Applying integrated assessment models to assess interactions between Sustainable Development Goals

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Material courtesy of

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Overview

- Analyzing SDG interactions with IAMs
  Interaction of mitigation policies with
  - Food security
  - Air pollution and health
  - (Environmental impacts and material needs)
  - (Water for energy)
- Synthesis of interactions across multiple SDGs

Using IAMs to explore SD-Pathways

Key Research Questions

- Which SDGs (or aspects thereof) are covered by IAMs (according to the modelers and their papers)?
- Which interactions between SDGs can be assessed using IAMs?

Key Publications

- Van Soest et al. (accepted) "Sustainable Development Goals: Analysing Interactions with Integrated Assessment Models“, Global Transistions.

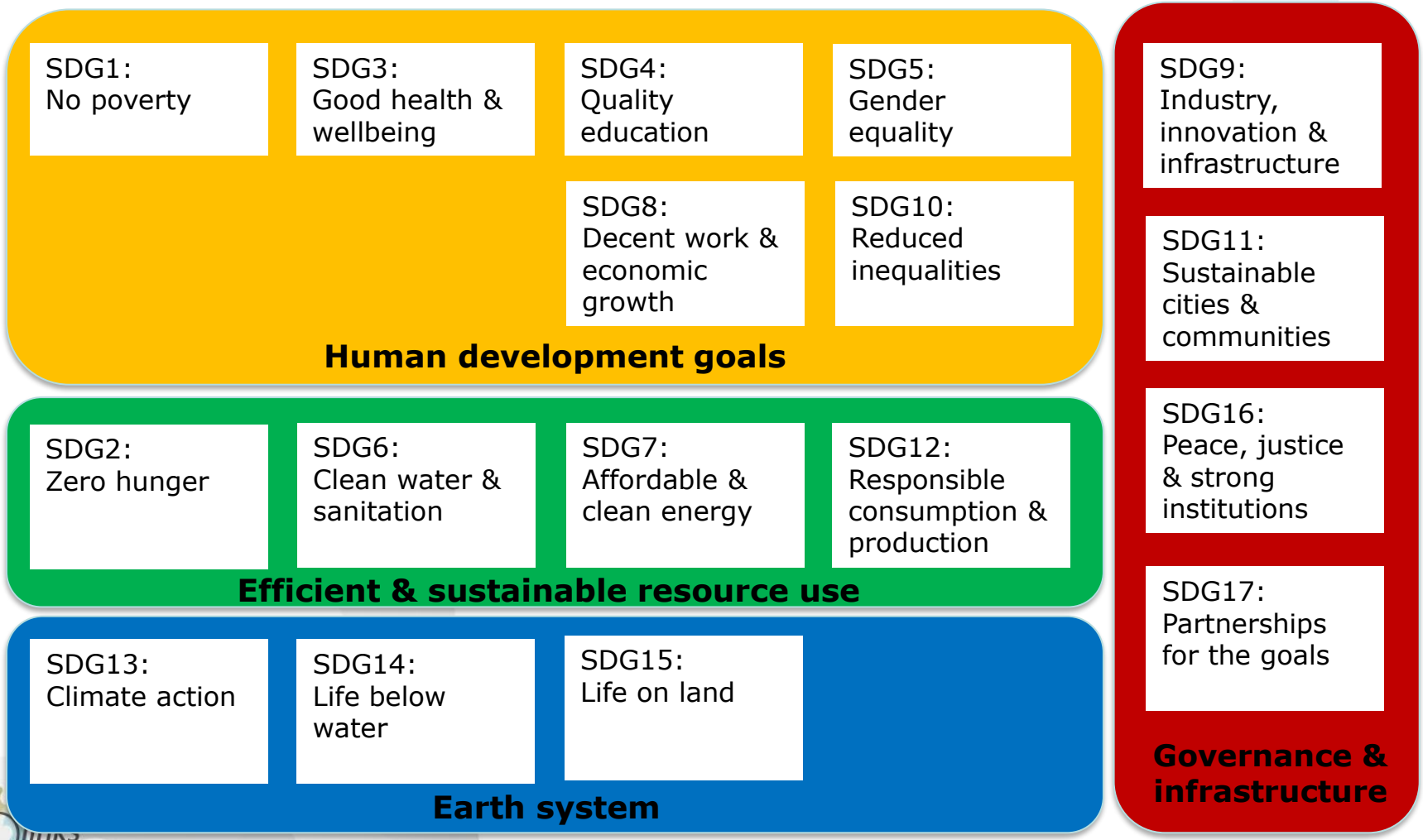
Source: van Soest et al. (2019)

Model Survey

- **IAMs**: AIM-CGE, China TIMES, DNE21+, GCAM, GEM-E3, IMAGE, IPAC, PRIMES, REMIND-MagPIE, MESSAGE-Brazil, MESSAGEix-GLOBIOM, WITCH
  - State of the art
  - Used in assessments: IPCC, SSPs, GEO…
  - Focus on mitigation- and process-focused IAMs
- Current and planned representation of individual SDGs
- Currently modeled and planned SDG interactions

Source: van Soest et al. (2019)

Clustering – SDGs in an IAM framework



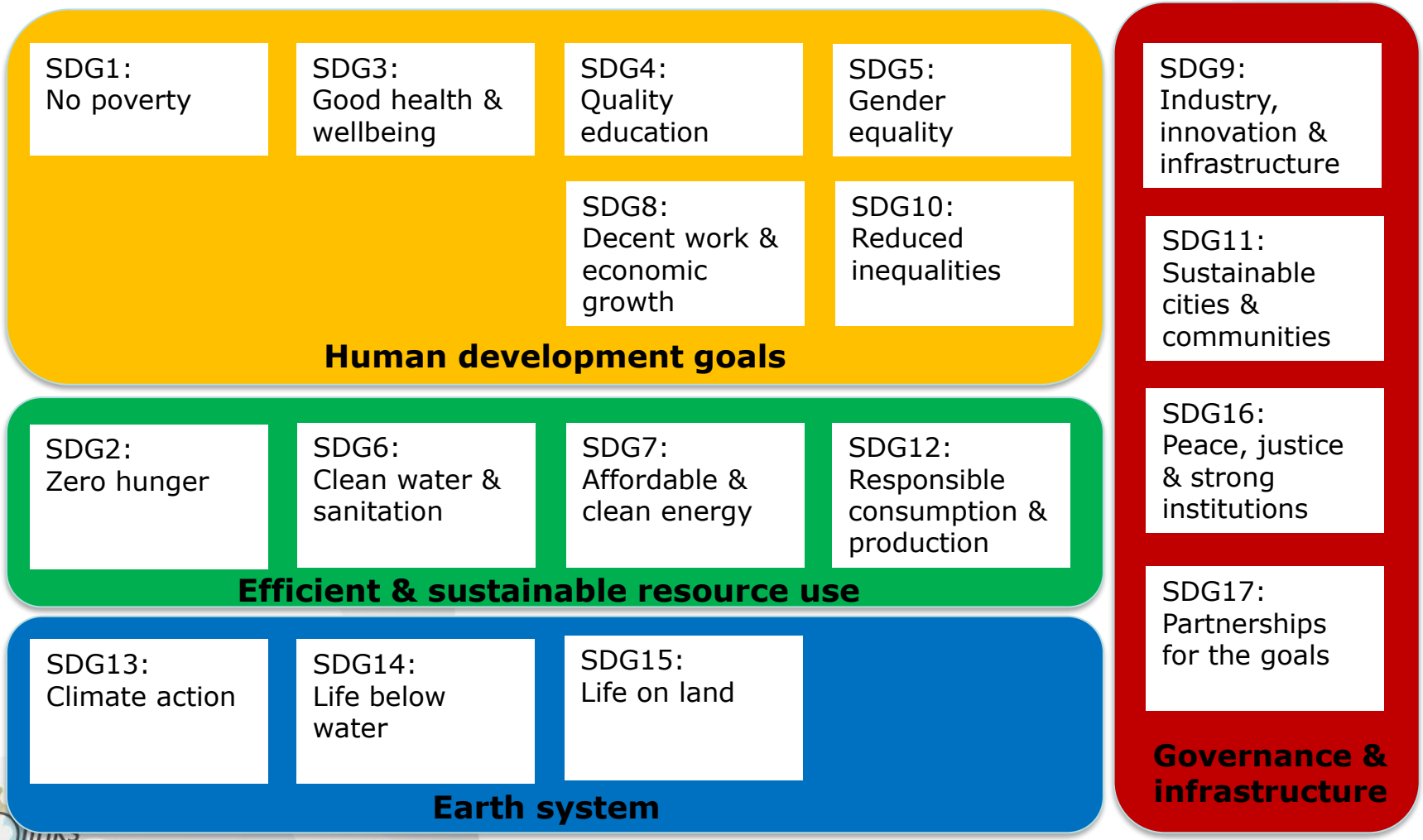
Source: van Soest et al. (2019)

Results: Model representation of individual SDGs

	All models	Key indicators
SDG1	1.4	Per capita / household consumption, food/energy expenditure households, people living below poverty line, GINI
SDG3	2.2	Air pollution related mortality/air quality, DALY, health expenditures
SDG4	1.1	Enrolment ratios and educational attainment, education expenditures
SDG5	0.2	-
SDG8	2.6	GDP(/growth), consumption, investment, economic structure, sector value added, employment, labour wages, food/water/steel/cement/energy efficiency
SDG10	0.5	GINI, private consumption, labour share of GDP
SDG2	2.5	Undernourishment, food availability/consumption per capita, food prices/expenditure, people at risk of hunger, agricultural productivity
SDG6	1.6	Population with access to safe drinking water/sanitation, wastewater treatment, water stress, water used for energy, water prices, irrigation water withdrawal
SDG7	4.4	People without access to electricity/relying on solid fuels/traditional biomass use, energy prices for consumers, share of renewable energy, energy intensity
SDG12	2.4	energy (renewable/fossil) resource estimates/utilization, recycling rates, labour/capital/material/energy productivities, material consumption, food waste/consumption
SDG13	3.8	NDC and policy implementation, climate forcing indicators, adaptation costs/investments/damages, residual damage, heating/cooling demand, planting dates and variety change
SDG14	0.5	Ocean acidification, fertilizer use/losses, adaptation capacity coastal areas, fisheries as % of GDP, Nitrogen cycle indicators, MSA in aquatic ecosystems
SDG15	1.8	Land use/cover area, forest/deforested/terrestrial ecosystems area, area under sustainable forest management, N losses agriculture, terrestrial acidification, MSA/wilderness/species richness indicators, reforestation/protection targets
SDG9	3.6	Transport/industry energy demand, manufacturing value added/employment, CO_2 emissions per sector/per value added, travel demand
SDG11	2.2	Travel demand/per capita, transport energy use, waste/waste water volumes, air pollutant emissions, urbanisation rate
SDG16	0.0	-
SDG17	1.2	GDP per capita, economic structure, private/public consumption, investments, sector value added, exports, taxes as % of GDP, import duties per product, share of exports of developing countries in global exports by sector, average tariffs faced by developing countries

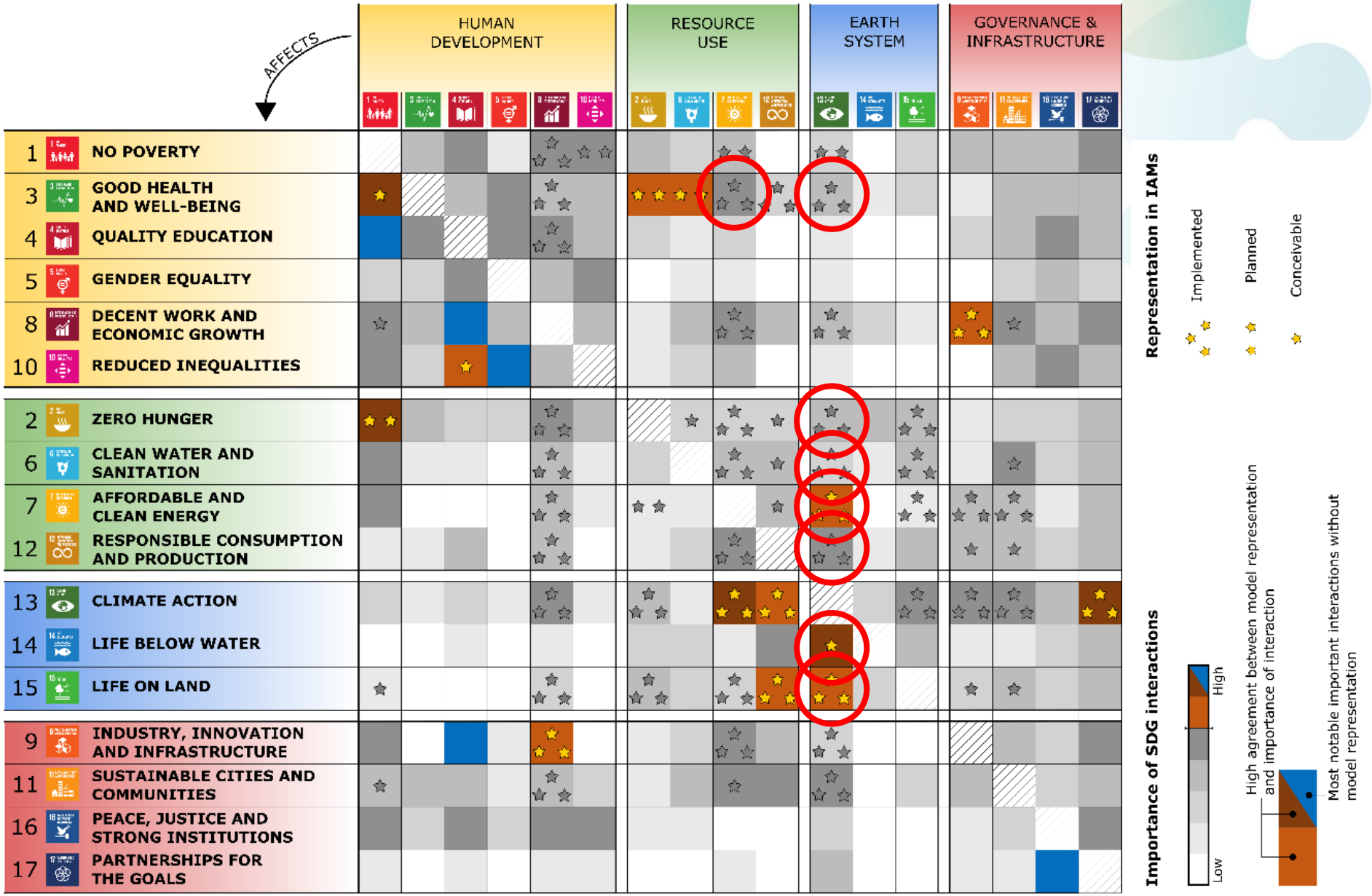
Source: van Soest et al. (2019)

Results – Model assessment: representation of SDGs in IAMs



Source: van Soest et al. (2019)

IAM Representation of SDG Interactions



Source: van Soest et al. (2019)

Conclusions

- Many SDGs can (partly) be quantified by IAMs
  - Especially in 'Efficient & sustainable resource use' + 'Prevent environmental degradation' clusters
- More challenging in 'Human development goals' + 'Good governance and infrastructure'
  - Institution/policy/legal framework indicators
  - Key planned developments: poverty→hunger, hunger & water → health
- Some SDGs not quantifiable in IAMs (inequalities, education, peace, *cities, oceans*)
- Interactions mainly in and between 'Efficient and sustainable resource use' and 'Prevent environmental degradation' clusters - & links with economy

Source: van Soest et al. (2019)

Linking models – an ingredient for broader sustainability assessments

Data template and post-processing

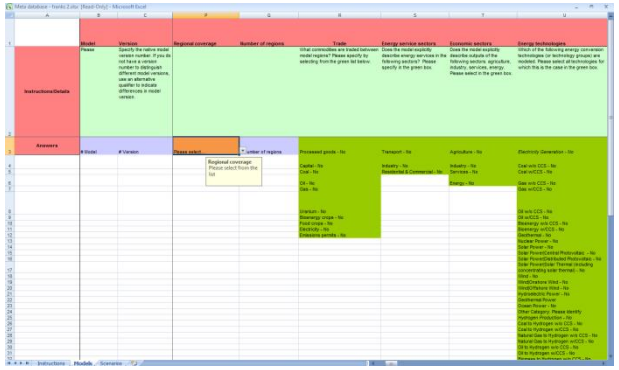
- Machine-readable data and meta data template developed by IAMC (since 2009)
- Interactive web databases to support community activities
- Automated aggregation to “standard regions”
- Automated quality checks (model, variable and region names, base year data, variable ranges)
- Download functionality for database snapshots
- Application Programming Interface (API)
- Data visualization and dissemination to the public

Standardized IAMC Data Template

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	Model	Scenario	Region	Variable	Unit	2005	2010	2020	2030	2040	2050	2060	2070	2080	2090	210
2				Population|Total	million											
3				Population|Urban	million											
4				Population|Rural	million											
5				GDP|Total|MER	billion US$2005/yr											
6				GDP|Total|PPP	billion US$2005/yr											
7				GDP|Industry|MER	billion US$2005/yr											
8				GDP|Services|MER	billion US$2005/yr											
9				GDP|Agriculture|MER	billion US$2005/yr											
10				Primary Energy|Total	EJ/yr											
11				Primary Energy|Fossil|Total	EJ/yr											
12				Primary Energy|Fossil|w/ CCS	EJ/yr											
13				Primary Energy|Fossil|w/o CCS	EJ/yr											
14				Primary Energy|Coal|Total	EJ/yr											
15				Primary Energy|Coal|w/ CCS	EJ/yr											
16				Primary Energy|Coal|w/o CCS	EJ/yr											
17				Primary Energy|Nuclear|Total	EJ/yr											
18				Primary Energy|Non-Biomass Renewables	EJ/yr											
19				Primary Energy|Hydro|Total	EJ/yr											
20				Primary Energy|Wind|Total	EJ/yr											
21				Primary Energy|Solar|Total	EJ/yr											
22				Primary Energy|Geothermal|Total	EJ/yr											
23				Primary Energy|Ocean|Total	EJ/yr											
24				Primary Energy|Secondary Energy Trade|Total	EJ/yr											
25				Primary Energy|Other	EJ/yr											
26				Secondary Energy|Electricity|Total	EJ/yr											
27				Secondary Energy|Electricity|Coal|Total	EJ/yr											
28				Secondary Energy|Electricity|Coal|w/ CCS	EJ/yr											
29				Secondary Energy|Electricity|Coal|w/o CCS	EJ/yr											
30				Secondary Energy|Electricity|Oil|Total	EJ/yr											
31				Secondary Energy|Electricity|Oil|w/ CCS	EJ/yr											
32				Secondary Energy|Electricity|Oil|w/o CCS	EJ/yr											
33				Secondary Energy|Electricity|Gas|Total	EJ/yr											
34				Secondary Energy|Electricity|Gas|w/ CCS	EJ/yr											
35				Secondary Energy|Electricity|Gas|w/o CCS	EJ/yr											
36				Secondary Energy|Electricity|Biomass|Total	EJ/yr											
37				Secondary Energy|Electricity|Biomass|w/ CCS	EJ/yr											
38				Secondary Energy|Electricity|Biomass|w/o CCS	EJ/yr											

	A	B	C	D	E	F	G	H	I
1	**Model**	**Scenario**	**Region**	**Variable**	**Unit**	**2005**	**2010**	**2015**	**2020**
2	MESSAGE	CD-LINKS 400	World	Primary Energy	EJ/y	454.5	479.6	...	...

Meta Data: Models and Scenarios (Examples)



Model

- Model name & version
- Time horizon
- Model type (e.g., general vs. partial equilibrium; recursive-dynamic vs. inter-temporal)
- Cost metrics: GDP & consumption losses/system cost
- …

Scenario

- Part of a bigger exercise? (e.g., EMF27, AMPERE)
- Type: baseline/climate policy/diagnostic
- Climate Target (e.g., none/temperature/radiative forcing/emissions)
- Climate Policy: cap (and trade), price, regional policies
- Status: published (peer-reviewed/non-peer reviewed), preliminary
- …

Food Security

Food security analysis

Key Research Questions

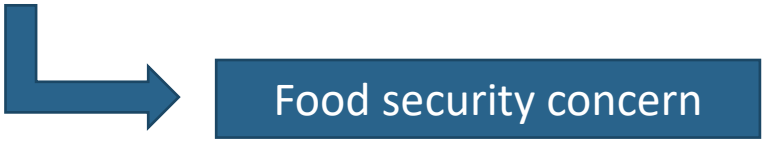
- What are potential trade-offs between climate change mitigation and food security objectives?
- How can these trade-offs be managed by inclusive policy design/complementary policies?
- How robust are model-based assessments in assessing the interactions between climate change and food security objectives?

Key Publications

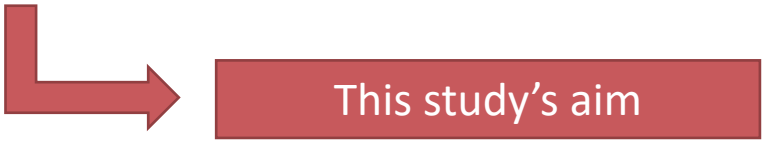
- Fujimori et al. (2018). Inclusive climate change mitigation and food security policy under 1.5°C climate goal. *Environmental Research Letters*, *13*(7). https://doi.org/10.1088/1748-9326/aad0f7
- Fujimori et al. (2019). A multi-model assessment of food security implications of climate change mitigation. *Nature Sustainability*, *2*(5), 386–396. https://doi.org/10.1038/s41893-019-0286-2

Background

- Paris Agreement to be the long-term climate policy design
  - Reaffirm 2°C goal and pursue 1.5°C
- Stringent climate policy leads to
  - Large scale afforestation
  - Bioenergy crop expansion (associated with BECCS)
  - Non-CO2 emissions (incl. CH4 and N2O) reduction and taxation

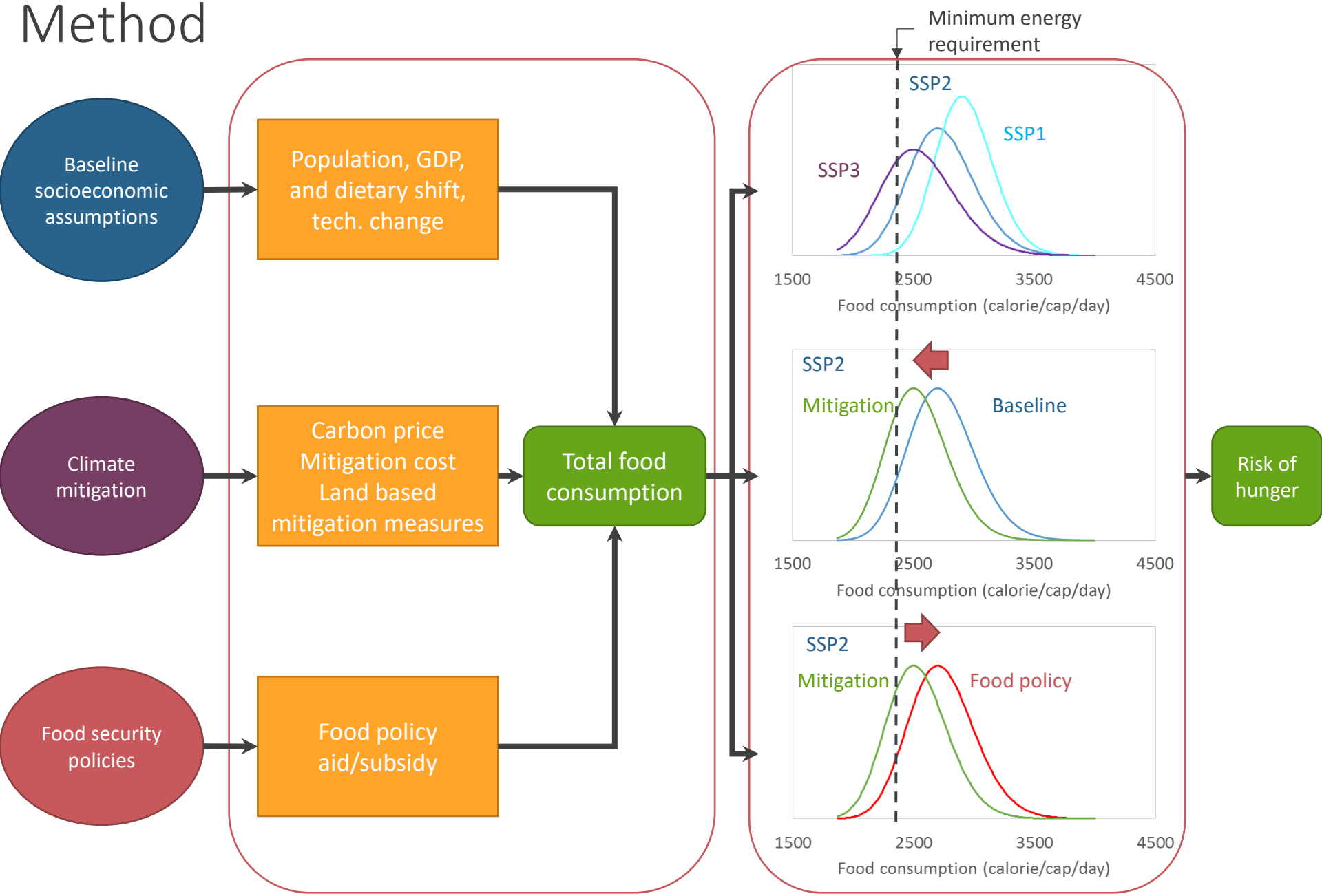


- No studies about
  - Paris Agreement (2°C and 1.5°C) and food security analysis.
  - Complementary policy designs to prevent adverse effect of climate policy on food consumption.



Source: Fujimori et al. (2018)

Method



Core of market interactions in CGE framework

FAO approach to estimate risk of hunger

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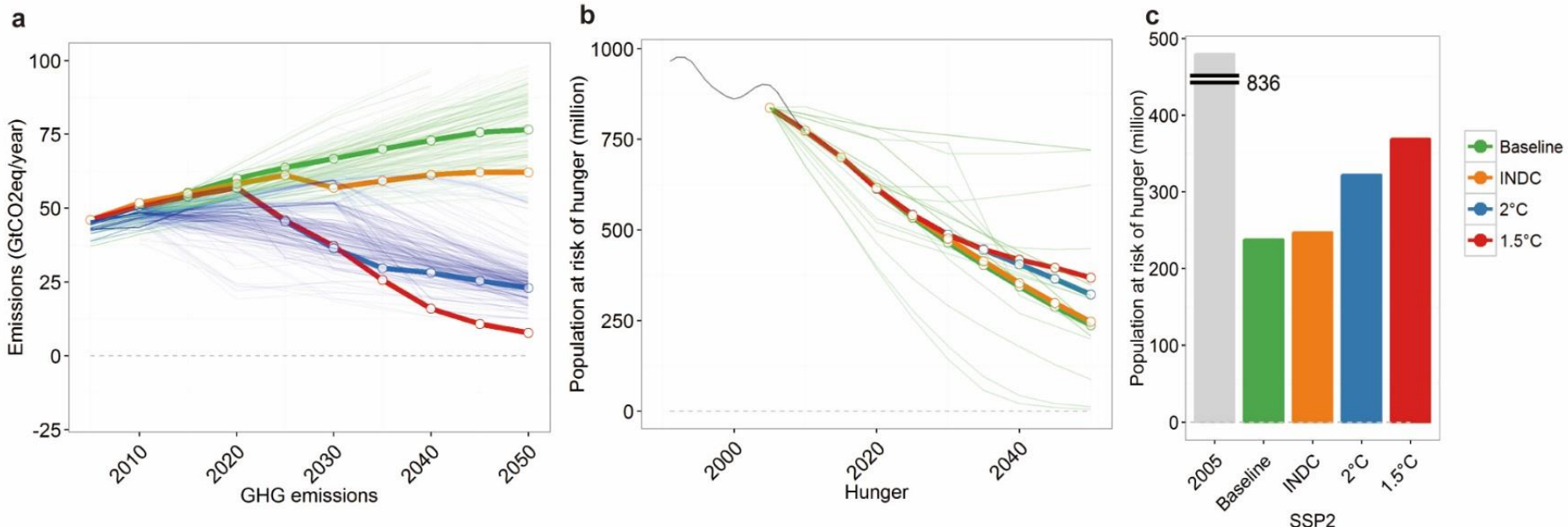
Scenario framework

Socioeconomic development	• SSP1 (Sustainability) • SSP2 (Middle of the road) • SSP3 (Regional Rivalry)
Climate policy	• Baseline (No climate policy) • INDC (Emissions targets under NDCs until 2030 and same carbon prices afterwards) • 2.0°C (from 2020 emission reduction starts and around 66% chance to stay below 1.5°C increase by 2100) • 1.5°C (from 2020 emission reduction starts 66% chance below 1.5°C increase in 2100)
Food security policy	• No • Int (International aid) • Dom (Domestic reallocation) • Bio (Bioenergy tax) • NonAgr (Not taxing the non-CO2 emissions from agriculture)

Source: Fujimori et al. (2018)

Adverse side effect in exclusive climate policy



- Risk of hunger decreases along with the socioeconomic development
- Adverse side effect in climate policy cases
- The more stringent the climate policy, the higher side effect is observed.

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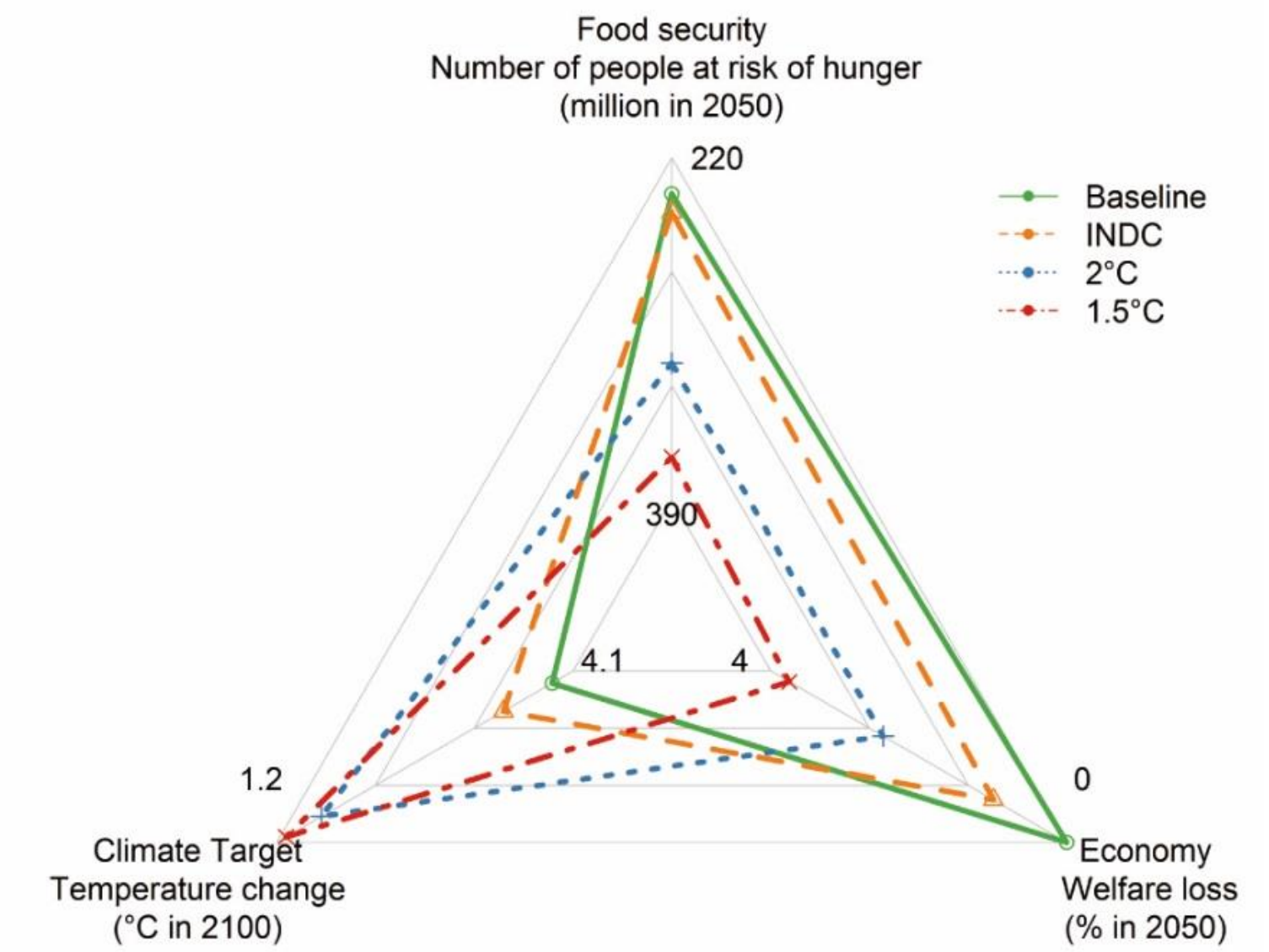
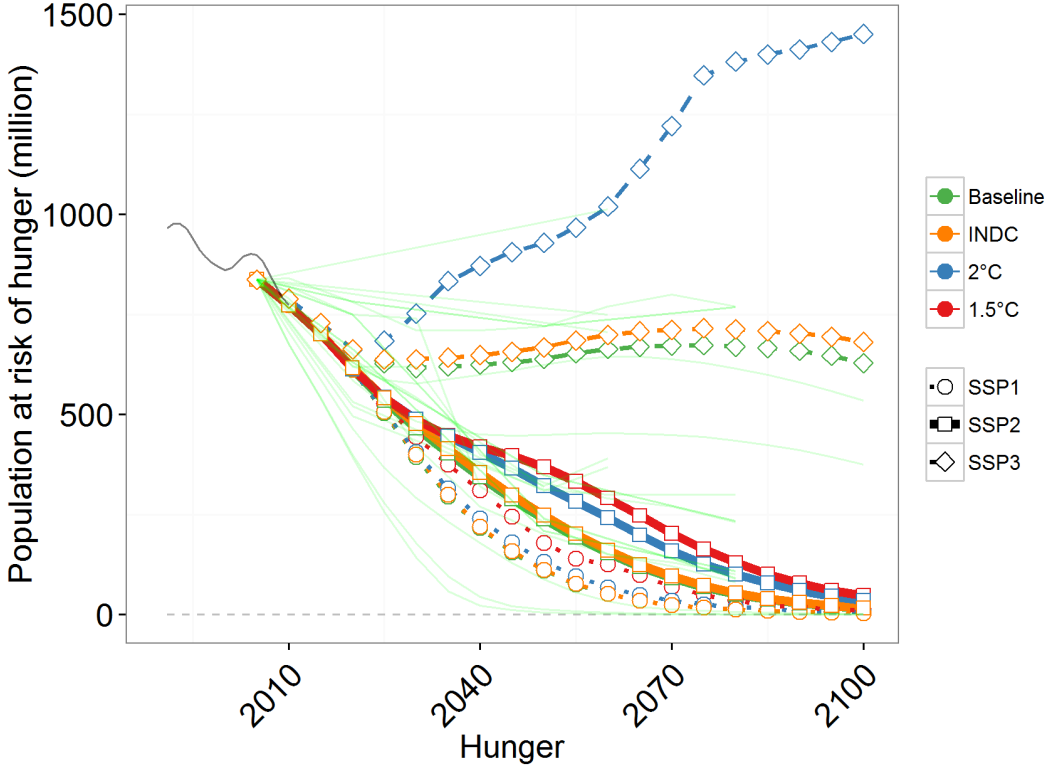
Source: Fujimori et al. (2018)

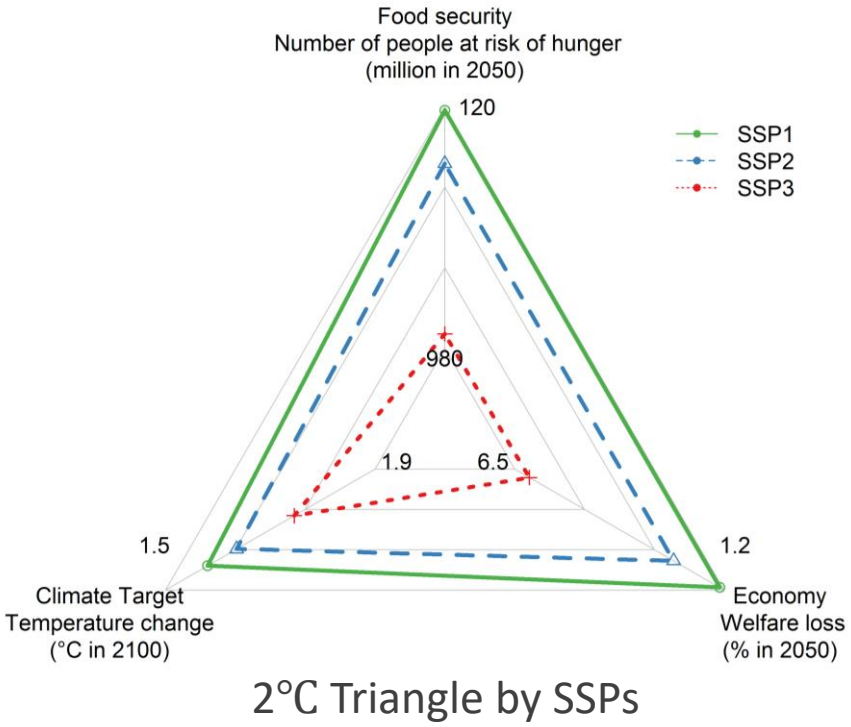
Adverse side effect in exclusive climate policy (SSP2)



Source: Fujimori et al. (2018)

Socioeconomic development





2°C Triangle by SSPs

- Hunger: SSP1< SSP2 < SSP3
- Adverse effect amplified by SSP assumptions
- Mitigation cost trend is the same

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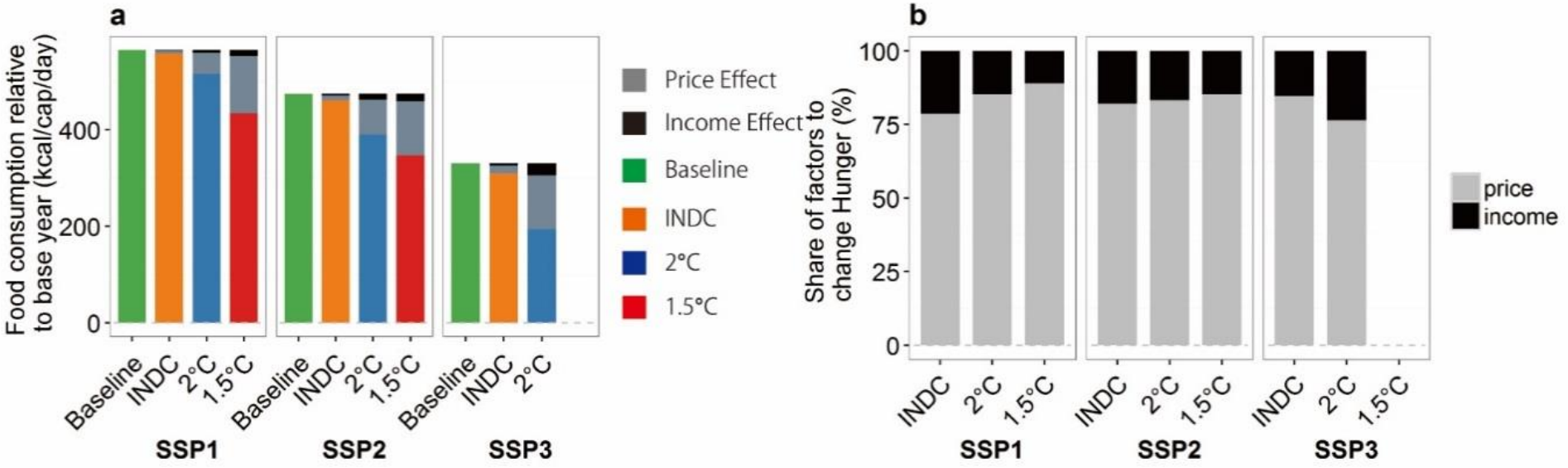
Source: Fujimori et al. (2018)

The channels of the negative impact



Price and income effect

- Income: energy system costs
- Price
  - Non-CO2 emission
  - Land rent increase

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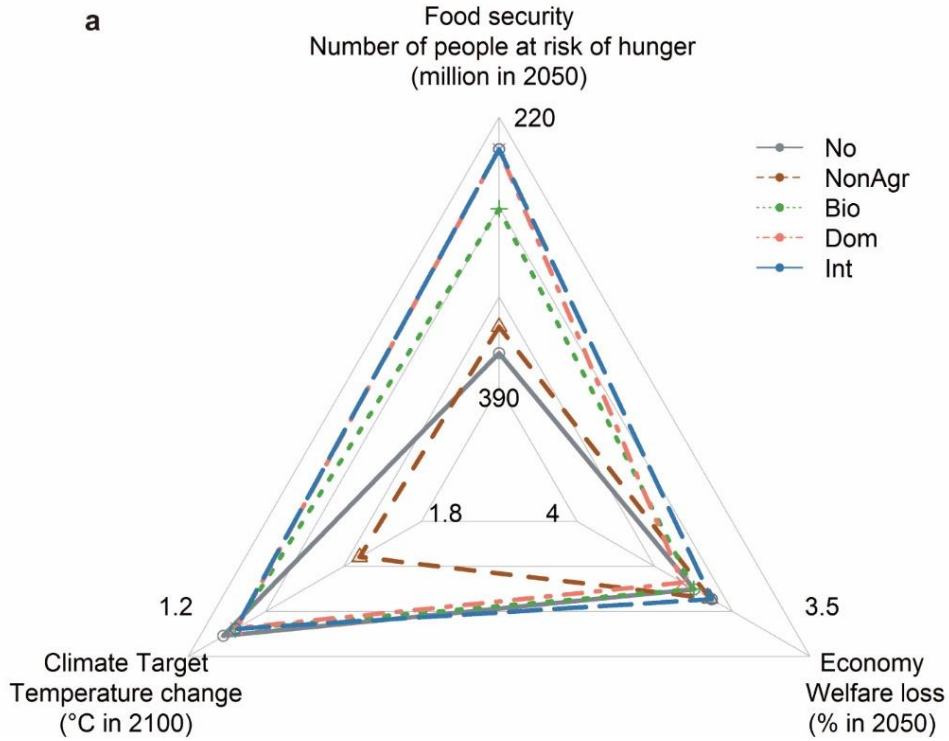
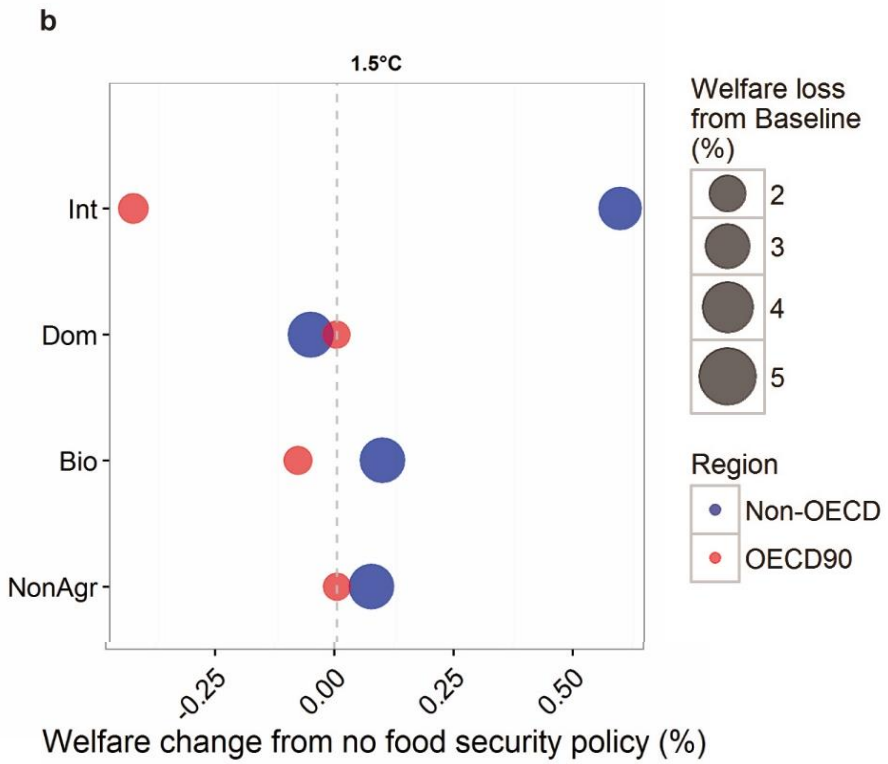
Source: Fujimori et al. (2018)

Inclusive climate policy effect and consequences



SSP2-1.5℃ Triangle



Welfare Change

- Incremental risk of hunger can be eradicated by some inclusive policies
- No changes in global total welfare, but distribution of welfare varies across food policy

Source: Fujimori et al. (2018)

Discussion and conclusion

- Exploration of possible trade-offs between mitigation policy and food security
- Identification of possible alternative policy designs to eradicate the negative side effect
  - Some policy packages might work but not exhaustive
- The stronger the climate policy, the higher the need for complementary food security policy
- Robust results across SSPs
- The real policy implementation may need more consideration of local circumstances and barriers.

Source: Fujimori et al. (2018)

Exploring Robustness of Insights: A Multi-model inter-comparison

Model name	Country	Institution	Model type
AIM	Japan	NIES	CGE-Recursive dynamic
IMAGE	Netherland	PBL	PE- Recursive dynamic (CGE for agriculture)
MESSAGE*ix*-GLOBIOM	Austria	IIASA	MESSAGE: PE-Intertemporal Optimization GLOBIOM: PE-Recursive dynamic optimization
POLES-GLOBIOM	European Commission	JRC	PE –Recursive dynamic simulation GLOBIOM: PE-Recursive dynamic optimization
REMIND-MAGPIE	Germany	PIK	REMIND: CGE- Intertemporal Optimization MAgPIE: PE-Recursive dynamic optimization
WITCH-GLOBIOM	Italy	CMCC	CGE-Intertemporal Optimization GLOBIOM: PE-Recursive dynamic optimization

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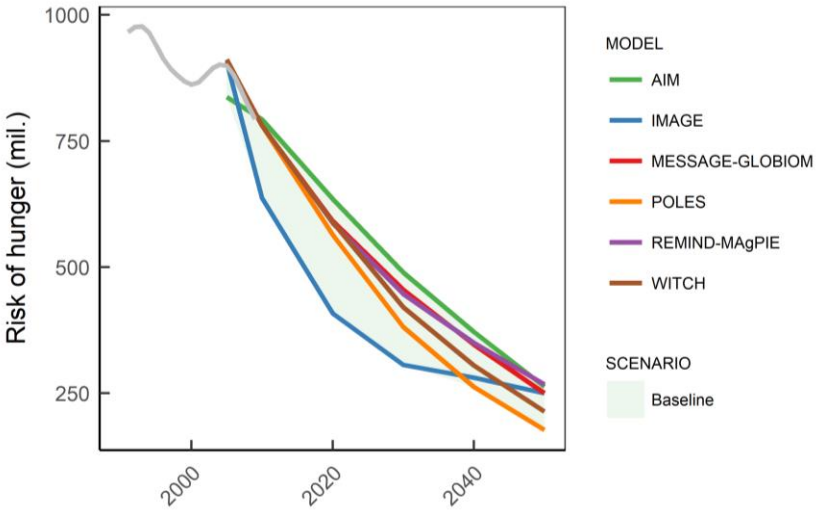
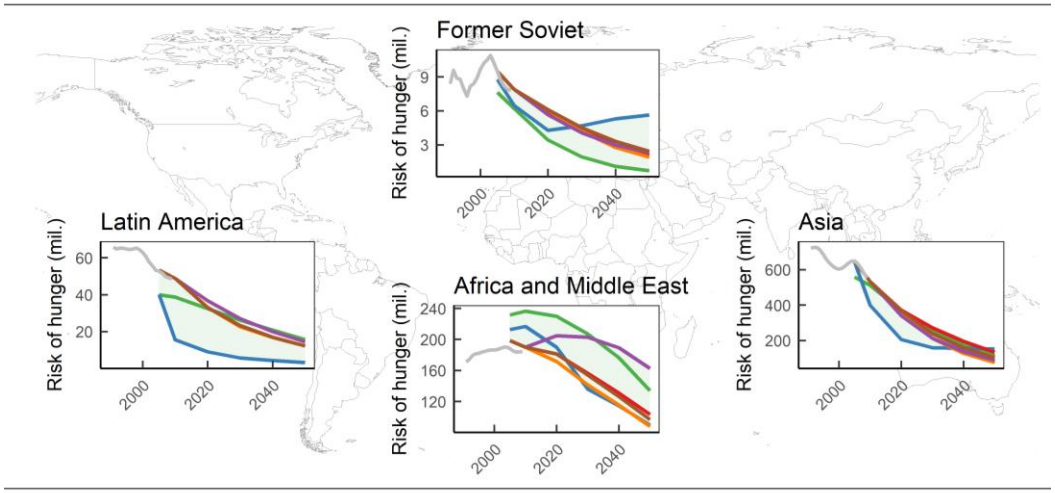
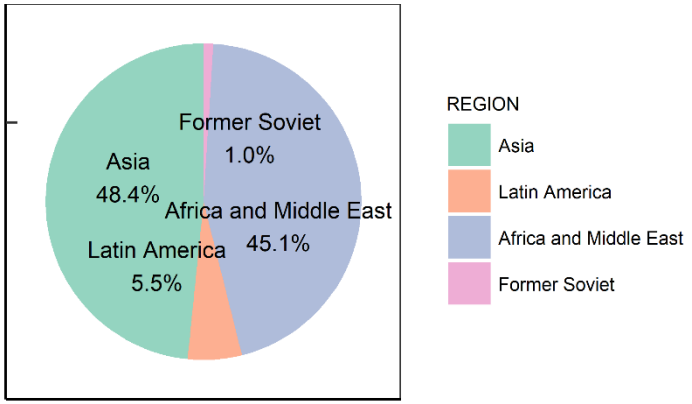
Source: Fujimori et al. (2019)

Baseline trend





- Globally continuous decreases
- Great decreases in Asia
- In 2050 Asia and Africa shares are almost equal



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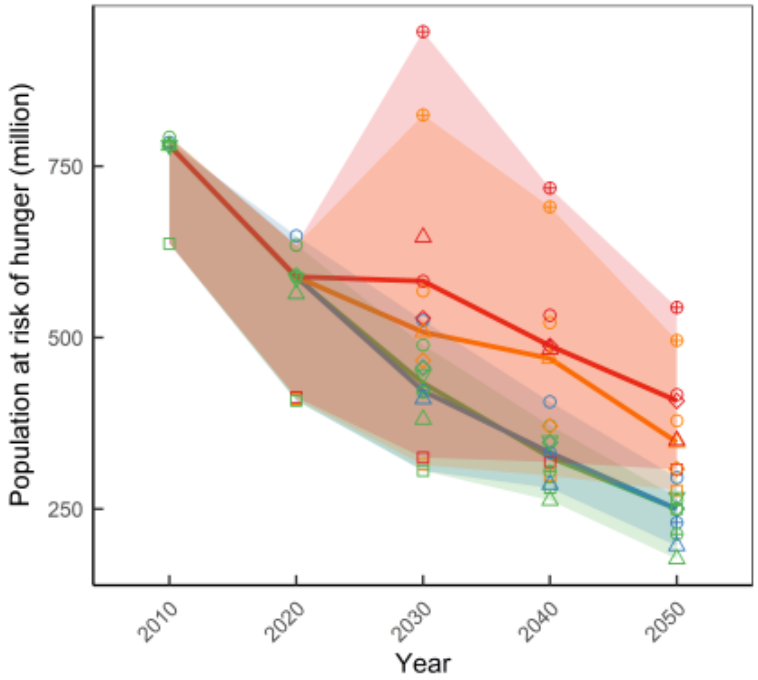
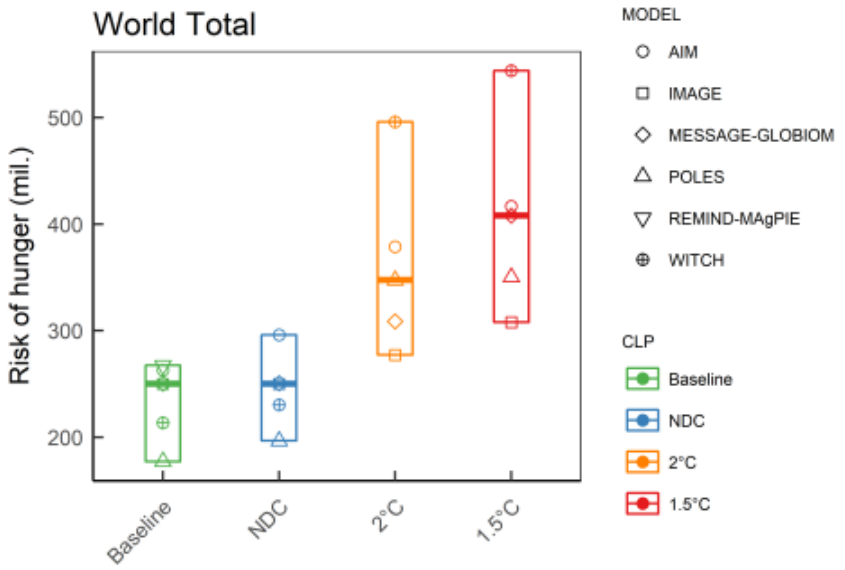
Source: Fujimori et al. (2019)

Adverse side effect (Global)



Time series

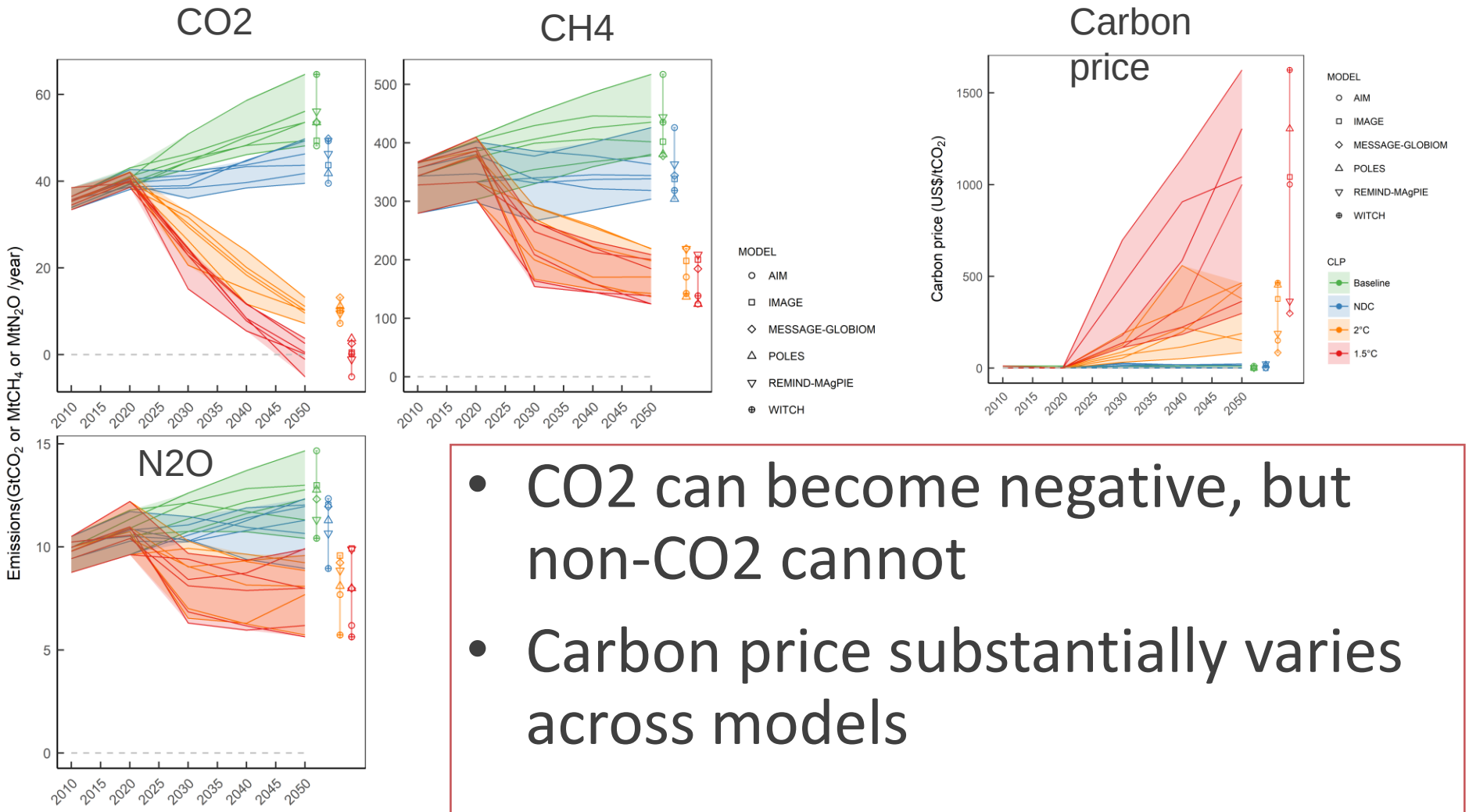


2050 snapshot

- Agreements
  - ✓ Adverse side effect of mitigation
  - ✓ Stringency of mitigation policy matters
    - ➢ Much larger in 2 and 1.5 °C
- Large uncertainty

Source: Fujimori et al. (2019)

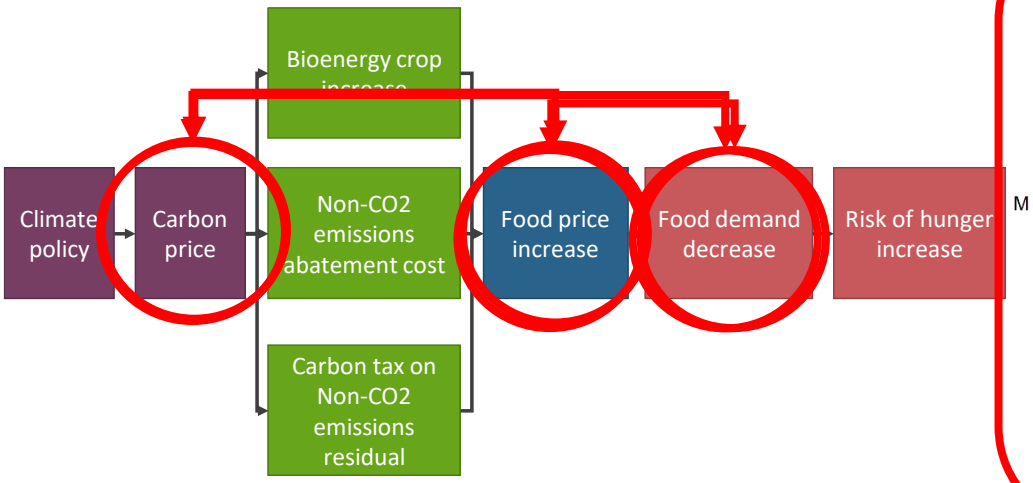
Emissions and carbon prices

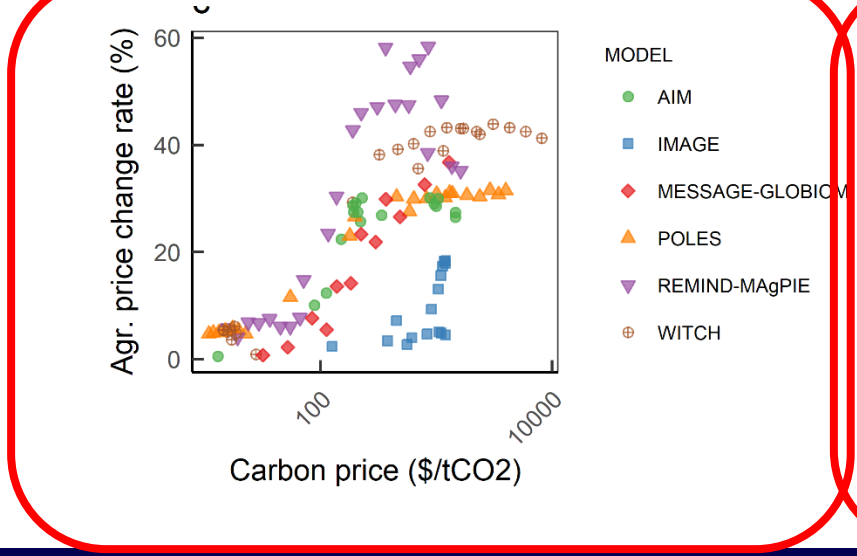


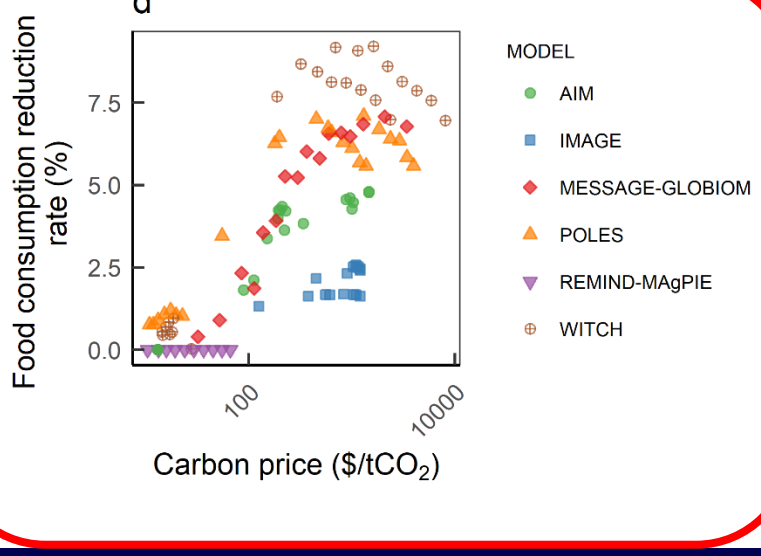
- CO2 can become negative, but non-CO2 cannot
- Carbon price substantially varies across models

Source: Fujimori et al. (2019)

Model responses are heterogenous







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Discussion and Conclusions

- Explored mitigation and food security trade-off with MIP
- Food security is robustly affected adversely
- Alternative policy designs that can help to eradicate negative side effect of mitigation policy
- Large model uncertainty - origins:
  - Food price elasticities (model assumptions)
  - Carbon price differences (mainly energy system representation)
  - Agricultural market or mitigation policy representation
- Further discussions and investigations needed, in particular about imposing GHG tax on agricultural systems needs further analysis

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Source: Fujimori et al. (2019)

Air Pollution and Health

Air pollution: a public health crisis

- Air pollution causes annually 5.5-7 million cases of premature deaths, about half from ambient pollution
- Largest environmental health burden

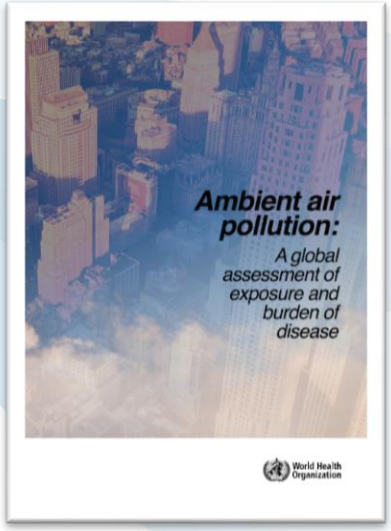
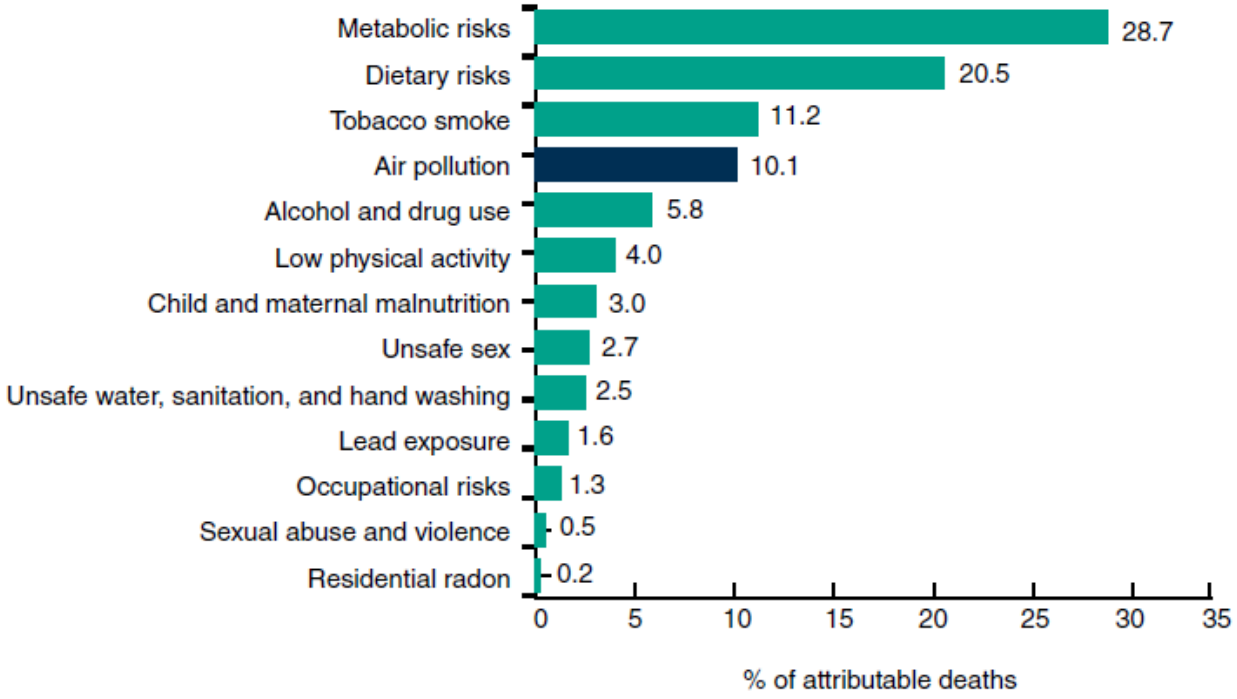


FIGURE 1.1 Percentage of Attributable Deaths by Risk Factor: Globally, 2013



Sources: World Bank and IHME, using data from IHME, GBD 2013.

Courtesy of Peter Rafaj

Welfare losses due to air pollution

Exposure to air pollution costs the world's economy some 5.1 trillion US-$/yr in welfare losses

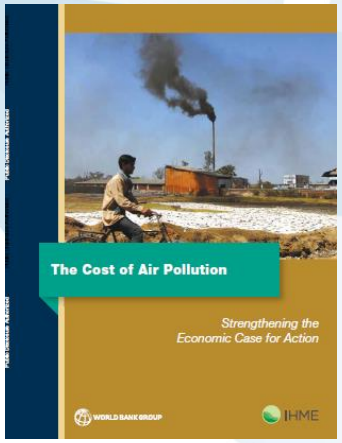
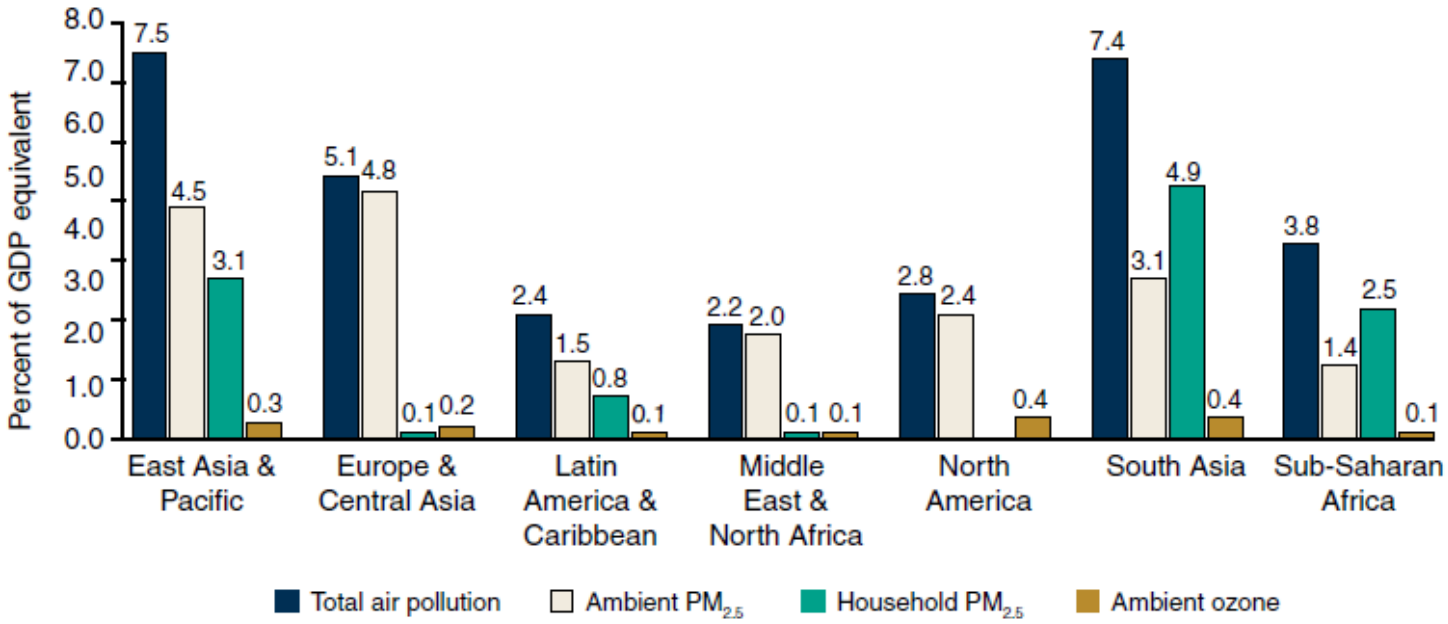


FIGURE ES.1 Welfare Losses Due to Air Pollution by Region, 2013



Sources: World Bank and IHME.

Note: Total air pollution damages include ambient $PM_{2.5}$, household $PM_{2.5}$, and ozone. GDP = gross domestic product.

GAINS - the central analytical tool for air pollution negotiations in Europe

Convention on Long-range Transboundary Pollution

1994 Second Sulphur Protocol

1999 Gothenburg Multi-pollutant/Multi-effect Protocol

2012 Revised Gothenburg Protocol

IIASA designated as EMEP Centre for Integrated Assessment Modelling

European Union

1995 EU Acidification Strategy

2001 National Emission Ceilings Directive

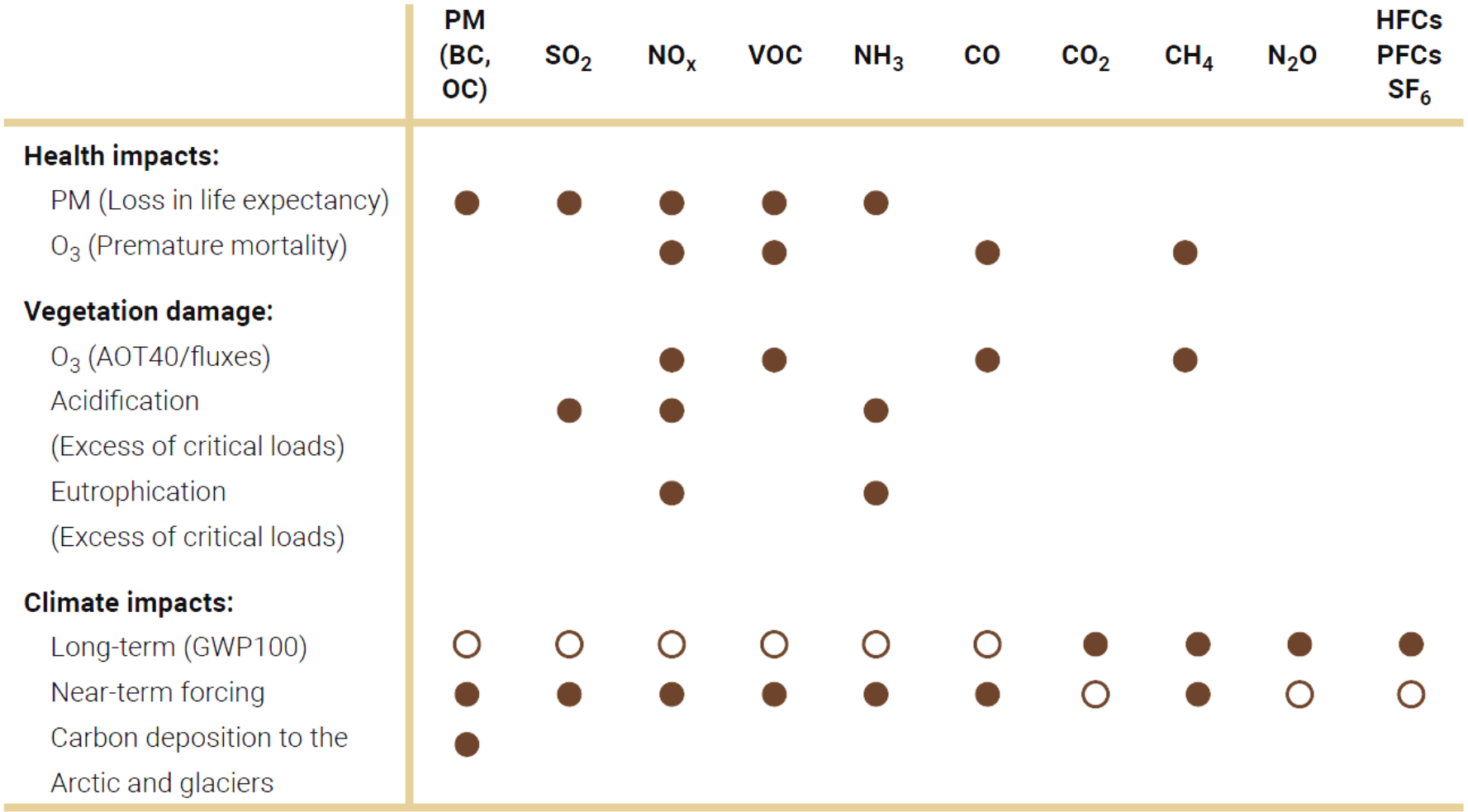
2005 Thematic Strategy on Air Pollution

2016 Clean Air Policy Package

IIASA leads the "European Consortium for Modelling of Air and Climate Strategies"

Courtesy of Peter Rafaj

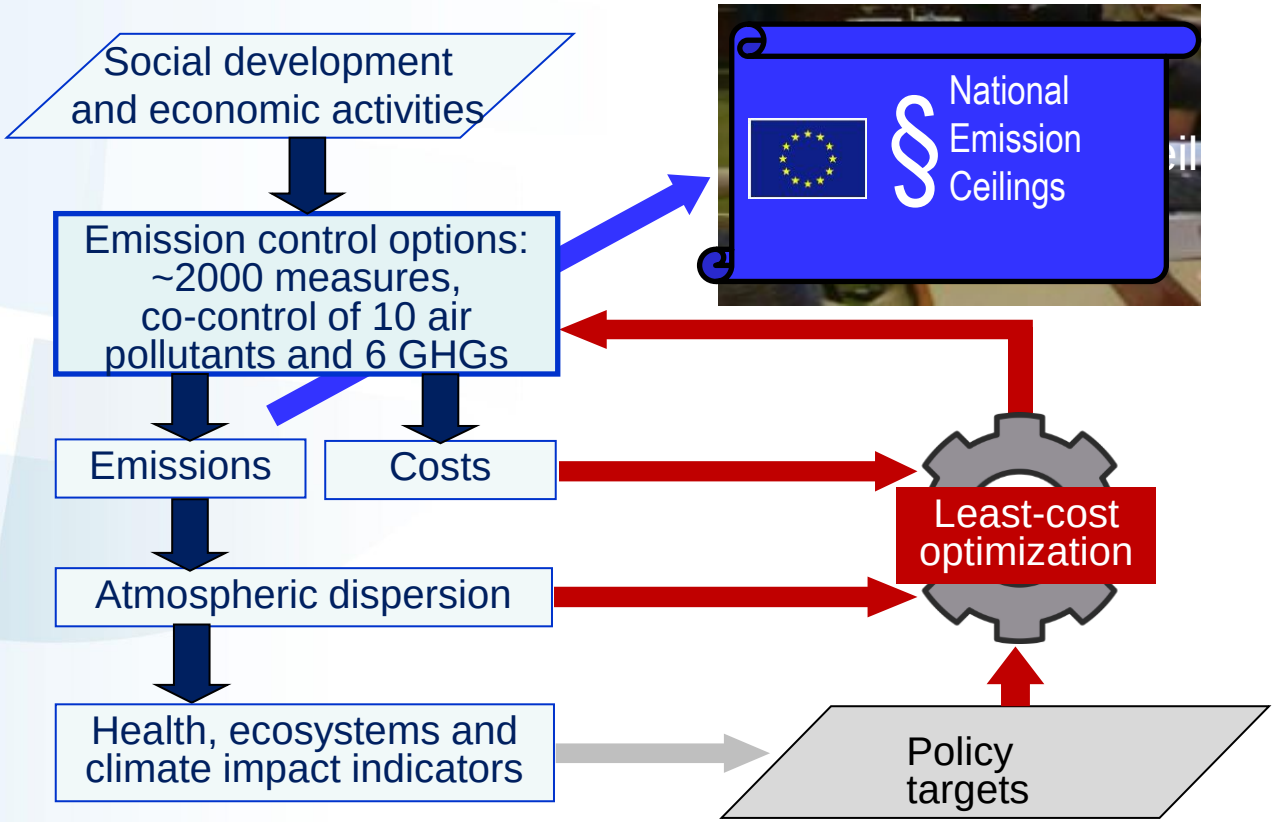
Relationship Between Air Pollutants and GHGs



Note: ● – important impact; ○ – small impact. GWP – global warming potential.

Courtesy of Peter Rafaj

Greenhouse gas–Air pollution Interactions and Synergies:
IIASA's GAINS model provides a systems approach for negotiations



Courtesy of Peter Rafaj

Emission calculation principles

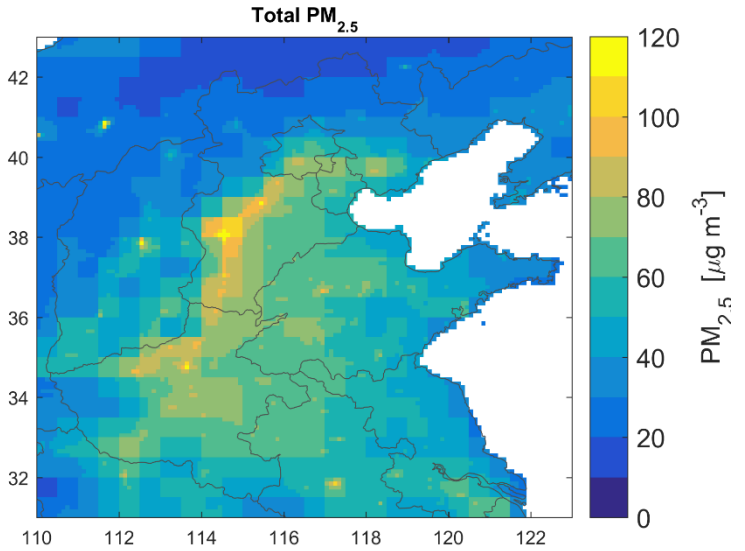
$$E_i = \sum_{j,k,m} E_{i,j,k,m} = \sum_{j,k,m} A_{i,j,k} ef_{i,j,k} (1 - eff_m) X_{i,j,k,m}$$

i,j,k,m	Country, sector, fuel, abatement technology
E_i	Emissions in country *i*
A	Activity in a given sector
ef	"Raw gas" emission factor
eff_m	Reduction efficiency of the abatement option *m*
X_m	Implementation rate of the considered abatement measure *m*

Courtesy of Peter Rafaj

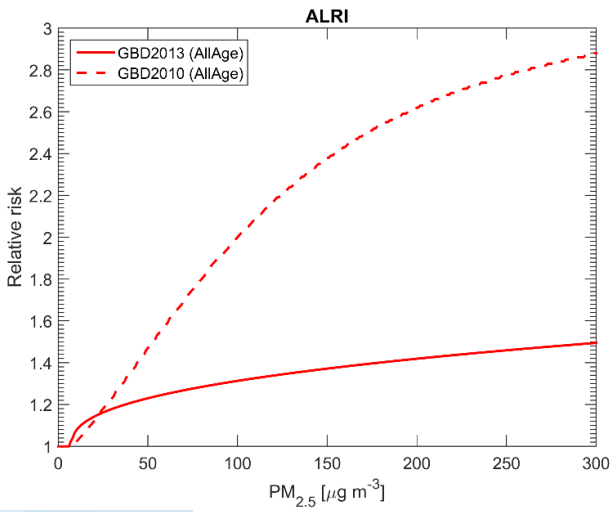
Annual mean ambient $PM_{2.5}$ calculations

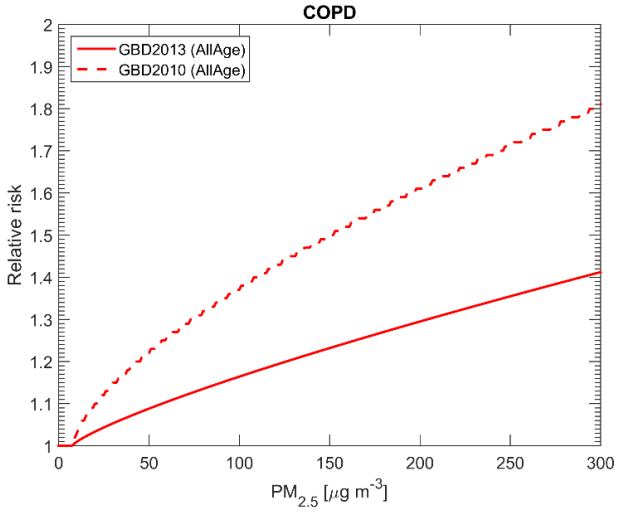
- PM2.5 is calculated from emissions of primary PM, SO2, NOx, NH3, VOCs
- Methodology: “Transfer coefficients” = linear relationships which describe the influence of emissions of one pollutant from one source region to a grid cell
- Grid resolution needs to be adequate to the purpose! typically a few km (GAINS global: 0.1º)
- Example from “global” GAINS model:

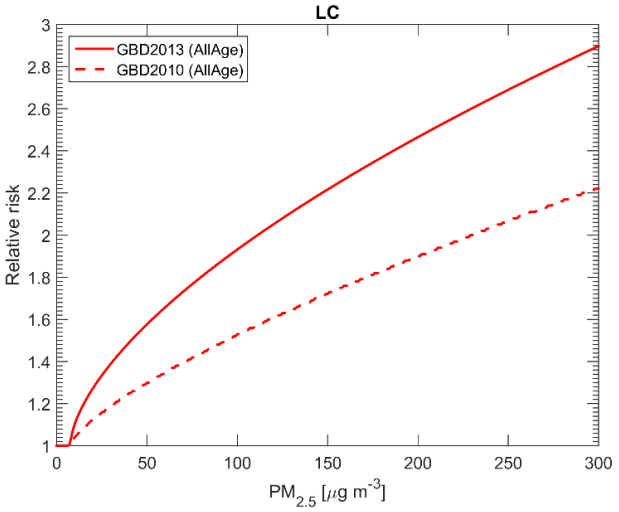


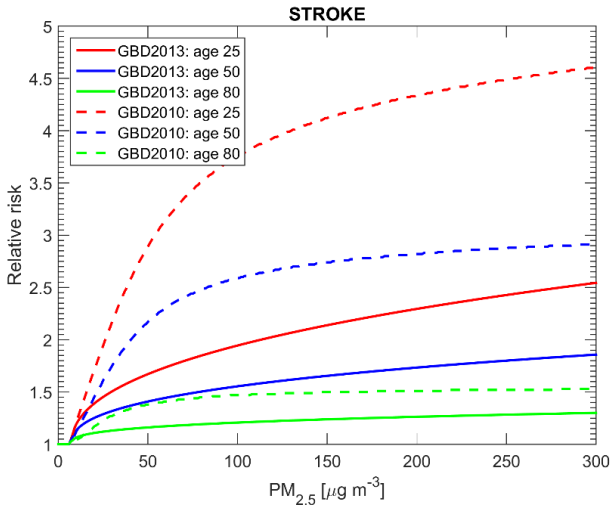
Courtesy of Peter Rafaj

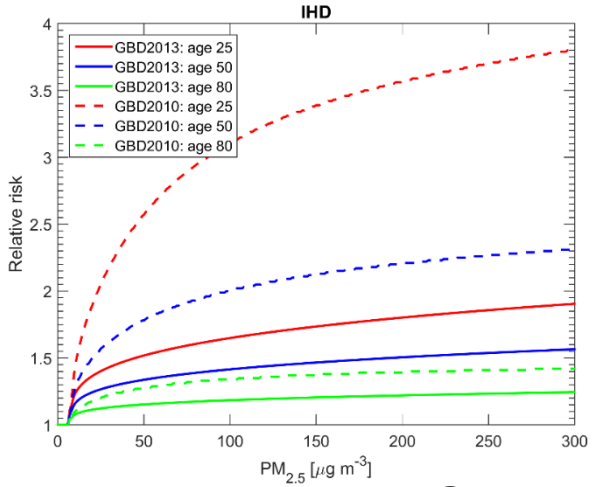
Exposure-response functions: GBD 2013











Courtesy of Peter Rafaj

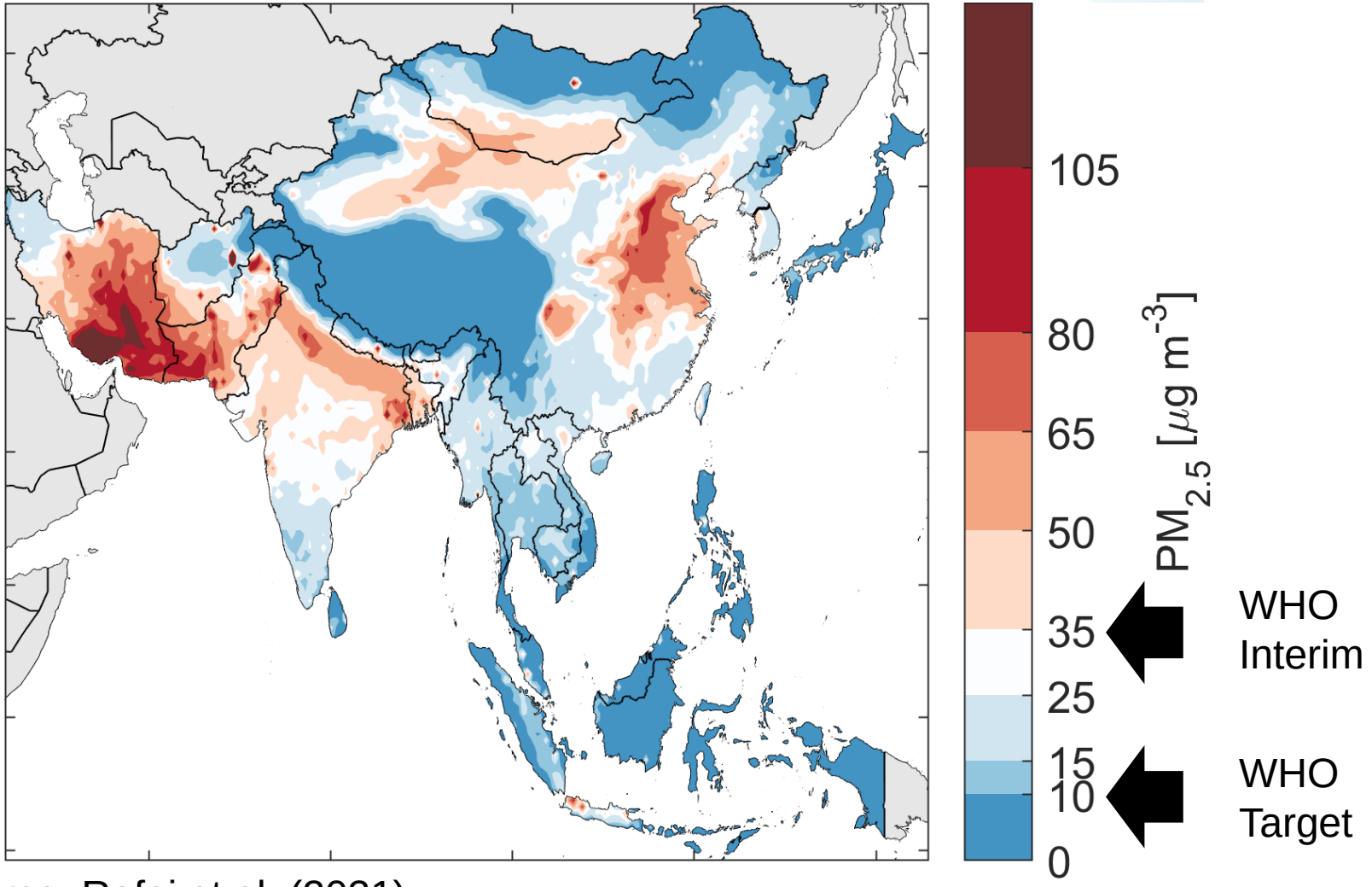
IAM-GAINS linkage: Standardized variable mapping

CD-LINKS sector		CD-LINKS fuel	←	GAINS fuel	GAINS sector				
Final Energy	Residential and Commercial	Biomass Coal Gases Liquids Electricity Heat Geothermal Solar	← ← ← ← ← ← ← ←	OS1 OS2 HC1 HC2 HC3 BC1 BC2 DC GAS MD GSL LPG HF ELE HT GTH STH	Residential (DOM_RES) Services (DOM_COM) Domestic others (DOM_OTH)				
Final Energy	Industry	Biomass Coal Gases Liquids Electricity Heat Other Other	← ← ← ← ← ← ← ←	OS1 OS2 HC1 HC2 HC3 BC1 BC2 DC GAS MD GSL LPG HF ELE HT GTH STH	Paper & Pulp (IN_PAP_OC) Paper & Pulp Boilers (IN_PAP_BO)	Iron & Steel (IN_ISTE_OC) Non-Metalic Minerals (IN_NMM_OC)	Chemical industry (IN_CHEM_OC) Chemical industry boilers (IN_CHEM_BO)	Non-Ferrous Metals (IN_NFME_OC) Conversion Sector Boilers (IN_CON_BO)	Other Industry (IN_OTH_OC) Other Industry Boilers (IN_OTH_BO)
Primary Energy	Input to Power sector incl. CCS	Biomass Coal Gas Oil Nuclear Hydro Geothermal Solar Wind	← ← ← ← ← ← ← ← ←	OS1 OS2 HC1 HC2 HC3 BC1 BC2 DC GAS MD GSL LPG HF NUC HYD GTH SPV STH WND	Existing power plants (PP_EX_OTH)	New plants (PP_NEW)	Advanced plants (PP_MOD)	IGCCplants (PP_IGCC)	Engines/DG-sets (PP_ENG)
Final energy	Transport	Biomass Coal Gases Oil Electricity Hydrogen	← ← ← ← ← ←	(included in mineral oil products) HC1 HC2 HC3 BC1 BC2 DC GAS MD GSL LPG HF ELE H2	Off-road 2-&4-stroke sources (TRA_OT_LD, TRA_OT_LB) Domestic aviation (TRA_OT_AIR) Two-wheelers 2-&4-stroke (TRA_RD_LD2, TRA_RD_M4)	Off-road machinery and construction (TRA_OT_CNS) Rail (TRA_OT_RAI) Cars (TRA_RD_LD4C)	Agriculture (TRA_OT_AGR) Light-duty cars (TRA_RD_LD4T)	Inland navigation (TRA_OT_INW) Buses (TRA_RD_HDB)	Maritime (TRA_OTS) Heavy-duty trucks (TRA_RD_HDT)

http://www.cd-links.org/wp-content/uploads/2016/06/D4.1_approved.pdf

PM2.5 Concentration: National Policies

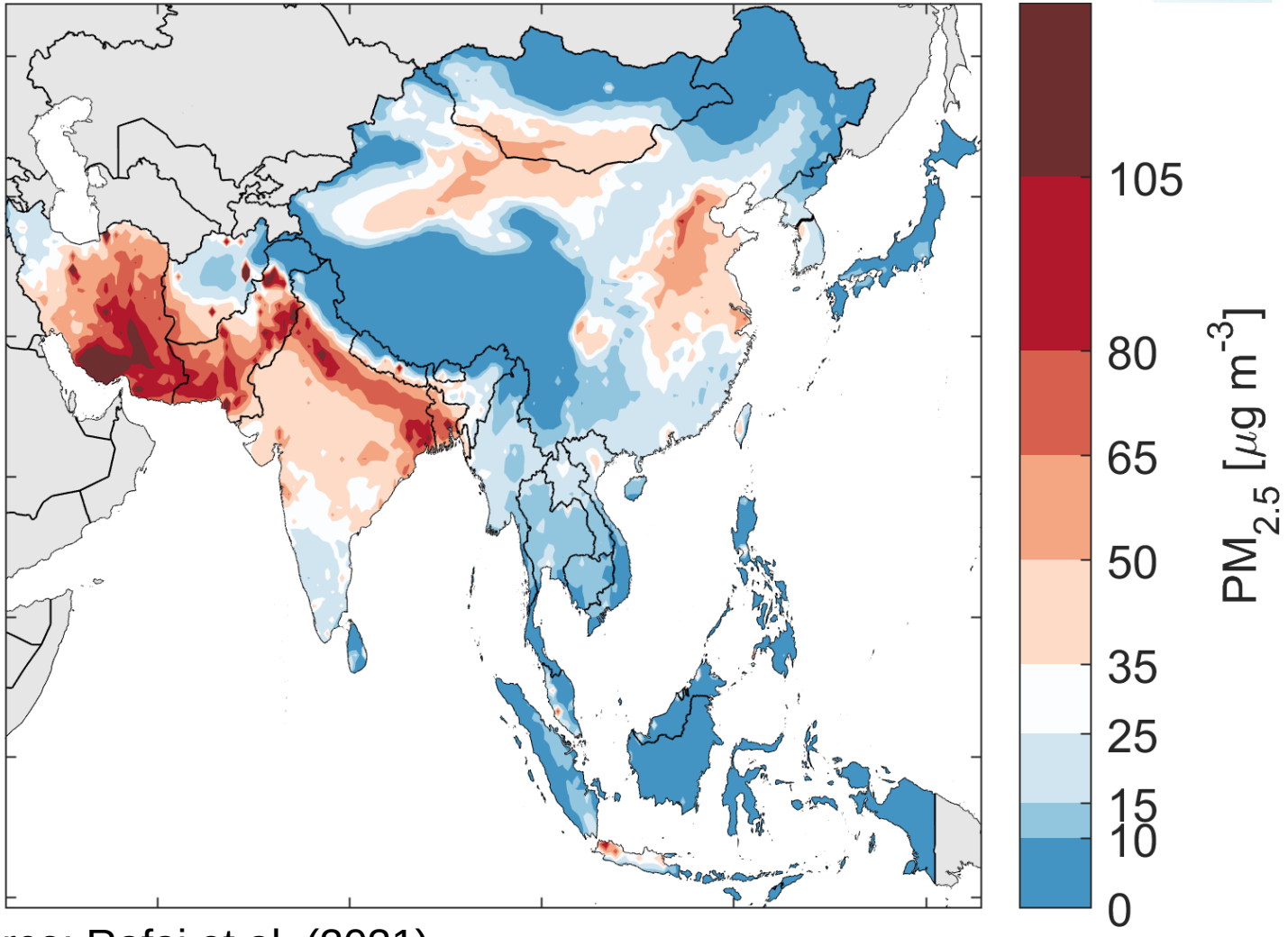
2015



Source: Rafaj et al. (2021)

PM2.5 Concentration: National Policies

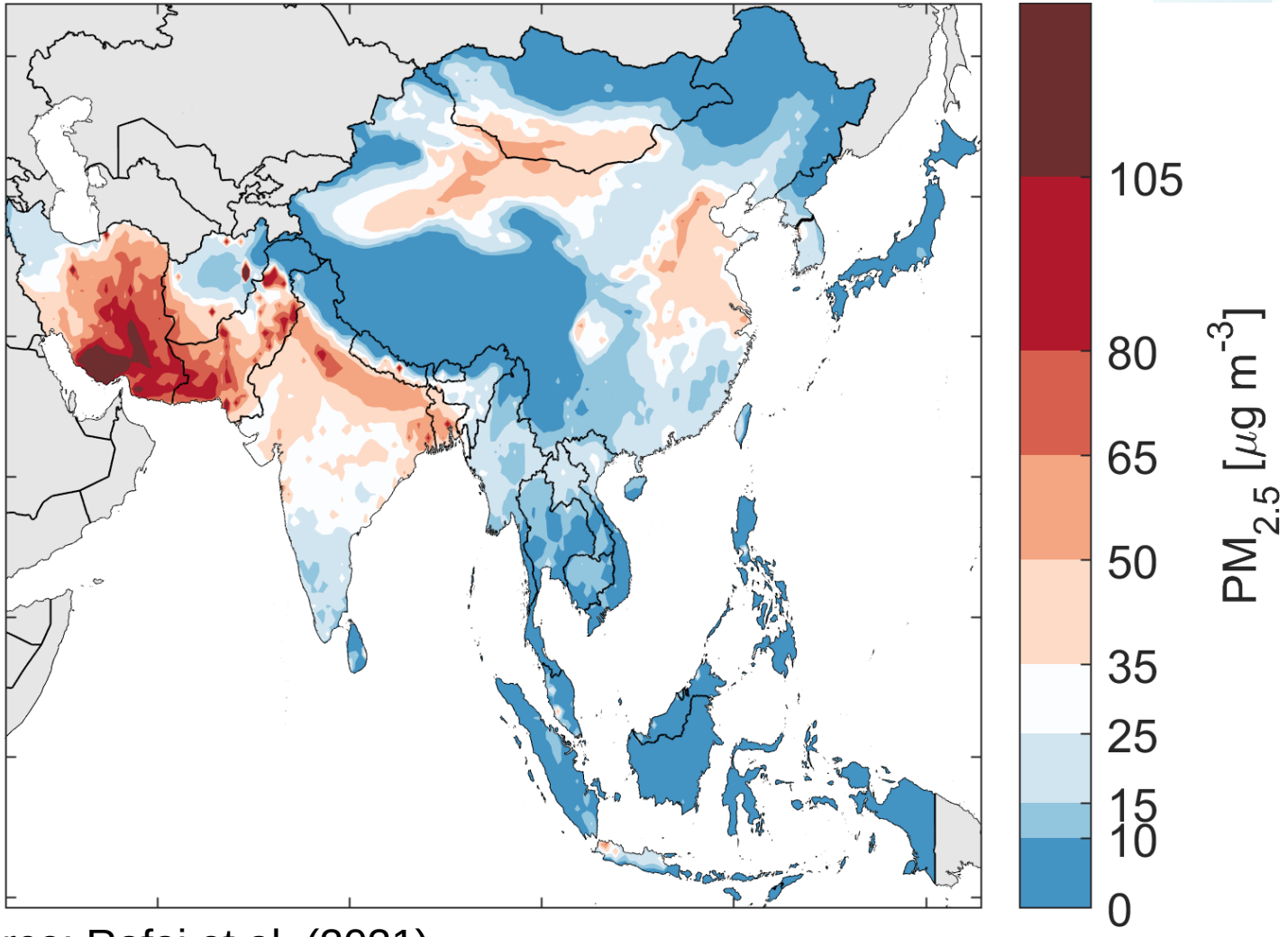
2050



Source: Rafaj et al. (2021)

PM2.5 Concentration: 2°C

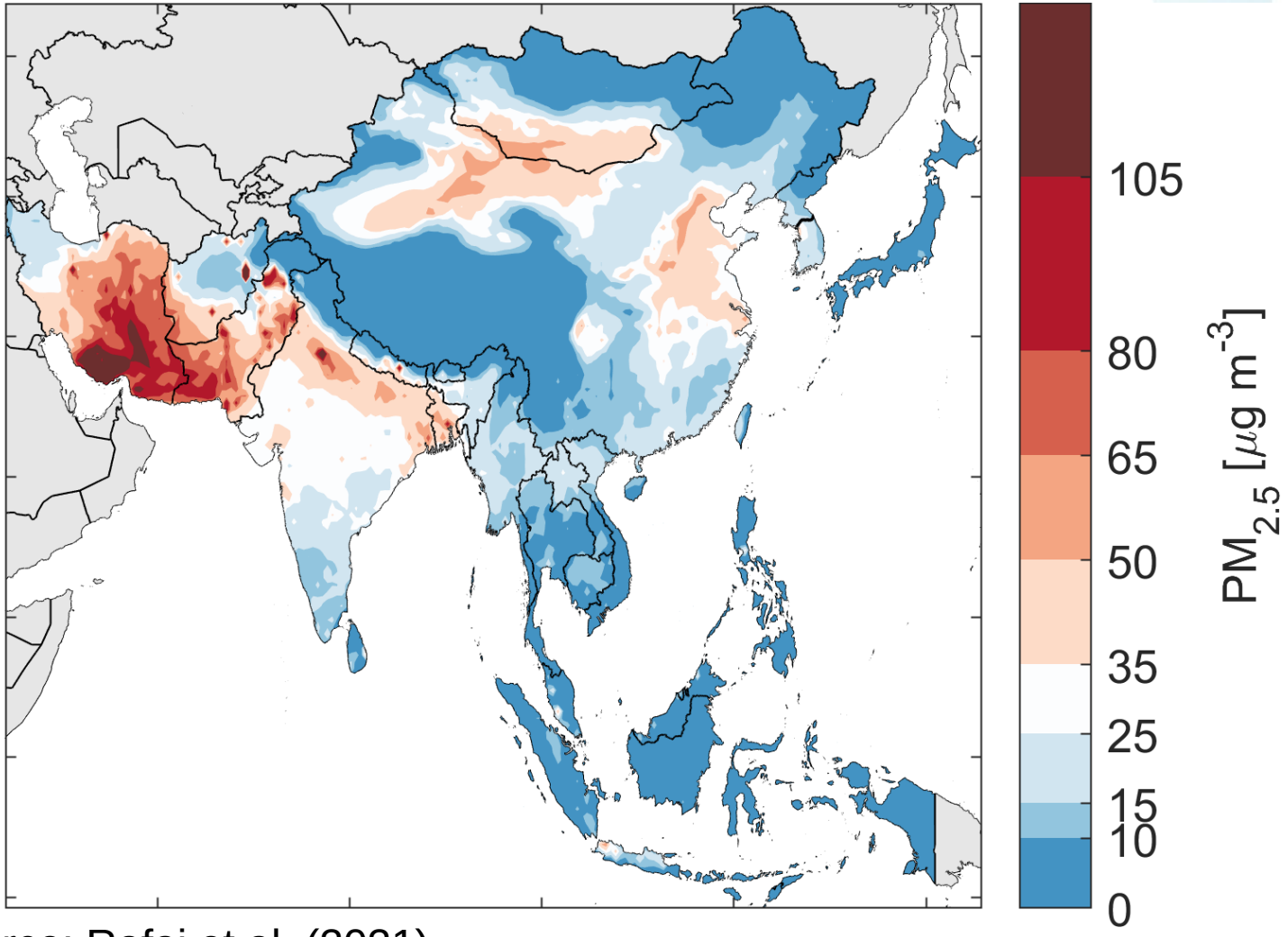
2050



Source: Rafaj et al. (2021)

PM2.5 Concentration: 1.5°C

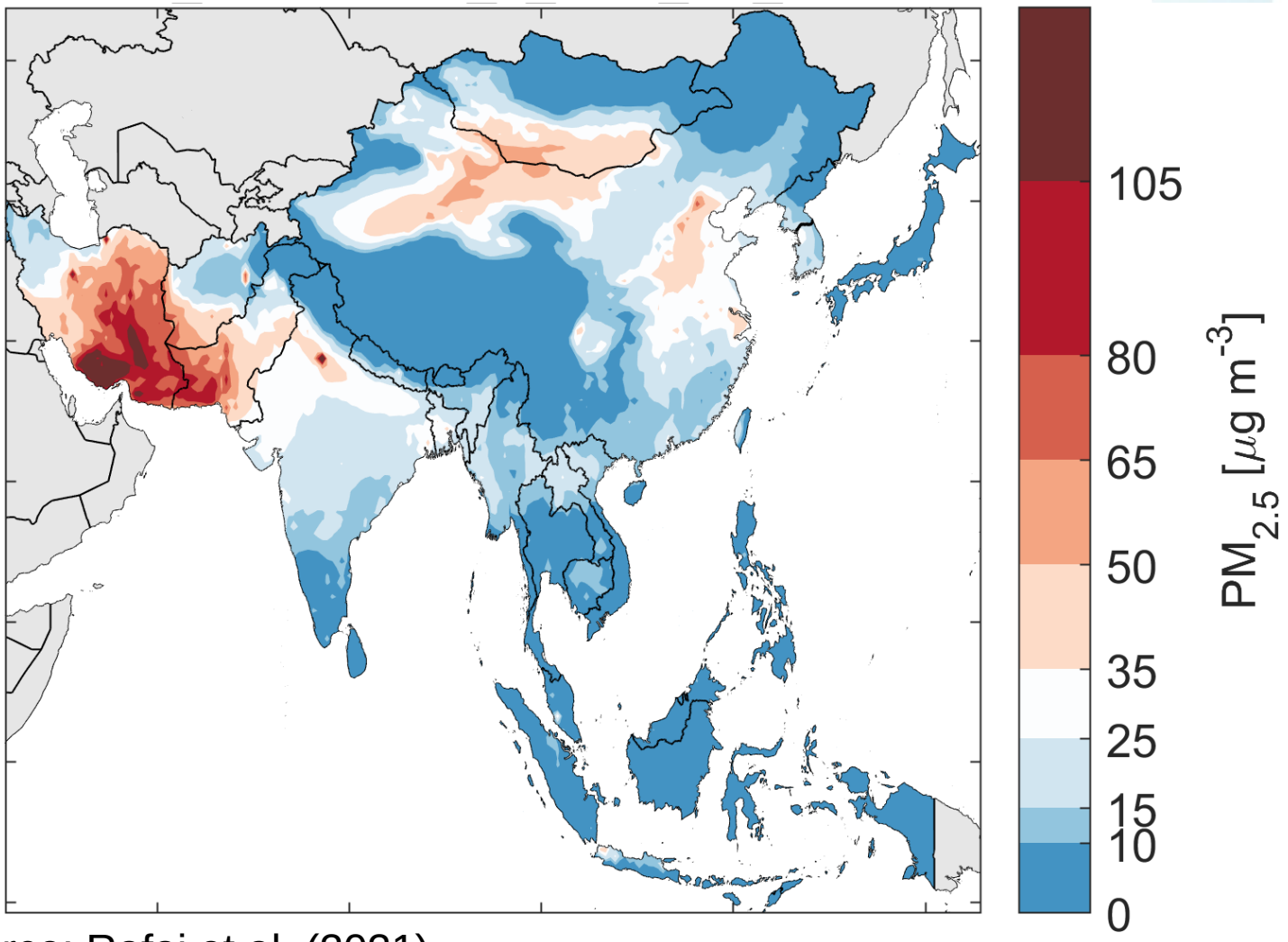
2050



Source: Rafaj et al. (2021)

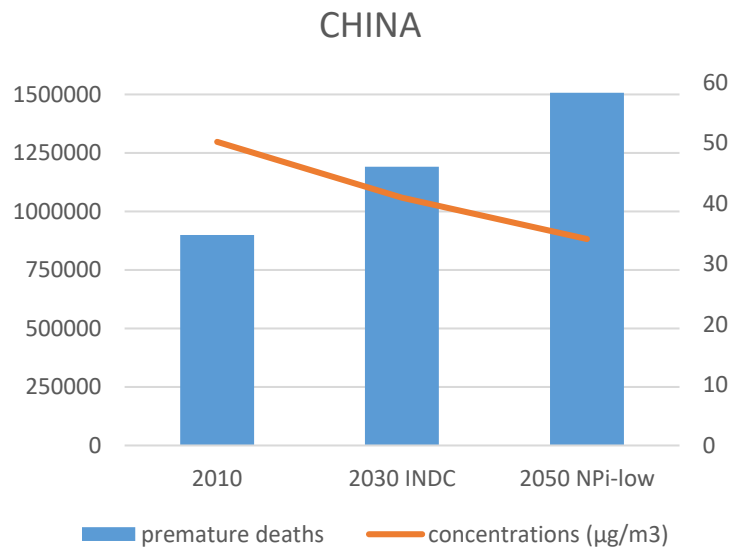
PM2.5 Concentration: 1.5°C + MFR

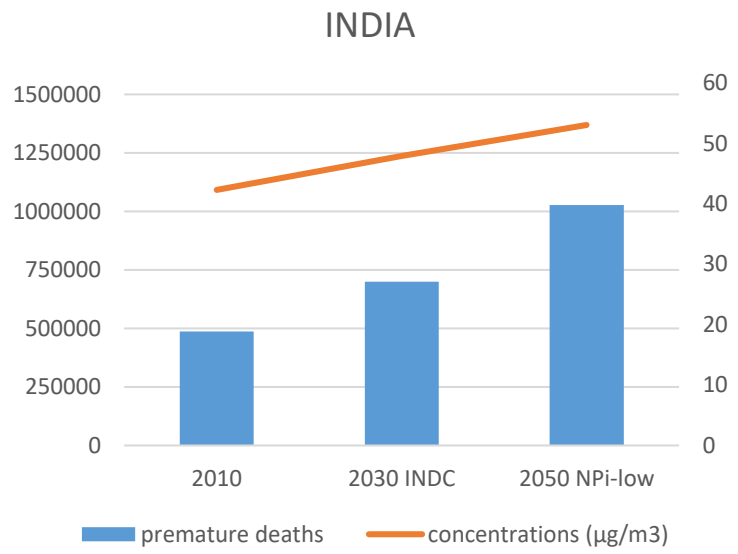
2050

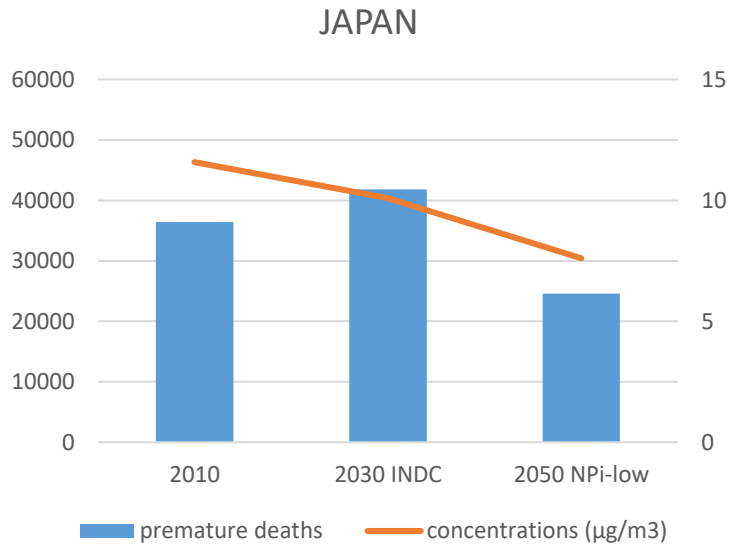


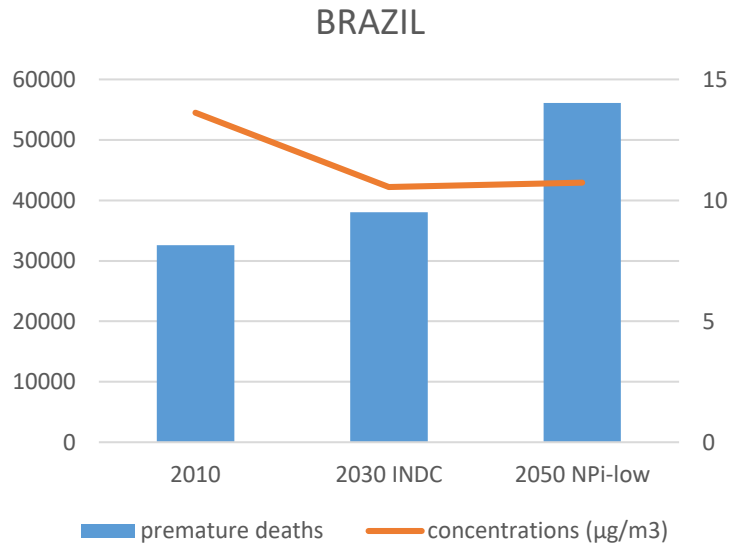
Source: Rafaj et al. (2021)

Co-benefits for $PM_{2.5}$ health impacts









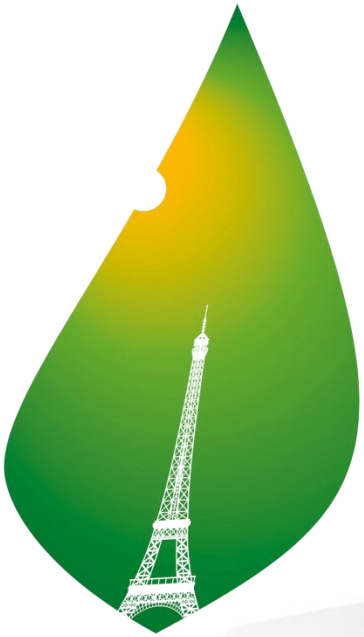
Source: Rafaj et al. (2021)

Applying integrated assessment models to assess interactions between Sustainable Development Goals

Volker Krey
International Institute for Applied Systems Analysis (IIASA)
CD-LINKS Consortium (http://www.cd-links.org/)

This project has received funding from the **European Union's Horizon 2020 research and innovation programme** under grant agreement No 642147 (CD-LINKS).

Integration across multiple SDGs



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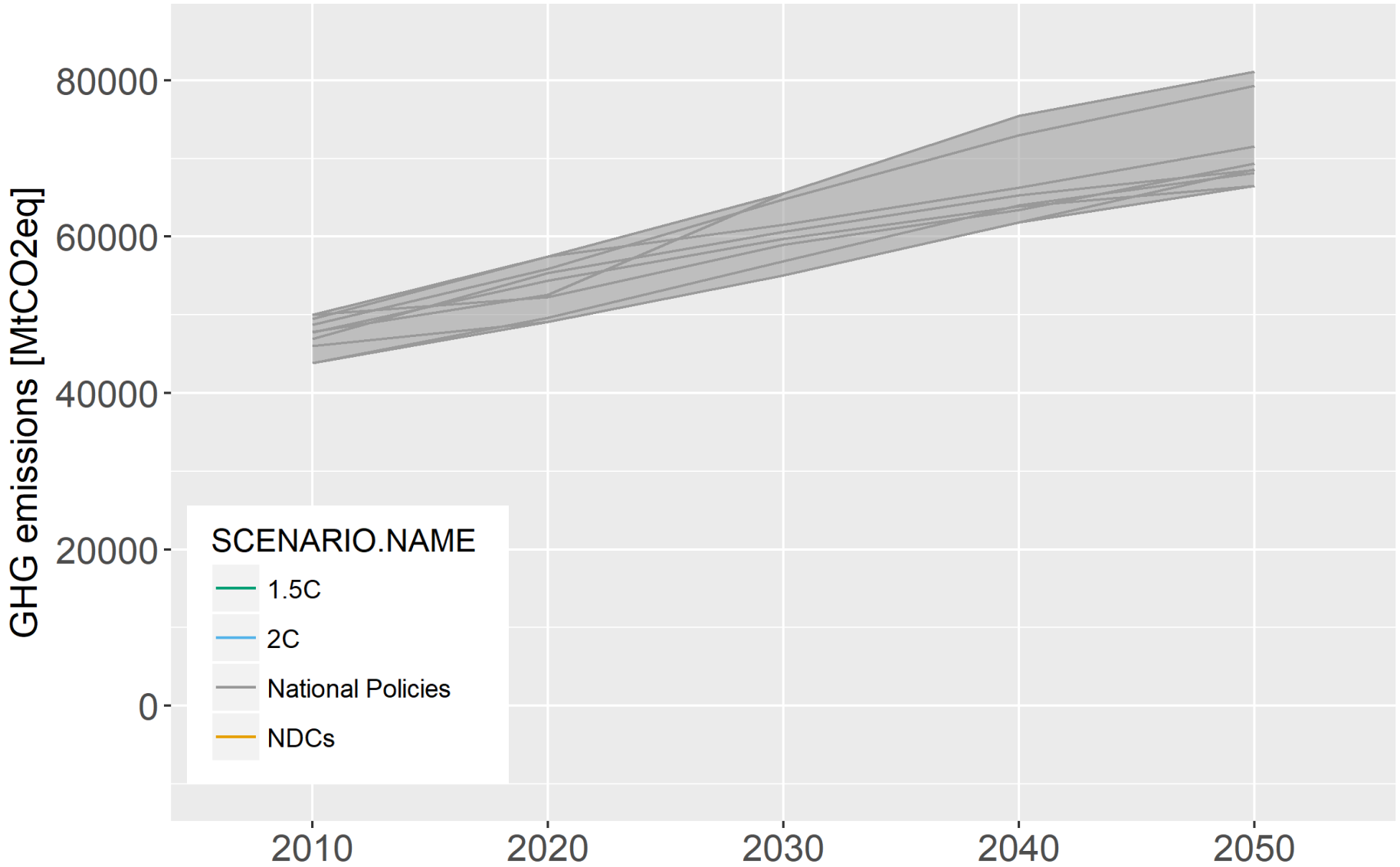
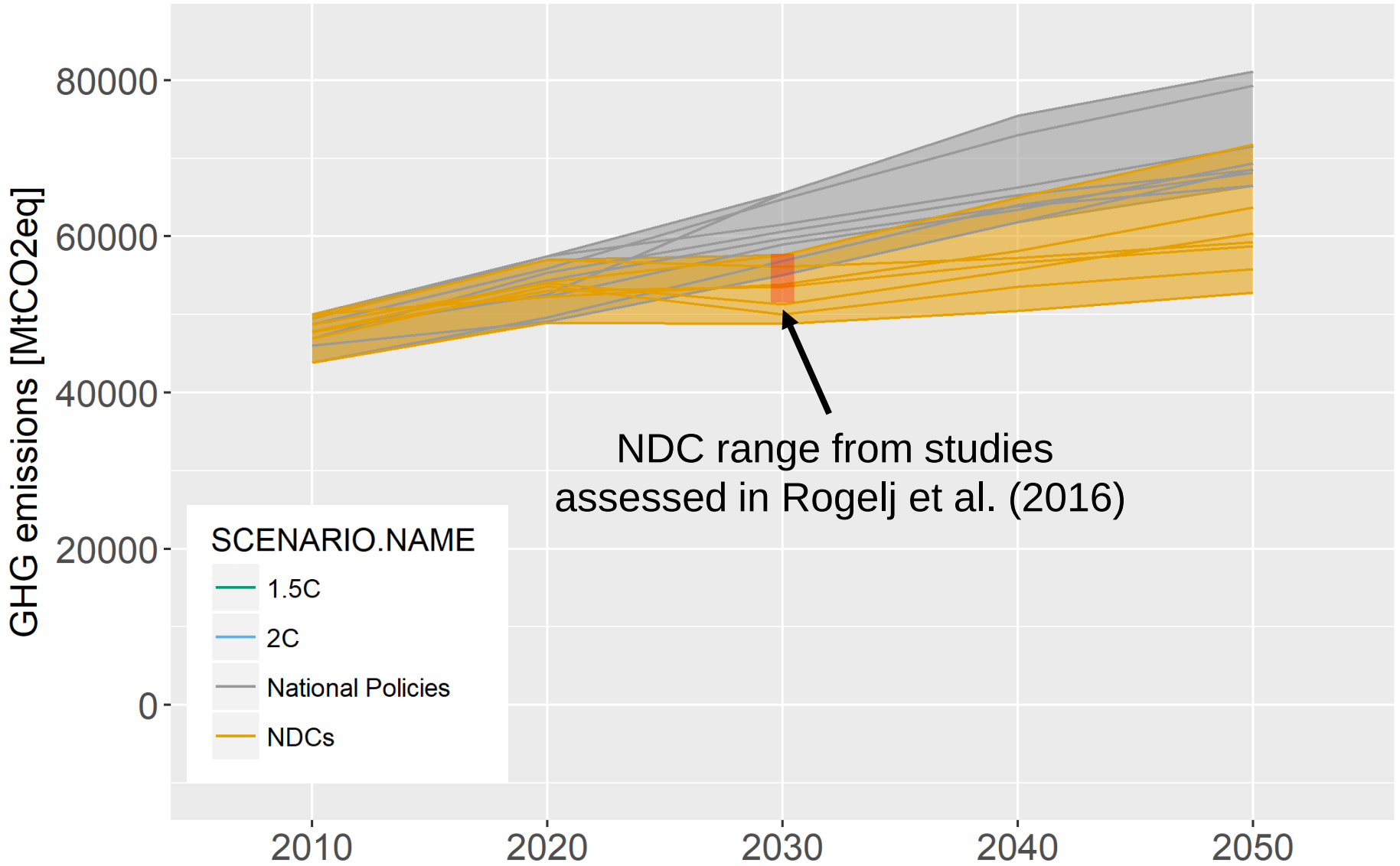
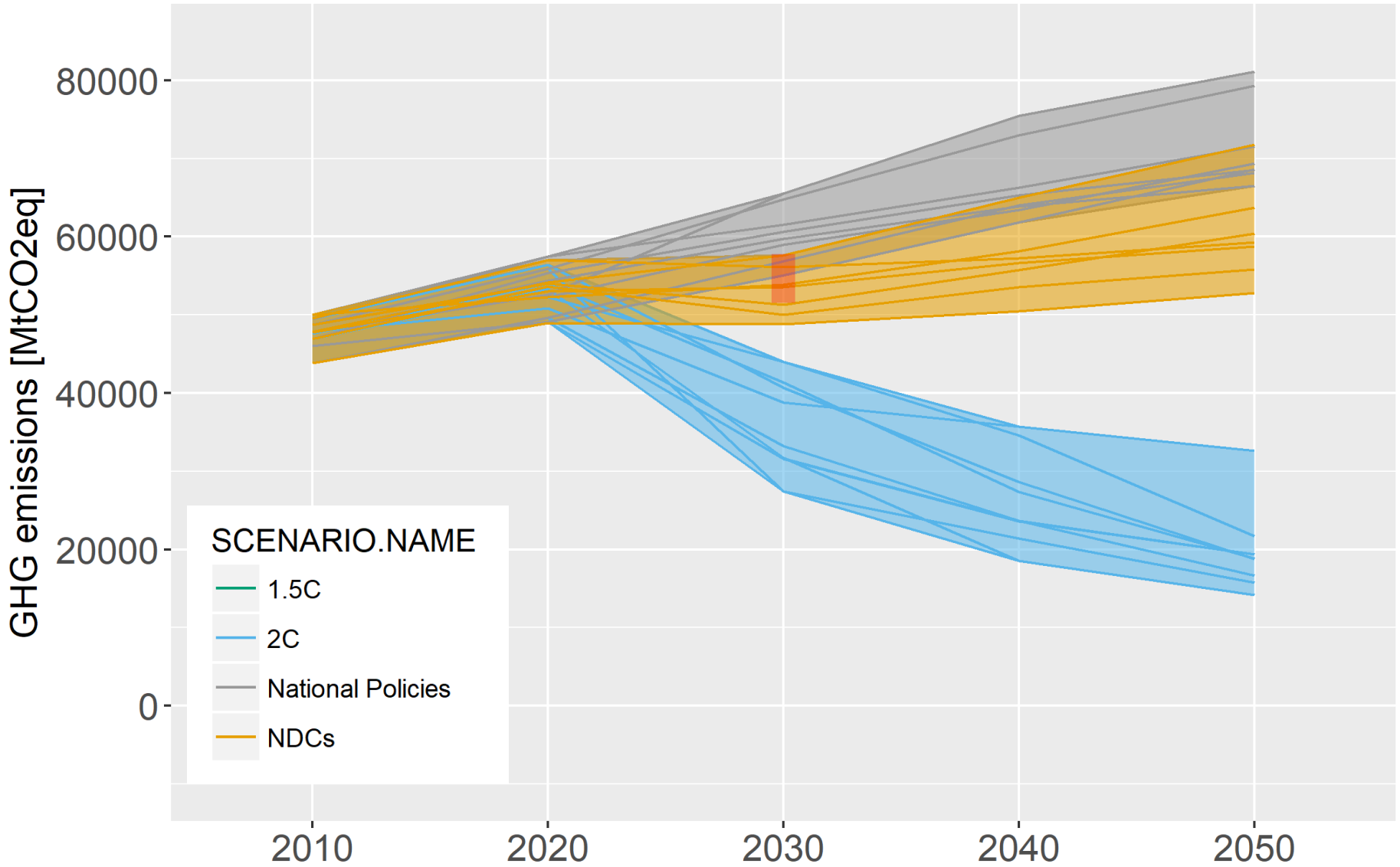
GHG Emissions



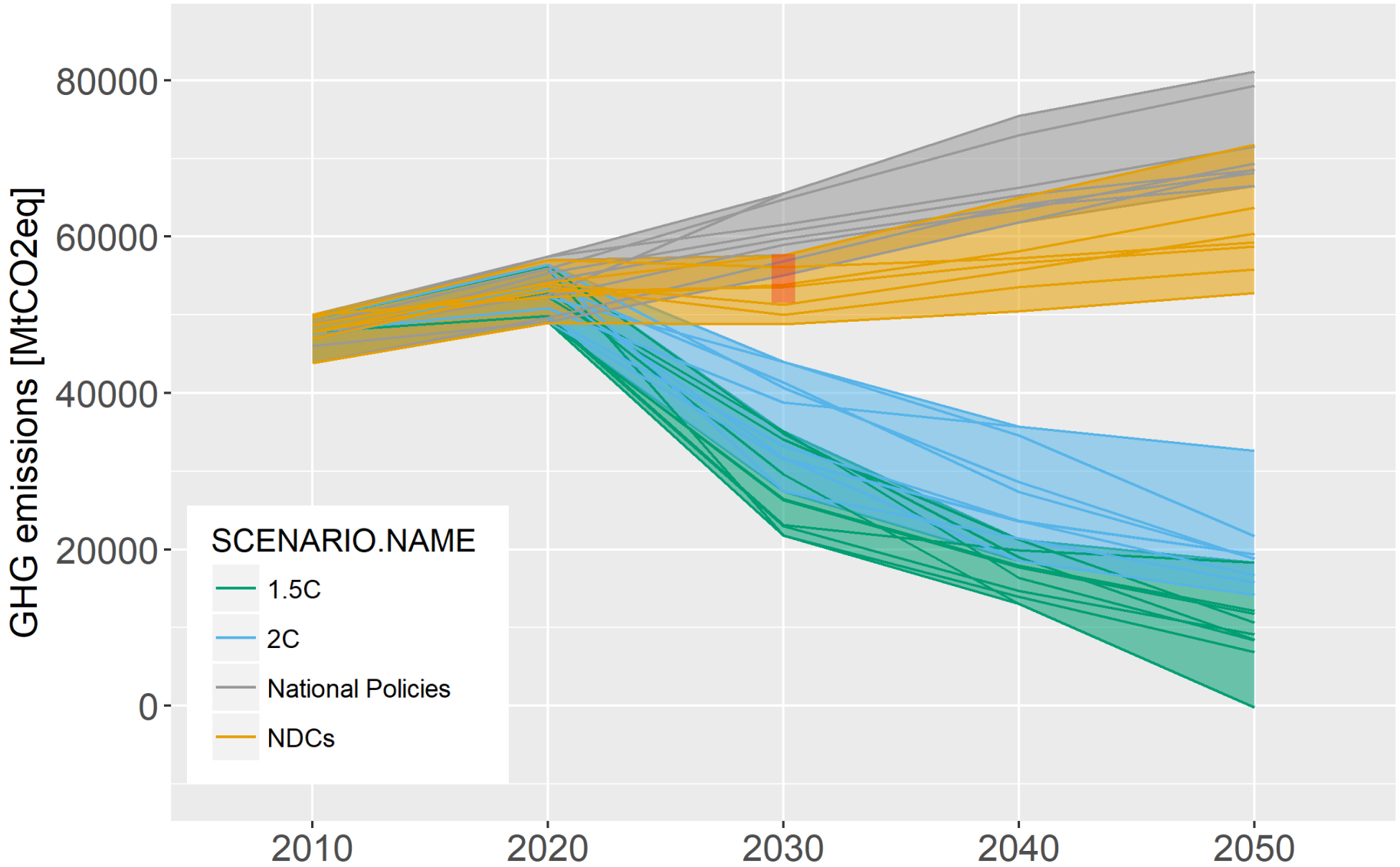
GHG Emissions



GHG Emissions



GHG Emissions



SUSTAINABLE DEVELOPMENT GOALS

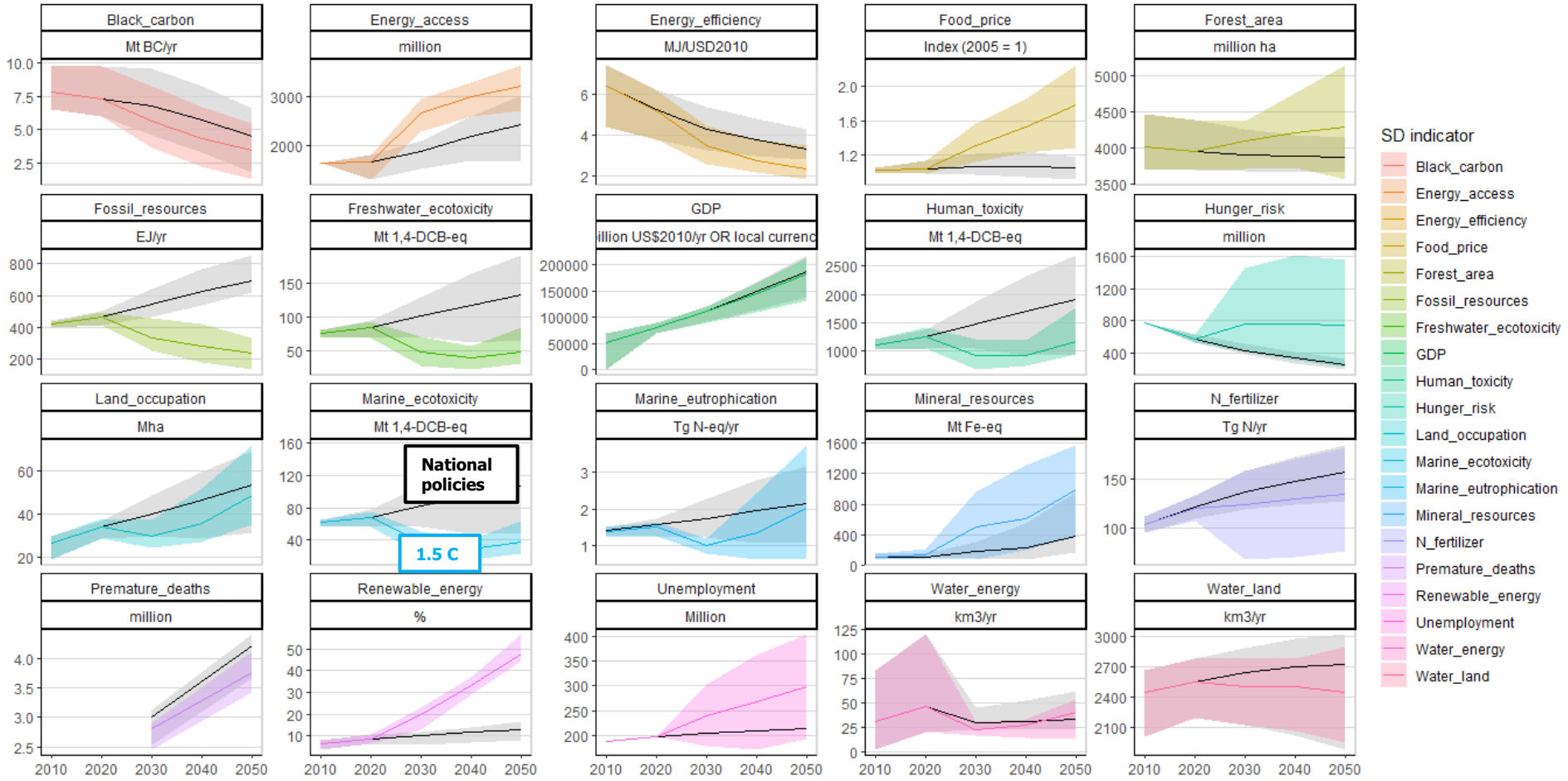
SUSTAINABLE DEVELOPMENT GOALS


SUSTAINABLE DEVELOPMENT GOALS
1 NO POVERTY
2 ZERO HUNGER
3 GOOD HEALTH AND WELL-BEING
4 QUALITY EDUCATION
5 GENDER EQUALITY
6 CLEAN WATER AND SANITATION
7 AFFORDABLE AND CLEAN ENERGY
8 DECENT WORK AND ECONOMIC GROWTH
9 INDUSTRY, INNOVATION AND INFRASTRUCTURE
10 REDUCED INEQUALITIES
11 SUSTAINABLE CITIES AND COMMUNITIES
12 RESPONSIBLE CONSUMPTION AND PRODUCTION
13 CLIMATE ACTION
14 LIFE BELOW WATER
15 LIFE ON LAND
16 PEACE, JUSTICE AND STRONG INSTITUTIONS
17 PARTNERSHIPS FOR THE GOALS
SUSTAINABLE DEVELOPMENT GOALS

SDG Indicators and Modeling Tools

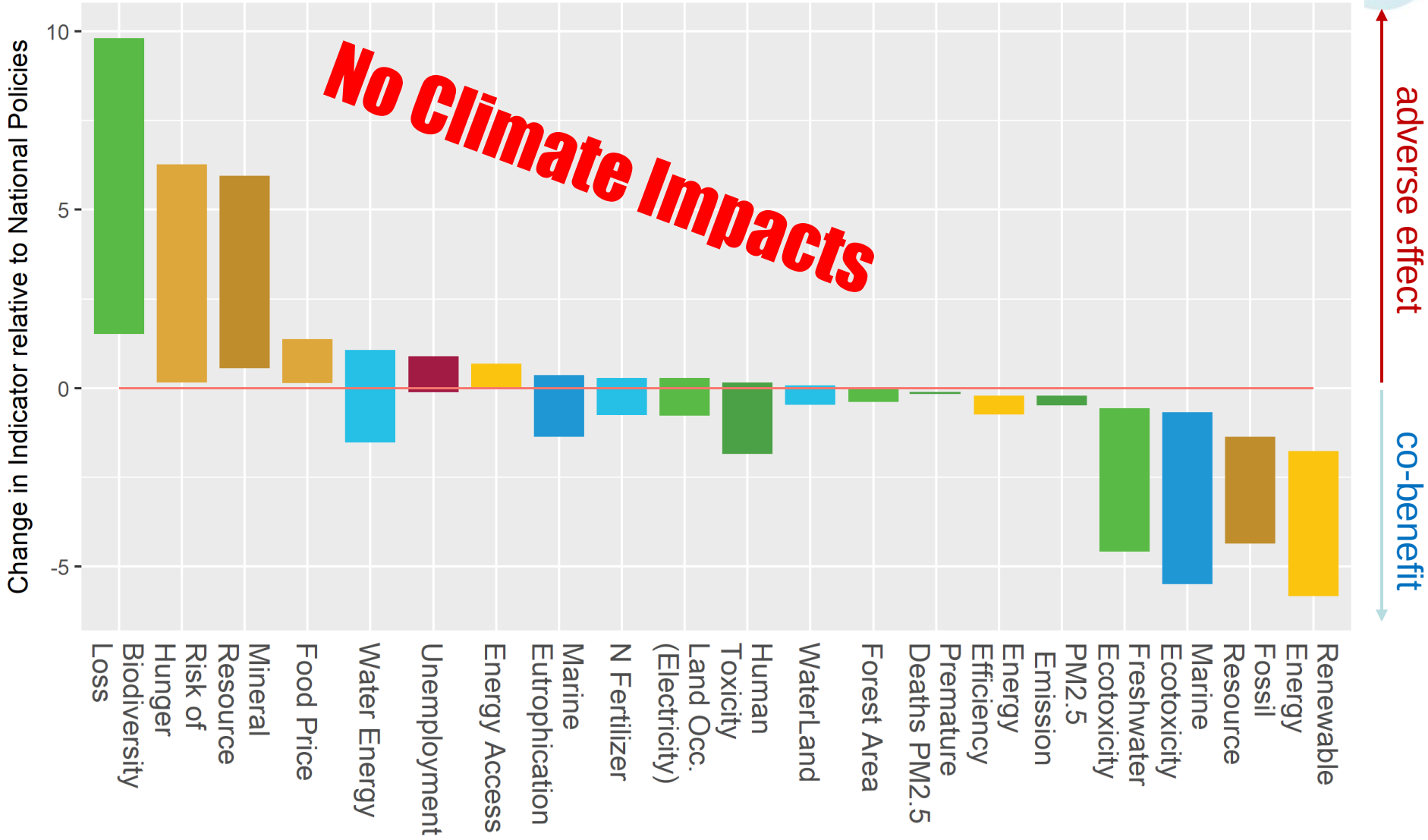
SDG		Target	Indicator (sectoral limitation) [units]	Evidence Base	
#				# of IAMs	Method
2	Zero Hunger	2.1	Population at risk of hunger [million]	5	ex-post (FAO)
			Food (non-energy crop & livestock) price index [-]	4	endogenous
3	Good Health and Well-being	3.9	Mortality due to outdoor air pollution (energy system) [million/yr]	3	ex-post (GAINS)
		3.9	PM2.5 emissions [kt PM2.5/yr]	3	ex-post (GAINS)
		3.9	Human toxicity (electricity generation) [kg 1,4-DCB-eq]	5	ex-post (LCA)
6	Clean Water and Sanitation	6.4	Water consumption (electricity generation) [km^3/yr]	5	endogenous
		6.4	Water withdrawal for irrigation (agriculture) [km^3/yr]	4	endogenous
		6.3	Nitrogen fertilizer use (agriculture) [TgN/yr]	4	endogenous
7	Affordable and Clean Energy	7.1	Population relying on solid cooking fuels [million]	5	ex-post (M-Access)
		7.2	Primary renewable energy share (excl. traditional biomass) [%]	6	endogenous
		7.3	Final energy intensity [MJ/$\$_{2010}$]	7	endogenous
8	Decent Work and Economic Growth	8.1	GDP per capita [1000 $\$_{2010}$/cap]	5	endogenous
		8.5	Unemployment [million]	1	endogenous
12	Responsible Consumption and Production	12.2	Mineral resource use (electricity generation) [Mt Fe-eq/yr]	5	ex-post (LCA)
		12.2	Fossil energy resource use [EJ/yr]	8	endogenous
14	Life Below Water	14.1	Marine eutrophication (electricity generation) [kg N-eq/yr]	5	ex-post (LCA)
			Marine ecotoxicity (electricity generation) [kg 1,4-DCB-eq]	5	ex-post (LCA)
15	Life on Land	15.1	Forest area [Mha]	6	endogenous
		15.1	Freshwater toxicity (electricity generation) [kg 1,4-DCB-eq]	5	ex-post (LCA)
			Land occupation (electricity generation) [Mha]	5	ex-post (LCA)
		15.5	Animal species with habitat loss >50% (agriculture/forestry) [%]	1	ex-post (AIM/Diversity)

Climate Policy Impact on SDG: Timeseries for selected variables



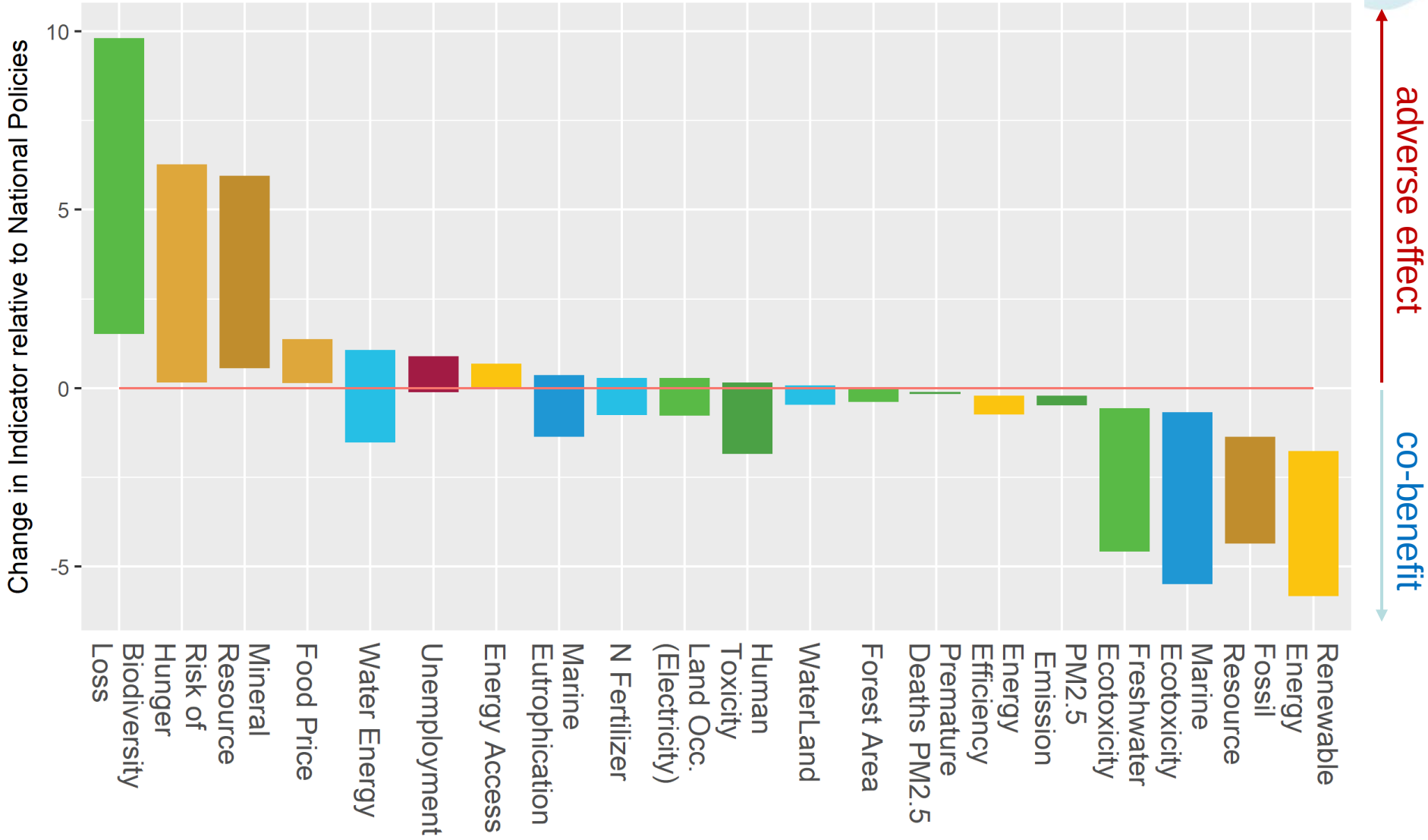
Climate Policy Impact on SDG: 1.5°C

2050

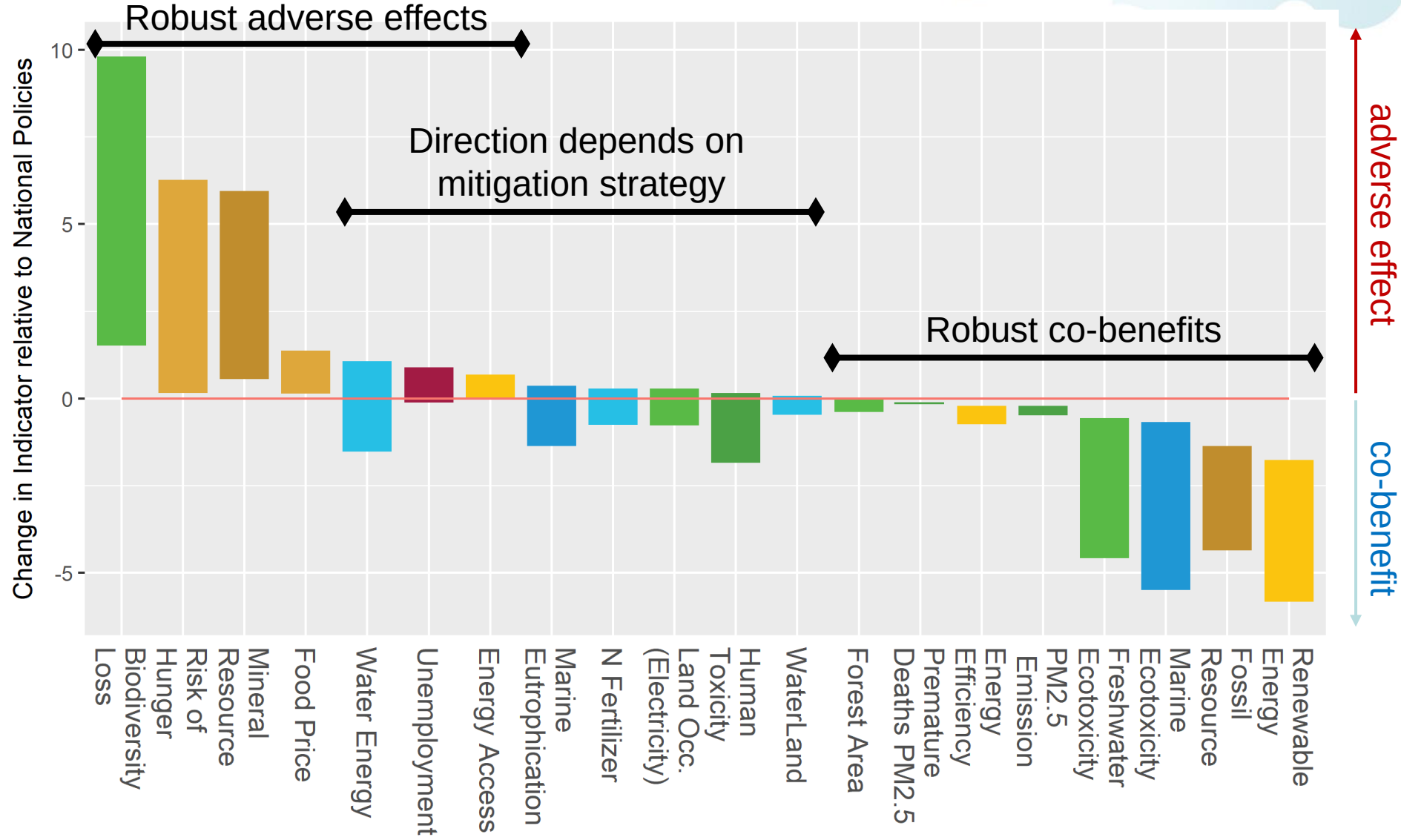


Climate Policy Impact on SDG: 1.5°C

2050

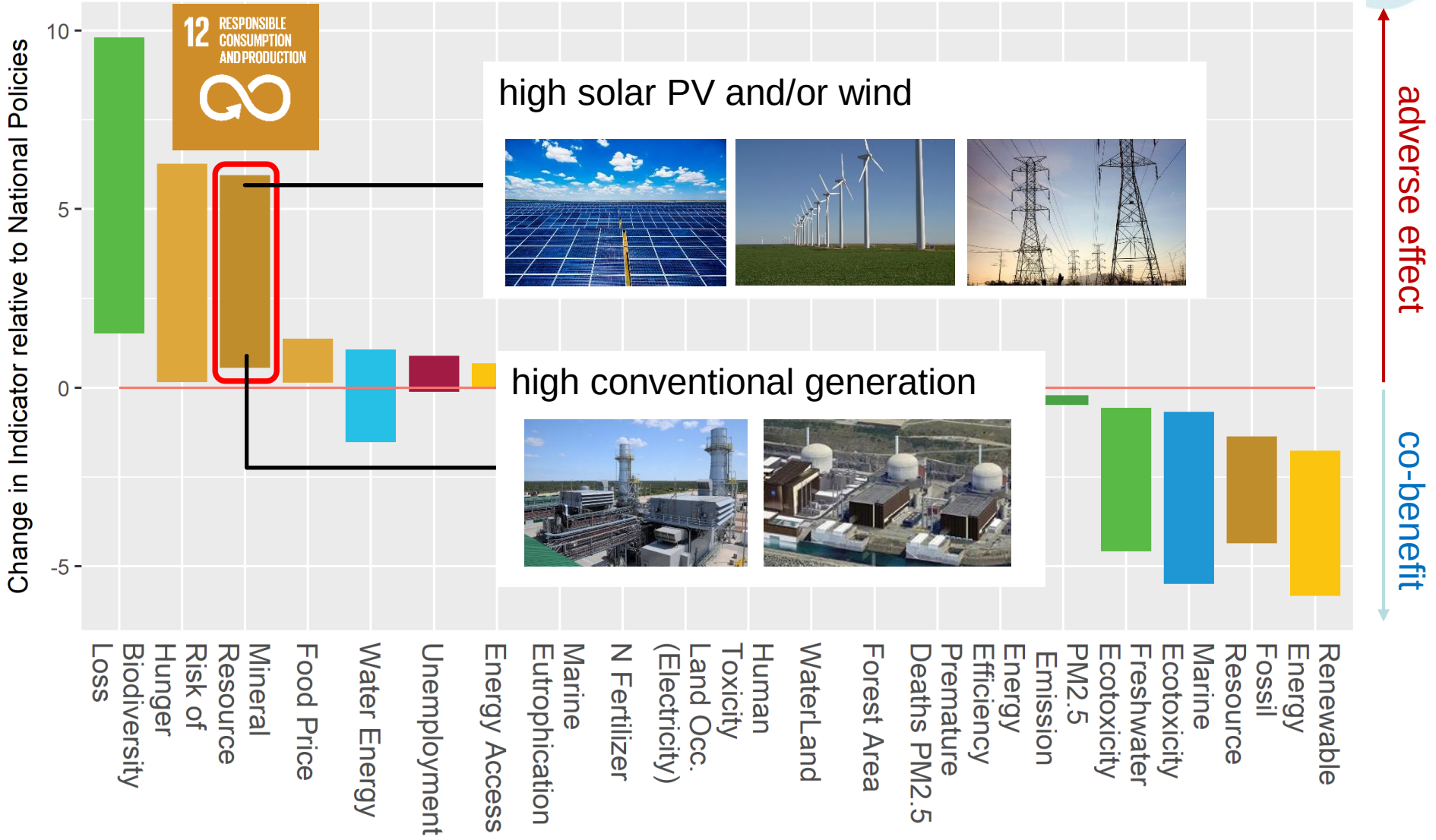


Climate Policy Impact on SDG: 1.5°C 2050



Climate Policy Impact on SDG: 1.5°C

2050



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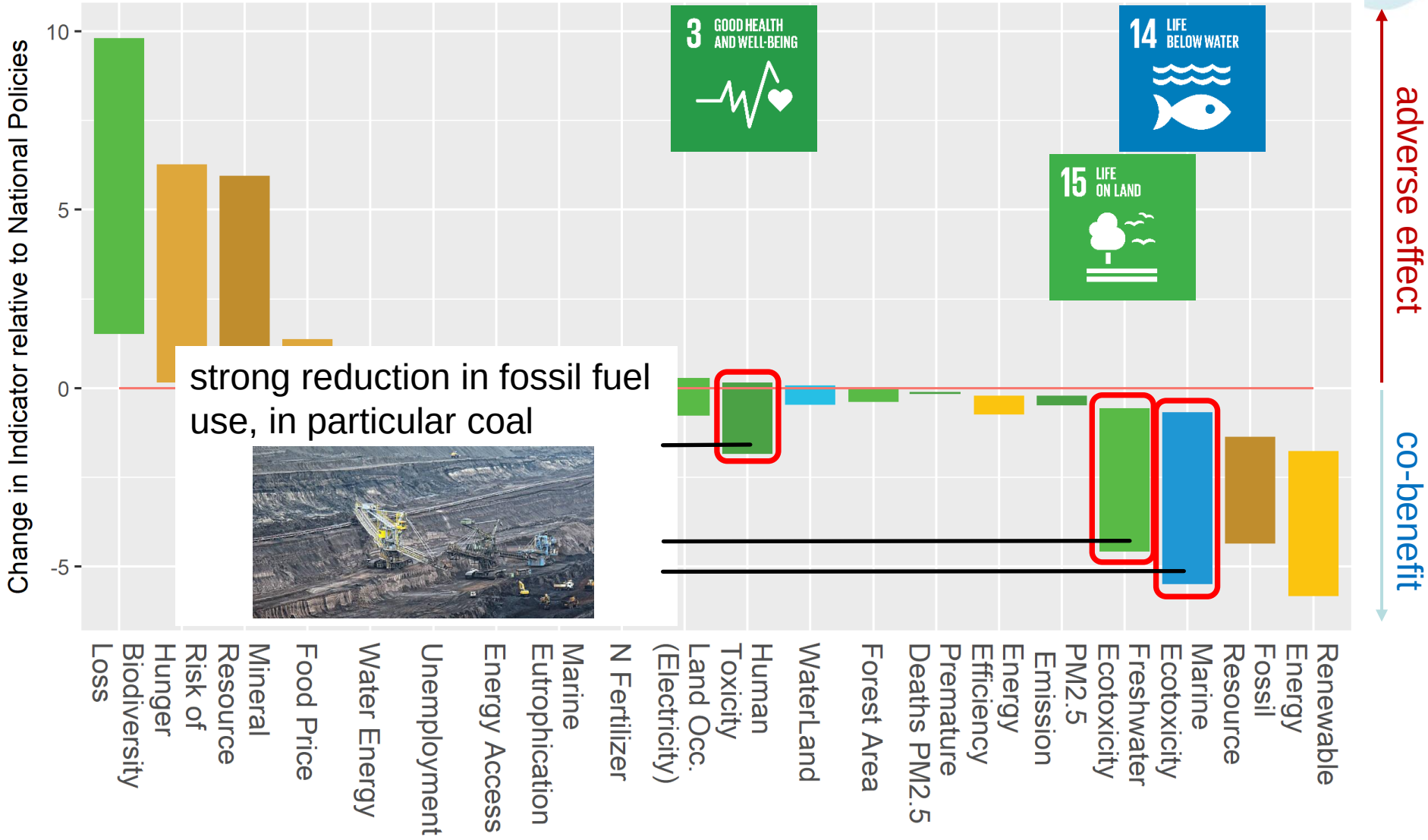

Climate Policy Impact on SDG: 1.5°C

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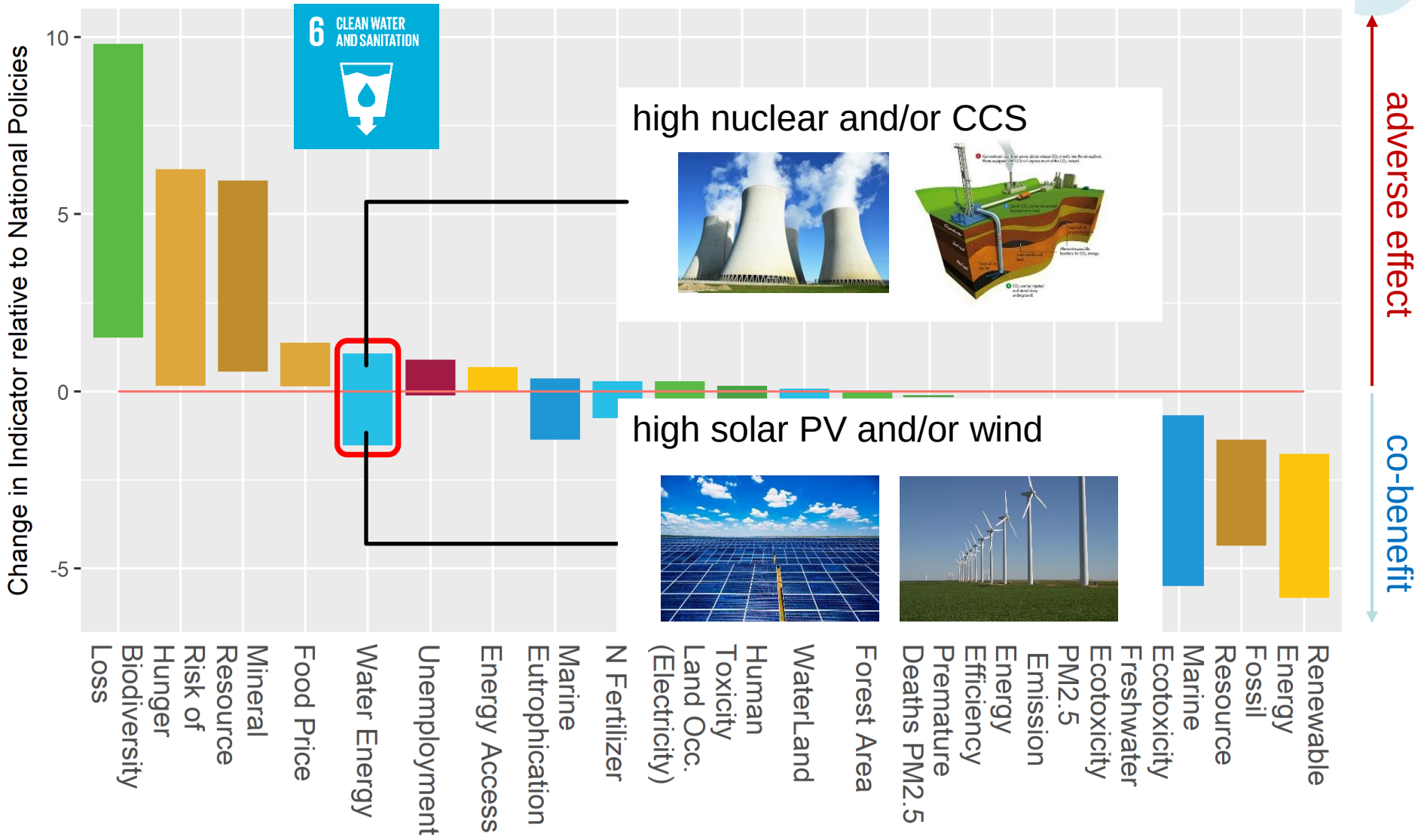

Climate Policy Impact on SDG: 1.5°C

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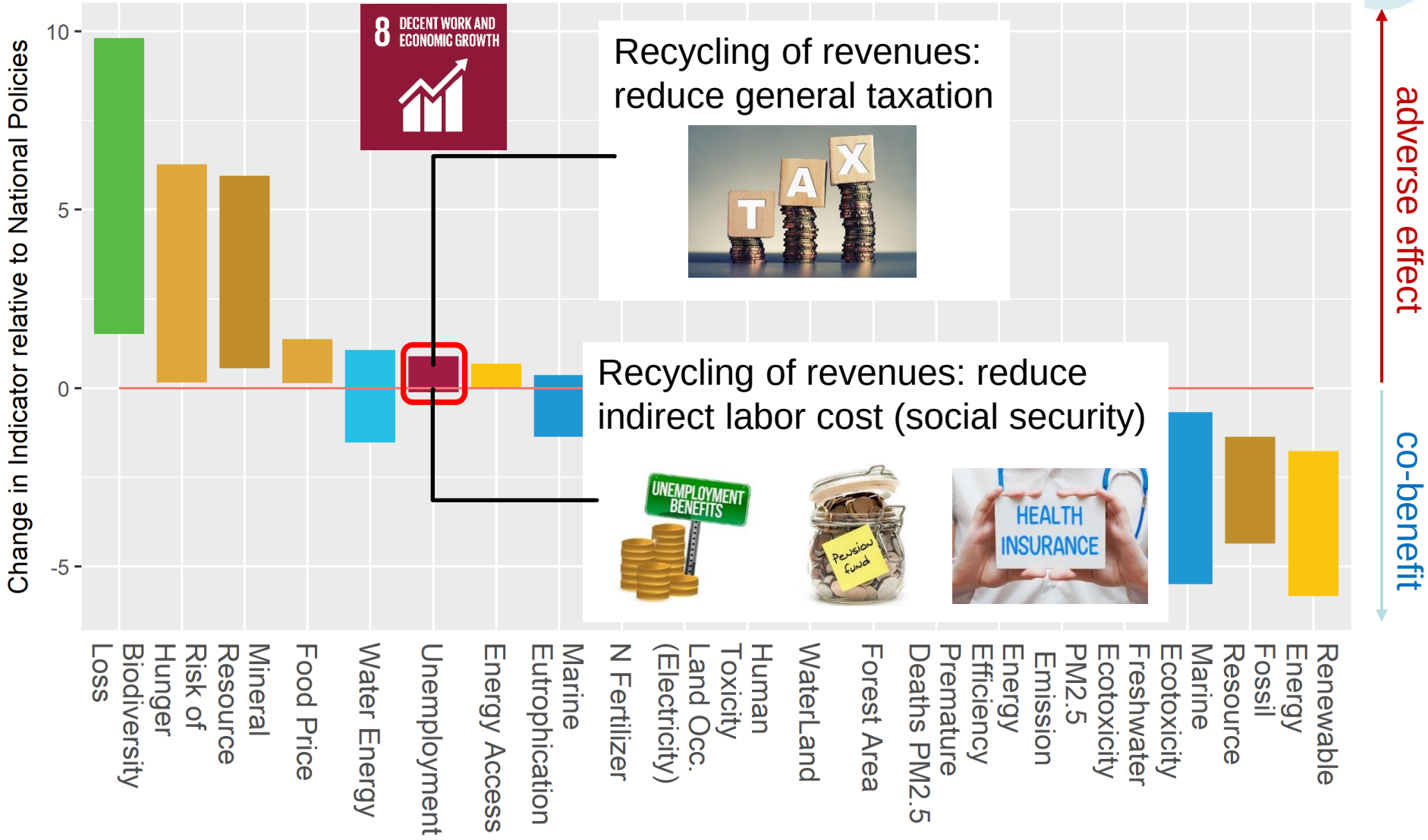
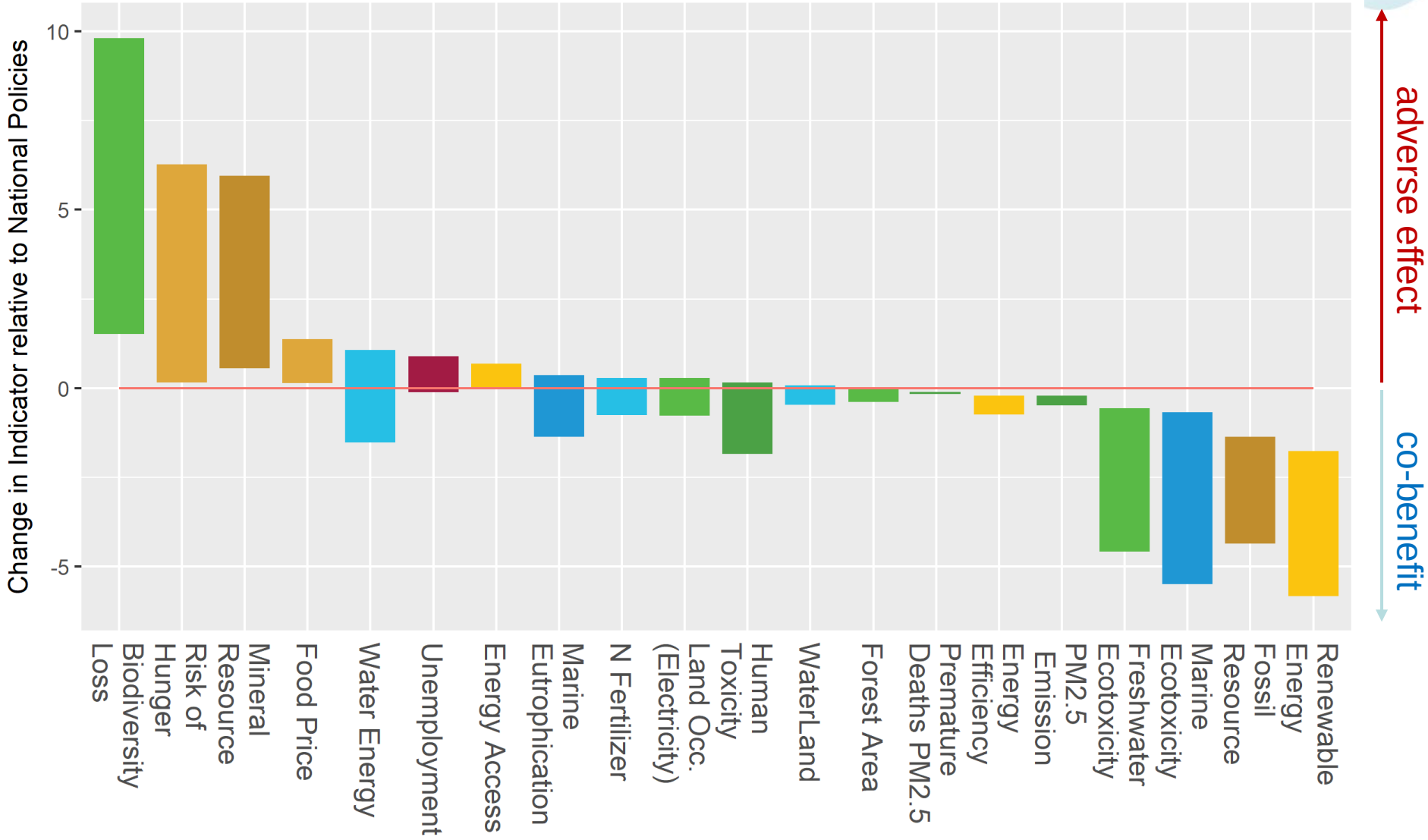


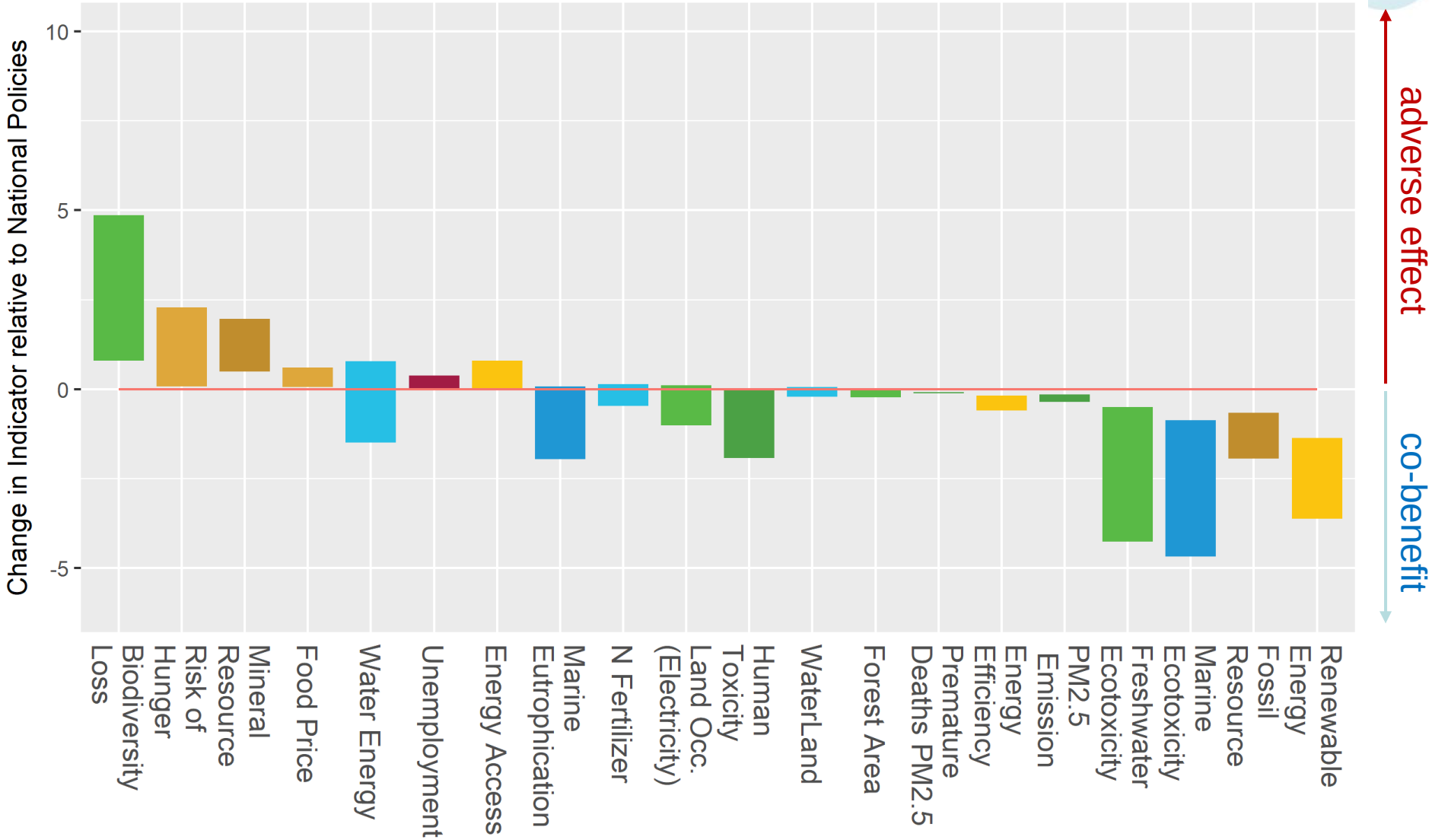
Climate Policy Impact on SDG: 1.5°C

2050

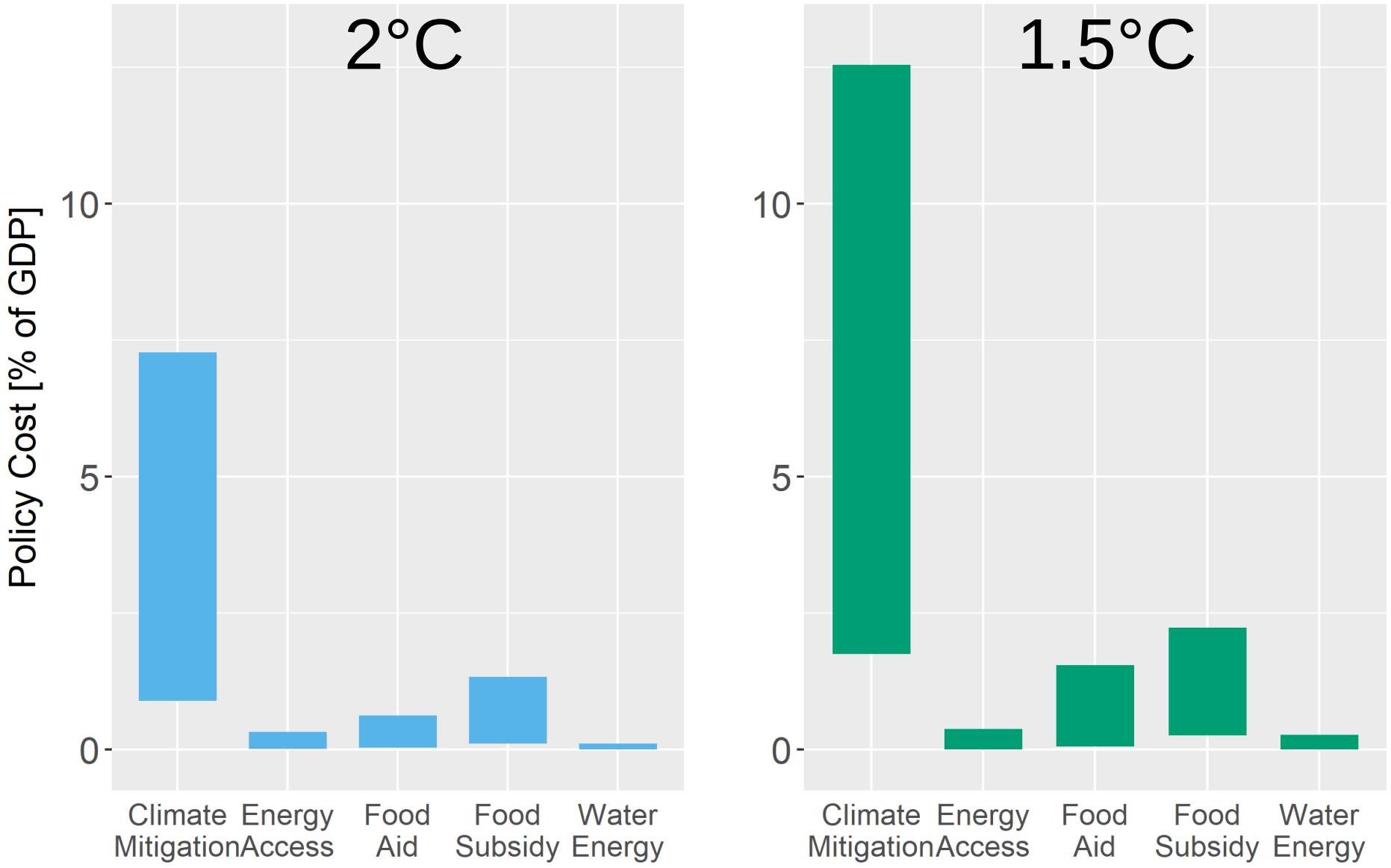


Climate Policy Impact on SDG: 2°C

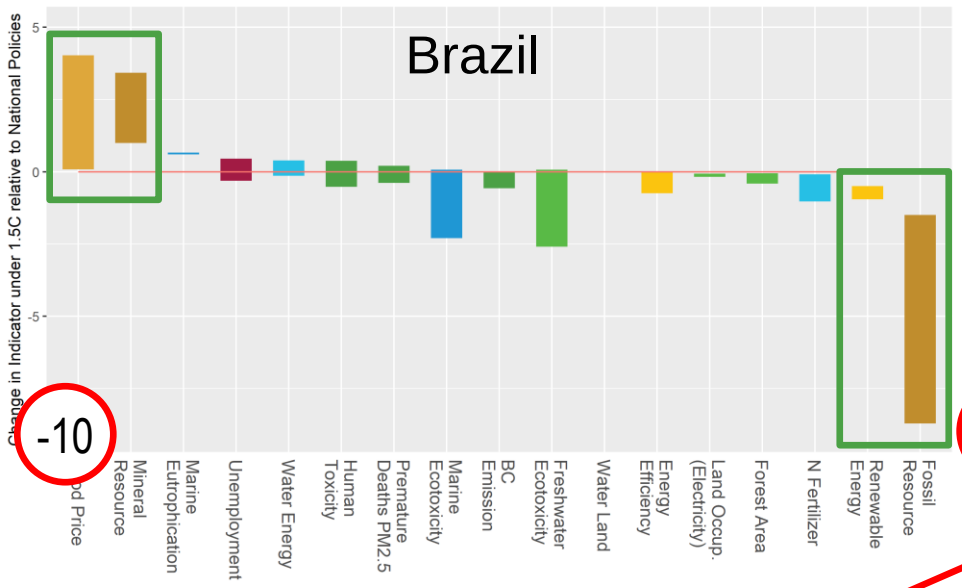
2050

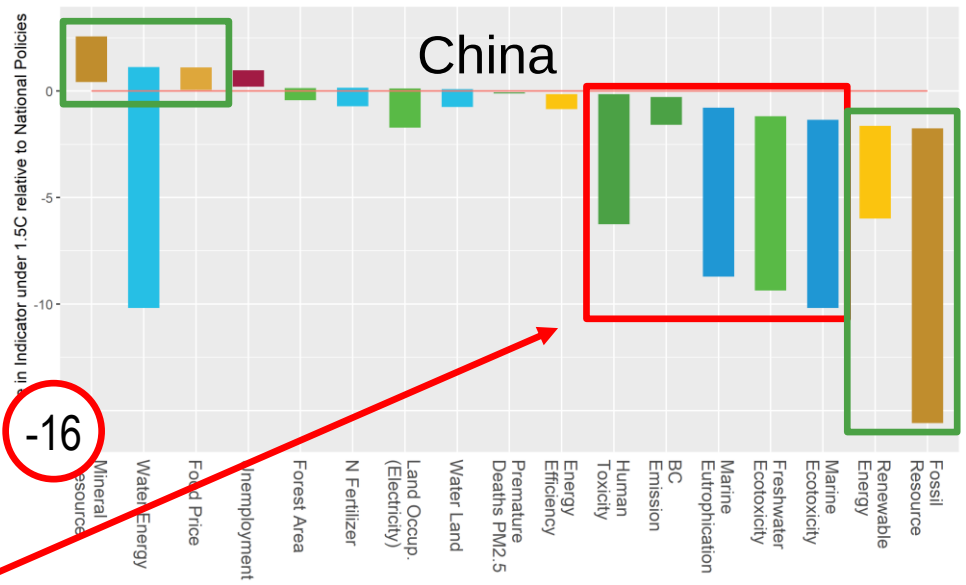


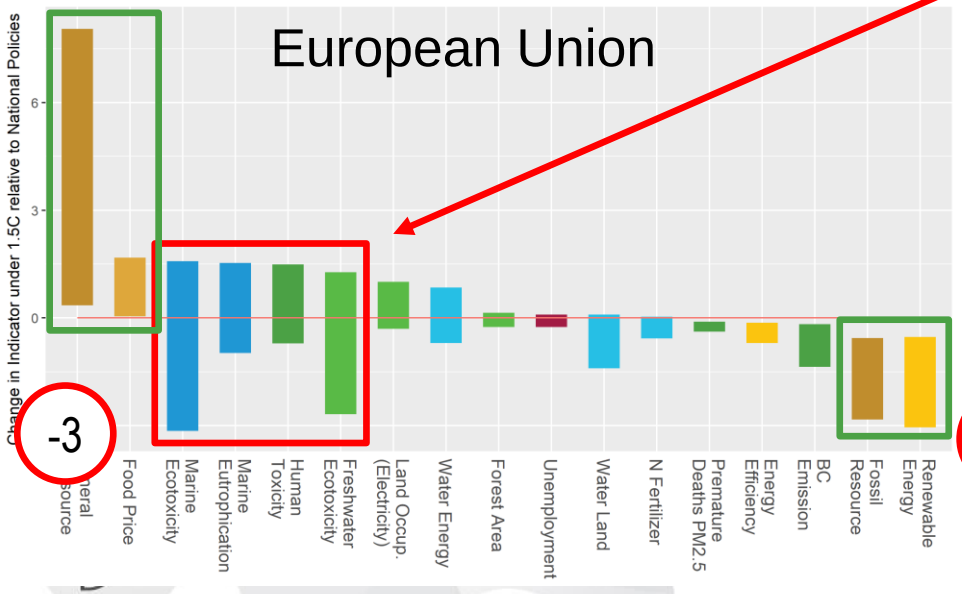
Integrated Policy Costs – 2050

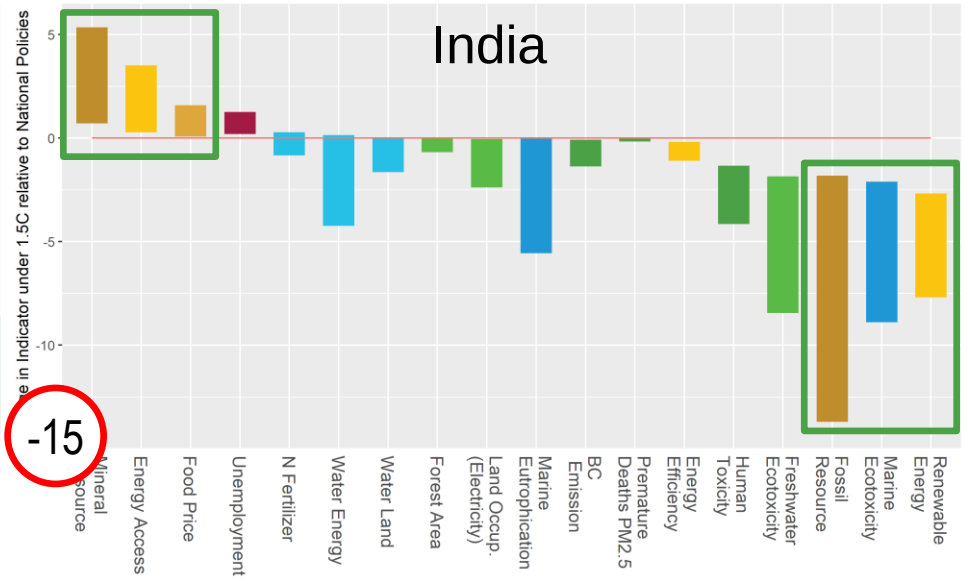


Regional Comparison









Conclusions

- Significant potential co-benefits and adverse side effects of climate policies
- Highest risks of adverse effects related to
  - Land-based mitigation
  - Basic needs of low-income households
- Complementary policies that address multiple objectives can avoid adverse side effects
- Policy type and institutional capacity will determine costs for holistic climate policies

Thank you!

http://www.cd-links.org

The CD-LINKS project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 642147.