



Introduction – Integrated Assessment Modelling – and the need to represent impacts and equity

Detlef van Vuuren

 @IMAGE_PBL

A brief introduction

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Lead author IPCC reports



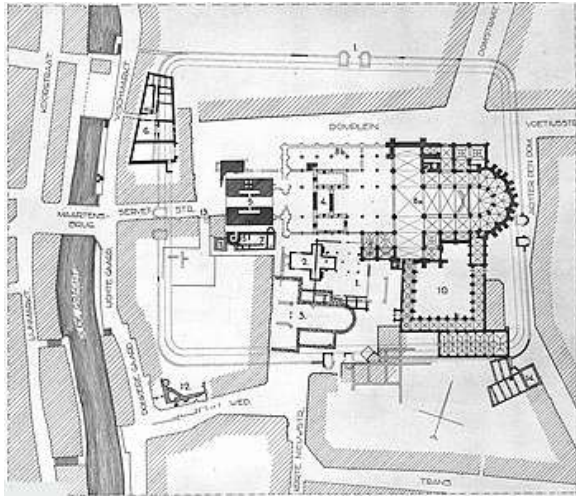
05:12 op zaterdag, 5 juli 2025 · Breda, Noord-Brabant

Climate classic

Although 2 weeks later than the real event. Event creates attention for climate by cycling along the NAP line (txs Marco). Did it now alone. Was a bit tired at the end. :-).

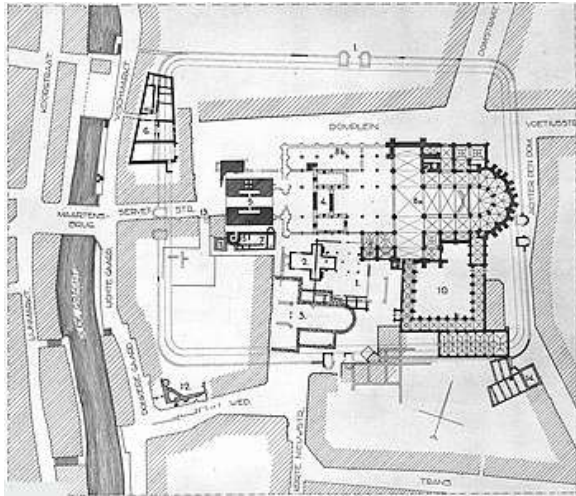


Welcome in Utrecht – Place of crossing boundaries



- Year 47-50: Roman Fortress (UI Trajectum)

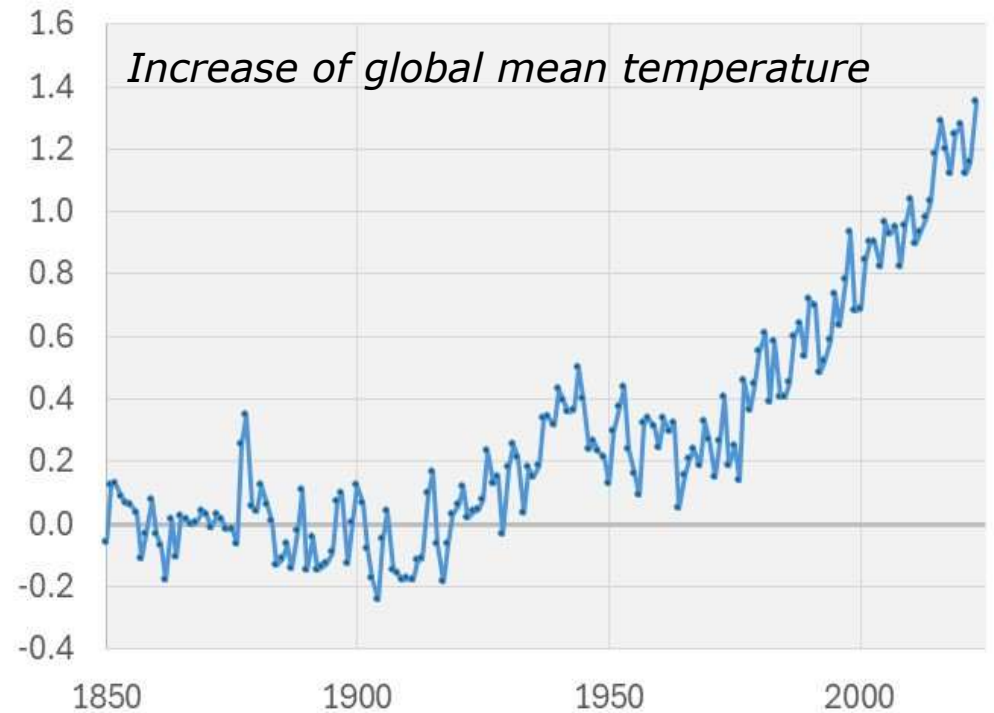
Welcome in Utrecht – Place of crossing boundaries



- Year 47-50: Roman Fortress (Utrechtum)
- ~270 Romans leave
- 1254 – Roman Catholic Cathedral
- 1579 – Union of Utrecht – justice as central aspect

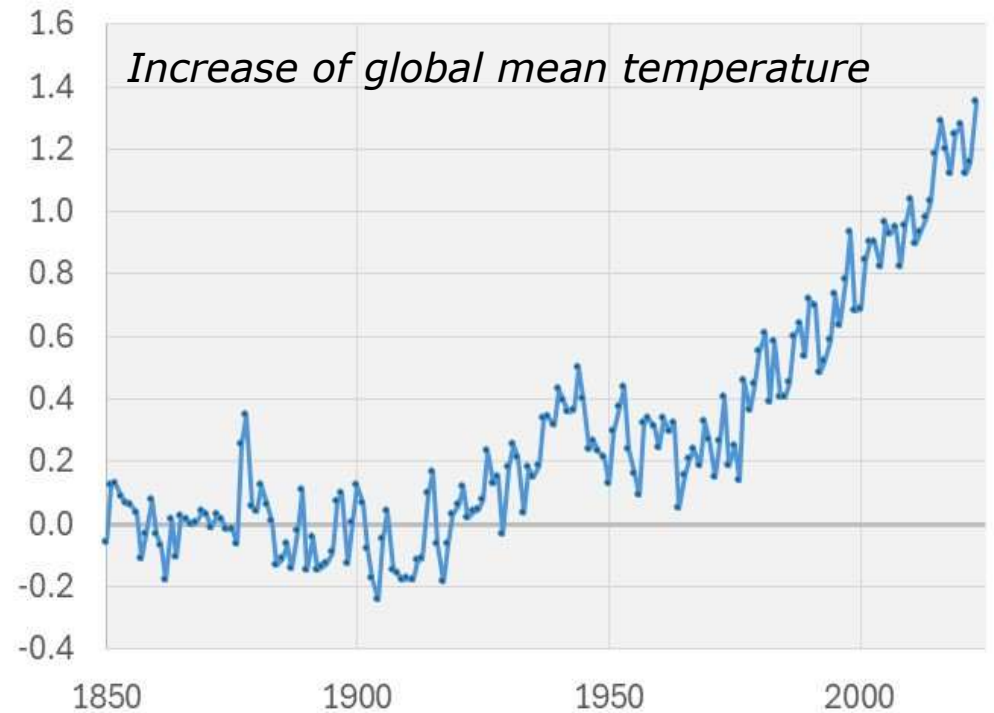
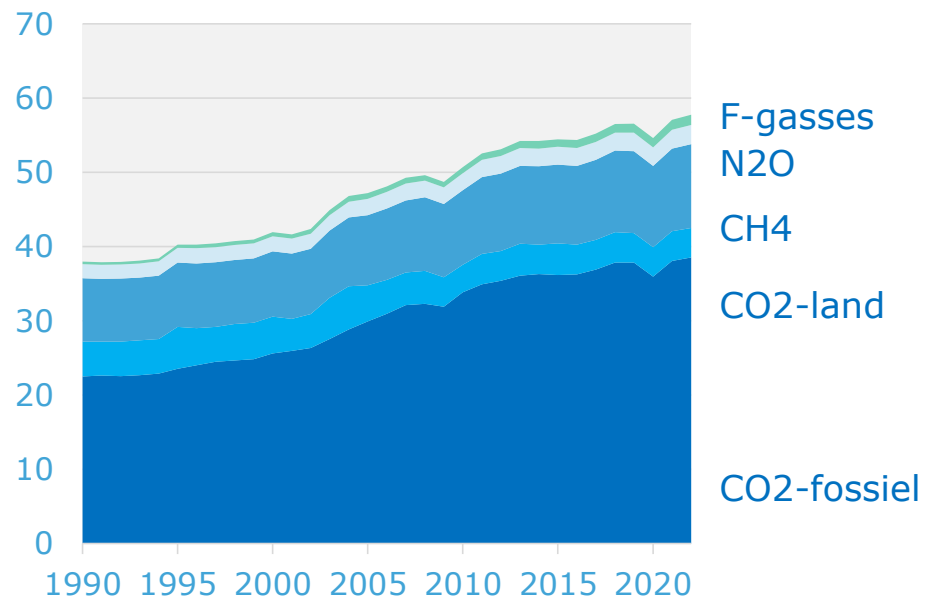


Climate change is visible



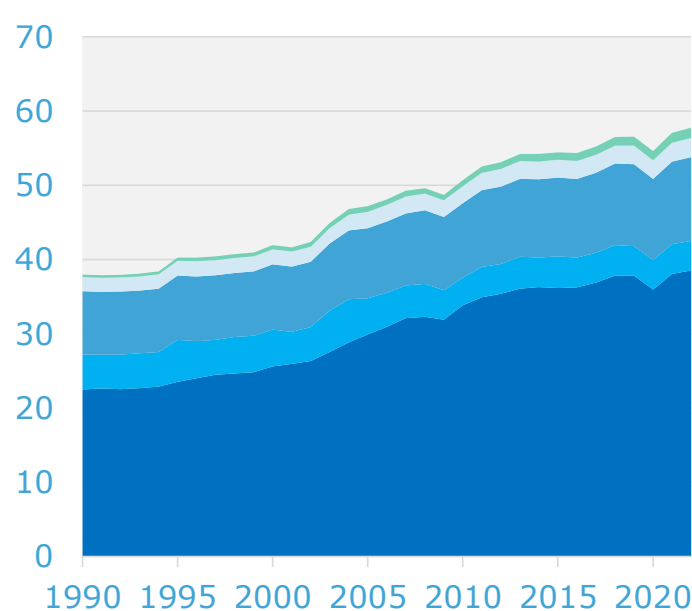
Climate change is visible

Growth emissions world wide

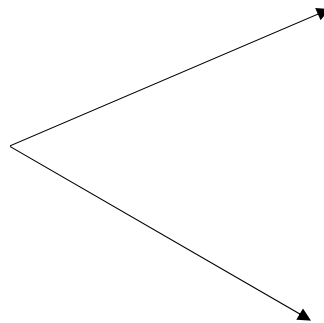


But where are we heading?

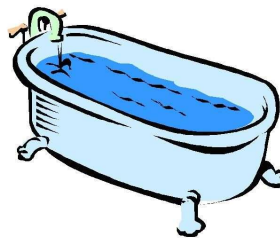
Growth emissions world wide



Increasing impacts



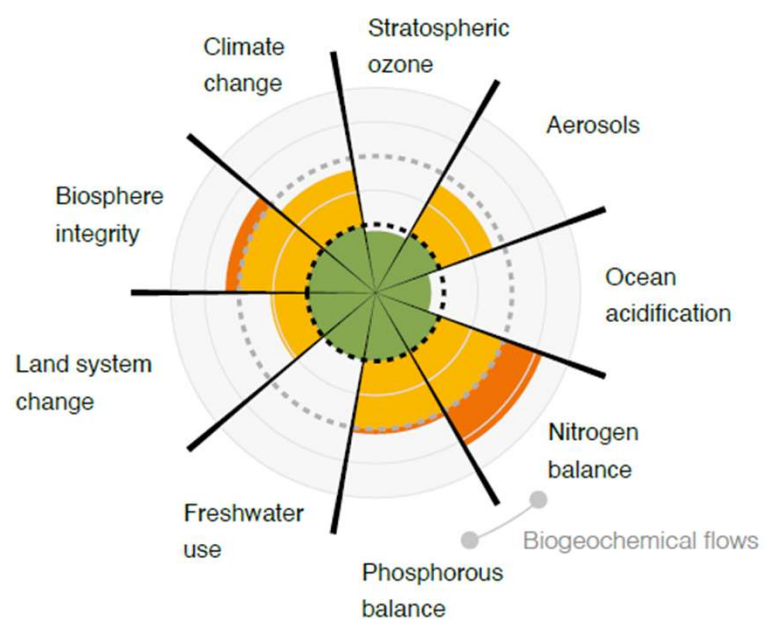
Stabilisation



The universal agreement's aim is to keep a global temperature rise this century **well below 2 degrees Celsius** and to drive efforts to limit the temperature increase even further to **1.5 degrees Celsius** above pre-industrial levels

But where are we heading?

b. 2015

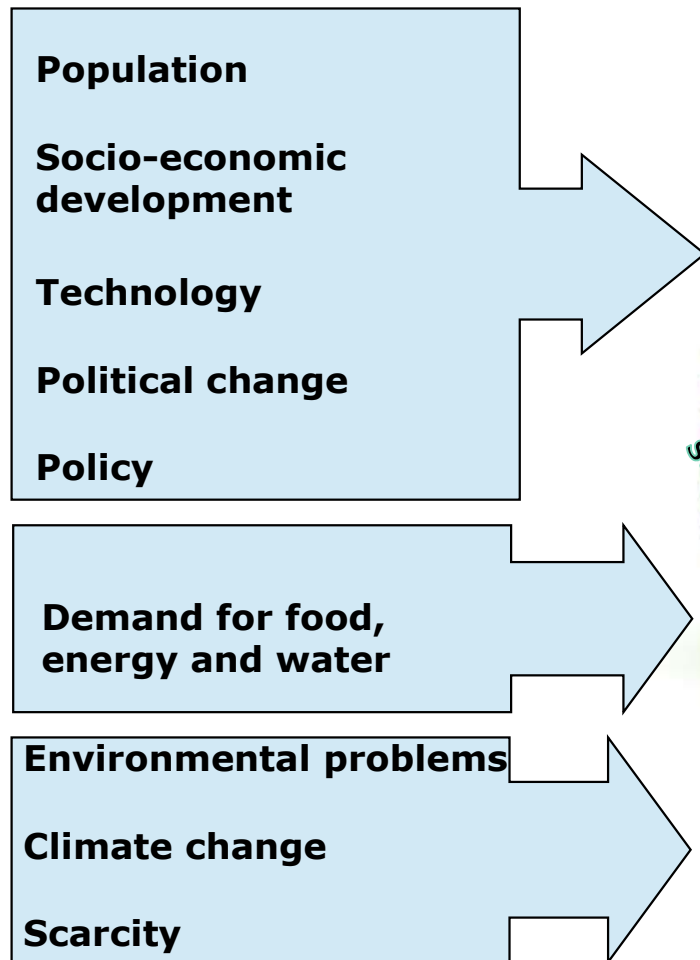


What will happen without new policies?
What is needed to meet these goals?



What will happen in the future

What will happen in the future



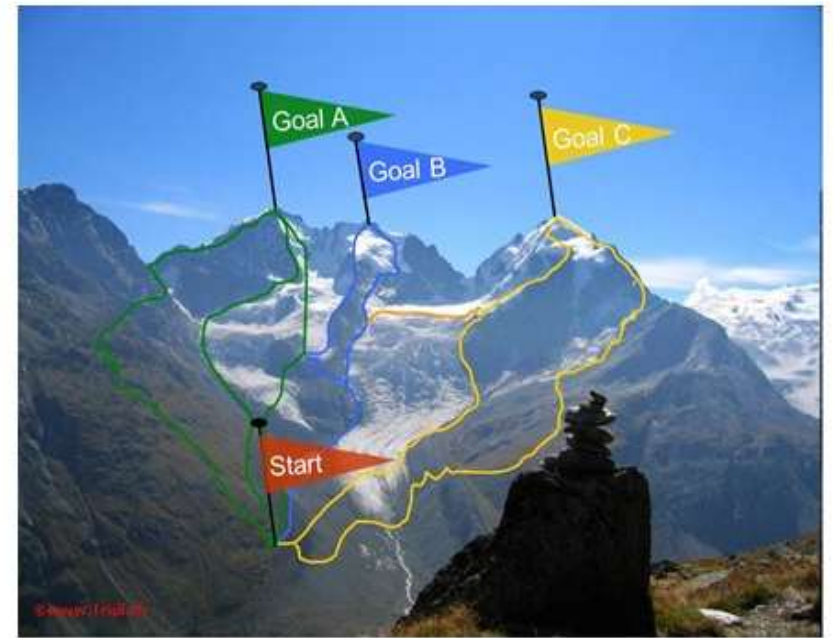
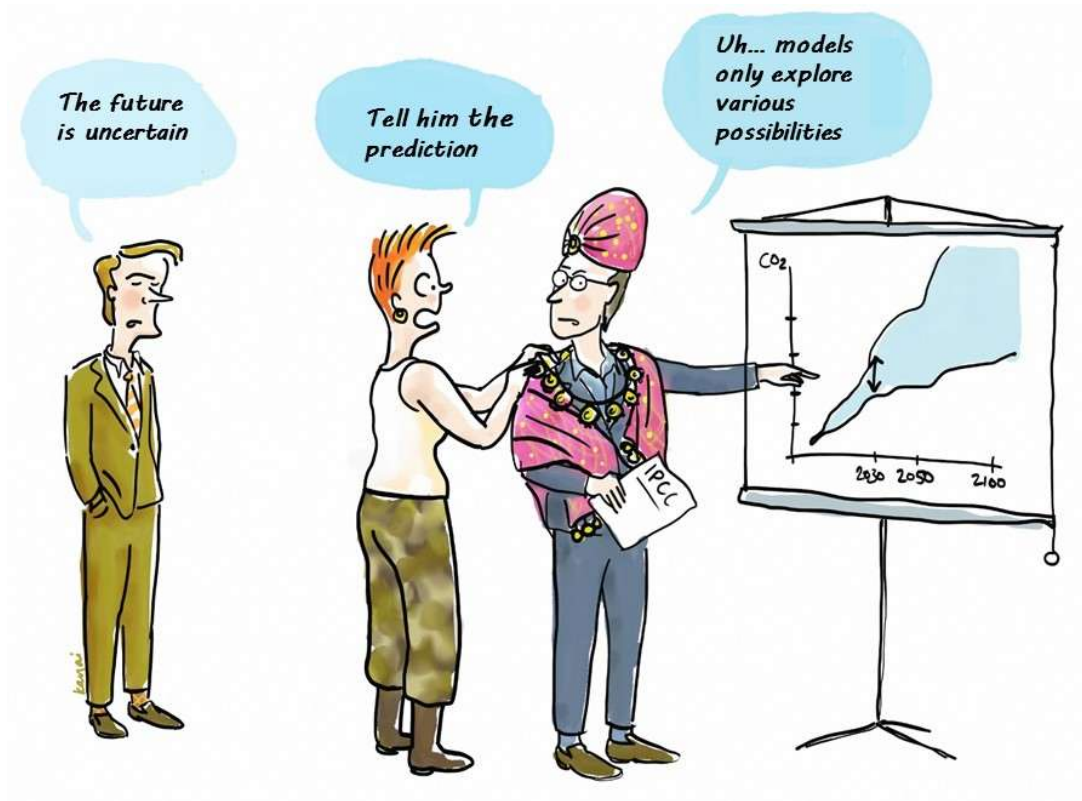
Different scales
Different time periods
Interactions
Uncertainty



**IMAGE-
model
PBL**

Model-based scenarios

What will happen in the future



Model-based scenarios

What will happen in the future

Exploring the future can:

- Help to understand more/less attractive routes
- Help to motivate to do the right thing
- Build consensus



Model-based scenarios



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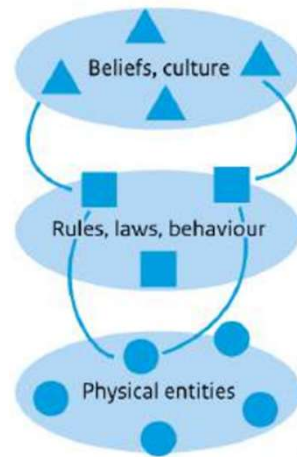


Model-based scenarios

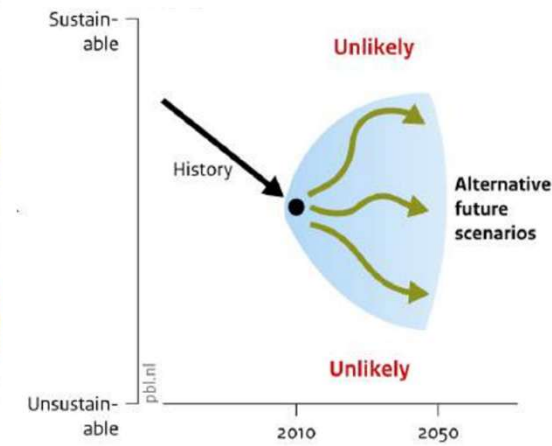
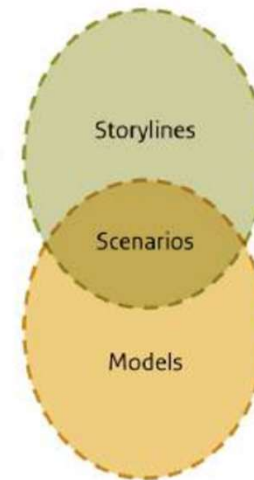
Scenarios:

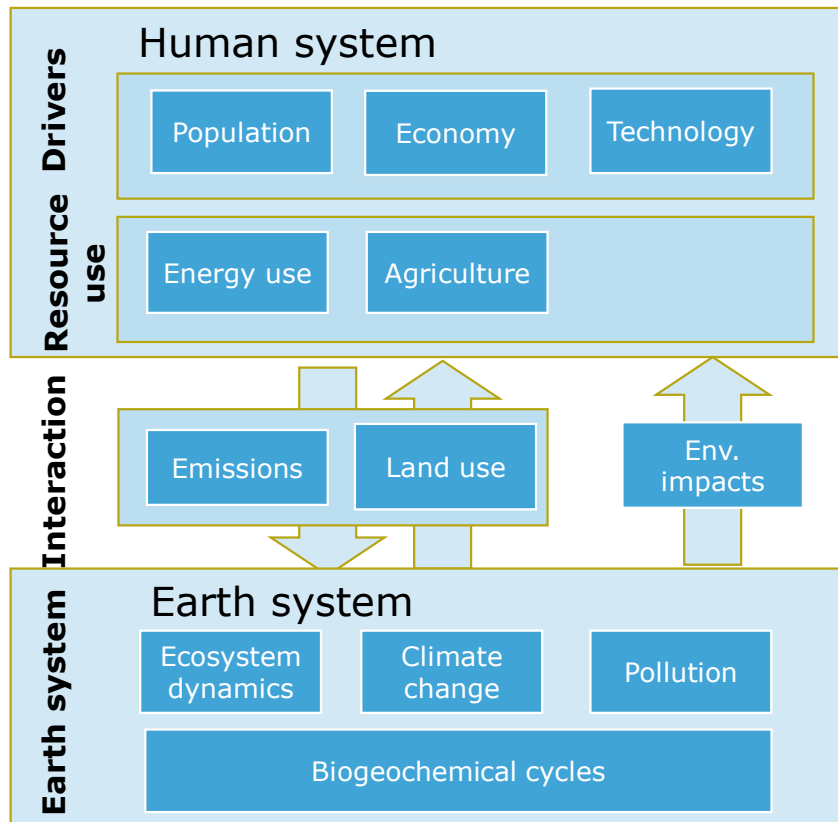
- Combination of narratives and modelling
- Modelling where there is enough knowledge to define quantitative relationships
- Narratives where there is need for complexity and flexibility

Describe evolution of future systems



Available tools



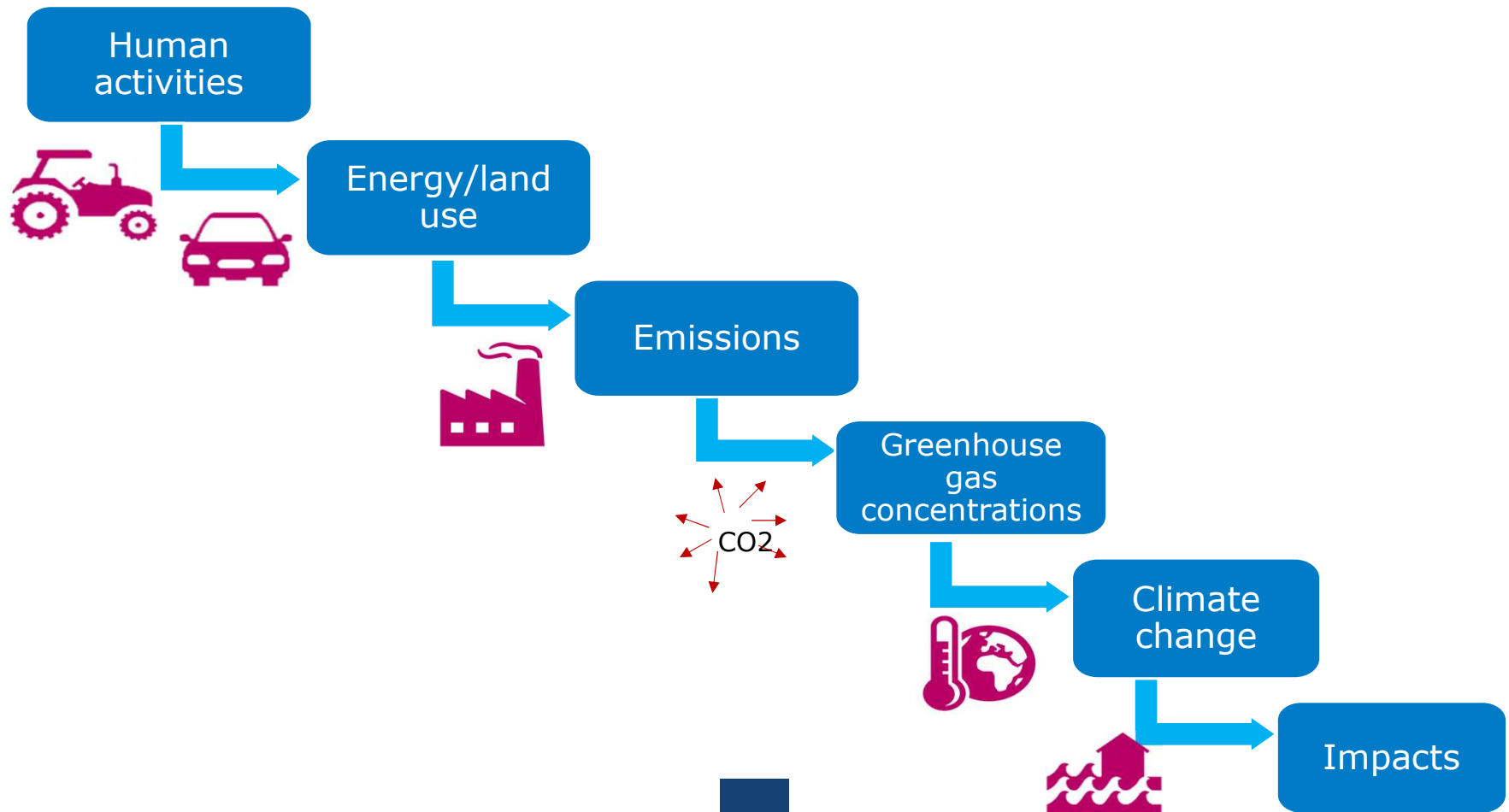


- **Cost-benefit IAMs** (DICE, FUND, MIMOSA)
- **Process-based IAMs**
 - Strong biophysical focus (IMAGE, GCAM)
 - Strong economic focus (WITCH, REMIND/MagPIE)
 - Strong engineering focus (MESSAGE, COFFEE)
- **CGEs** with climate change estimates (E3M)
- **System-dynamics models** (IFs)



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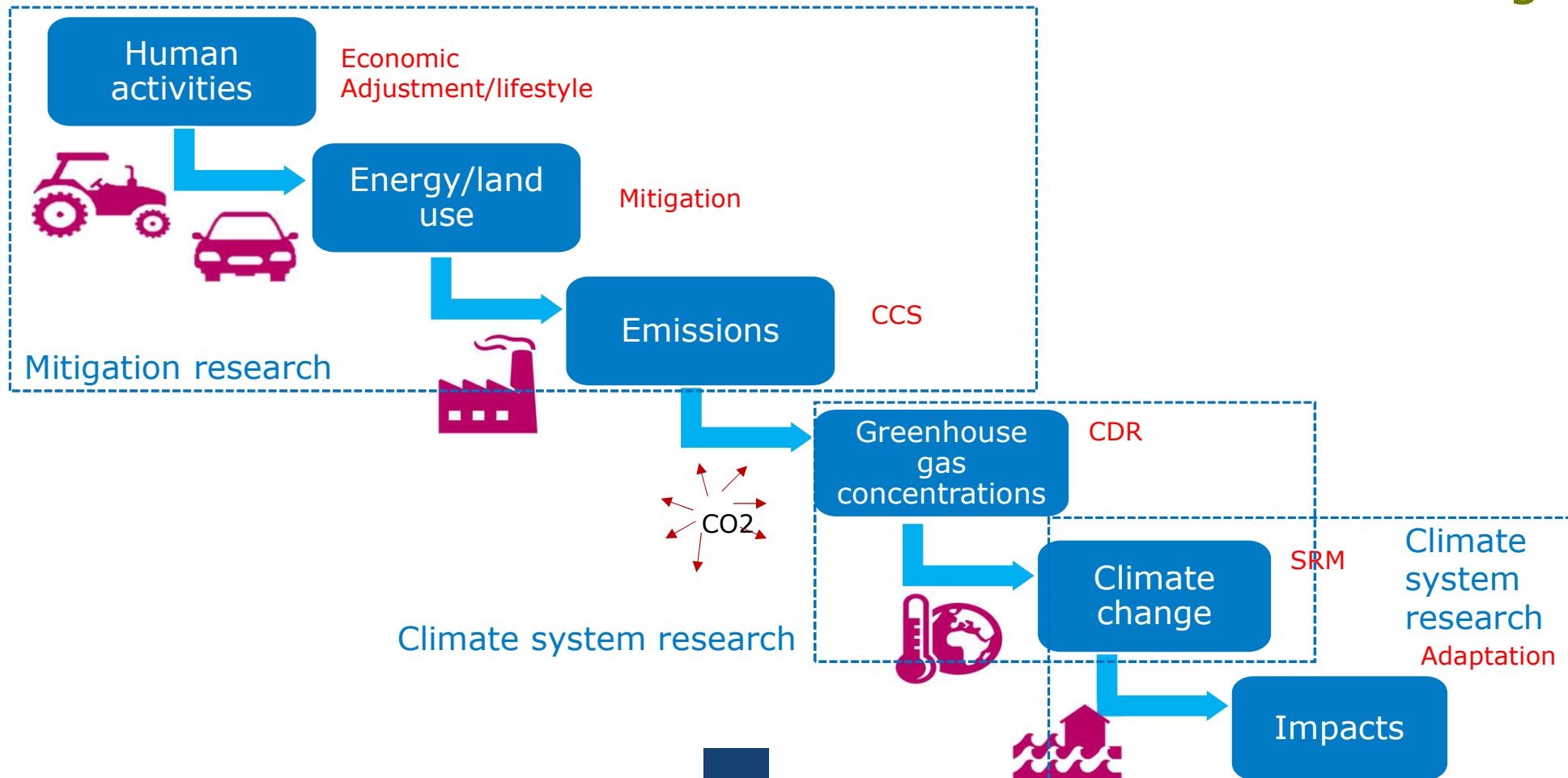
Model-based scenarios for climate change





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Model-based scenarios for climate change



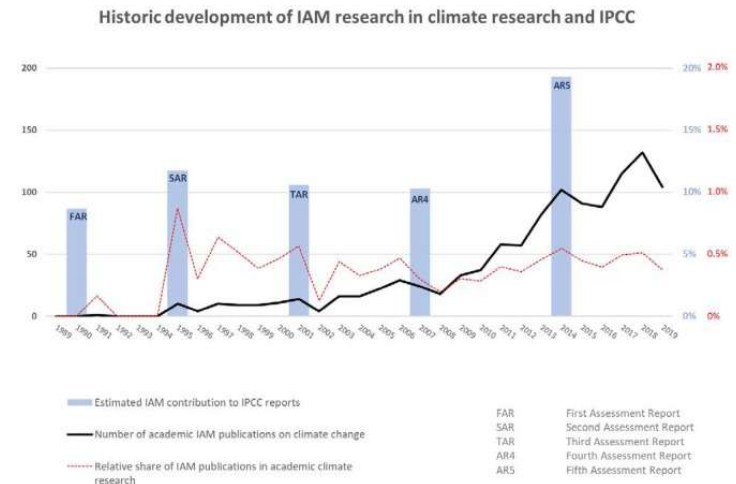


IAMs are very successful....

- IAM scenarios form backbone of IPCC reports
- Many policy documents clearly have IAM input
 - EU impact assessment
 - Paris Agreement
- Large amount of scientific literature (e.g. 1000s of papers based on SSPs)

Anticipating futures through models:
the rise of Integrated Assessment
Modelling in the climate science-
policy interface since 1970

Lisette van Beek ^{a b} ✉, Maarten Hajer ^b, Peter Pelzer ^{b c}, Detlef van Vuuren ^{a d},
Christophe Cassen ^e

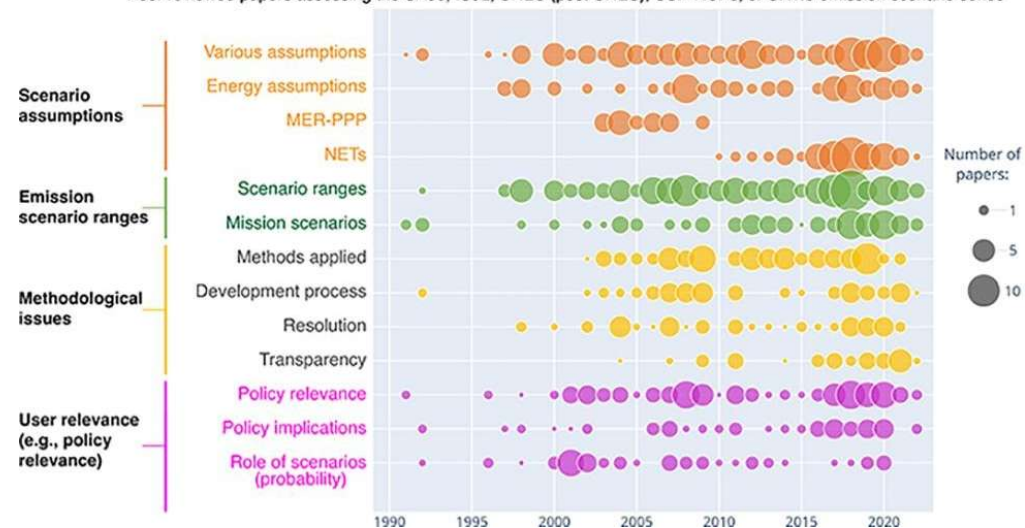




.... But there is also critique

- > Feasibility of specific options (e.g. BECCS)
- > Outdated assumptions (PV)
- > Black box
- > Not including impacts
- > Equity

b Emission scenario critiques and responses grouped by publication year. Based on 280 peer-reviewed articles (1990–2022)
Peer reviewed papers assessing the SA90, IS92, SRES (post-SRES), SSP-RCPs, or SR1.5 emission scenario series



IPCC emission scenarios: How did critiques affect their quality and relevance 1990–2022?



Impacts of not included

- › Process-based IAMs typically focused on mitigation
- › In SSP/RCPs deliberately excluded – avoid double counting
- › High uncertainty

But...

- › If climate change relevant... why futures without climate impacts (RCP8.5)?
- › Climate impacts on mitigation (afforestation, BECCS)
- › Focus on mitigation leads to only costs (no benefits)

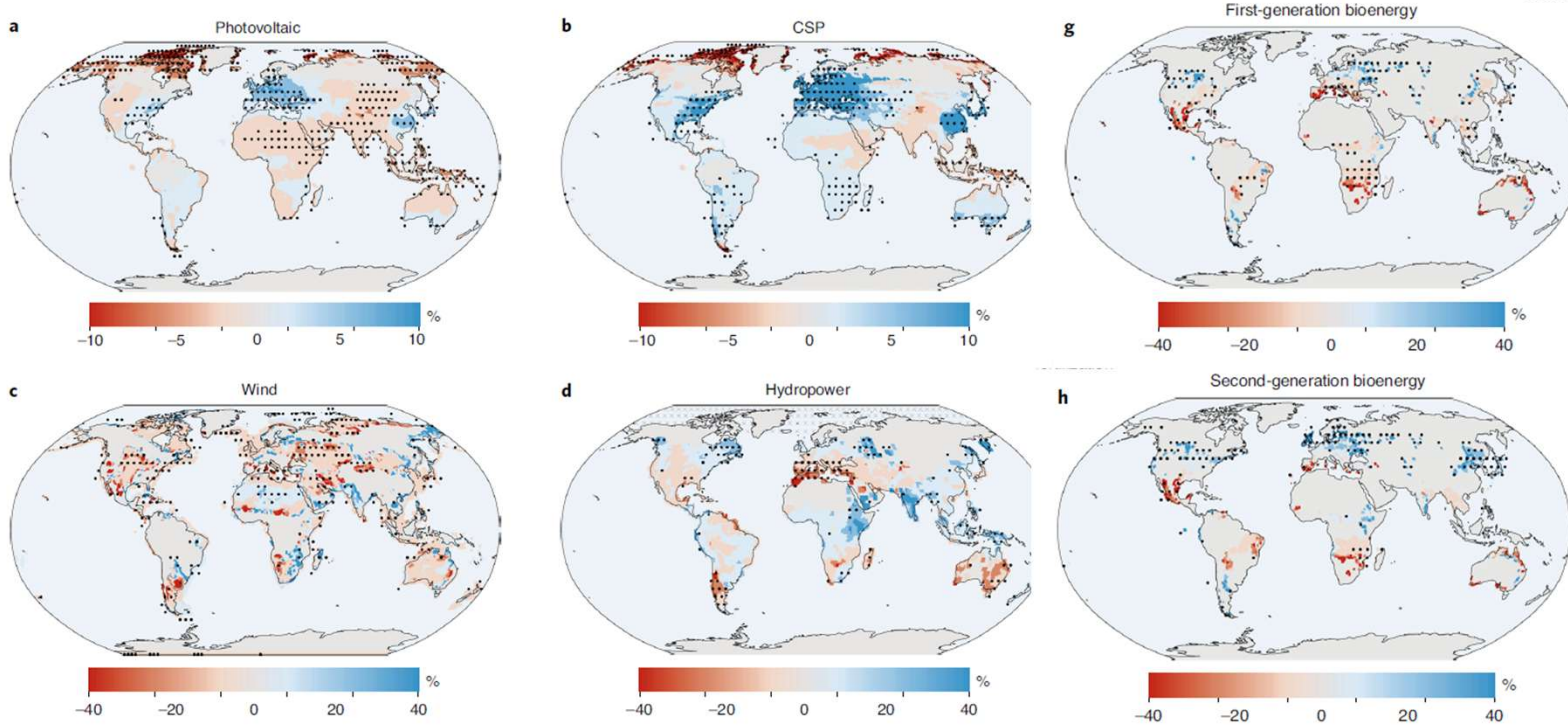


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Climate change impacts on renewable energy supply

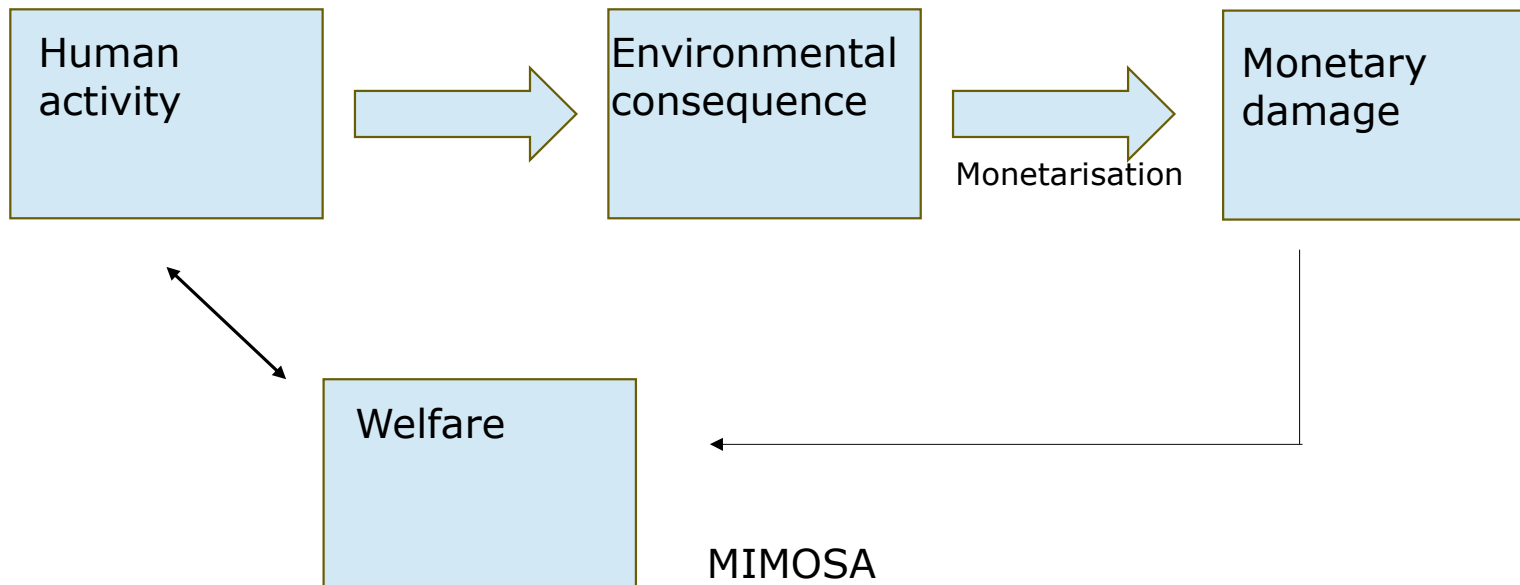
David E.H.J. Gernaat*, Harmen Sytze de Boer, Vassilis Daioglou, Seleshi G. Yalew, Christoph Müller, Detlef P. van Vuuren

Climate impacts on renewables



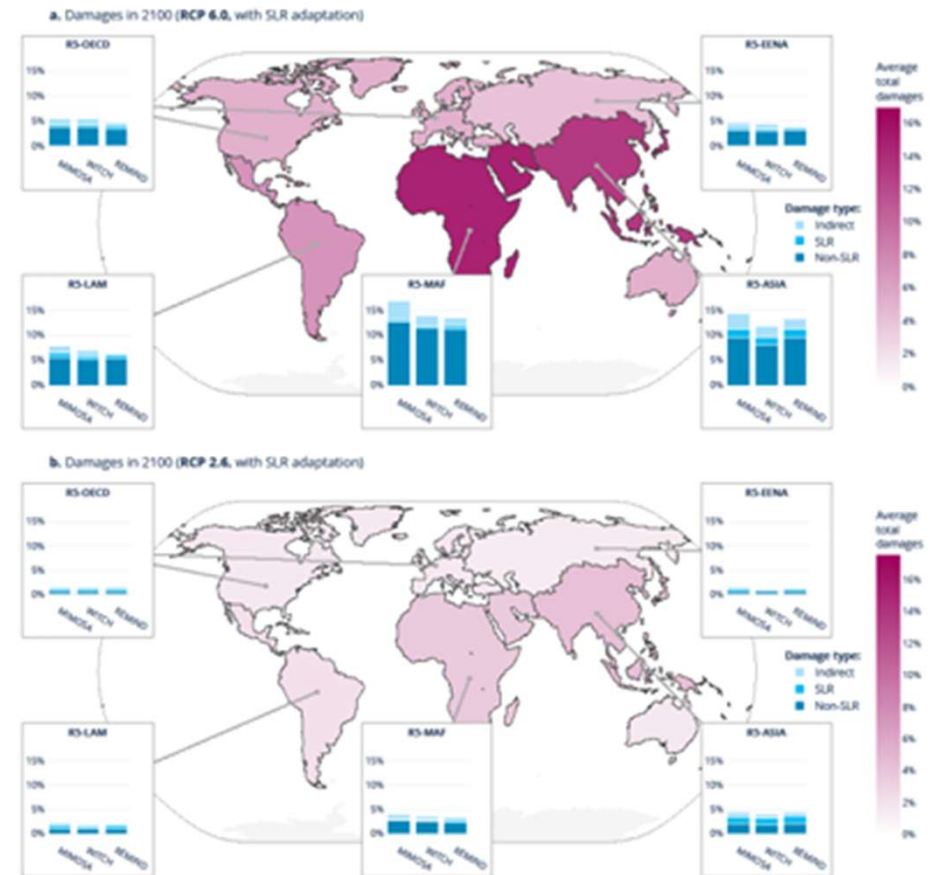
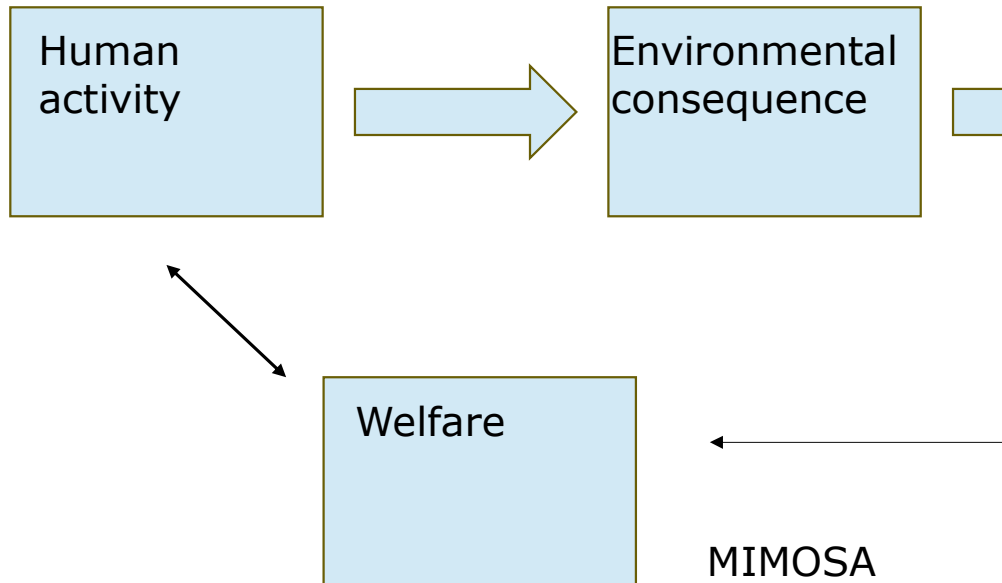


Economic implications



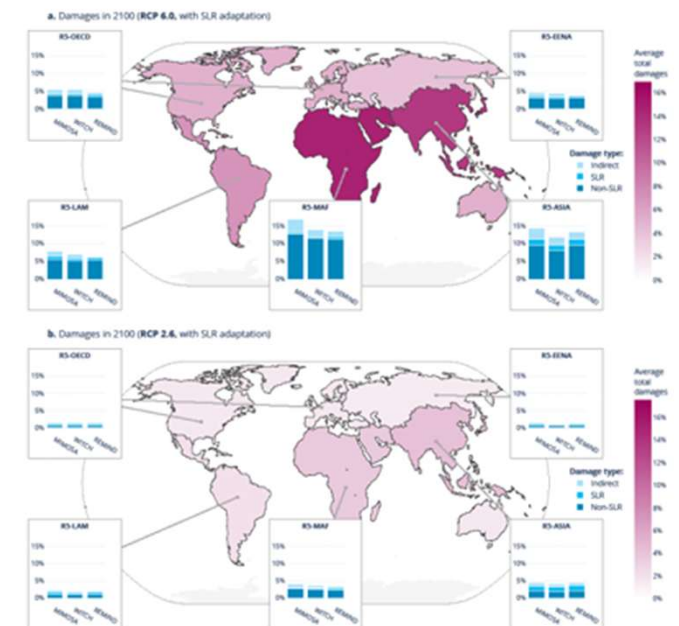
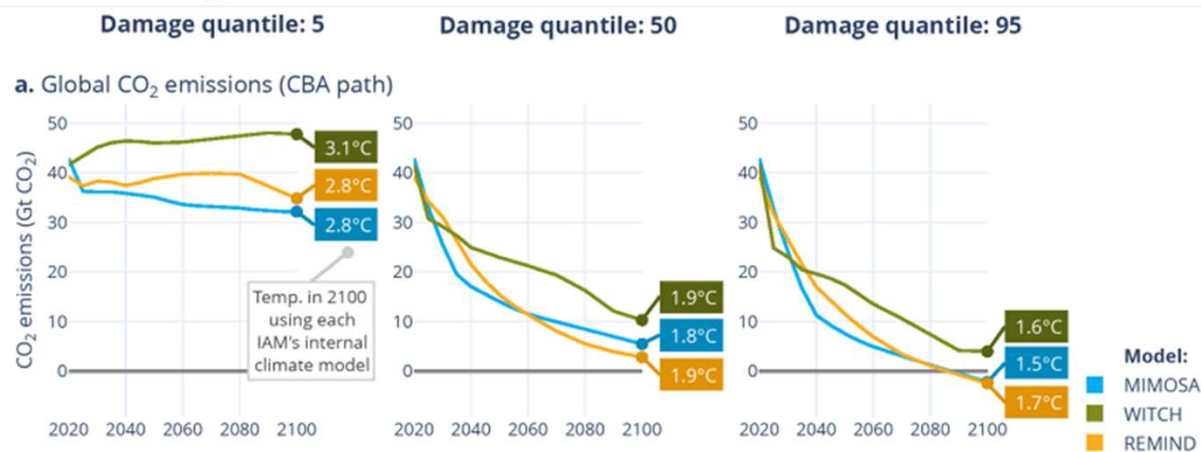
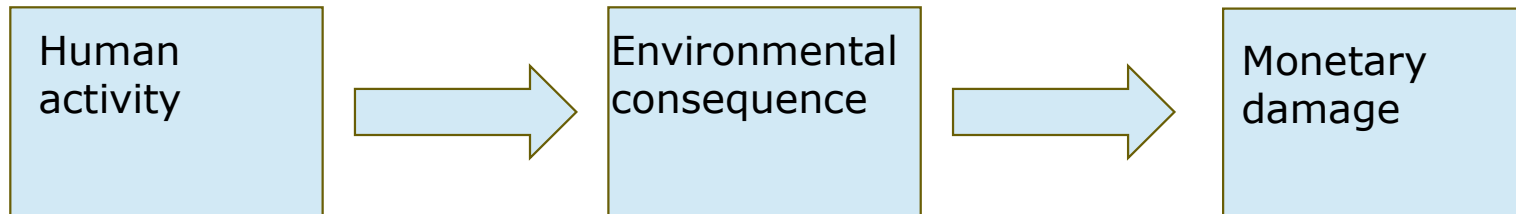


Economic implications



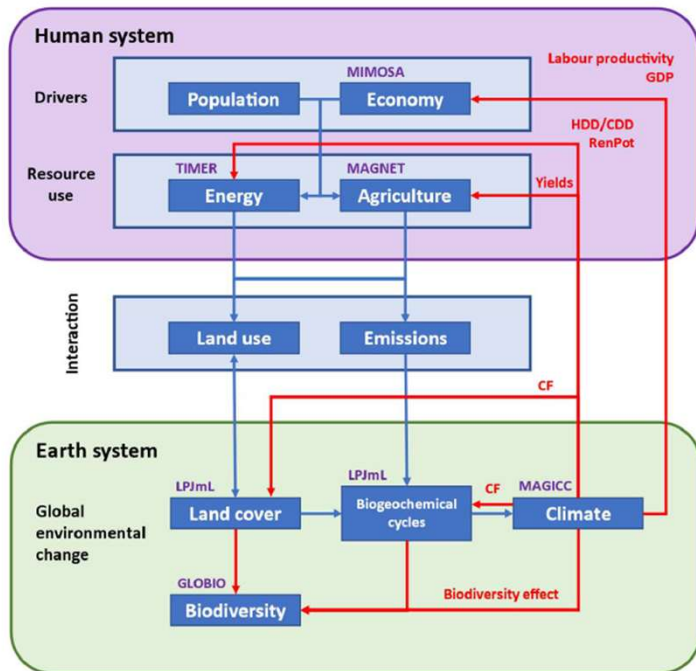


Economic implications

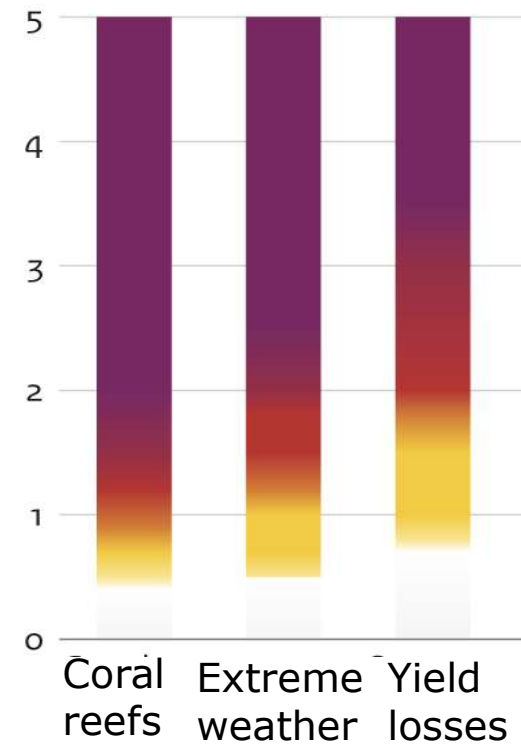
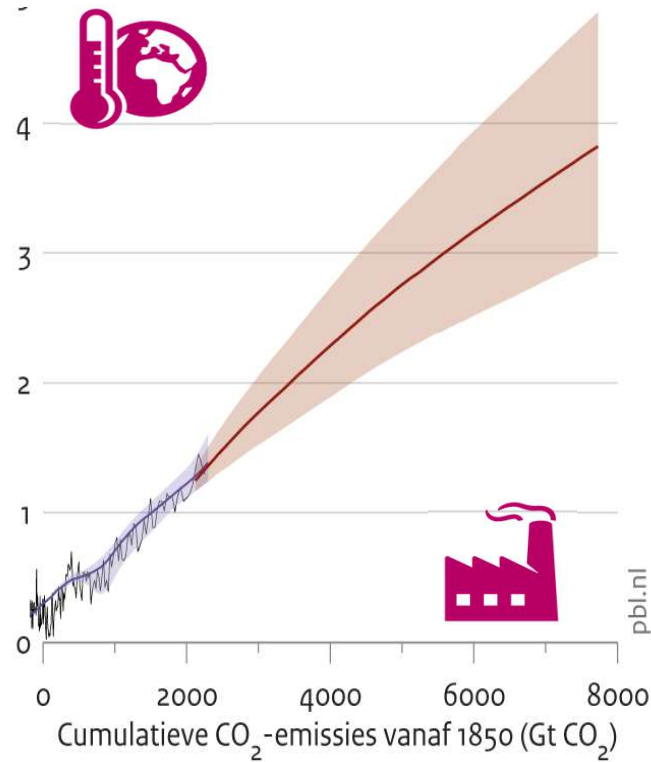
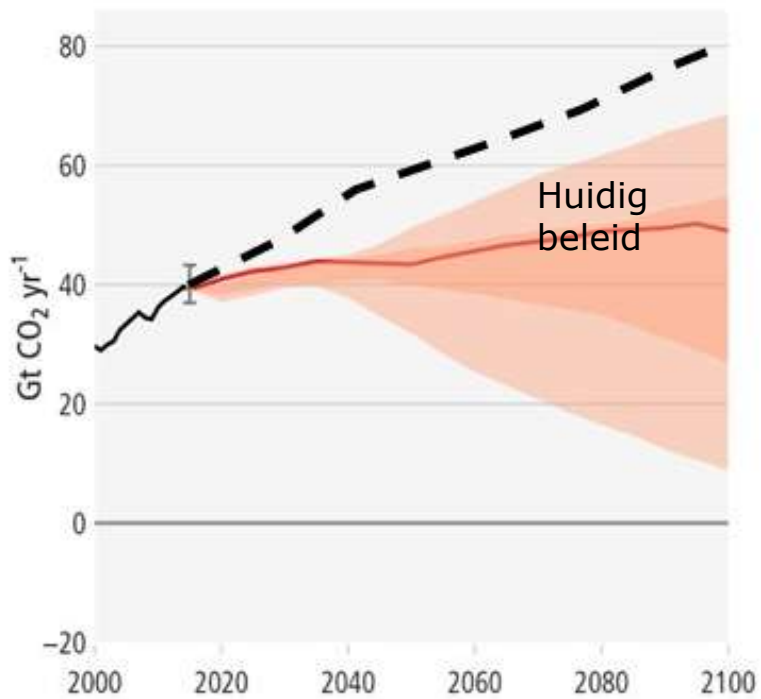




Closing the loop



Closing the loop



Equity crucial



- Differences in (historical) contribution
- Differences in capability to reduce emissions
- Differences in impacts
- Different consequences of mitigation (within and across regions)

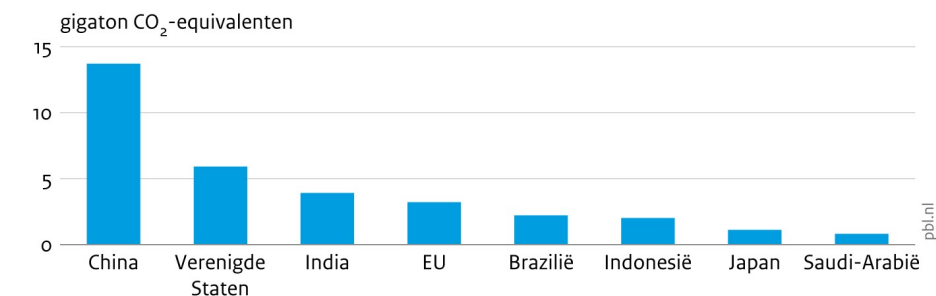
Equity crucial

- People do not accept solutions that are not considered 'just'

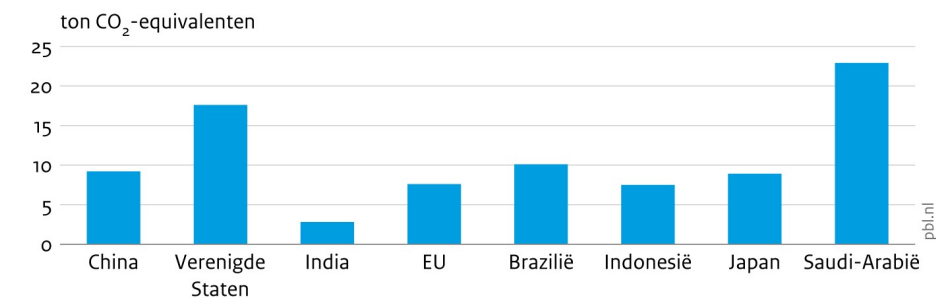


Emissie broeikasgassen

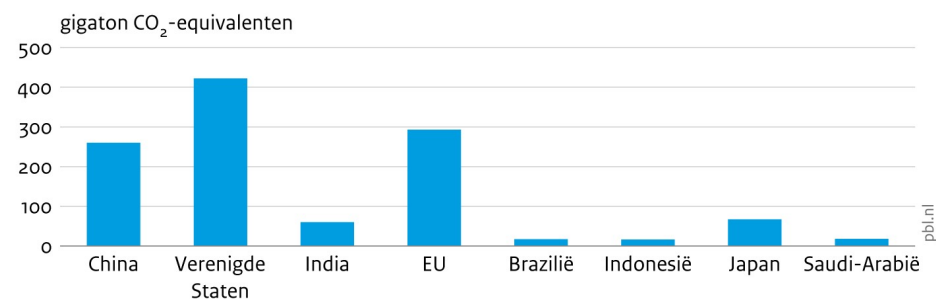
Totale emissie, 2021



Emissie per hoofd, 2021



Cumulatieve emissie, 1850 – 2021



Bron: Global Carbon Budget



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Historic CO₂ OECD = 66.8%
 2019 CO₂ OECD = 35.1%





Equity crucial

Different forms of justice

Procedural

Distributive

Corrective

Recognitional

Transformational

Responsibility

Equality

Capacity

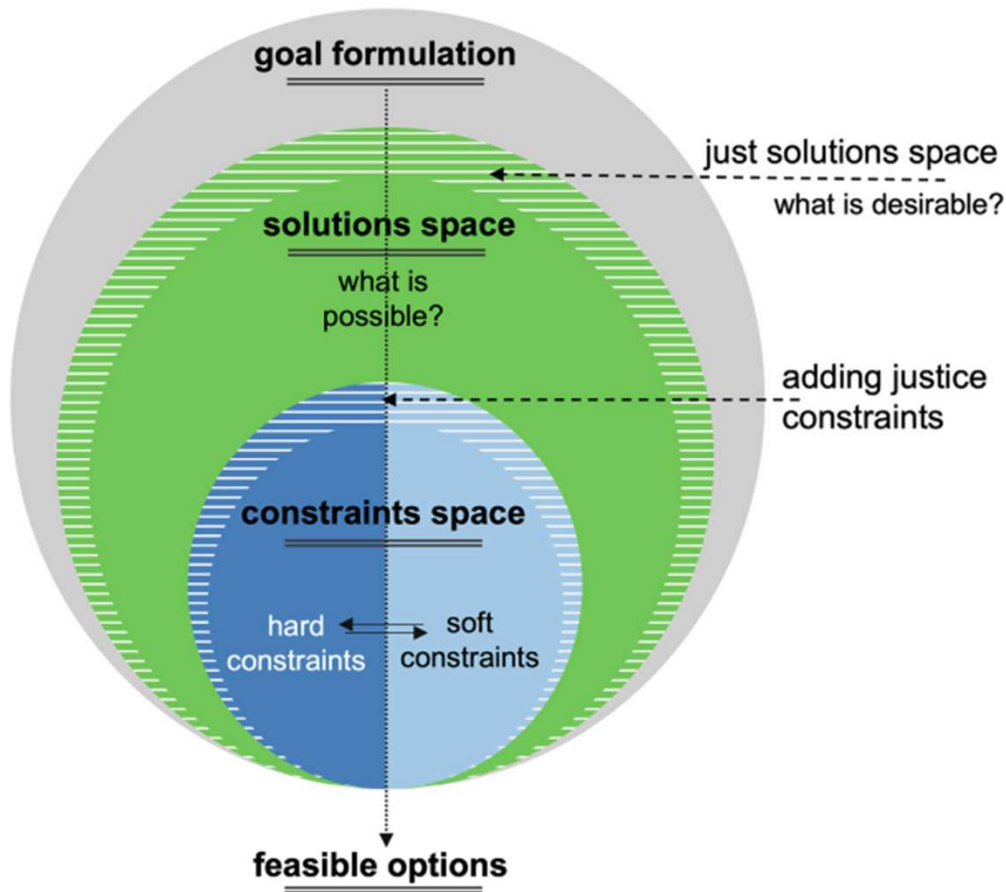
Cost-effective

Grandfathering

Justice considerations in climate research

[Caroline Zimm](#) , [Kian Mintz-Woo](#) , [Elina Brutschin](#), [Susanne Hanger-Kopp](#), [Roman Hoffmann](#), [Jarmo S. Kikstra](#), [Michael Kuhn](#), [Jihoon Min](#), [Raya Muttarak](#), [Shonali Pachauri](#), [Omkar Patange](#), [Keywan Riahi](#) & [Thomas Schinko](#)

Nature Climate Change **14**, 22–30 (2024) | [Cite this article](#)



Justice can and should become a part of feasibility assessments for climate mitigation policies

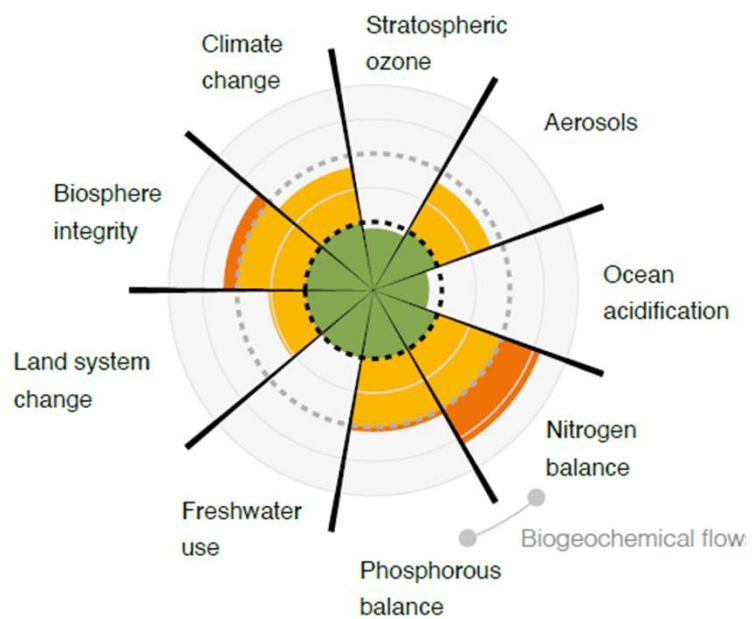
Maitreyee Sevekari [✉](#), Calum Brown, Elizabeth Díaz-General & Mark Rounsevell

[npj Climate Action](#) 4, Article number: 48 (2025) | [Cite this article](#)

1467 Accesses | 24 Altmetric | [Metrics](#)



b. 2015

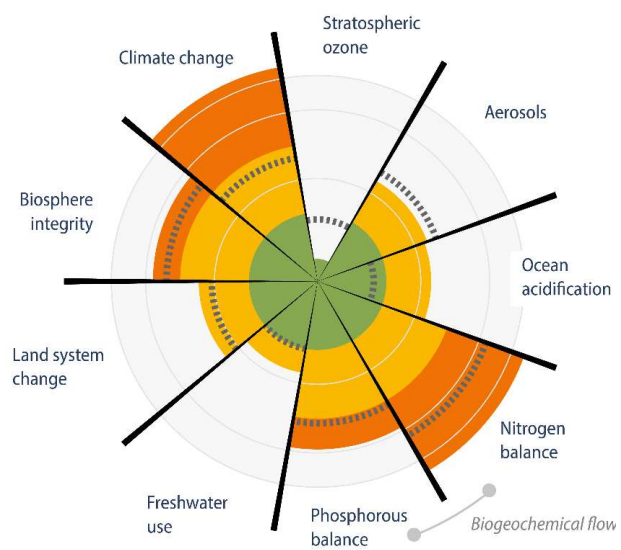


- Below boundary (safe)
- In zone of uncertainty (increasing risk)
- Beyond zone of uncertainty (high risk)

Comparison:

..... 2015

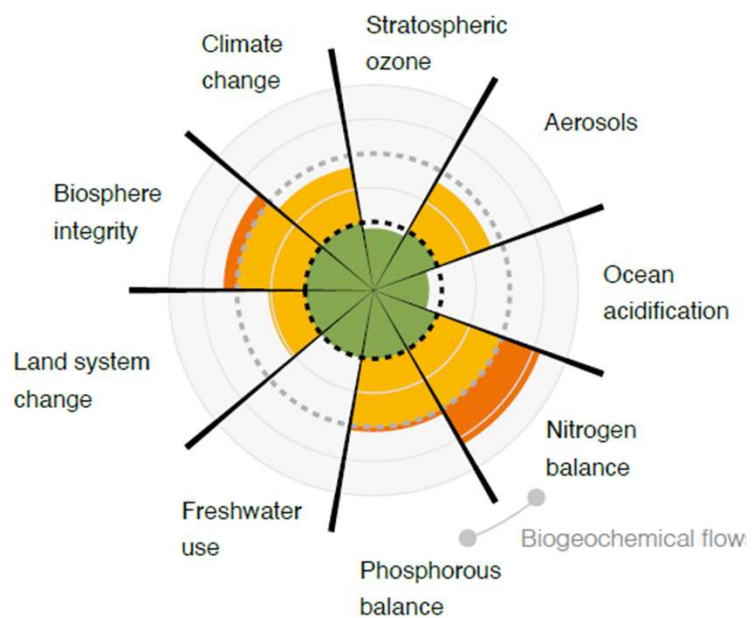
a. SSP2 (2050)





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b. 2015

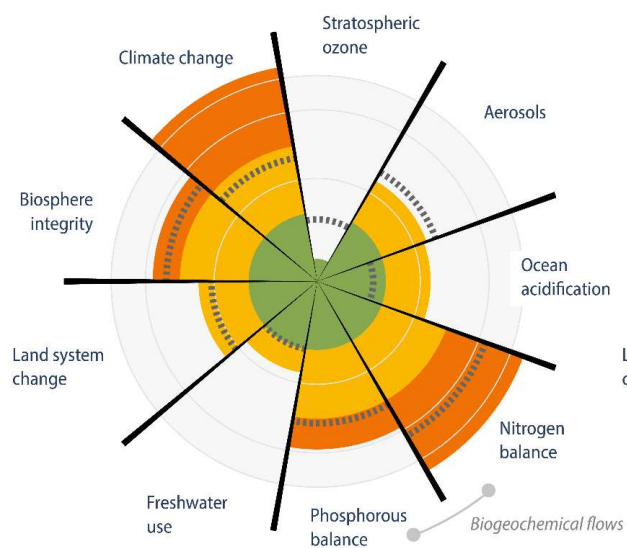


- Below boundary (safe)
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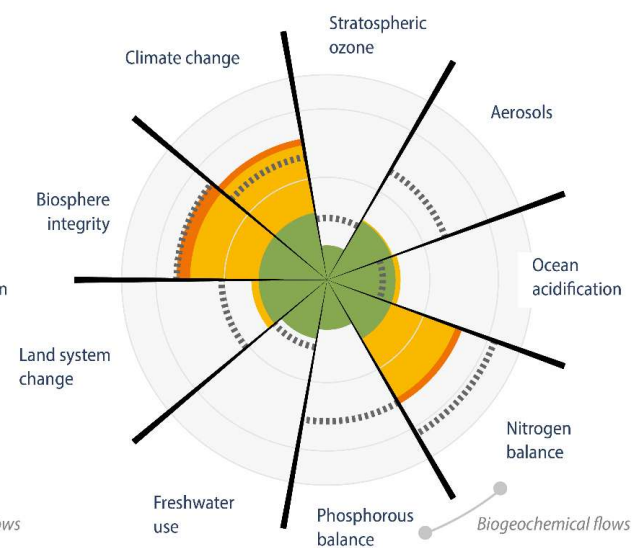
Comparison:

..... 2015

a. SSP2 (2050)



b. Sustainability (2050)

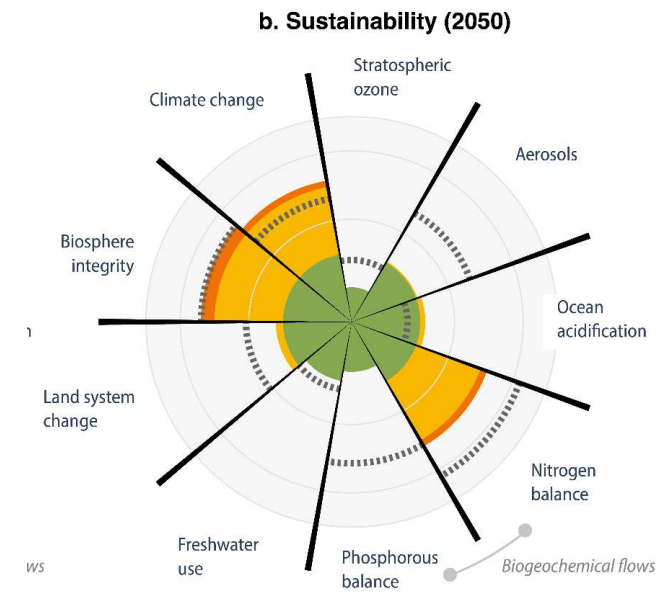




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Decent living

Food
Shelter
Water
Transport
Infrastructure
Cloths/goods
Education
Health





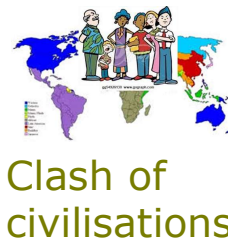
Shared Socio-economic Pathways: 5 possible stories about the future

SSP5: Fossil fuel-ed development

- Rapid growth, free trade
- High technology development,
- Environment and social goals not a priority: adaptive, technology-fix
- Focus on economic growth



Markets first



Clash of civilisations

SSP3: Regional rivalry

- Competition among regions
- Low technology development
- Environment and social goals not a priority
- Focus on domestic resources
- High population growth
- Slow economic growth dev. countries

SSP1: Green growth

- Global cooperation
- Rapid technology dev.
- Strong env. policy
- Low population growth
- Low inequity
- Focus on renewables and efficiency
- Dietary shifts
- Forest protection



UN world

SSP2: Middle of the Road



Have's and have not's

SSP4: Inequality

- Inequality across and within regions
- Low technology development
- Environment priority for those that can afford
- Limited trade



Some lessons

- › IAMs important tools
- › Improvement possible, including representation of justice and impacts
- › This week – we will discuss this a lot of detail