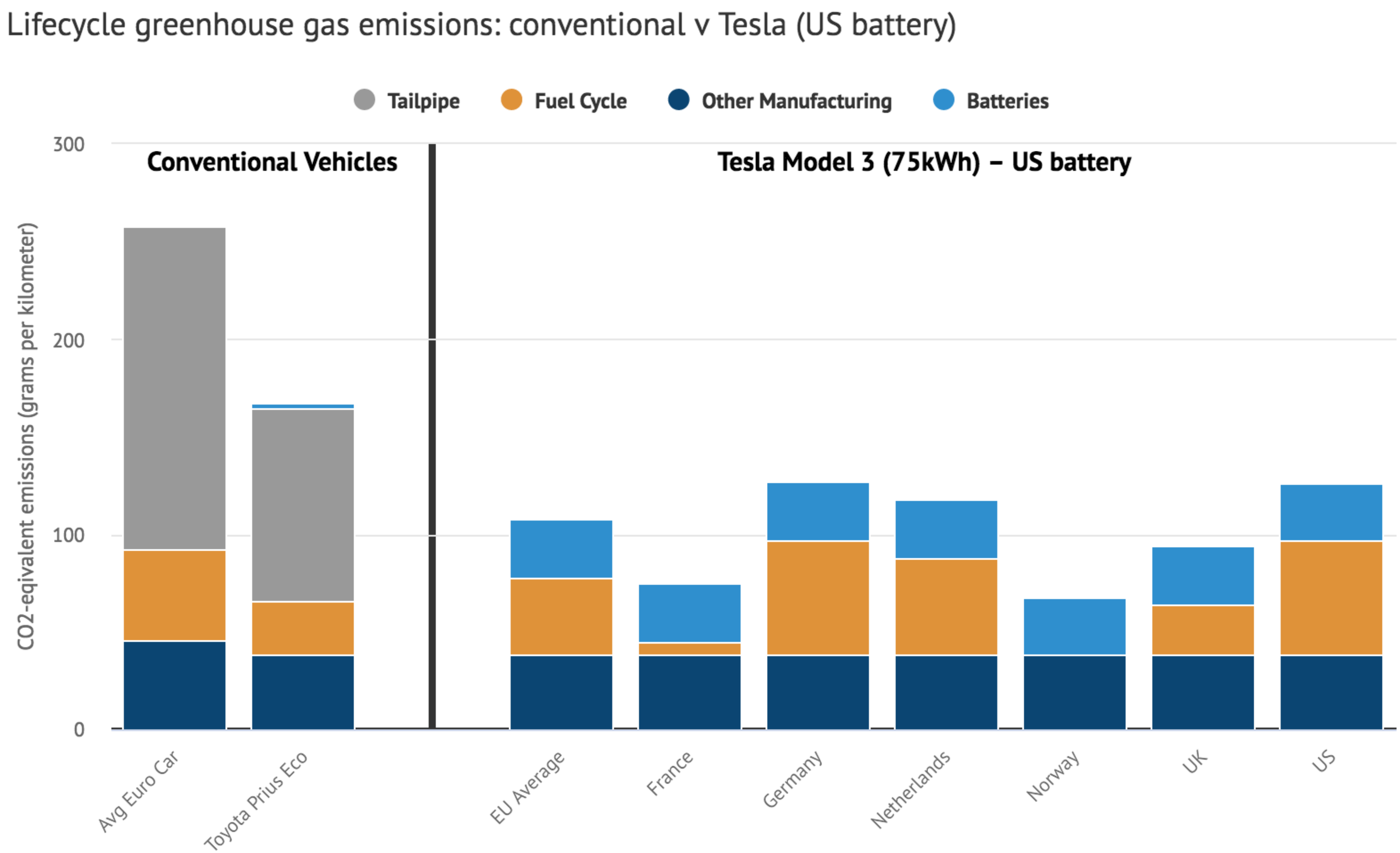
Technological Carbon Removal



Ten options for negative emissions technologies
1 Direct air capture (DAC)
Sucking carbon dioxide out of the air and either burying it underground or using it in chemical processes to make anything from plastic to fuel.
2 Cloud treatment to increase alkalinity
Adding alkali to clouds or the ocean to enhance the reaction that sees CO_2 dissolve in water, removing it from the air.
3 Enhanced weathering
Spreading pulverized rocks onto soils and/or the ocean to ramp up the natural rock weathering process that takes up CO_2 from the atmosphere and eventually sees it washed into the ocean as bicarbonate.
4 Enhanced ocean productivity
Adding iron or nitrogen to the ocean to increase the rate at which tiny microscopic plants photosynthesise, thus accelerating their take up of atmospheric CO_2.
5 'Blue carbon' habitat restoration
Conservation and restoration of degraded coastal and marine habitats, such as salt marshes, mangroves, and seagrass beds, so they continue to draw CO_2 out of the air.
6 Afforestation and reforestation
Planting trees where there were previously none (afforestation) or restoring areas where the trees have been cut down or degraded (reforestation).
7 Bioenergy with carbon capture and storage (BECCS)
Farming bioenergy crops, which extract CO_2 from the atmosphere as they grow, and then burning them for energy and sequestering the resulting emissions underground.
8 Building with biomass
Using plant-based materials in construction, storing carbon and preserving it for as long as the building remains standing.
9 Biochar
Burning biomass to create biochar and adding it to soils where it holds on to its carbon for hundreds or thousands of years.
10 Soil carbon sequestration
Using measures, such as modern farming methods, grassland restoration and creation of wetlands and ponds, to reverse past losses of soil carbon and sequester CO_2.
CarbonBrief

Source

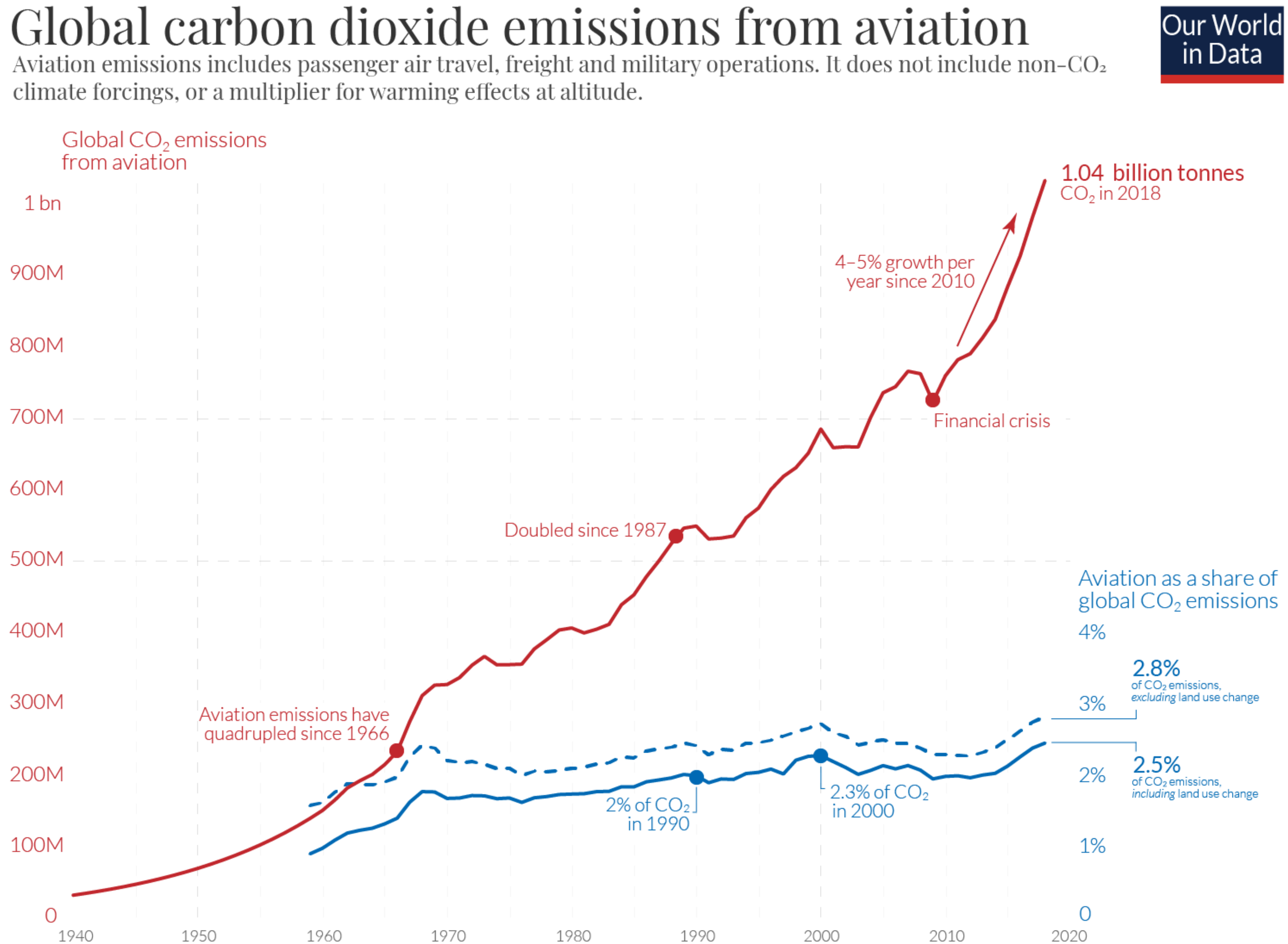
Transport



Hausfather (2019)

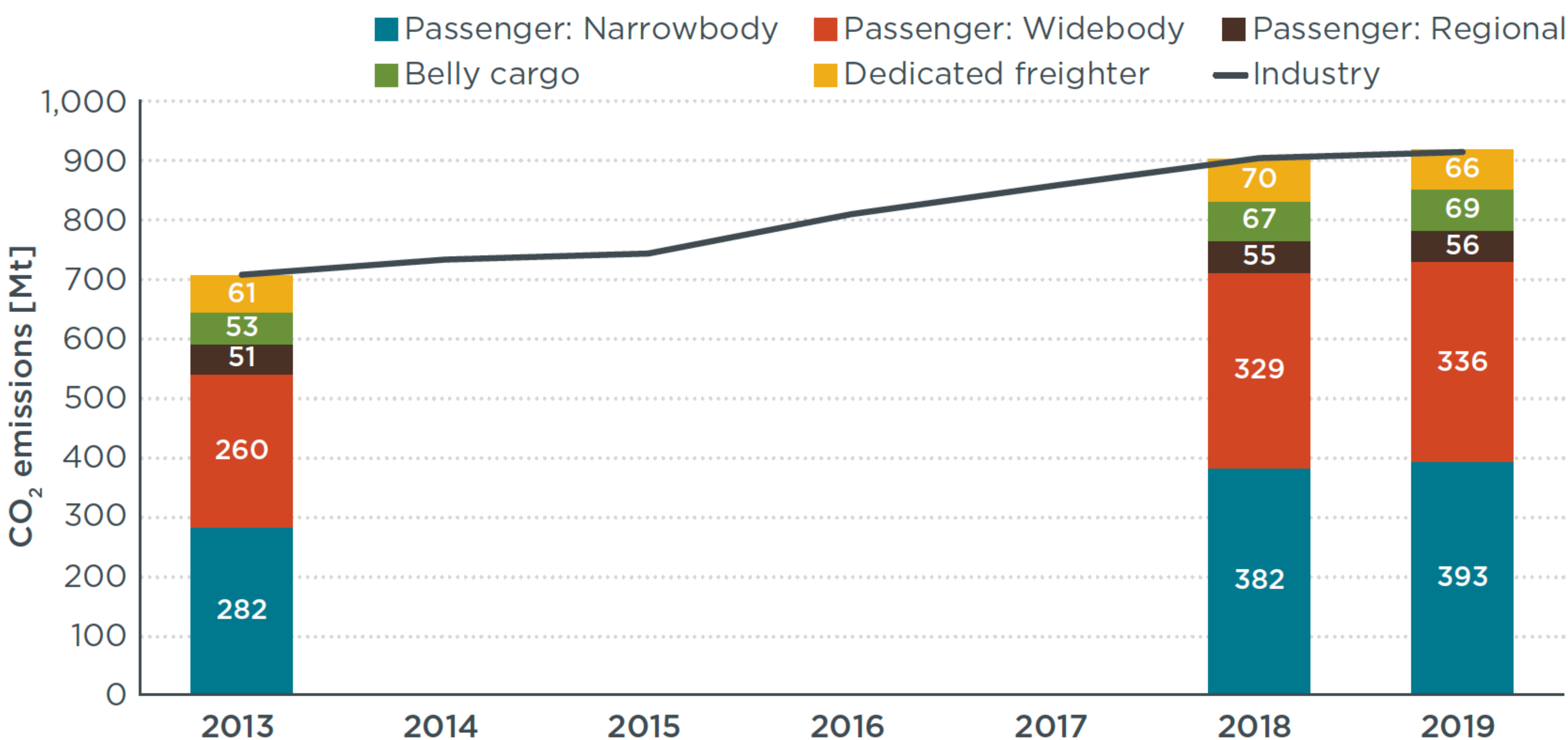
Global carbon dioxide emissions from aviation

Aviation emissions includes passenger air travel, freight and military operations. It does not include non-CO_2 climate forcings, or a multiplier for warming effects at altitude.



OurWorldinData.org – Research and data to make progress against the world's largest problems.
Source: Lee et al. (2020). The contribution of global aviation to anthropogenic climate forcing for 2000 to 2018; based on Sausen and Schumann (2000) & IEA.
Share of global emissions calculated based on total CO_2 data from the Global Carbon Project.

Ritchie (2020)



Graver, Rutherford, & Zheng (2020)

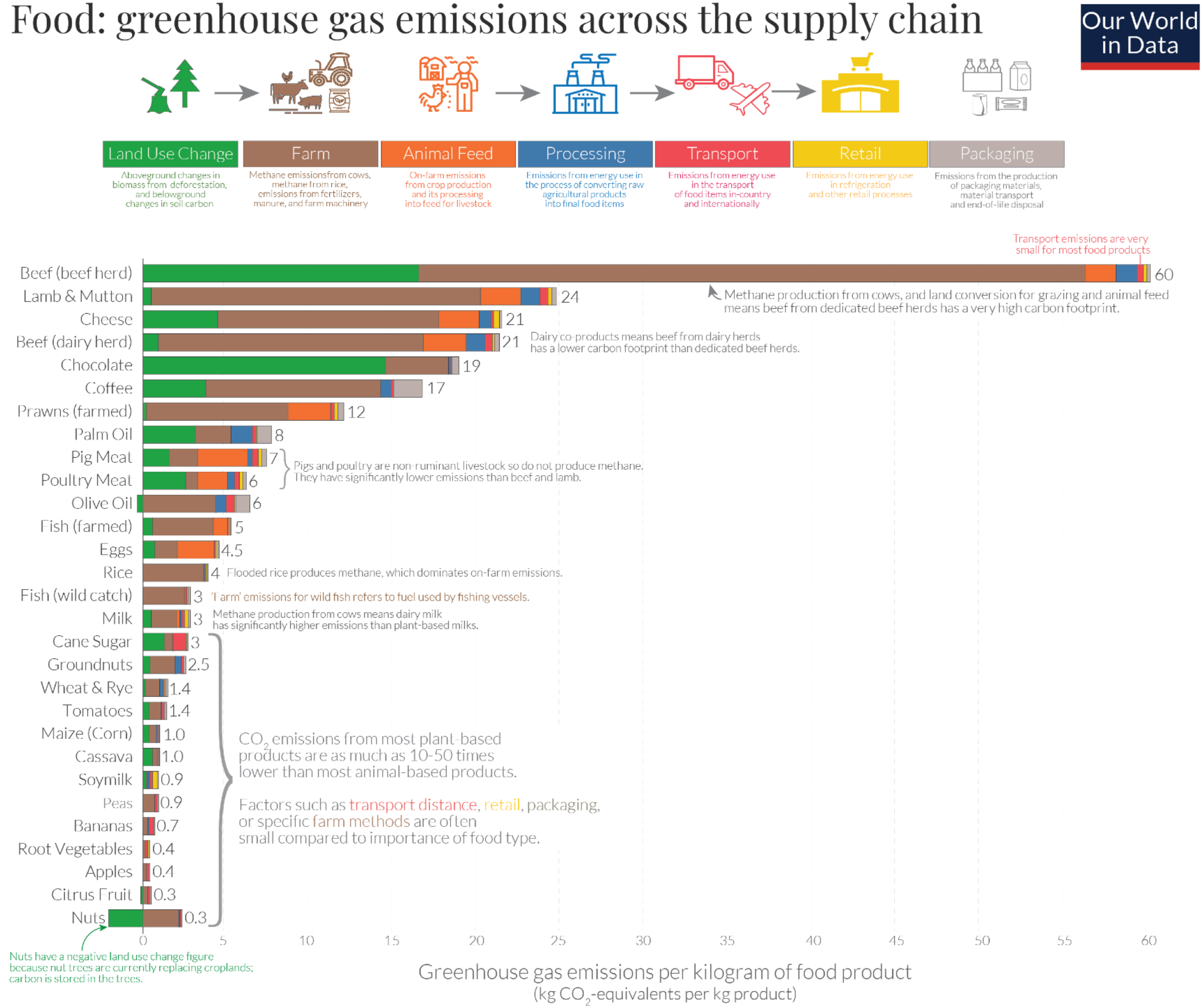
Food

Breadbaskets of the four major crops and their respective contributions to global production			
Maize	*Rice*	*Soybean*	*Wheat*
USA (34%)	China (28%)	USA (34%)	Europe (24%)
China (23%)	India (21%)	Brazil (30%)	China (18%)
Europe (10%)	Indonesia (10%)	Argentina (17%)	India (13%)
Brazil (8%)	Bangladesh (7%)	China (4%)	Russia (9%)
Argentina (4%)	Vietnam (6%)	India (3%)	USA (8%)

Supplementary Table 1. Contribution of top five production-based breadbaskets to global maize, rice, soybean, and wheat production based on 2013-2017 global crop production from the Food and Agricultural Organization. Europe includes all European countries except Russia.

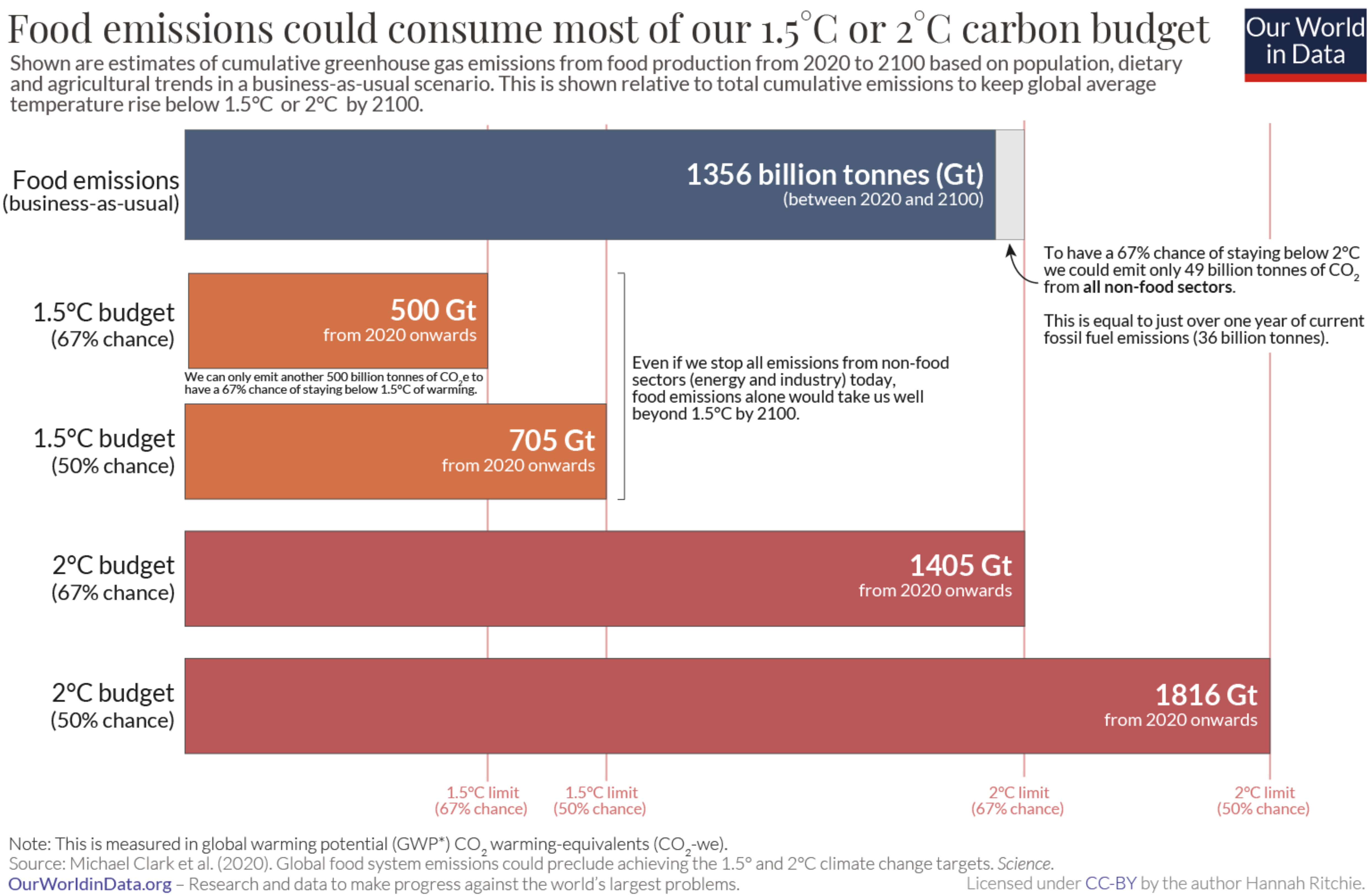
Caparas et al. (2021)

Food: greenhouse gas emissions across the supply chain

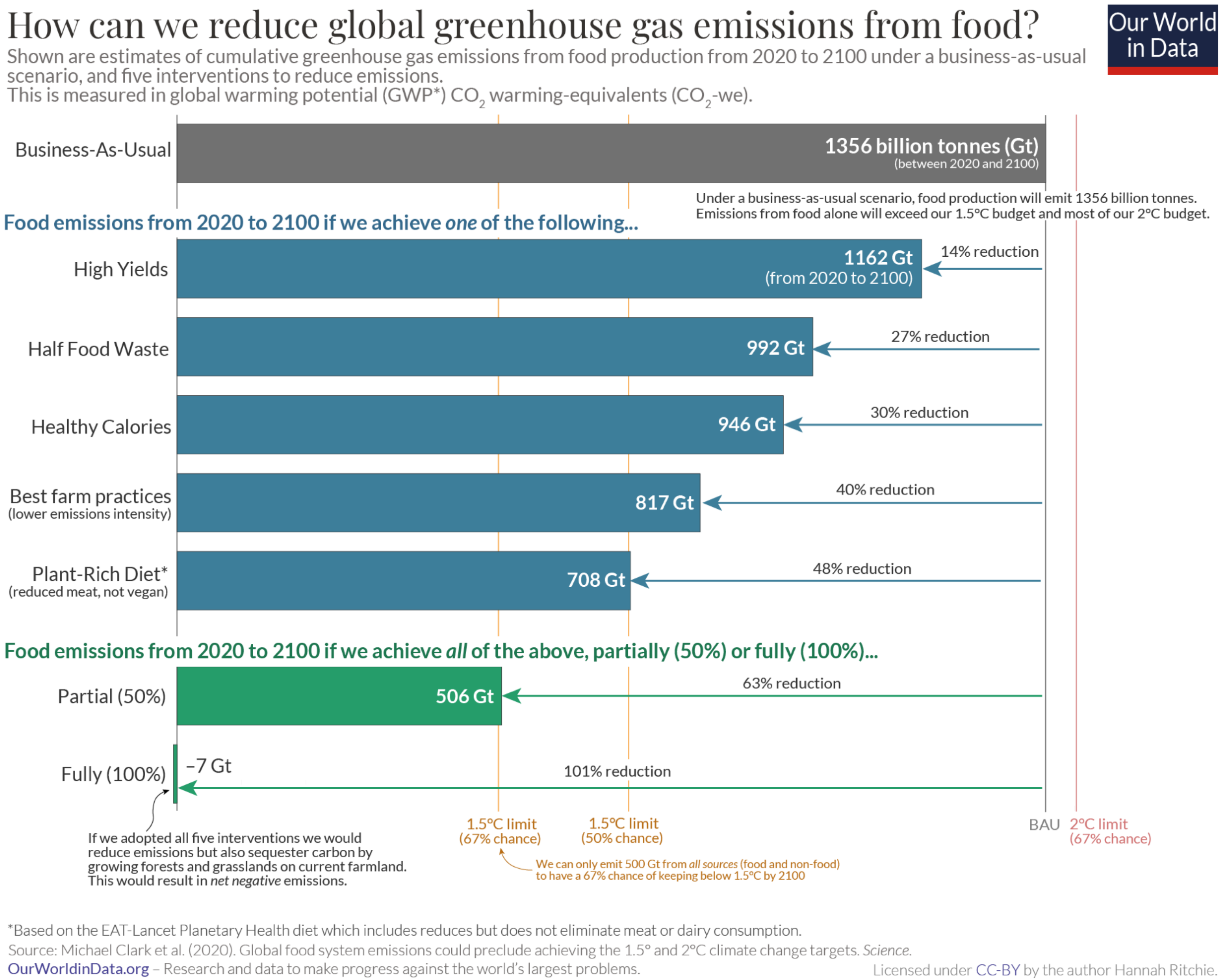


Note: Greenhouse gas emissions are given as global average values based on data across 38,700 commercially viable farms in 119 countries.
Data source: Poore and Nemecek (2018). Reducing food's environmental impacts through producers and consumers. *Science*. Images sourced from the Noun Project.
OurWorldinData.org – Research and data to make progress against the world's largest problems.

Source


Food emissions could consume most of our 1.5°C or 2°C carbon budget
Shown are estimates of cumulative greenhouse gas emissions from food production from 2020 to 2100 based on population, dietary and agricultural trends in a business-as-usual scenario. This is shown relative to total cumulative emissions to keep global average temperature rise below 1.5°C or 2°C by 2100.
Our World in Data
Food emissions (business-as-usual)
1356 billion tonnes (Gt) (between 2020 and 2100)
1.5°C budget (67% chance)
500 Gt from 2020 onwards
We can only emit another 500 billion tonnes of CO_2e to have a 67% chance of staying below 1.5°C of warming.
1.5°C budget (50% chance)
705 Gt from 2020 onwards
Even if we stop all emissions from non-food sectors (energy and industry) today, food emissions alone would take us well beyond 1.5°C by 2100.
To have a 67% chance of staying below 2°C we could emit only 49 billion tonnes of CO_2 from all non-food sectors.
This is equal to just over one year of current fossil fuel emissions (36 billion tonnes).
2°C budget (67% chance)
1405 Gt from 2020 onwards
2°C budget (50% chance)
1816 Gt from 2020 onwards
1.5°C limit (67% chance)
1.5°C limit (50% chance)
2°C limit (67% chance)
2°C limit (50% chance)
Note: This is measured in global warming potential (GWP*) CO_2 warming-equivalents (CO_2-we).
Source: Michael Clark et al. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. Science.
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the author Hannah Ritchie.

Source



How can we reduce global greenhouse gas emissions from food?
Shown are estimates of cumulative greenhouse gas emissions from food production from 2020 to 2100 under a business-as-usual scenario, and five interventions to reduce emissions.
This is measured in global warming potential (GWP*) CO_2 warming-equivalents (CO_2-we).
Our World in Data
Business-As-Usual
1356 billion tonnes (Gt)
(between 2020 and 2100)
Under a business-as-usual scenario, food production will emit 1356 billion tonnes. Emissions from food alone will exceed our 1.5°C budget and most of our 2°C budget.
Food emissions from 2020 to 2100 if we achieve *one* of the following...
High Yields
1162 Gt
(from 2020 to 2100)
14% reduction
Half Food Waste
992 Gt
27% reduction
Healthy Calories
946 Gt
30% reduction
Best farm practices
(lower emissions intensity)
817 Gt
40% reduction
Plant-Rich Diet*
(reduced meat, not vegan)
708 Gt
48% reduction
Food emissions from 2020 to 2100 if we achieve *all* of the above, partially (50%) or fully (100%)...
Partial (50%)
506 Gt
63% reduction
Fully (100%)
−7 Gt
101% reduction
If we adopted all five interventions we would reduce emissions but also sequester carbon by growing forests and grasslands on current farmland. This would result in *net negative* emissions.
1.5°C limit
(67% chance)
1.5°C limit
(50% chance)
We can only emit 500 Gt from *all sources* (food and non-food) to have a 67% chance of keeping below 1.5°C by 2100
BAU
2°C limit
(67% chance)
*Based on the EAT-Lancet Planetary Health diet which includes reduces but does not eliminate meat or dairy consumption.
Source: Michael Clark et al. (2020). Global food system emissions could preclude achieving the 1.5° and 2°C climate change targets. *Science*.
OurWorldinData.org – Research and data to make progress against the world's largest problems.
Licensed under CC-BY by the author Hannah Ritchie.

Source

Economics

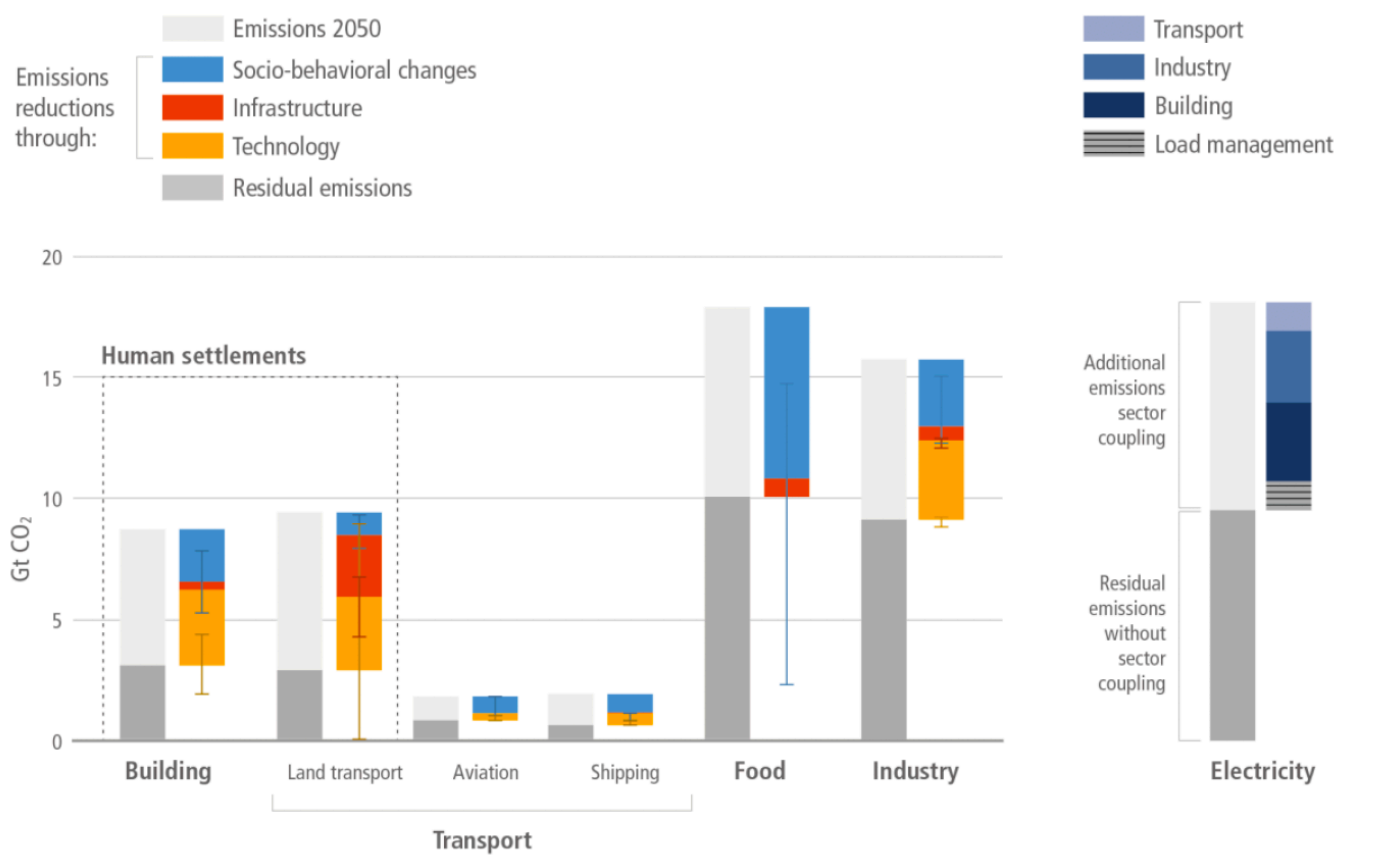
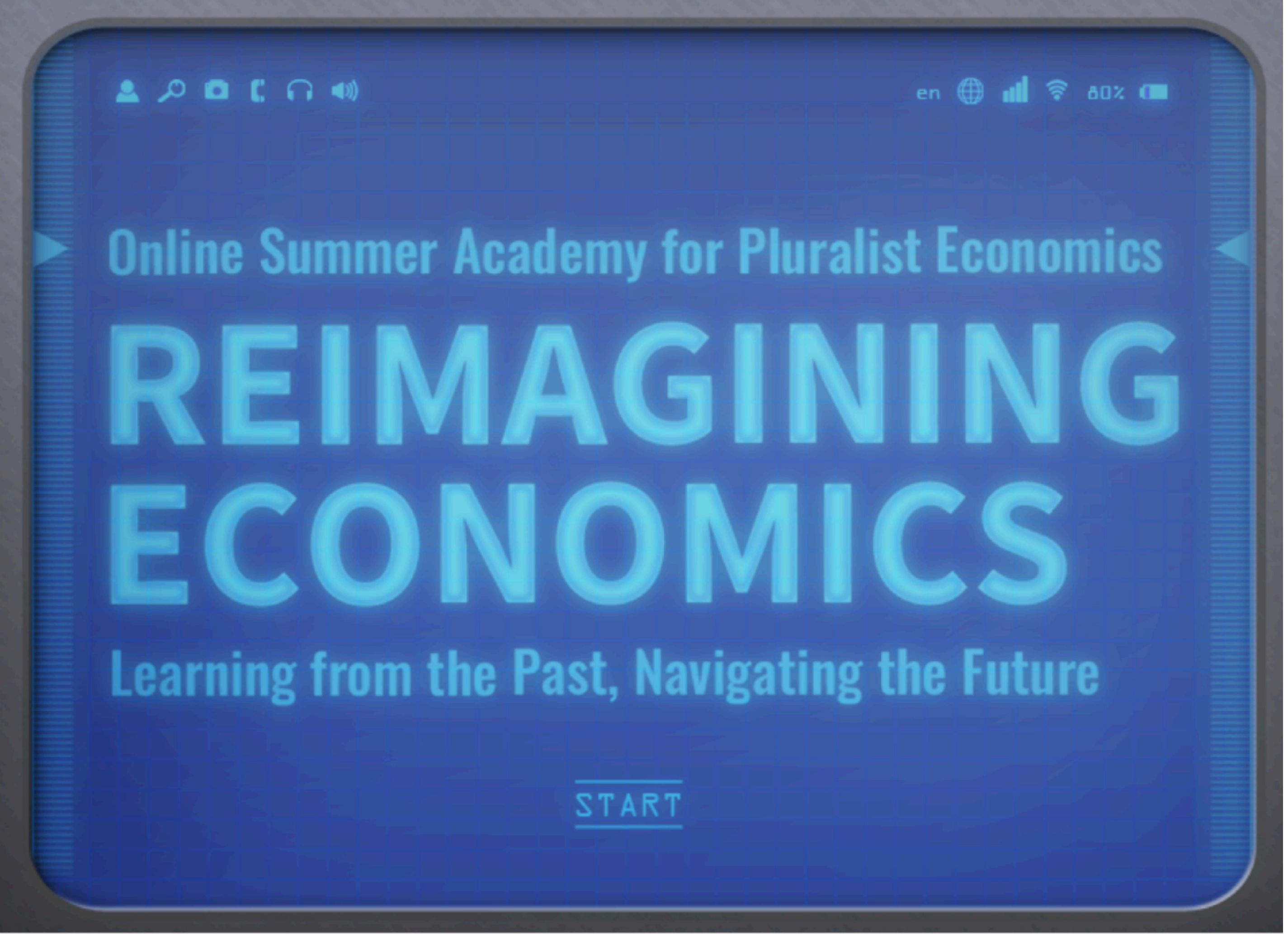
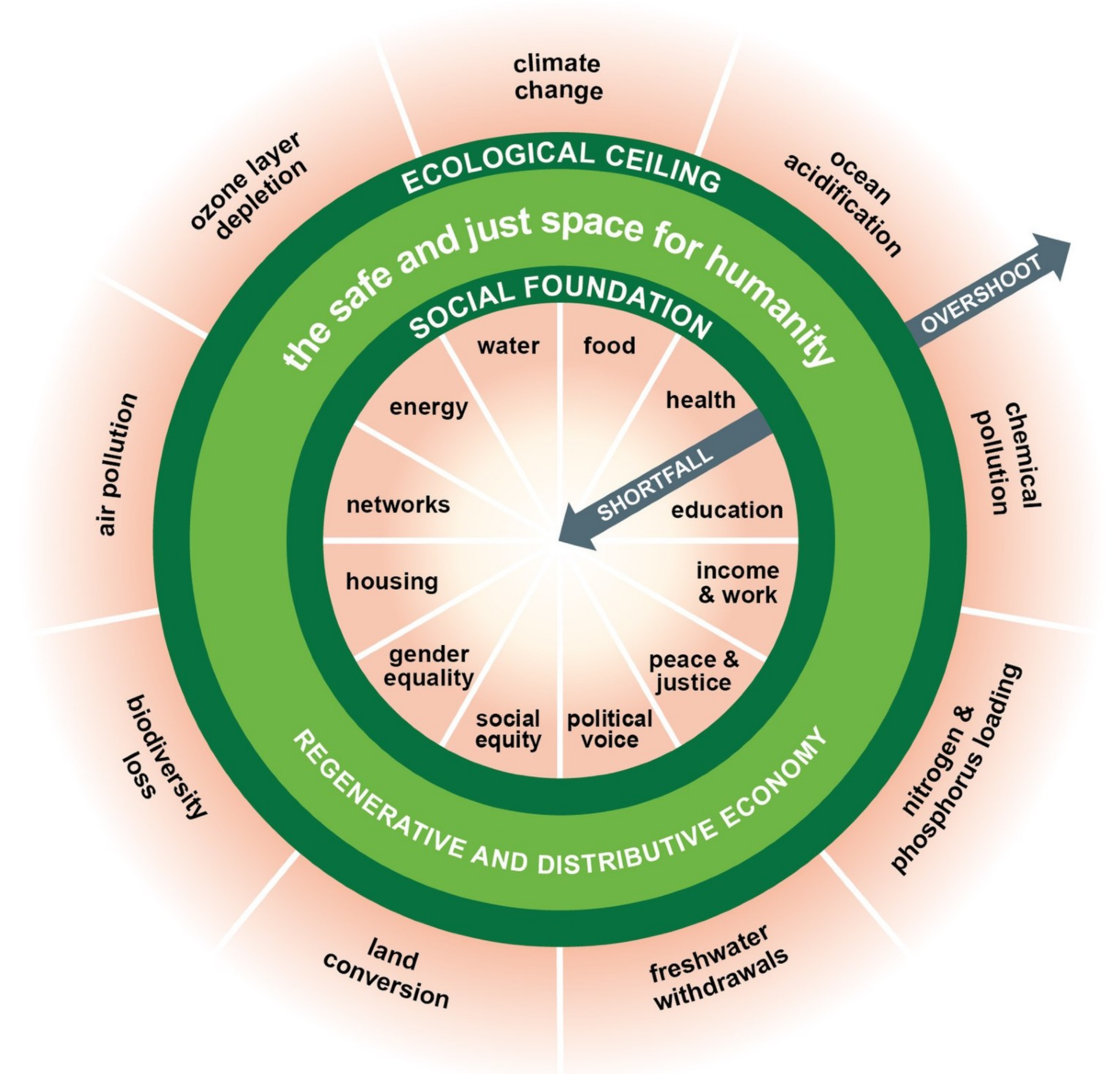


Figure SPM.8 | Climate change mitigation potentials classified in socio-behavioural, infrastructural, and technological options can reduce GHG emissions by 50-80% in end-use sectors by 2050. Drawing on the full potential requires changes in social norms, the provision in low-carbon infrastructures, and wide-range adoption of granular efficient end-use technologies. Electrification of transport, building and industry sector increases the demand on the electricity sector and associated indirect emissions, while demand side measures and load management compensate for this increased load. Based on review of studies estimating demand-side

Source





Equitable Downscaling to Address the Climate Crisis with a focus on Europe

Policy Brief[1]

Andrea Bacilieri, Fabian Dablander, Rayssa Ferrari, Sophie Reisinger, Federico Sibaja, Mara Strenger

Raworth (2017)

PDF

System Transformations

STATE OF CLIMATE ACTION 2021

Systems Transformations Required to Limit Global Warming to 1.5°C

RACE TO ZERO · RACE TO RESILIENCE · climateworks FOUNDATION · Climate Action Tracker · BEZOS EARTH FUND · WORLD RESOURCES INSTITUTE

FOREWORD		iv
EXECUTIVE SUMMARY		1
CHAPTER 1.	SNAPSHOT OF A CHANGING CLIMATE	20
CHAPTER 2.	METHODOLOGY FOR ASSESSING PROGRESS	24
CHAPTER 3.	POWER	40
CHAPTER 4.	BUILDINGS	52
CHAPTER 5.	INDUSTRY	64
CHAPTER 6.	TRANSPORT	86
CHAPTER 7.	TECHNOLOGICAL CARBON REMOVAL	120
CHAPTER 8.	LAND USE AND COASTAL ZONE MANAGEMENT	127
CHAPTER 9.	AGRICULTURE	150
CHAPTER 10.	FINANCE	168
CHAPTER 11.	EQUITY AND JUST TRANSITION	184
CONCLUSION		189

Launch Event

Exponential change possible

Exponential change possible

Exponential change unlikely

ON TRACK

STAGNANT

OFF TRACK

WRONG DIRECTION

WELL OFF TRACK

INSUFFICIENT DATA

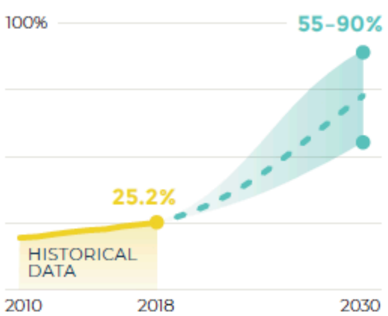
ON TRACK: Change is occurring at or above the pace required to achieve the 2030 targets

None

OFF TRACK: Change is heading in the right direction at a promising, but insufficient pace

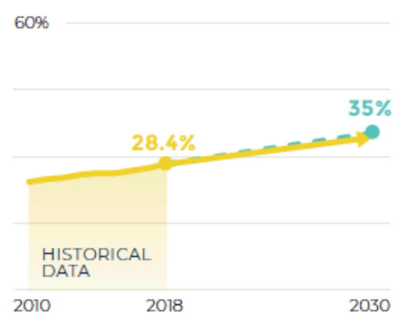
POWER N/A

Increase the share of renewables in electricity generation to 55–90%



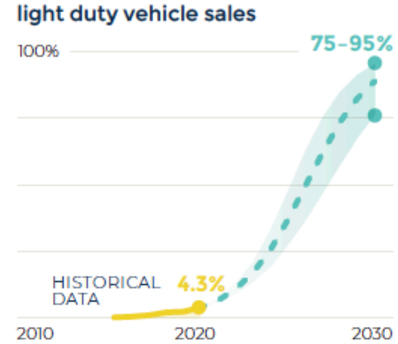
INDUSTRY 1.1x

Increase the share of electricity in the industry sector's final energy demand to 35%



TRANSPORT N/A

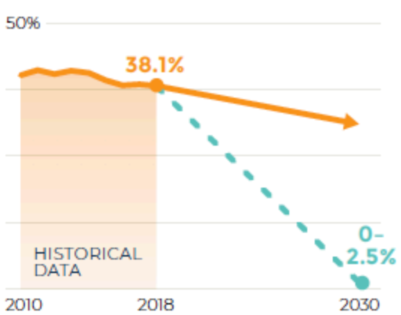
Increase the share of electric vehicles to 75–95% of total annual light duty vehicle sales



WELL OFF TRACK: Change is heading in the right direction, but well below the required pace

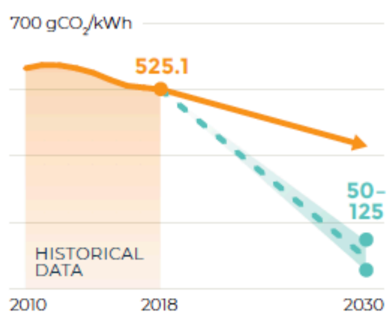
POWER 5.2x

Lower the share of unabated coal in electricity generation to 0–2.5%



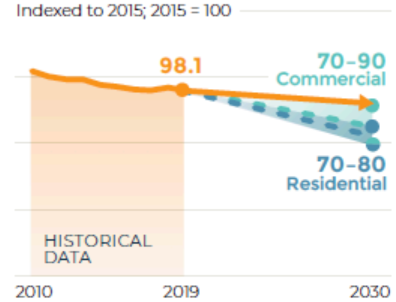
POWER 3.2x

Reduce carbon intensity of electricity generation to 50–125 gCO_2/kWh



BUILDINGS 2.7x[d]

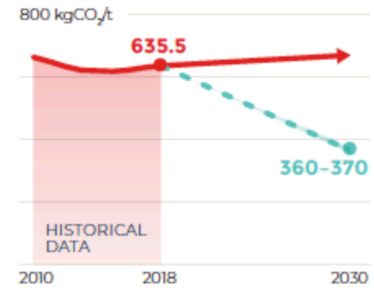
Decrease the energy intensity of operations in key countries and regions by 20–30% in residential buildings and by 10–30% in commercial buildings, relative to 2015



STAGNANT: Change is stagnating, and a step change in action is needed

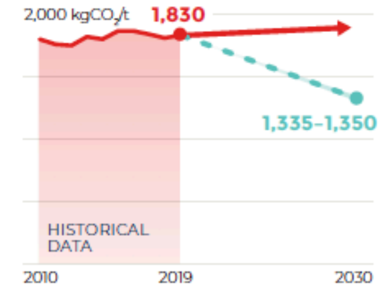
INDUSTRY N/A

Reduce carbon intensity of global cement production by 40%, relative to 2015



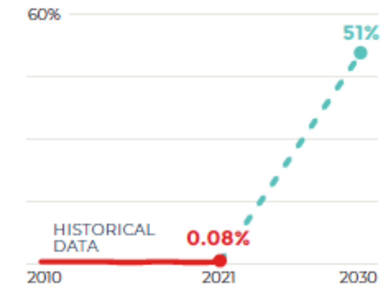
INDUSTRY N/A

Reduce carbon intensity of global steel production by 25–30%, relative to 2015



FINANCE N/A

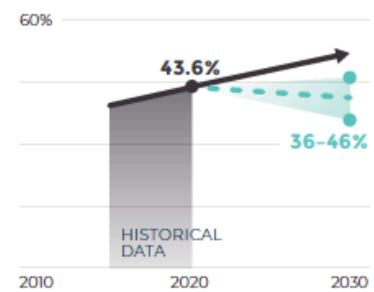
Ensure that a carbon price of at least $135/$tCO_2e$ covers the majority of the world's GHG emissions



WRONG DIRECTION: Change is heading in the wrong direction, and a U-turn is needed

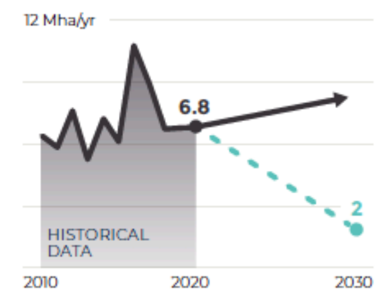
TRANSPORT N/A

Reduce the percentage of trips made by private light duty vehicles to between 4% and 14% below BAU levels



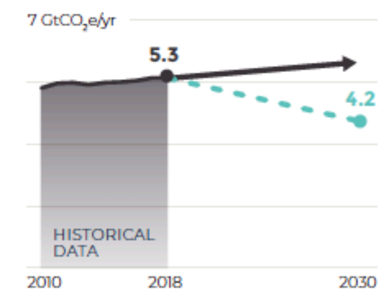
LAND USE AND COASTAL ZONE MANAGEMENT N/A

Reduce the rate of deforestation by 70%, relative to 2018



AGRICULTURE N/A

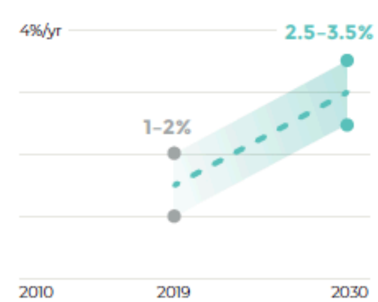
Reduce agricultural production emissions by 22%, relative to 2017



INSUFFICIENT DATA: Data are insufficient to assess the gap in action required for 2030[g]

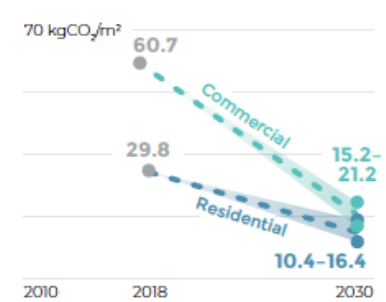
BUILDINGS Ins. data

Increase buildings' retrofitting rate to 2.5–3.5% annually



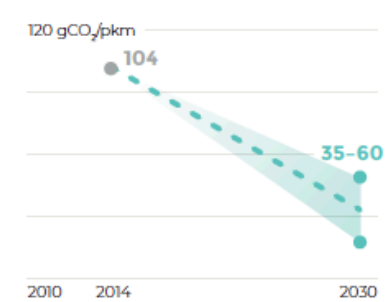
BUILDINGS Ins. data

Reduce the carbon intensity of operations in select regions by 45–65% in residential buildings and by 65–75% in commercial buildings, relative to 2015 ($kgCO_2/m^2$)



TRANSPORT Ins. data

Reduce the carbon intensity of land-based passenger transport to 35–60 gCO_2/pkm



Exponential change possible | **ON TRACK**

Exponential change possible | **OFF TRACK**

Exponential change unlikely | **WELL OFF TRACK**

STAGNANT

WRONG DIRECTION

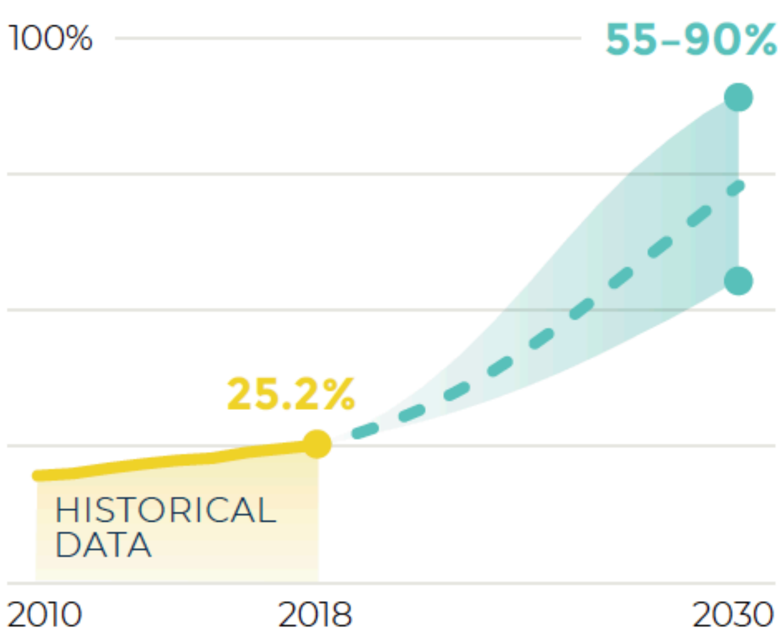
INSUFFICIENT DATA

Power

- ON TRACK
- OFF TRACK
- WELL OFF TRACK
- STAGNANT
- WRONG DIRECTION
- INSUFFICIENT DATA

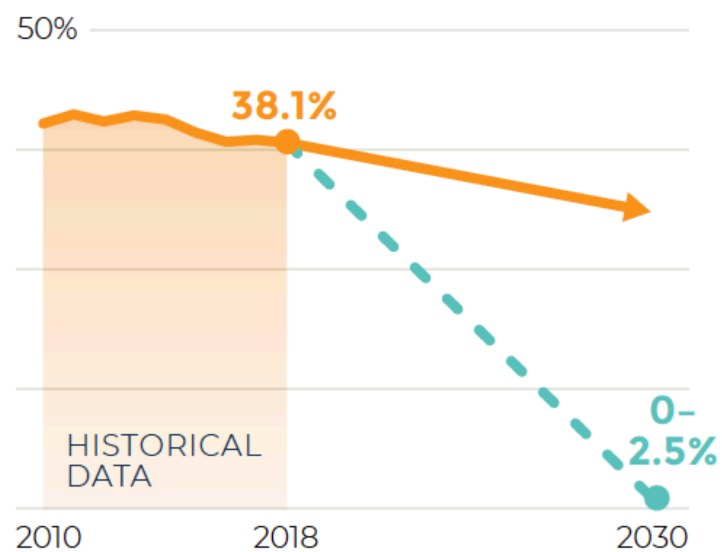
POWER N/A

Increase the share of renewables in electricity generation to 55–90%



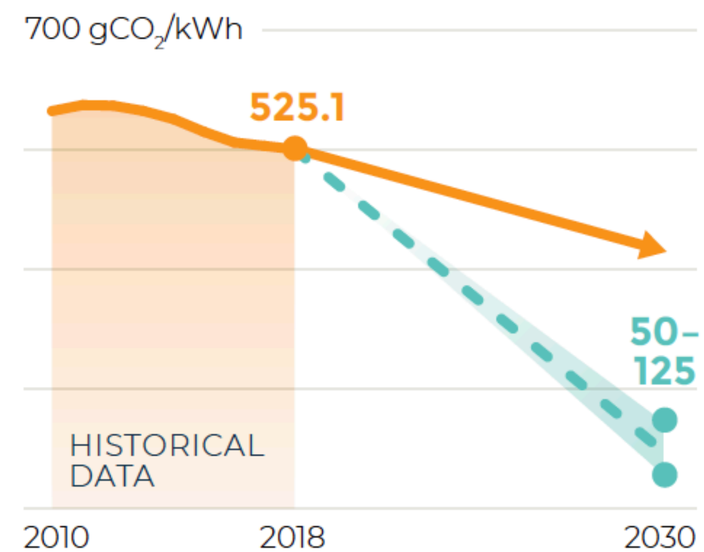
POWER 5.2x

Lower the share of unabated coal in electricity generation to 0–2.5%



POWER 3.2x

Reduce carbon intensity of electricity generation to 50–125 gCO_2/kWh

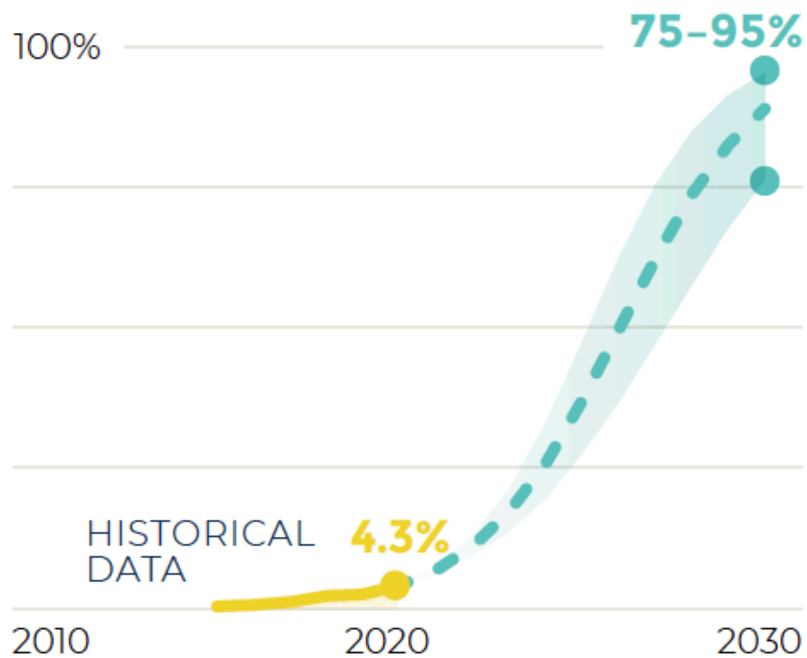


Transport

ON TRACK
STAGNANT:
OFF TRACK:
WRONG DIRECTION:
WELL OFF TRACK:
INSUFFICIENT DATA:

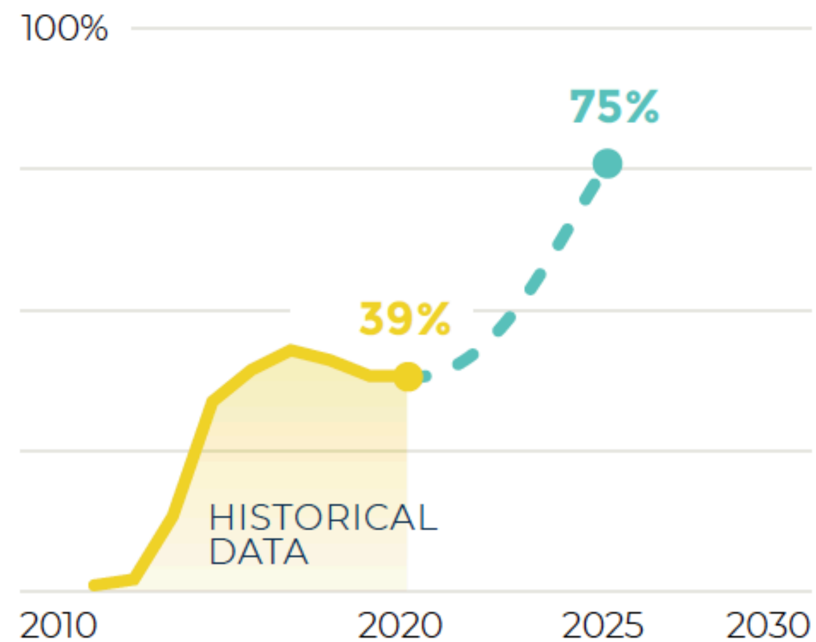
TRANSPORT N/A

Increase the share of electric vehicles to 75–95% of total annual light duty vehicle sales



TRANSPORT N/A[a]

Boost the share of battery and fuel cell electric vehicles to reach 75% of global annual bus sales by 2025

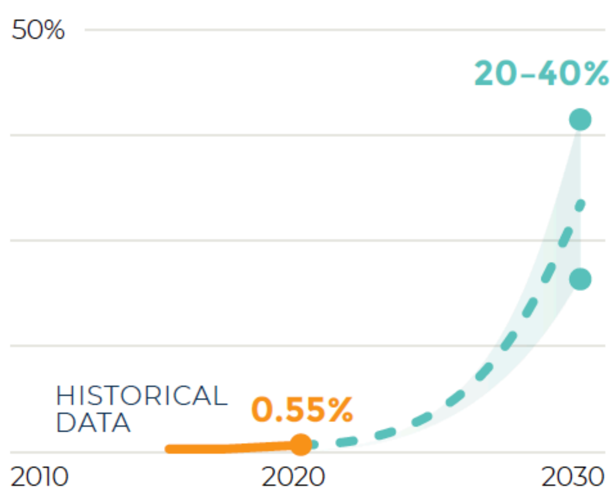


Transport

ON TRACK:
OFF TRACK:
WELL OFF TRACK:
STAGNANT:
WRONG DIRECTION:
INSUFFICIENT DATA:

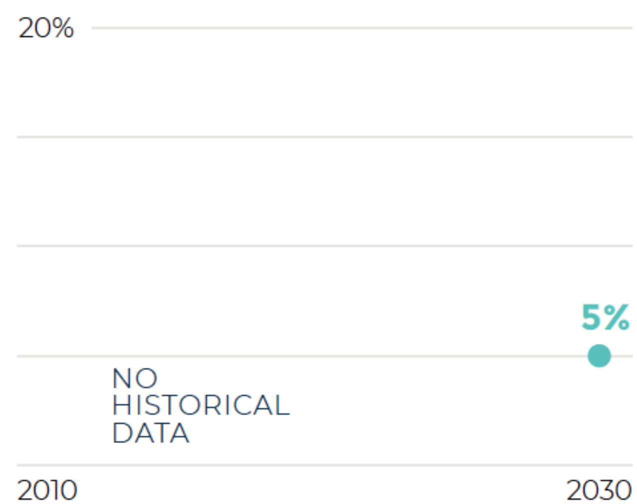
TRANSPORT N/A[f]

Expand the share of electric vehicles to account for 20–40% of total light duty vehicle fleet



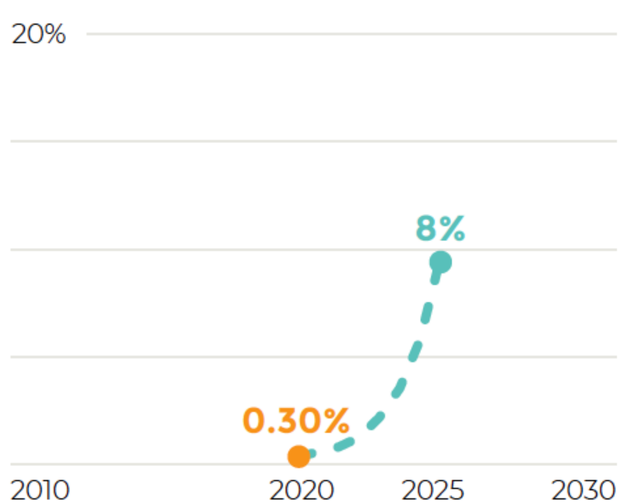
TRANSPORT N/A

Raise zero-emissions fuel's share of international shipping fuel to 5%



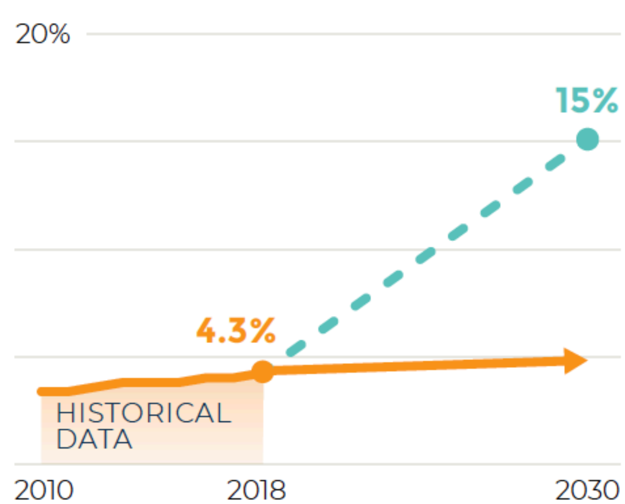
TRANSPORT N/A

Increase the share of battery and fuel cell electric vehicles to 8% of global annual medium- to heavy-duty vehicle sales by 2025



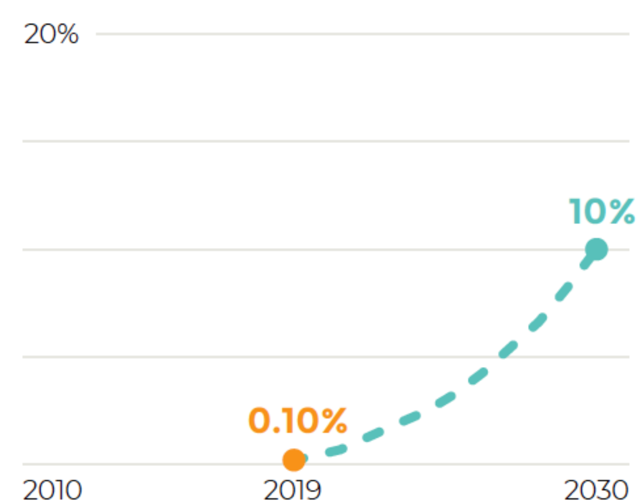
TRANSPORT 12x

Raise the share of low-emissions fuels in the transport sector to 15%



TRANSPORT N/A

Increase sustainable aviation fuel's share of global aviation fuel supply to 10%

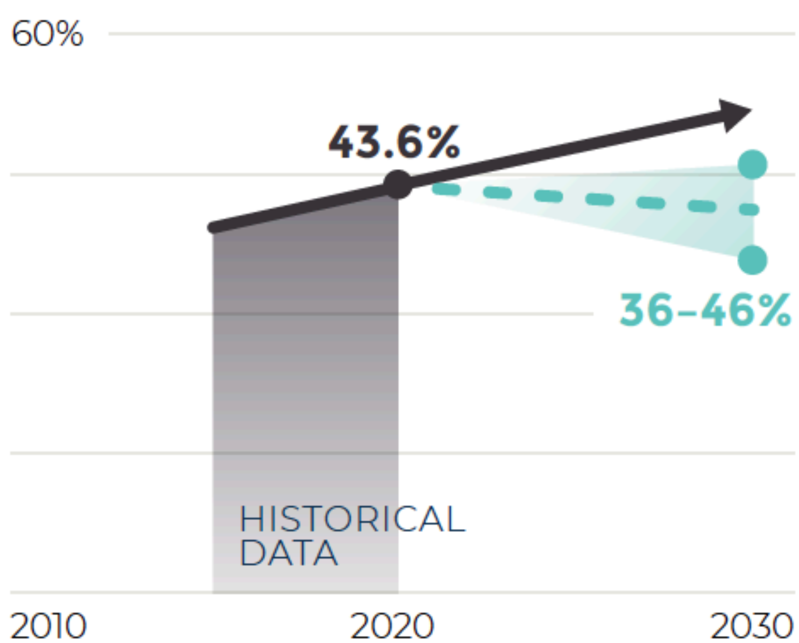


Transport

ON TRACK
STAGNANT:
OFF TRACK:
WRONG DIRECTION:
WELL OFF TRACK:
INSUFFICIENT DATA:

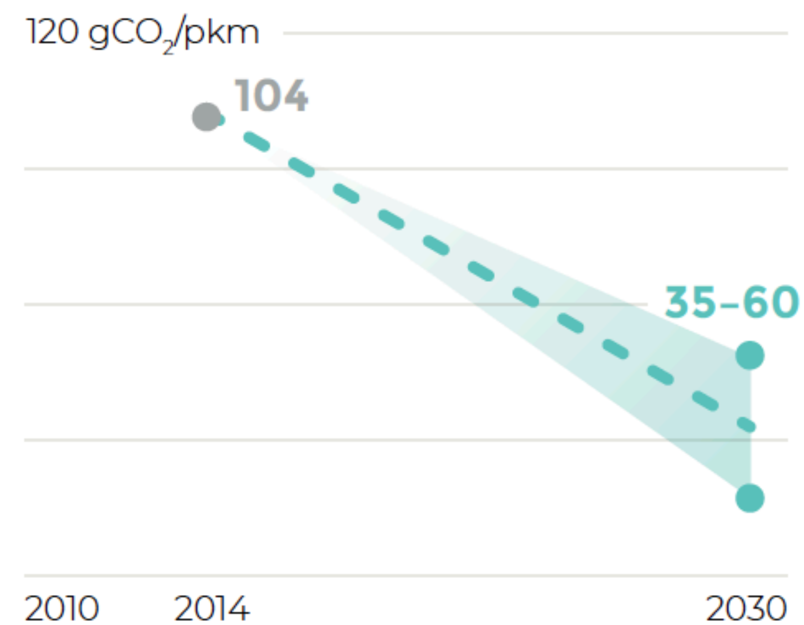
TRANSPORT N/A

Reduce the percentage of trips made by private light duty vehicles to between 4% and 14% below BAU levels



TRANSPORT Ins. data

Reduce the carbon intensity of land-based passenger transport to 35–60 gCO_2/pkm

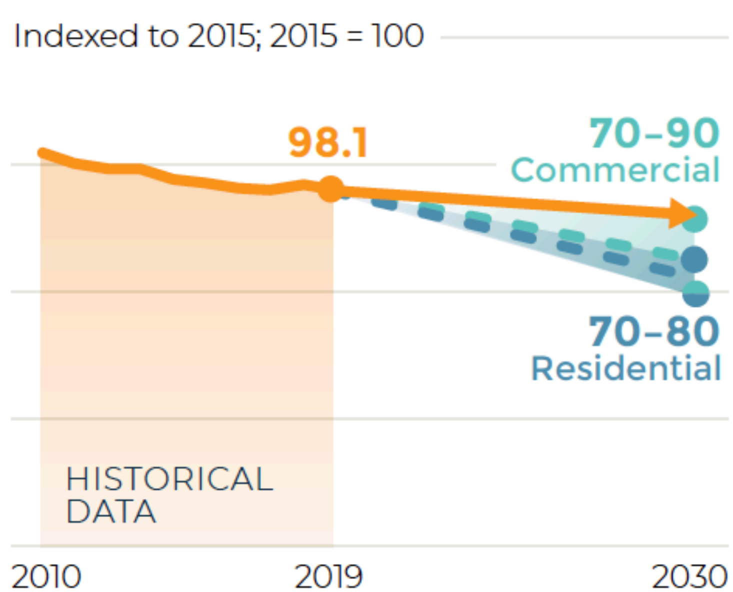


Buildings

ON TRACK
OFF TRACK
WELL OFF TRACK
STAGNANT
WRONG DIRECTION
INSUFFICIENT DATA

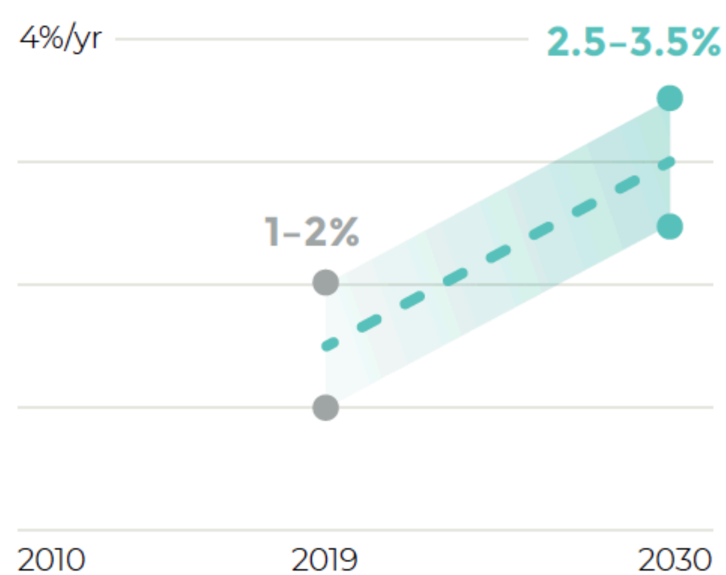
BUILDINGS 2.7x[d]

Decrease the energy intensity of operations in key countries and regions by 20–30% in residential buildings and by 10–30% in commercial buildings, relative to 2015



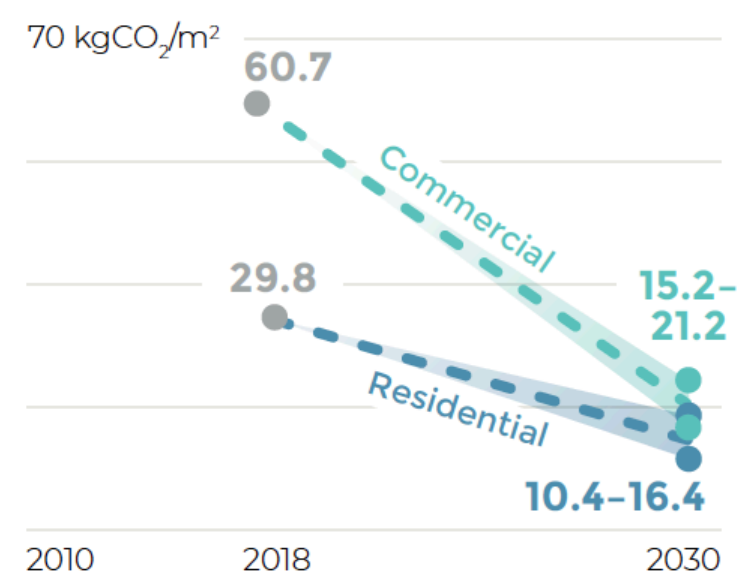
BUILDINGS Ins. data

Increase buildings' retrofitting rate to 2.5–3.5% annually



BUILDINGS Ins. data

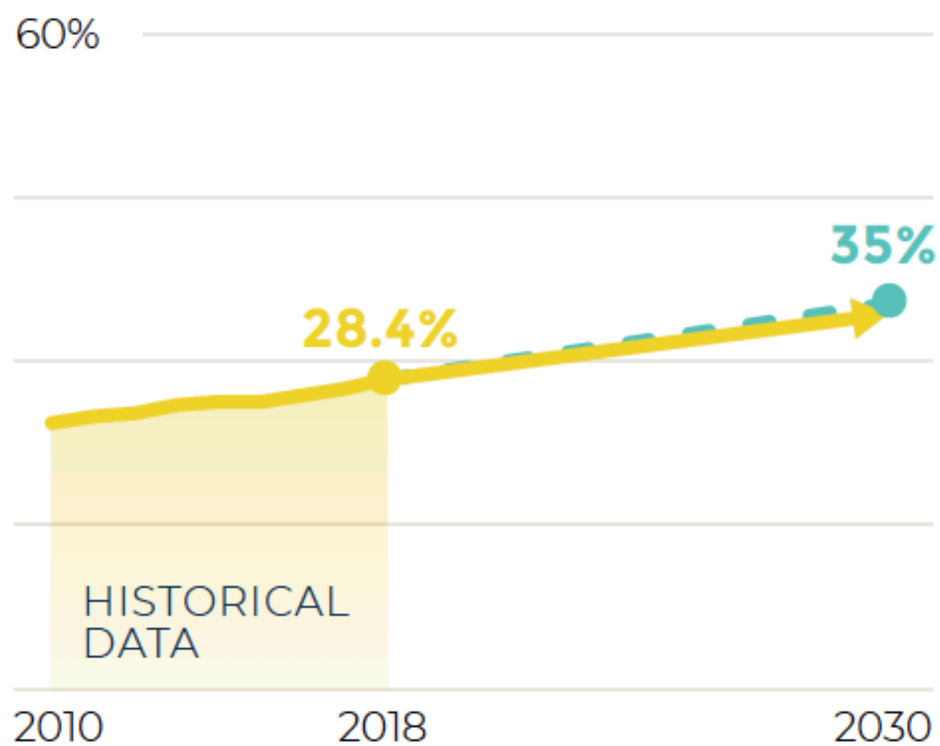
Reduce the carbon intensity of operations in select regions by 45–65% in residential buildings and by 65–75% in commercial buildings, relative to 2015 ($kgCO_2/m^2$)



Industry

INDUSTRY 1.1x

Increase the share of electricity in the industry sector's final energy demand to 35%

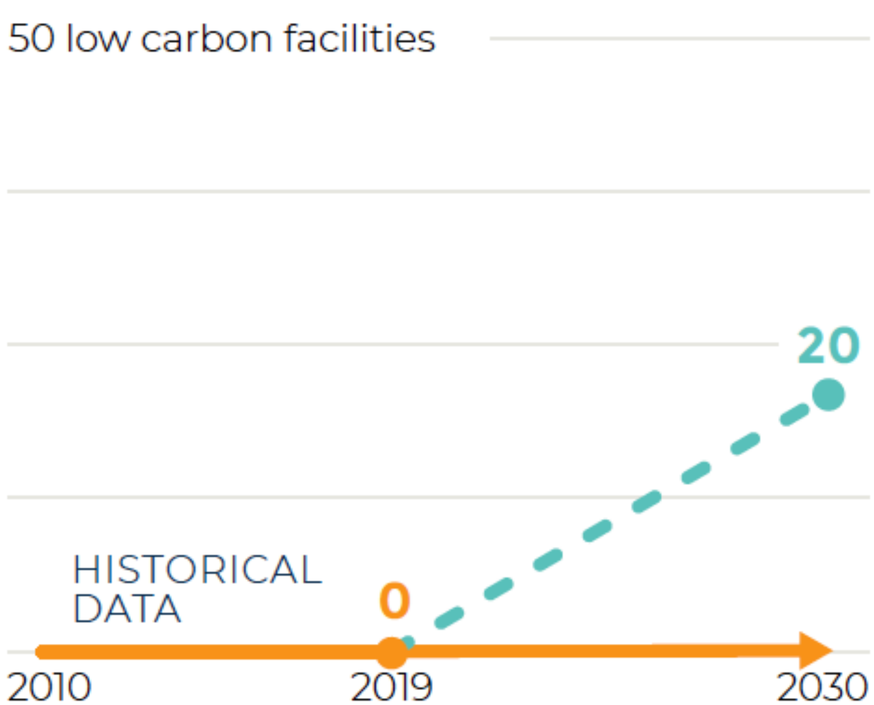


Industry

ON TRACK
STAGNANT
OFF TRACK
WRONG DIRECTION
WELL OFF TRACK
INSUFFICIENT DATA

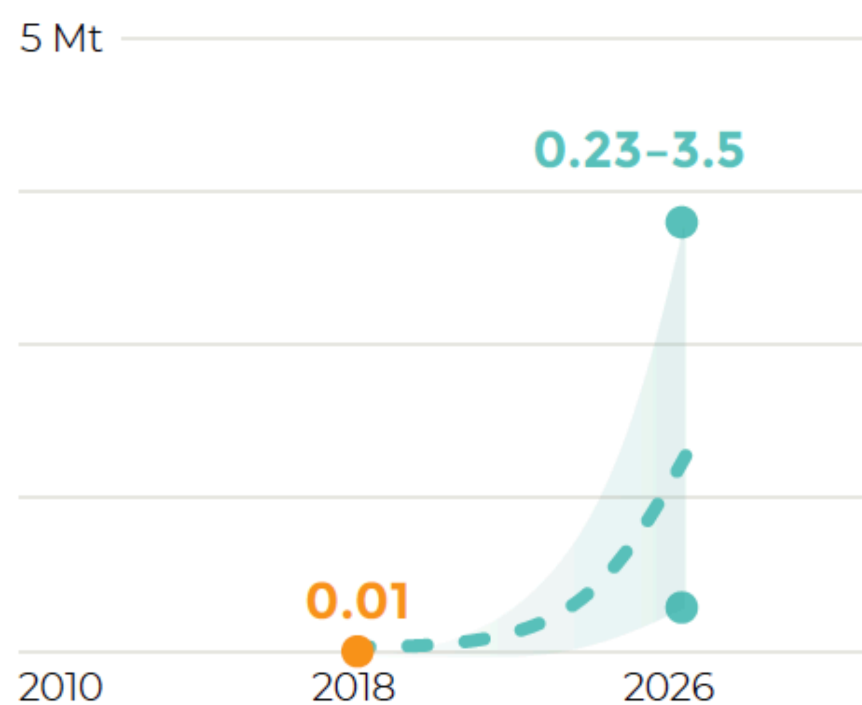
INDUSTRY Ins. data[e]

Build and operate 20 low-carbon commercial steel facilities, with each producing at least 1 million tonnes annually



INDUSTRY N/A

Boost green hydrogen production capacity to 0.23–3.5 Mt (25 GW cumulative electrolyzer capacity) by 2026

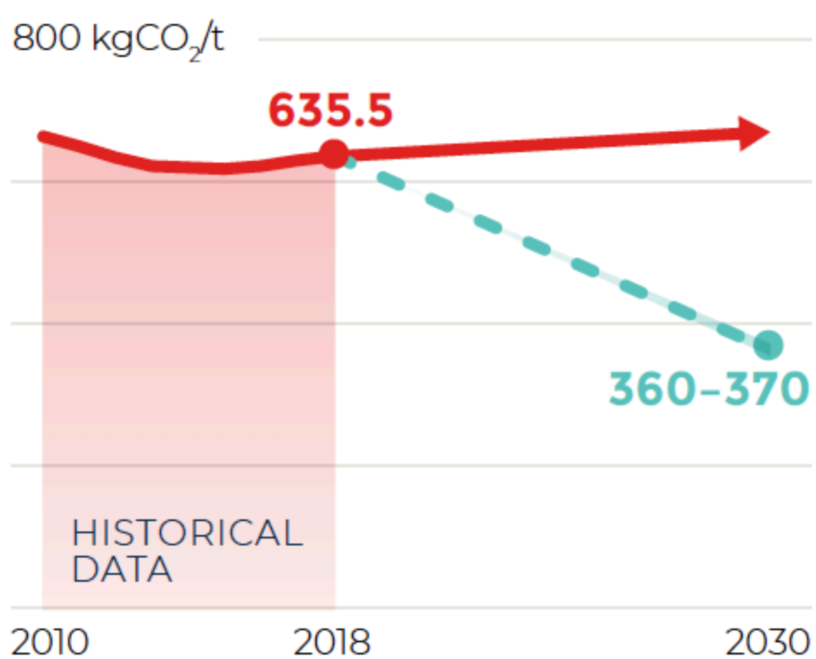


Industry

ON TRACK
OFF TRACK
WELL OFF TRACK
STAGNANT
WRONG DIRECTION
INSUFFICIENT DATA

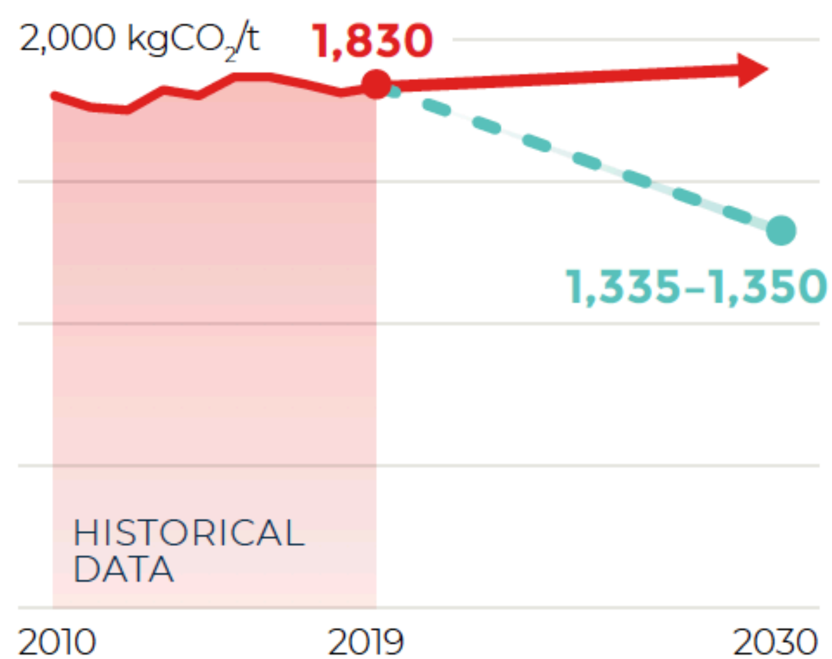
INDUSTRY N/A

Reduce carbon intensity of global cement production by 40%, relative to 2015



INDUSTRY N/A

Reduce carbon intensity of global steel production by 25–30%, relative to 2015

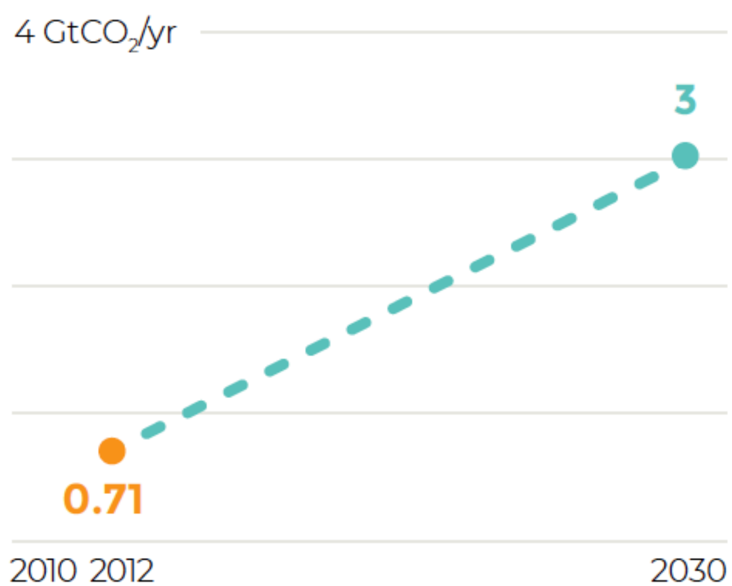


Land Use & Coastal Zone Management

ON TRACK
STAGNANT:
OFF TRACK:
WRONG DIRECTION:
WELL OFF TRACK:
INSUFFICIENT DATA:

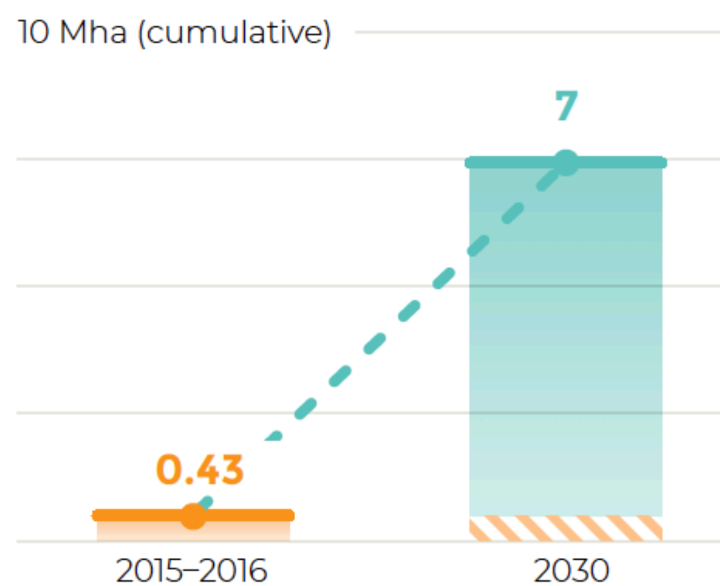
LAND USE AND COASTAL ZONE MANAGEMENT 4.2x

Remove 3.0 $GtCO_2$ annually through reforestation



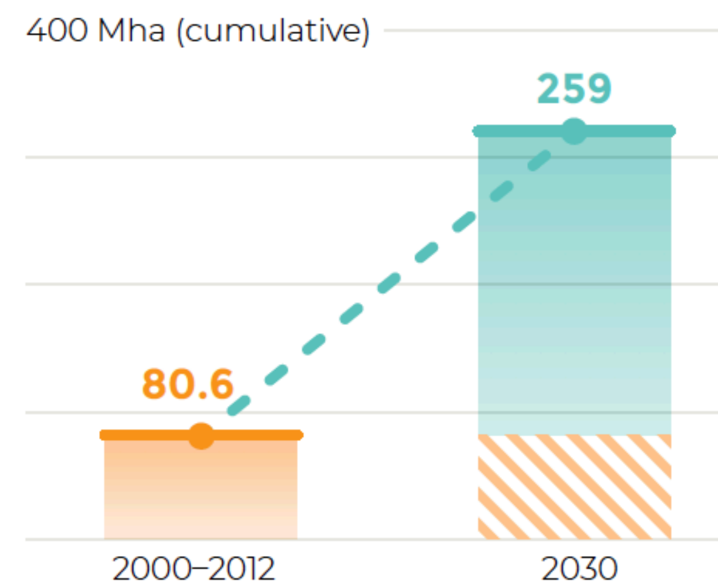
LAND USE AND COASTAL ZONE MANAGEMENT 2.7x

Restore 7 Mha of coastal wetlands, relative to 2018



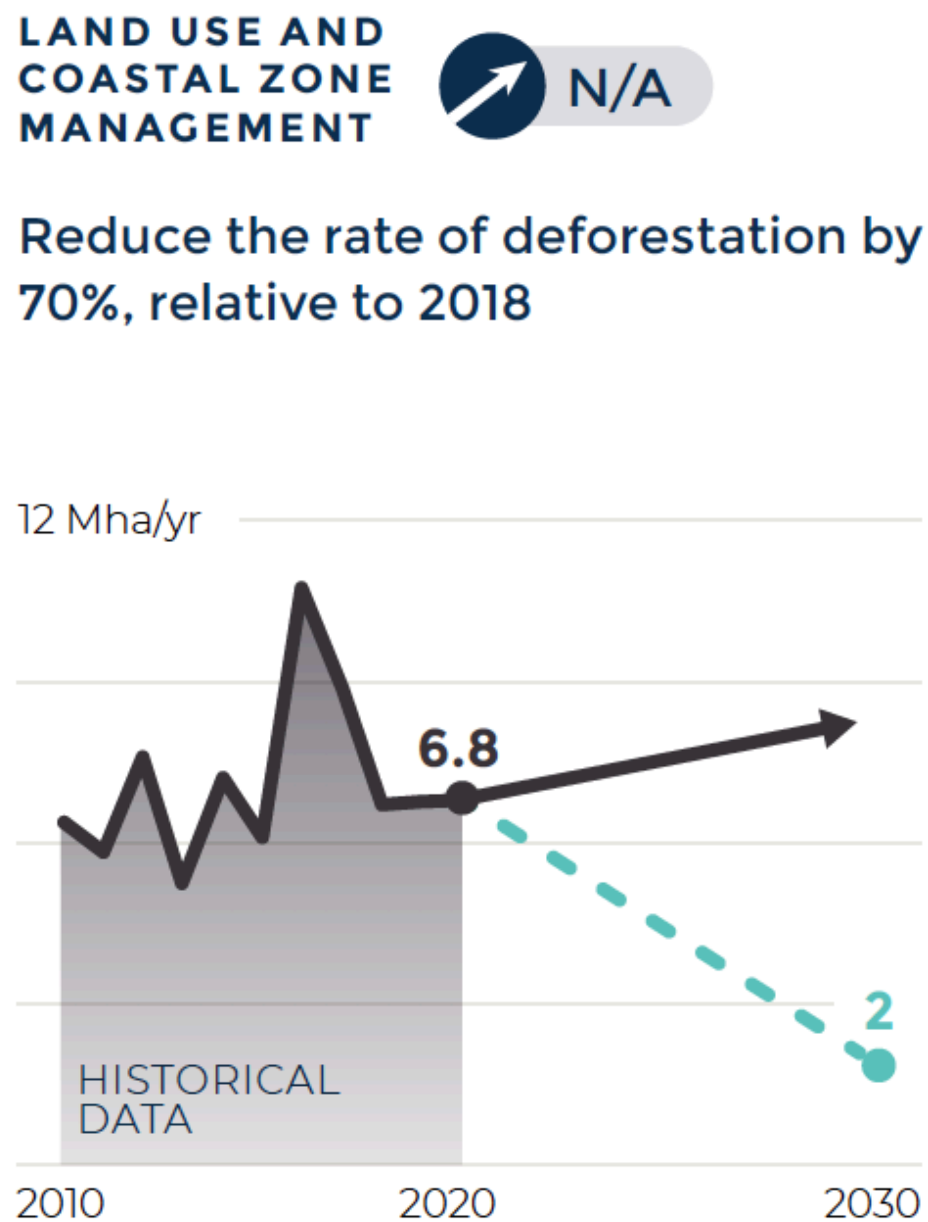
LAND USE AND COASTAL ZONE MANAGEMENT 3.2x

Reforest 259 Mha of land, relative to 2018



Land Use & Coastal Zone Management

ON TRACK
OFF TRACK
WELL OFF TRACK
STAGNANT
WRONG DIRECTION
INSUFFICIENT DATA

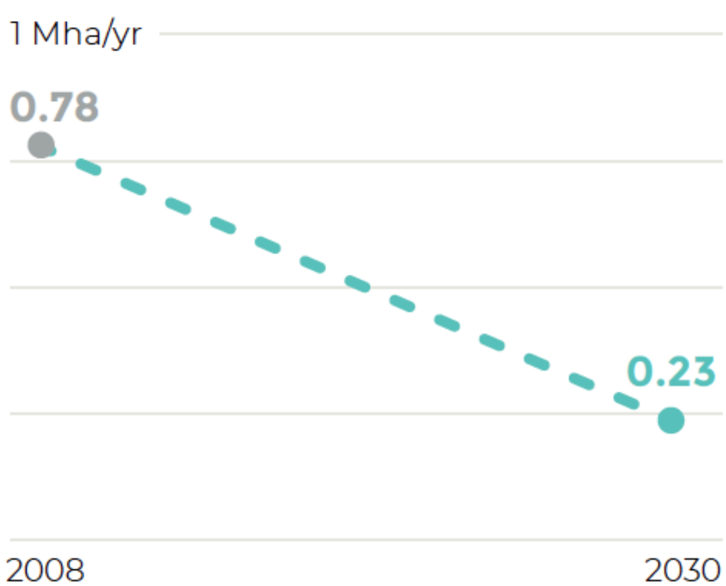


Land Use & Coastal Zone Management

ON TRACK
OFF TRACK:
WELL OFF TRACK:
STAGNANT:
WRONG DIRECTION:
INSUFFICIENT DATA:

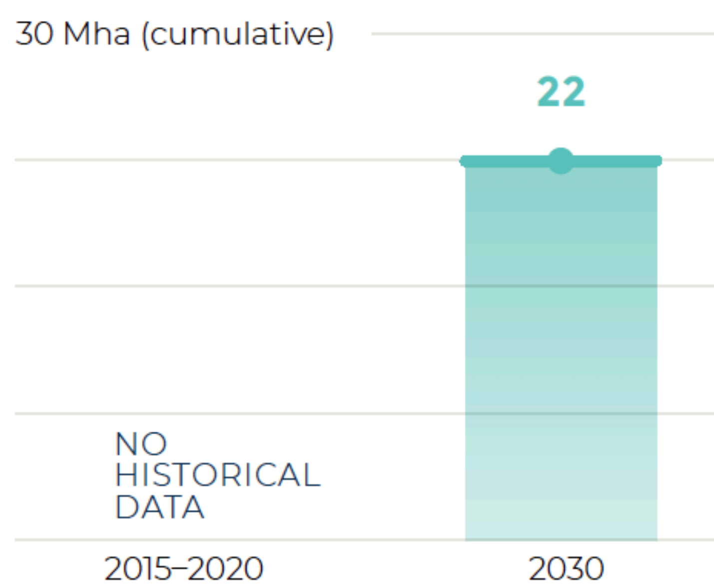
LAND USE AND COASTAL ZONE MANAGEMENT — Ins. data

Reduce degradation and destruction of peatlands by 70%, relative to 2018



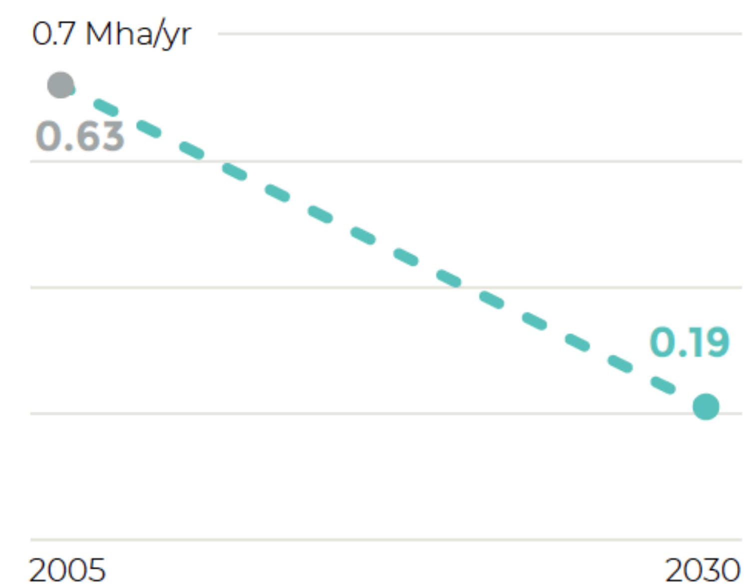
LAND USE AND COASTAL ZONE MANAGEMENT — Ins. data

Restore 22 Mha of peatlands, relative to 2018



LAND USE AND COASTAL ZONE MANAGEMENT — Ins. data

Reduce the conversion of coastal wetlands by 70%, relative to 2018

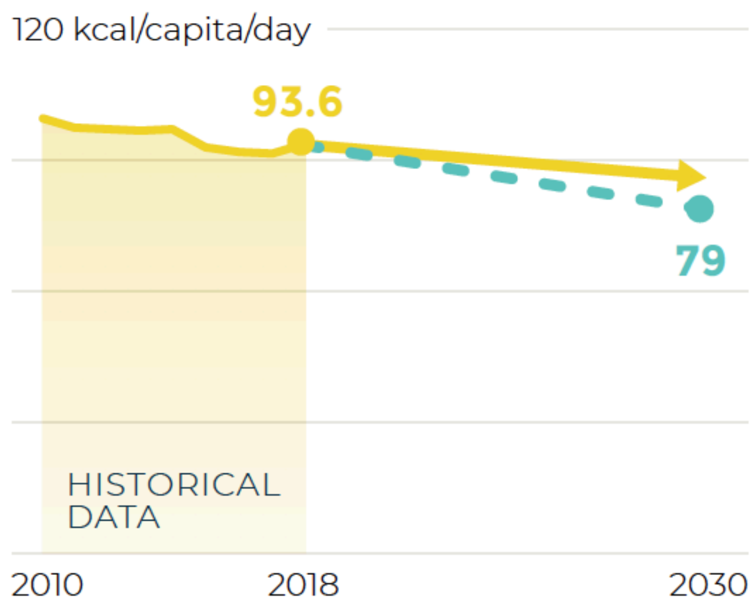


Agriculture

ON TRACK
OFF TRACK
WELL OFF TRACK
STAGNANT
WRONG DIRECTION
INSUFFICIENT DATA

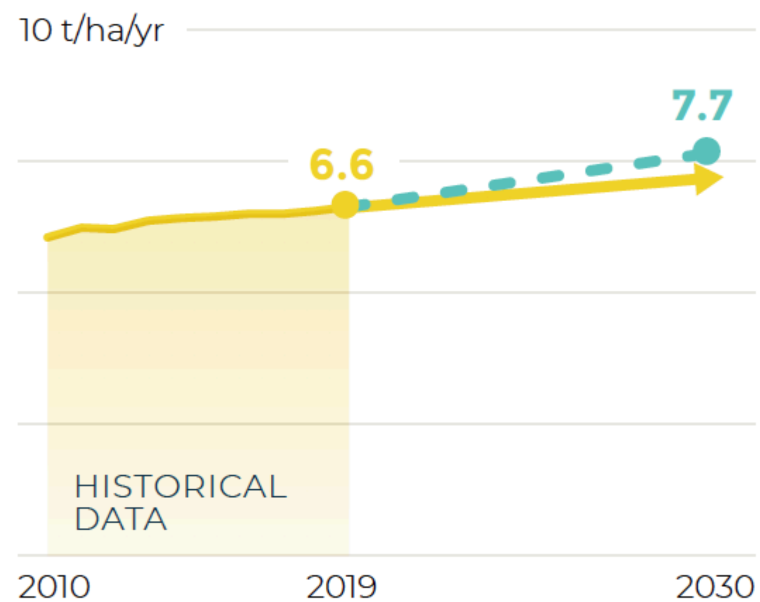
AGRICULTURE 1.5x

Reduce ruminant meat consumption in high-consuming regions to 79 kcal/capita/day by 2030[b]



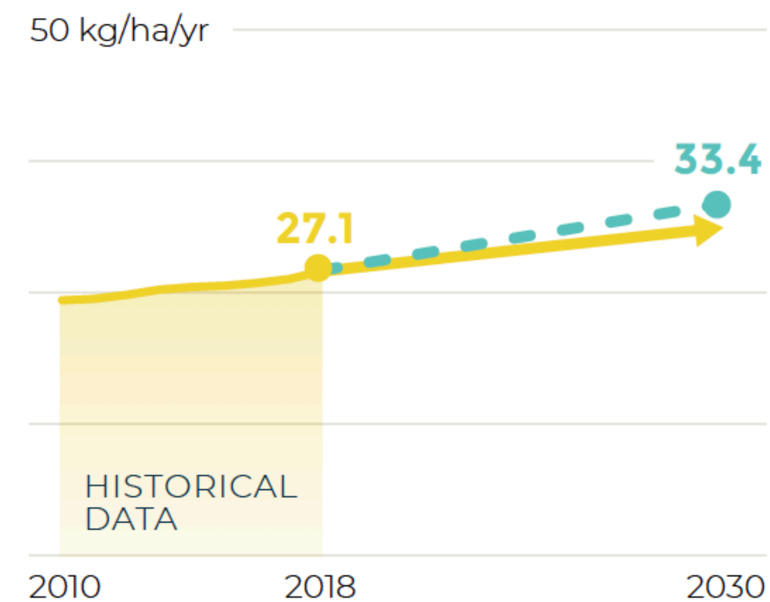
AGRICULTURE 1.9x

Increase crop yields by 18%, relative to 2017

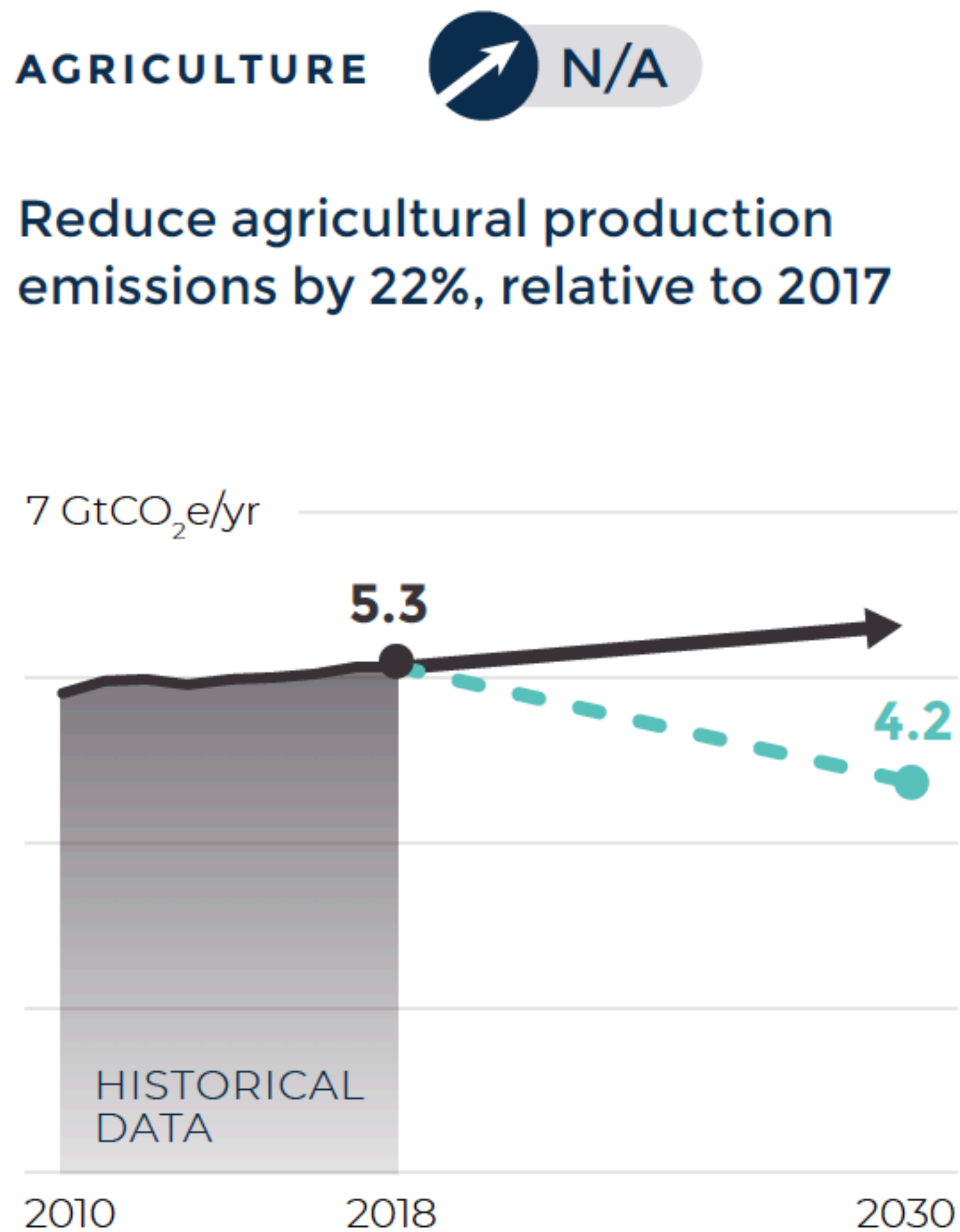


AGRICULTURE 1.6x

Increase ruminant meat productivity per hectare by 27%, relative to 2017



Agriculture

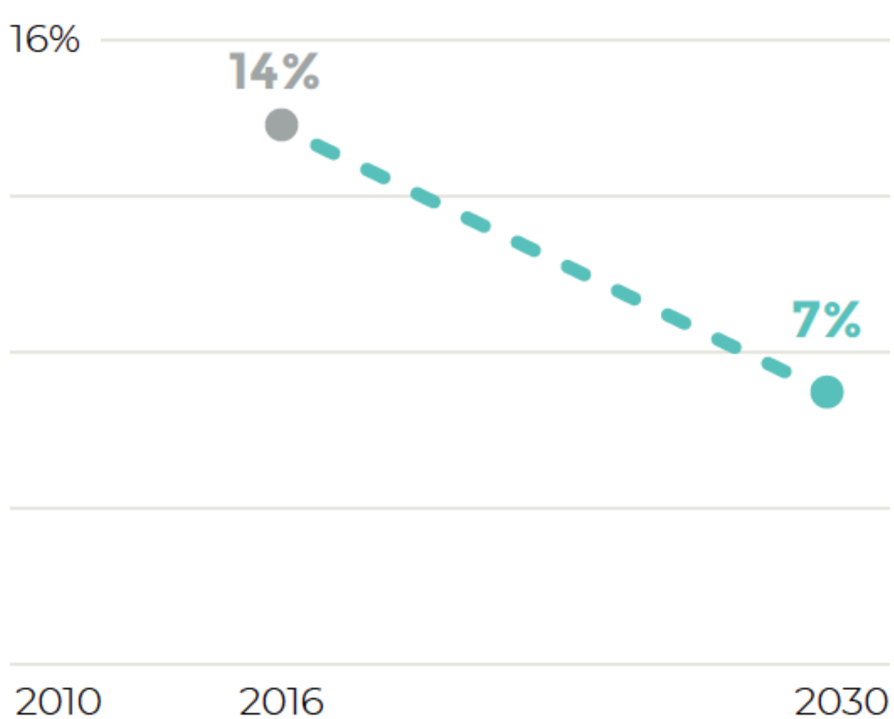


Agriculture

ON TRACK
OFF TRACK:
WELL OFF TRACK:
STAGNANT:
WRONG DIRECTION:
INSUFFICIENT DATA:

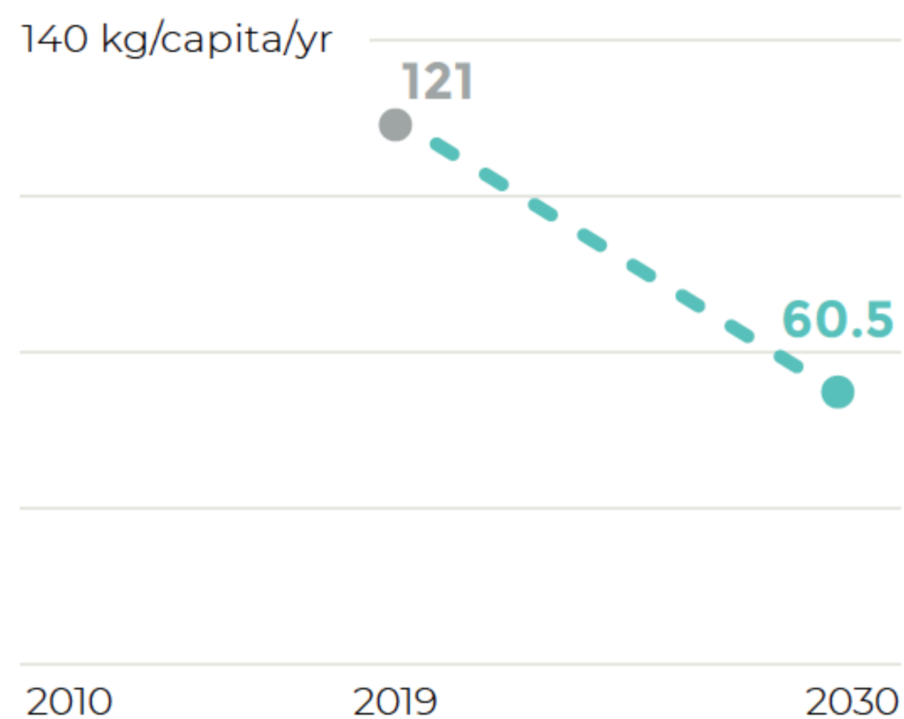
AGRICULTURE Ins. data

Reduce share of food loss by 50%, relative to 2016

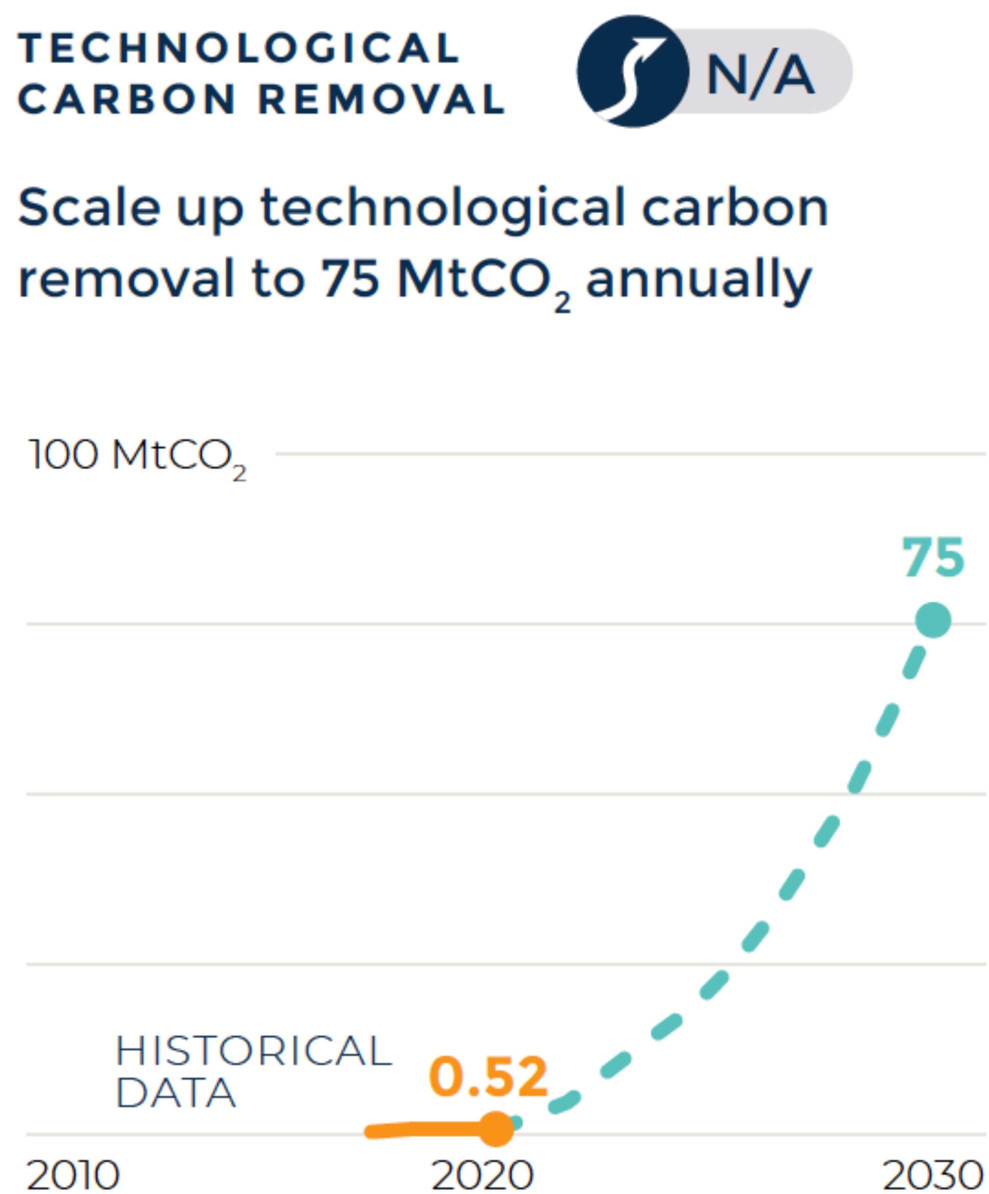


AGRICULTURE Ins. data

Reduce per capita food waste by 50%, relative to 2019



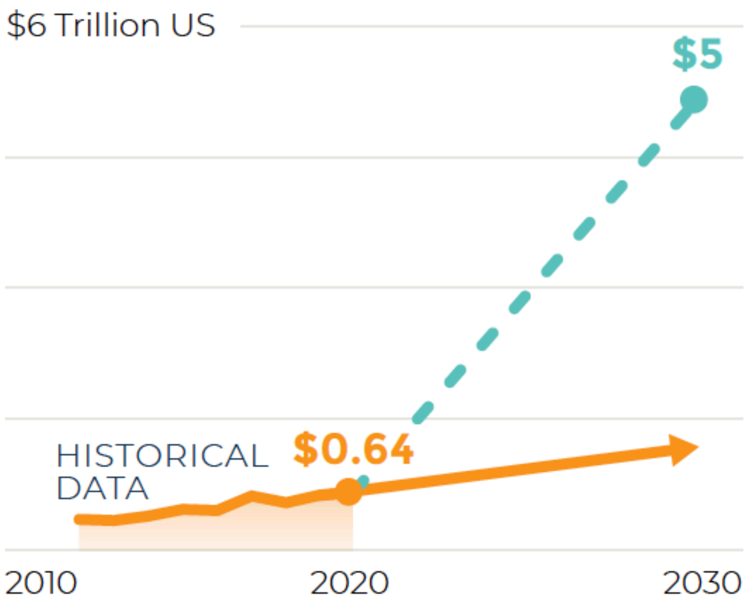
Technological Carbon Removal



Finance

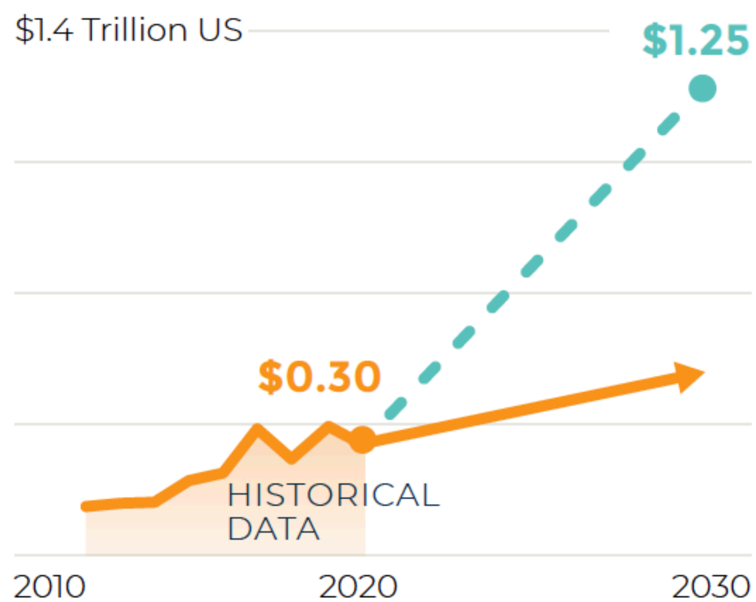
FINANCE 13x

Increase total climate finance flows to $5 trillion per year



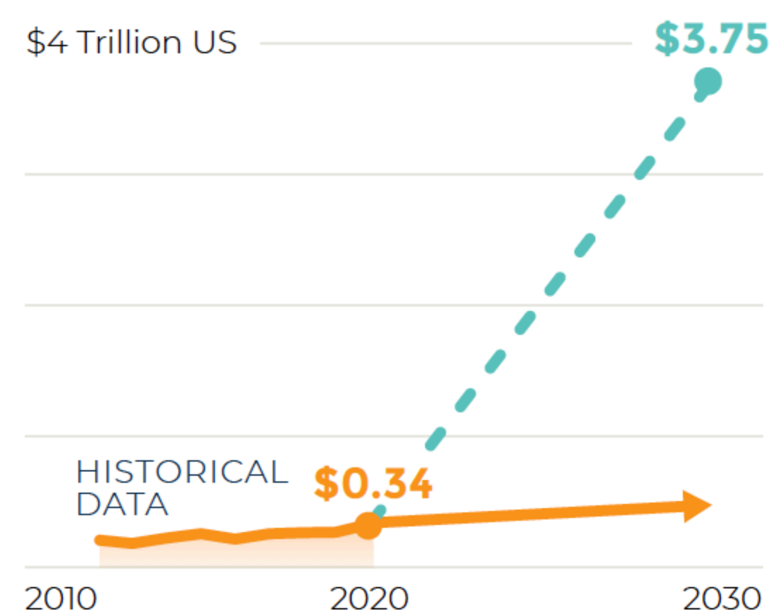
FINANCE 5x

Raise public climate finance flows to at least $1.25 trillion per year



FINANCE 23x

Boost private climate finance flows to at least $3.75 trillion per year

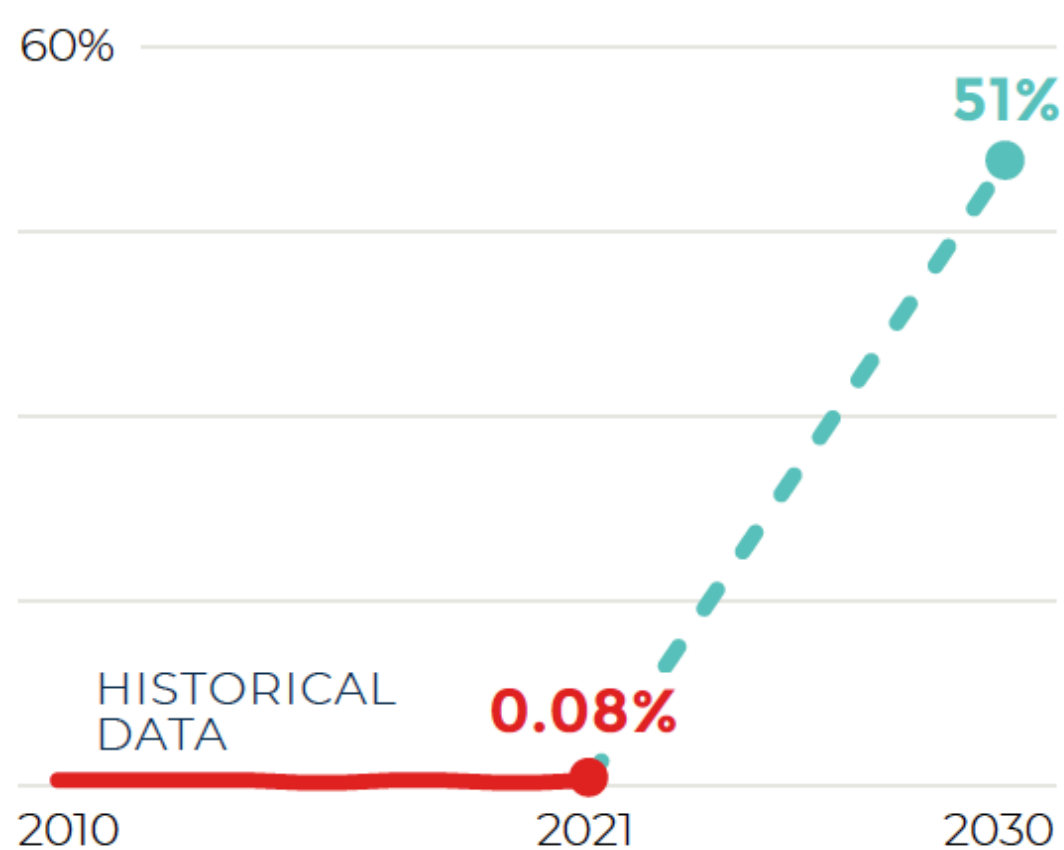


Finance

ON TRACK
STAGNANT:
OFF TRACK:
WRONG DIRECTION:
WELL OFF TRACK:
INSUFFICIENT DATA:

FINANCE N/A

Ensure that a carbon price of at least \$135/tCO_2e covers the majority of the world's GHG emissions

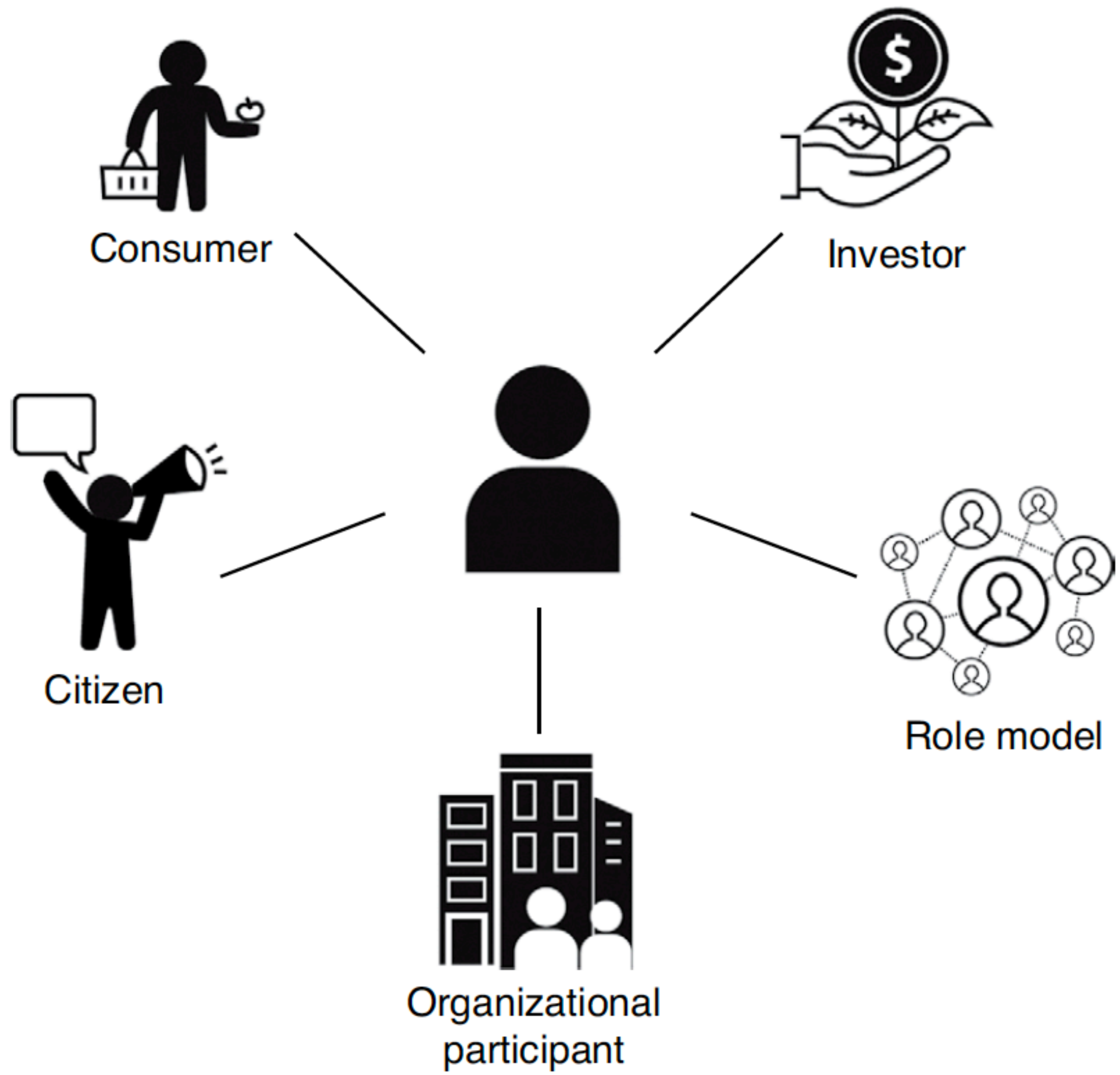


Finance

ON TRACK
OFF TRACK:
WELL OFF TRACK:
STAGNANT:
WRONG DIRECTION:
INSUFFICIENT DATA:

FINANCE Ins. data

Jurisdictions representing three-quarters of global emissions mandate TCFD-aligned climate risk reporting, and all of the world's 2,000 largest public companies report on climate risk in line with TCFD recommendations



Nielsen et al. (2021)

Thank You!