AIM modeling and recent on-going research activities

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IAMC webinar @online

AIM
ASIA-PACIFIC INTEGRATED MODEL

KYOTO UNIVERSITY
KYOTO JAPAN
FOUNDED 1897

Outline

- AIM modeling team
  - ✓ History of AIM
  - ✓ Team organization
- Recent activities
  - ✓ Expanding representation; multi-dimensional human system interacting with climate change mitigation and impacts
  - ✓ Asian climate mitigation policy assessment
- SWGs on national scenarios

AIM modeling team

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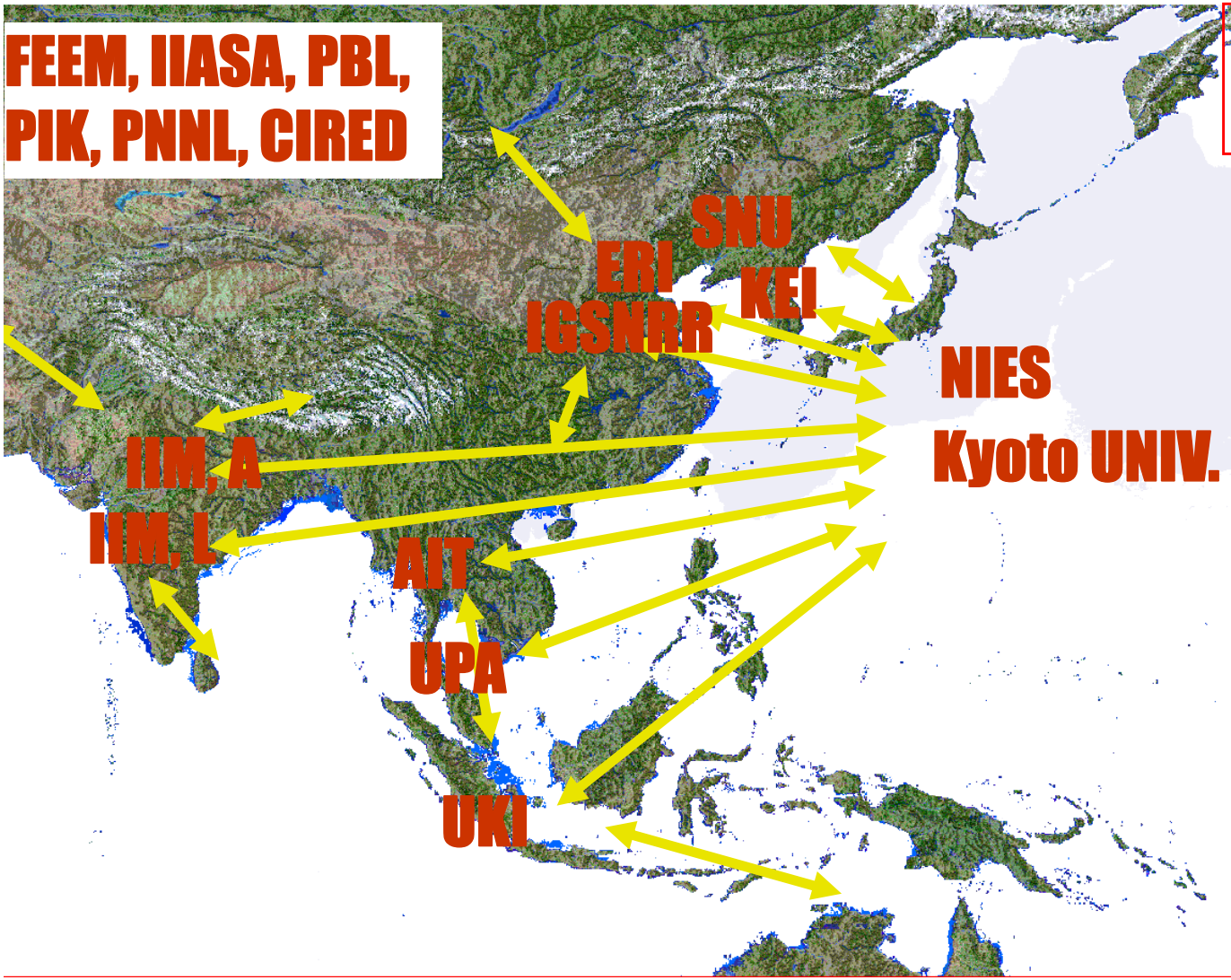
Photo from 21st AIM international workshop held in 2015

The AIM as INTERNATIONAL COLLABORATION PROGRAM



JAPAN
National Institute for Environmental Studies (NIES)
Kyoto University

CHINA
Energy Research Institute (ERI)
Institute of Geographical Science and Natural Resources Research (IGSNRR)

INDIA
Indian Institute of Management (IIM), Ahmedabad
Indian Institute of Management (IIM), Lucknow

KOREA
Seoul National University (SNU)
Korea Environment Institute (KEI)

THAILAND
Asian Institute of Technology (AIT)

MALAYSIA
University Putra Malaysia (UPM)

INDONESIA
Universitas Kristan Indonesia（UKI)

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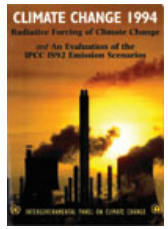
AIM brief history (1)

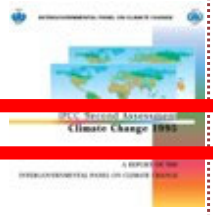
Dawn

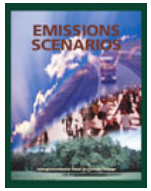
		International activity	National activity
1990	AIM project launched Impact Model development		
1992	First AIM/Enduse model development		
1993	Long-term emissions scenario development	• IS92 scenario	
		• IPCC SAR	• Carbon tax policy

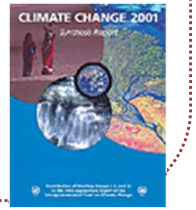
International participation and growing

1996	1st AIM international workshop	• EMF	• Japan Kyoto Protocol emissions target assessment
1997	1st AIM training workshop		
1998	CGE model development	• IPCC SRES	
2000		• GEO2	
2001	AIM/Enduse[global] model development	• IPCC TAR	









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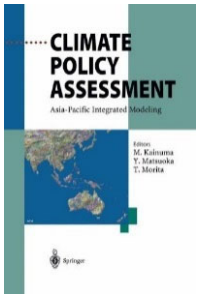
AIM brief history (2)

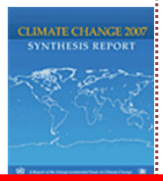
Play significant roles in Int' and domestic policy

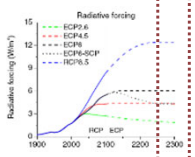
		International activity	National activity
2002	AIM book published Ecosystem model development	• GEO3	
2004		• UNEP MA	• Japan LCS project
2005	First COP side event		
		• IPCC AR4	• Japanese med-term target
2009			• Asian LCS project

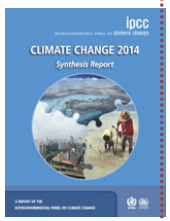
Diversified and intensified in many research area

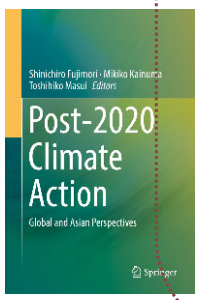
2010	2nd generation CGE[global] model development	• RCP development • LIMITS, AMPERE • AgMIP, ISIMIP	
2013	Fukushima branch	• ADVANCE	• SLCP project
2014		• IPCC AR5	
2015	Land use model AIM/PLUM development	• CD-LINKS, MILES	• Impact economics project
2017	AIM/CGE book published	• SSP development	

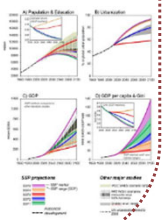












Training workshop at NIES 2015

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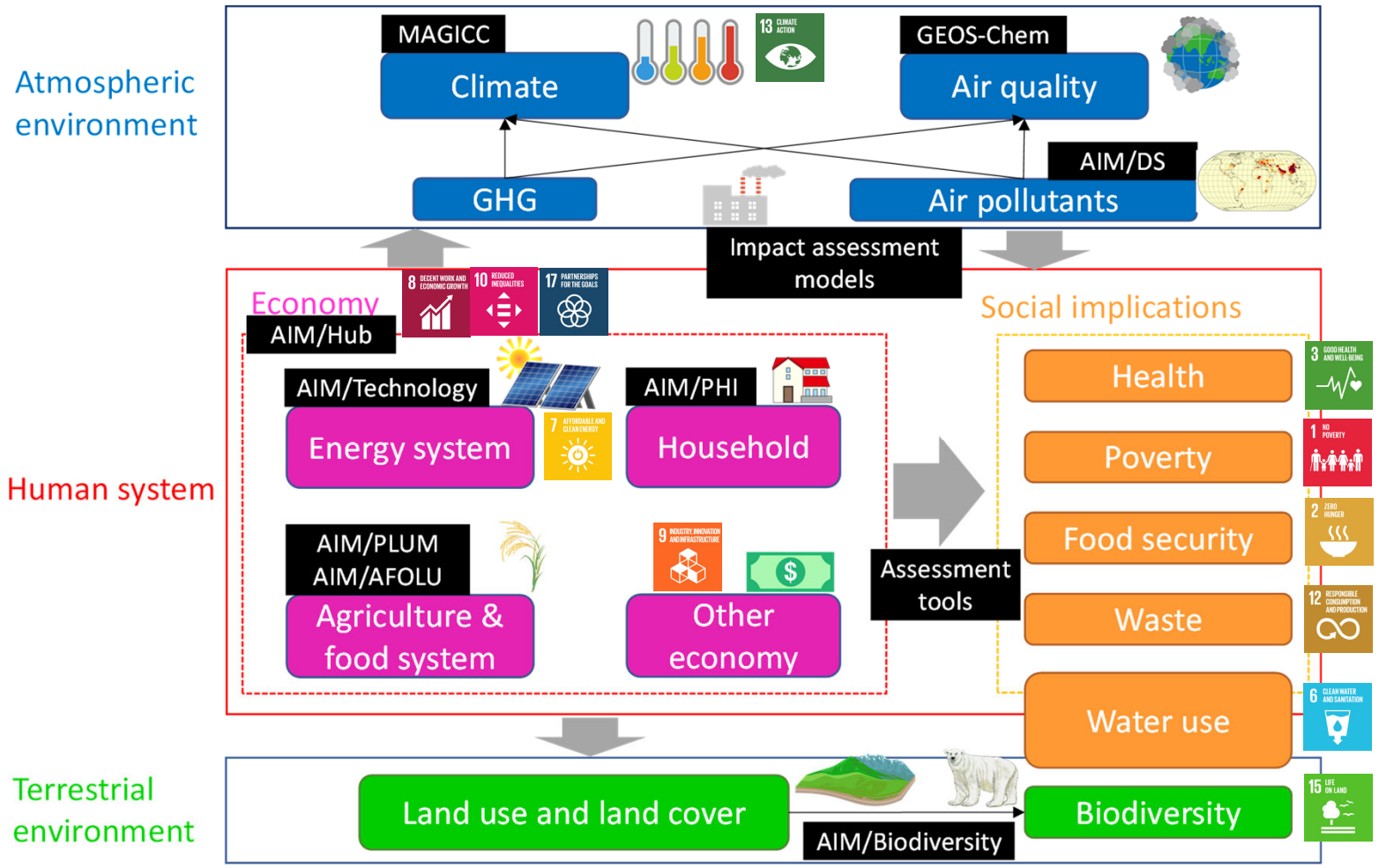
Global integrated assessment model *AIM*



SUSTAINABLE DEVELOPMENT GOALS

- An integrated assessment platform with computer simulation models
- Assess human system and global natural environment interactions consistently
- Policy designs or human behavioral changes
- Climate change is a center of study focuses
- Broader social, economic and environmental issues are under coverage.
- Contributing to IPCC and other relevant international activities

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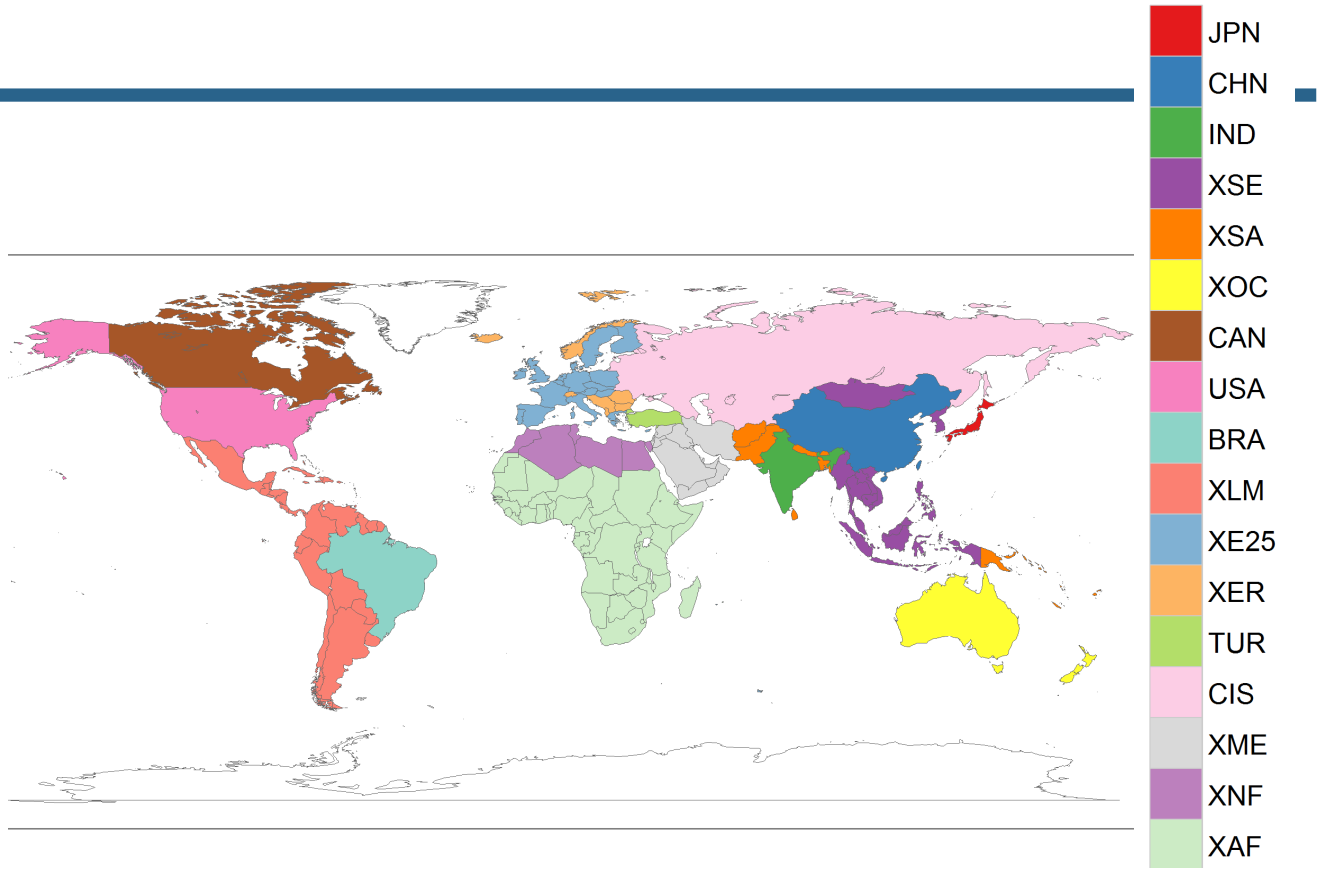
AIM/Hub

- General equilibrium global economic model
- 43 industrial sectors (Energy and agriculture are highly disaggregated) and 17 region.
- Recursive dynamic
- Domestic and international market is assumed



- Emissions; CO2, CH4, N2O, SOx, NOx, CO, BC, OC, VOC, NH3

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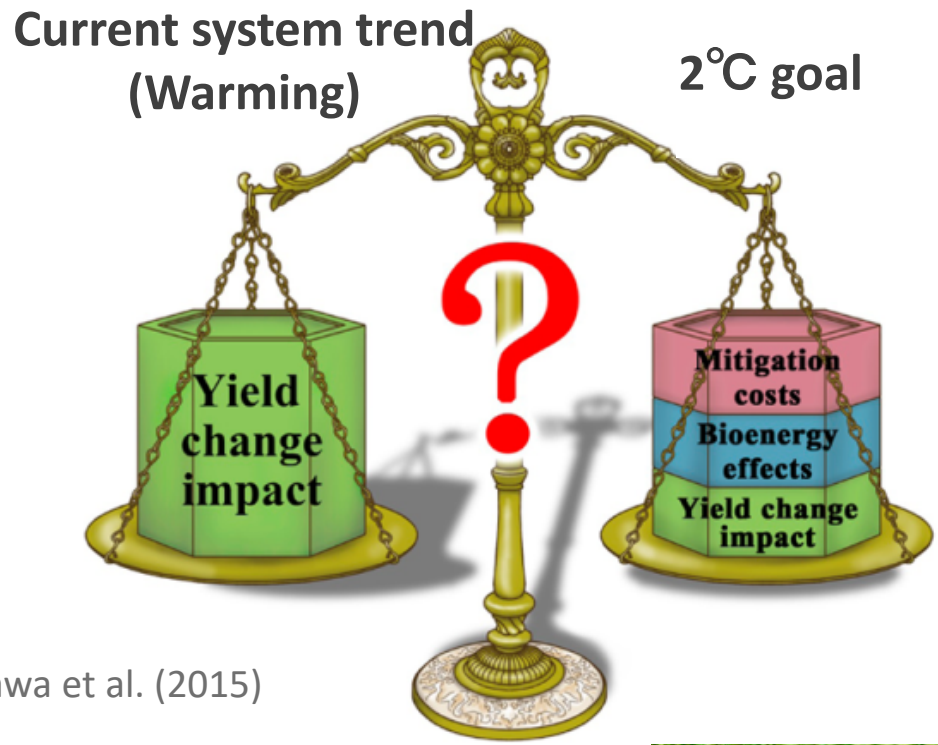
Food security

Food security issue in climate change issue



Hasegawa et al. (2015)

https://www.lettuceclub.net/news/article/119053/
http://www.biofuels.co.jp/page5.html
https://www.cnn.co.jp/fringe/35020107.html

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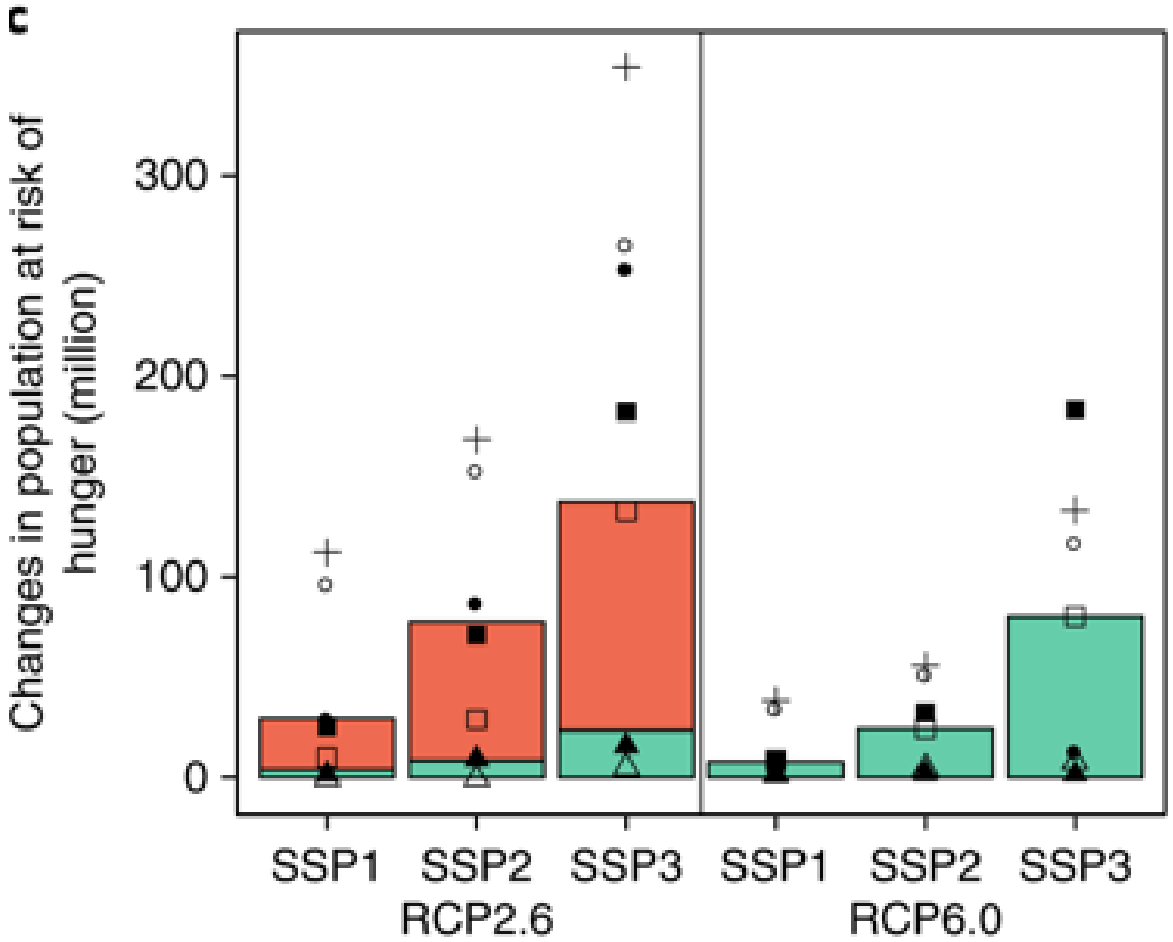
Emissions reduction or warming?



GHG reduction effects

Climate change impacts

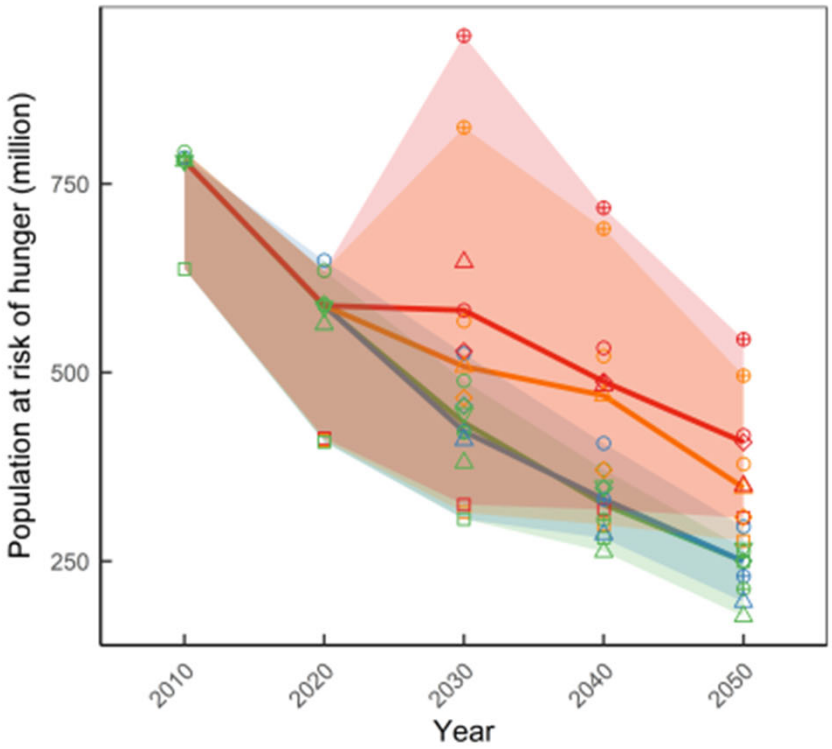
2℃ climate change mitigation

Warming Baseline

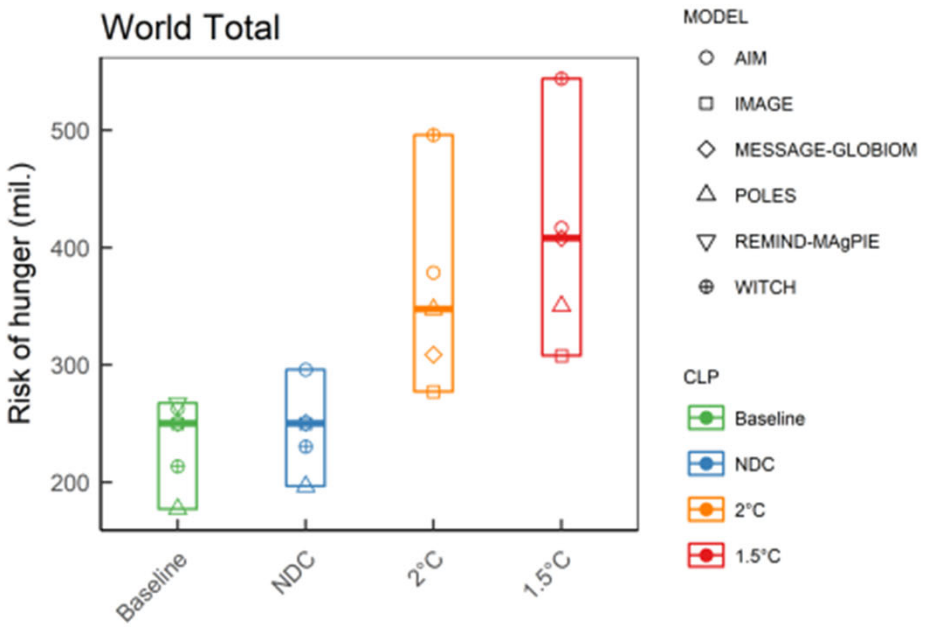
- Agricultural prices can increase significantly due to the climate change mitigation

Hasegawa et al. (2018)

Adverse side effect (Global)



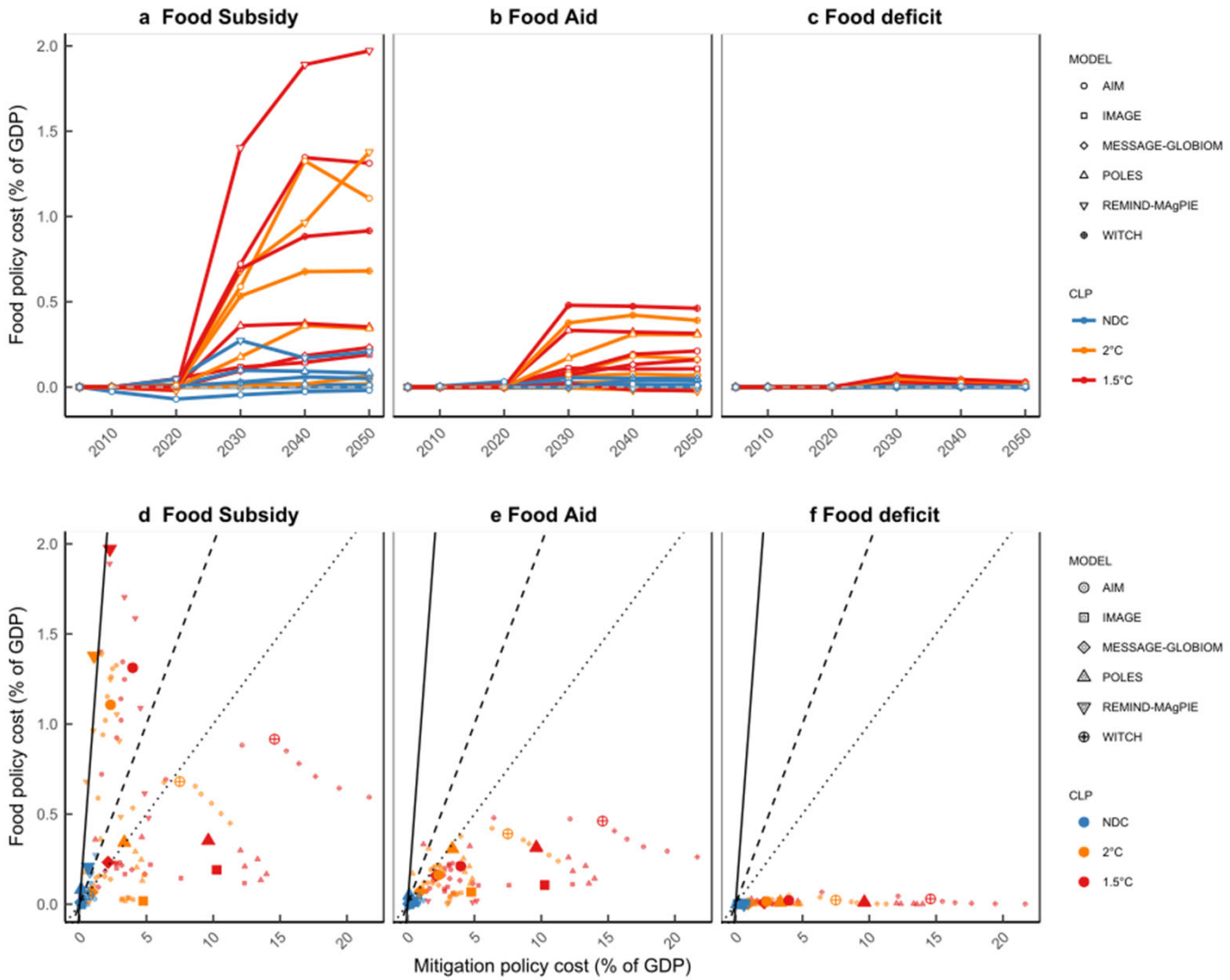
Time series



2050 snapshot

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

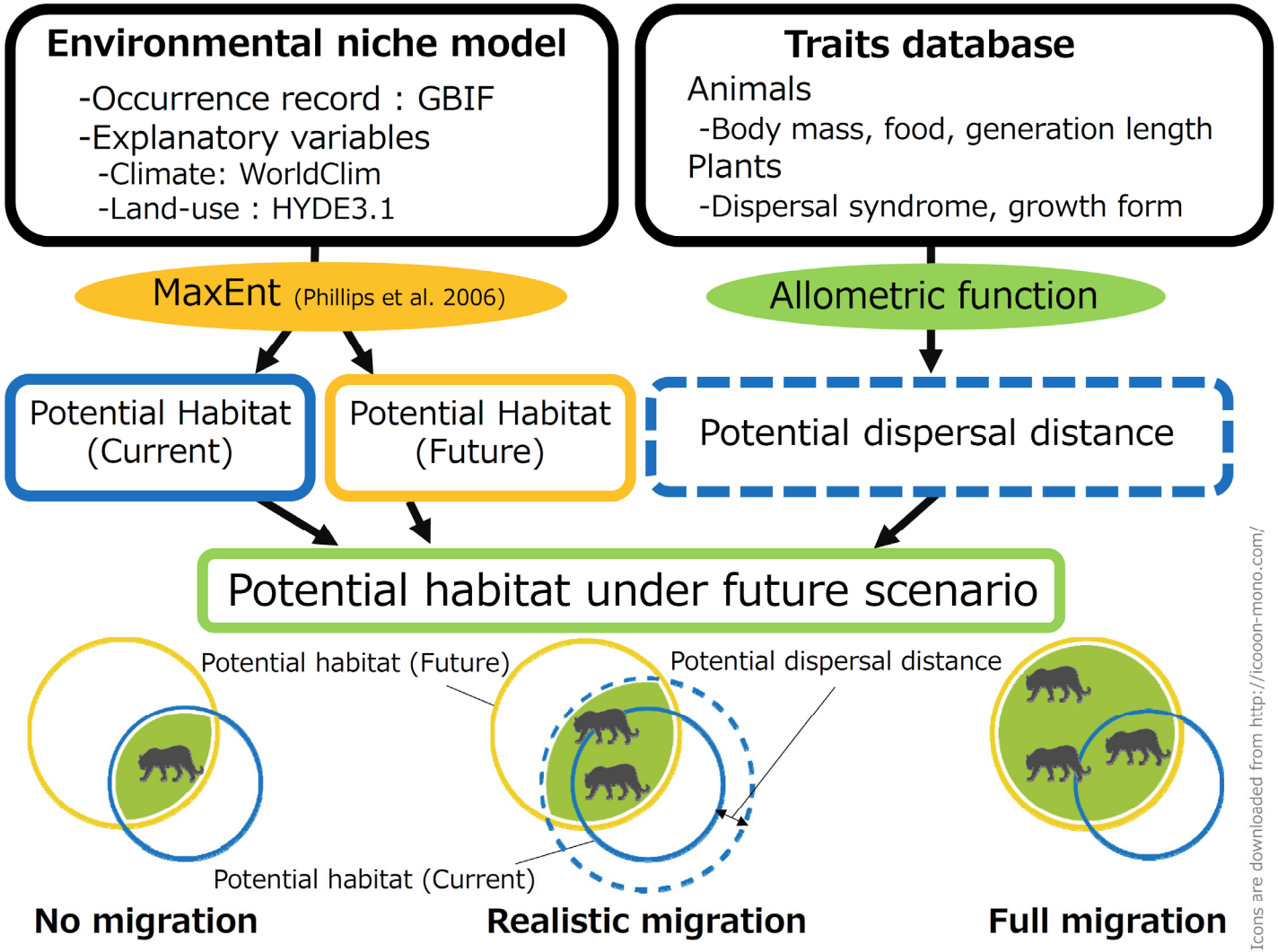
Complementary policy designs



- Food policy cost increases from 2030
- Food-aid is cheaper than food-subsidy
- Food-subsidy could be comparable with climate mitigation cost
- Food-aid is substantially less than climate mitigation cost

Biodiversity

AIM/Biodiversity



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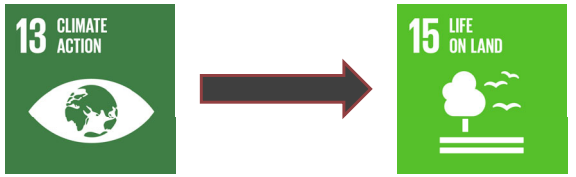
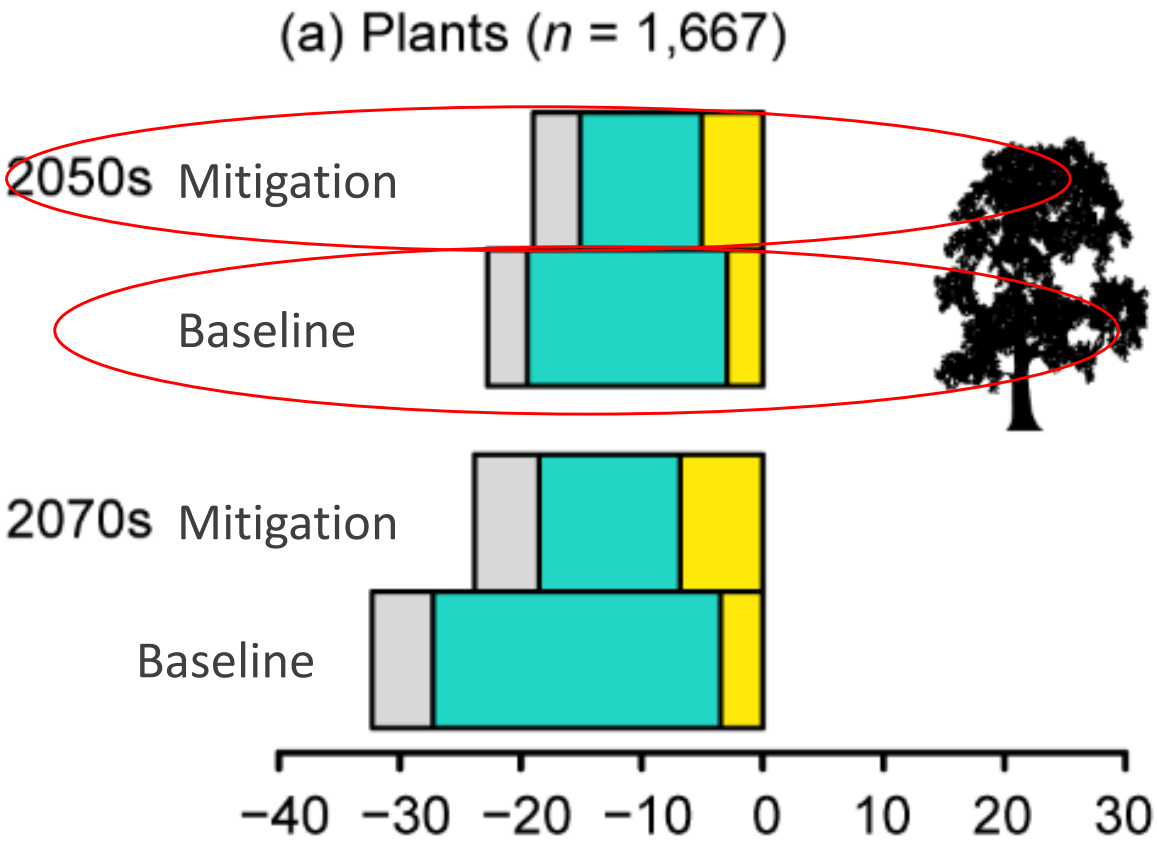
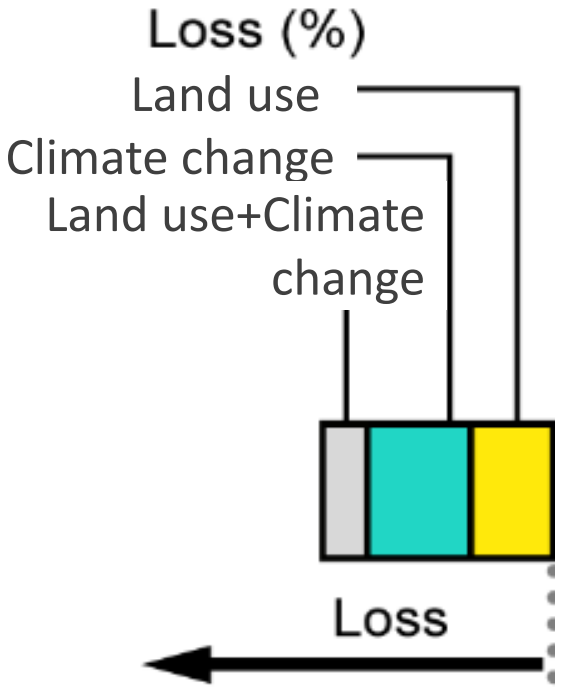
Climate Change and Biodiversity







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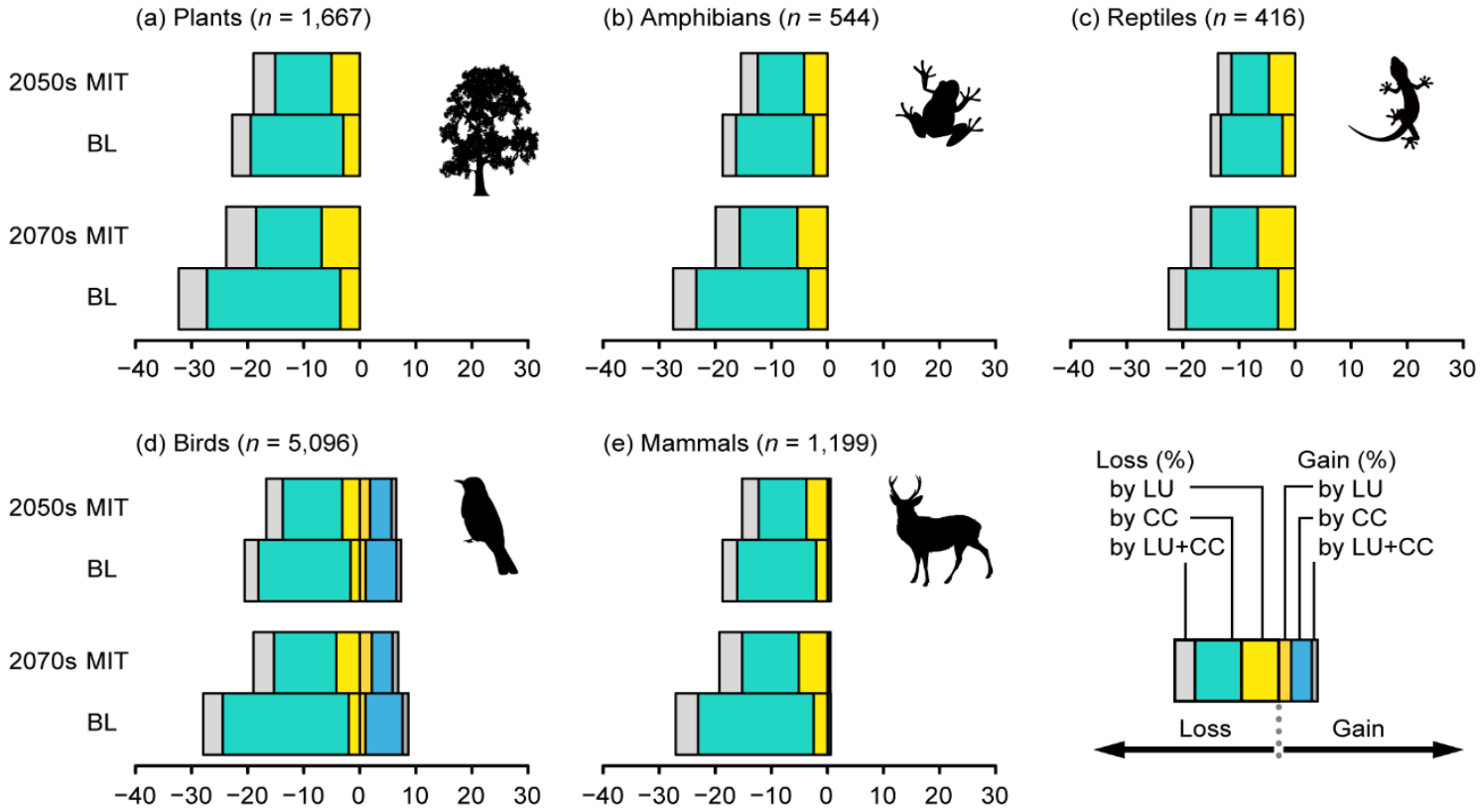
Ohashi et al. (2019) *Nature Communications*

Climate Change and Biodiversity

The same tendency can be seen.

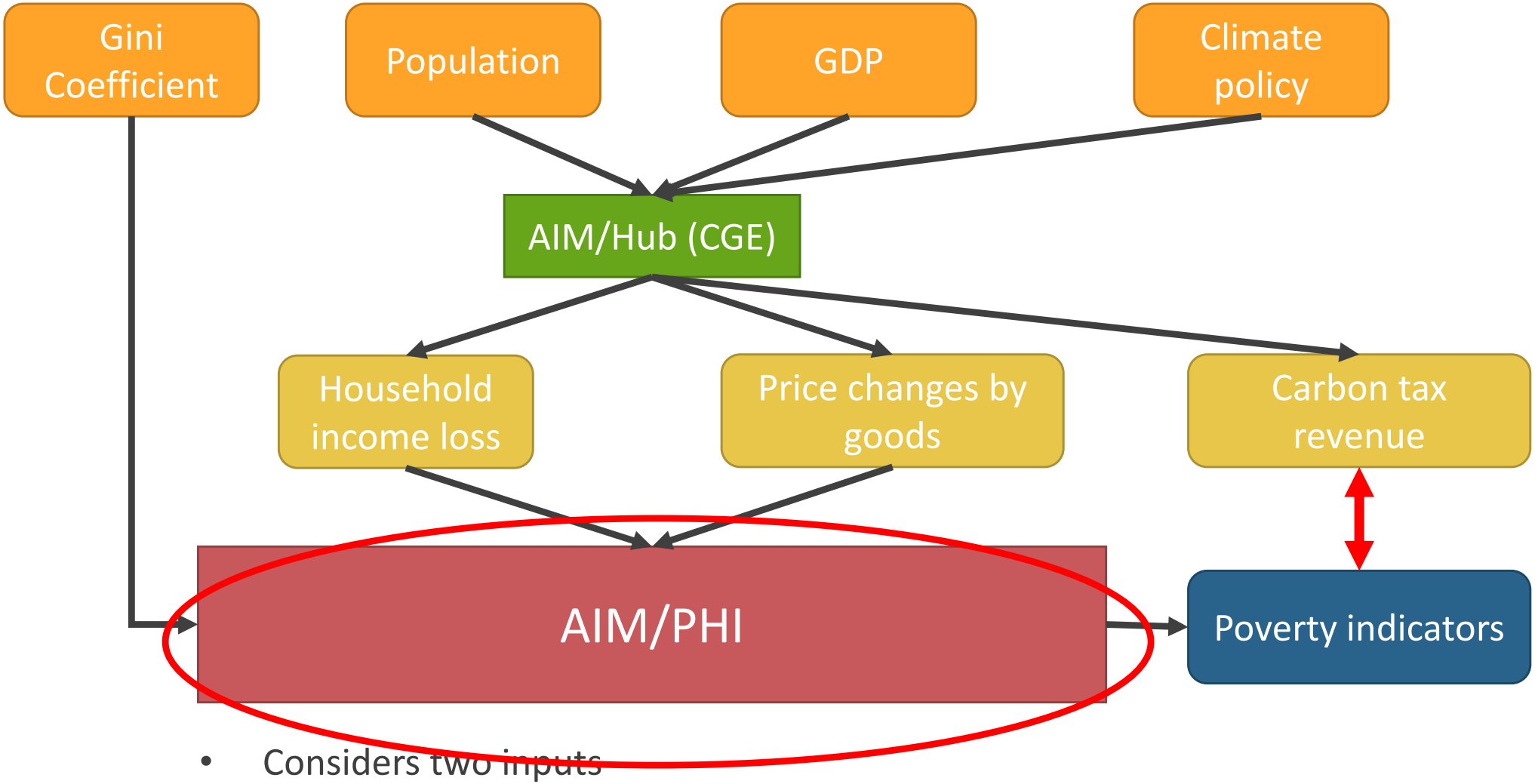
- Climate change mitigation would bring more benefit in biodiversity
- There should be careful consideration for the adverse-side effects of land use change



Ohashi et al. (2019) *Nature Communications*

Poverty

Method – Modeling framework



- Considers two inputs
  - ✓ Macroeconomic income changes associated with policy intervention (e.g. climate mitigation)
  - ✓ Price changes associated with policy intervention (e.g. climate mitigation)
- Computes household consumption by income segments and goods

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AIM/PHI (Poverty, Household and Income) models

17 regions AIM/Hub classification → change ratio is taken

Household income loss

Price changes by goods

Carbon tax revenue

AIM/PHI

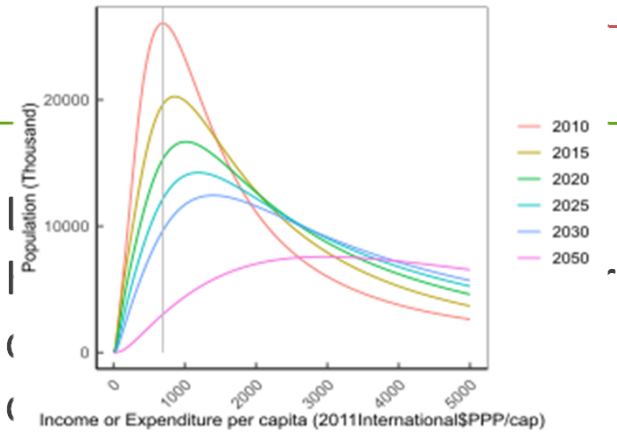
190 countries

Income module

Expenditure module

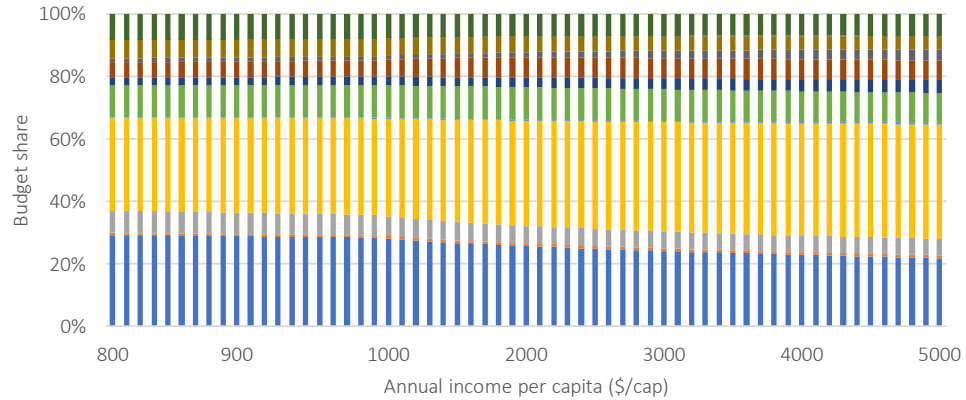
Poverty indicators

Income distribution within countries



- Considers macroeconomic income losses

Actual expenditure by income segments



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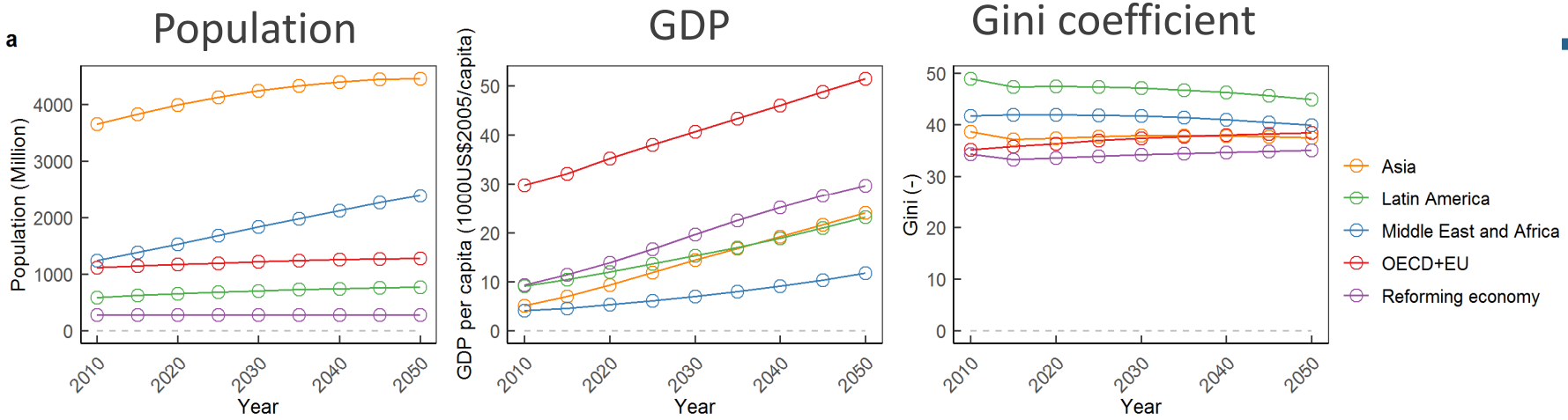
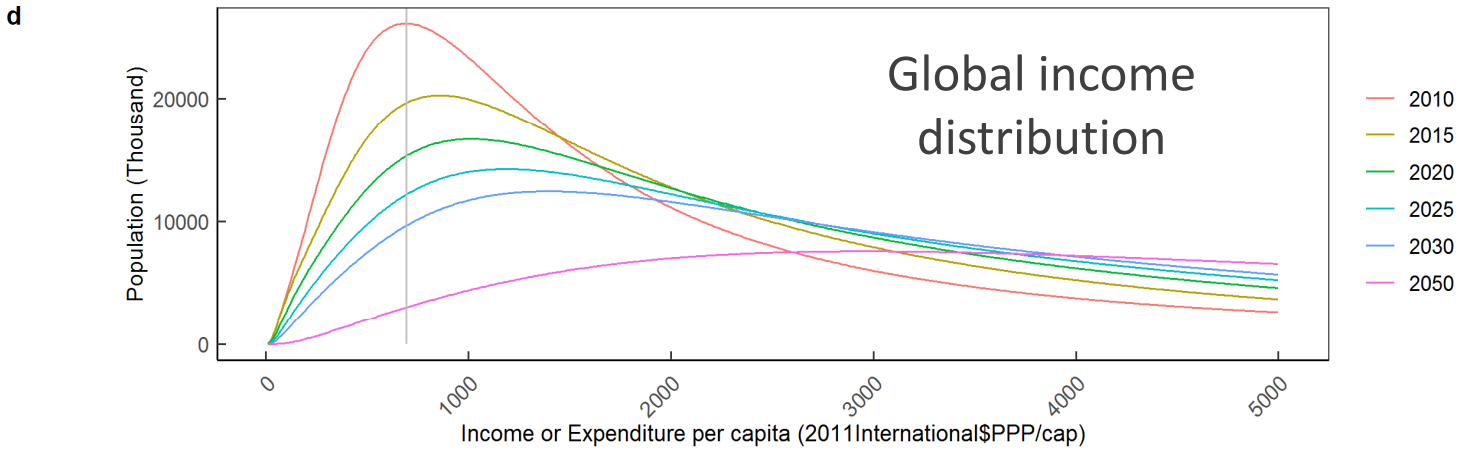
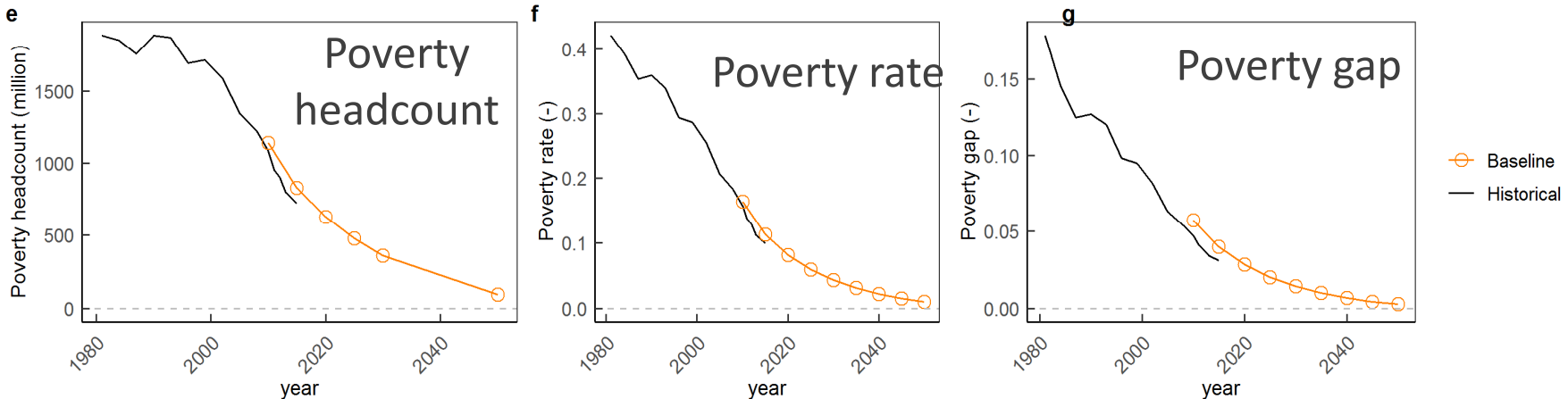
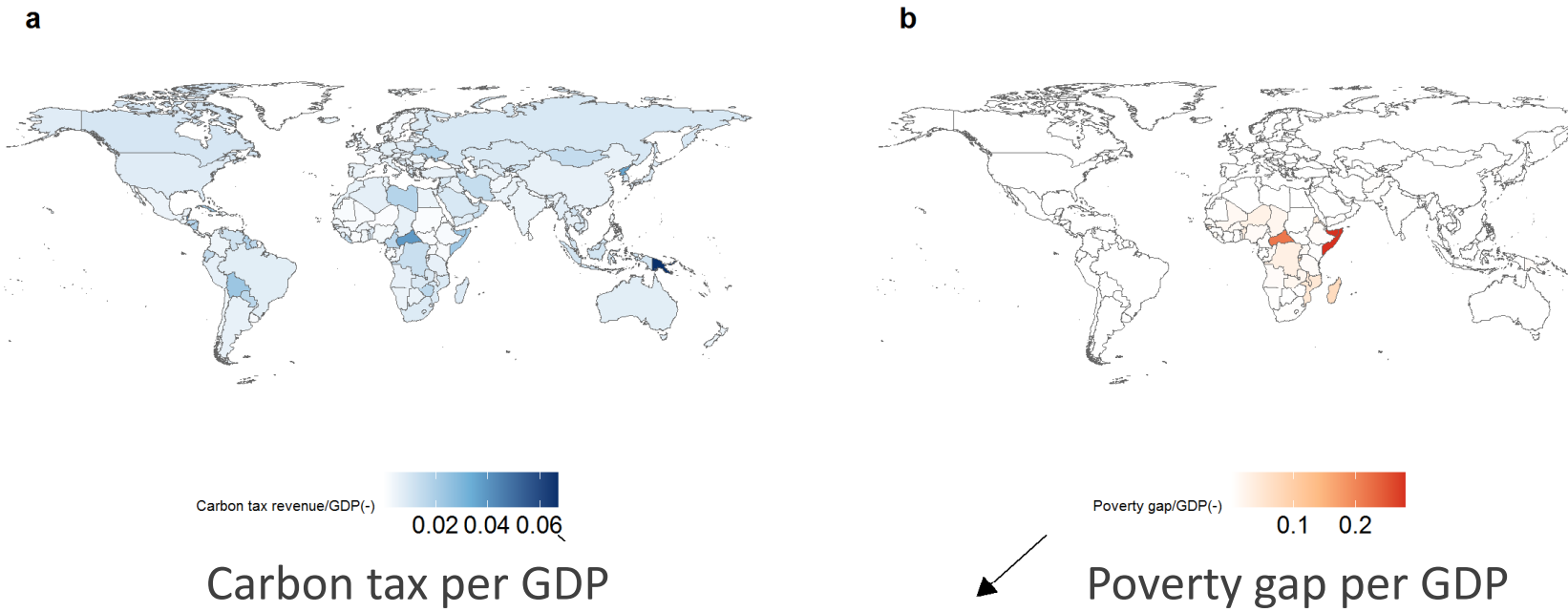
Results in baseline





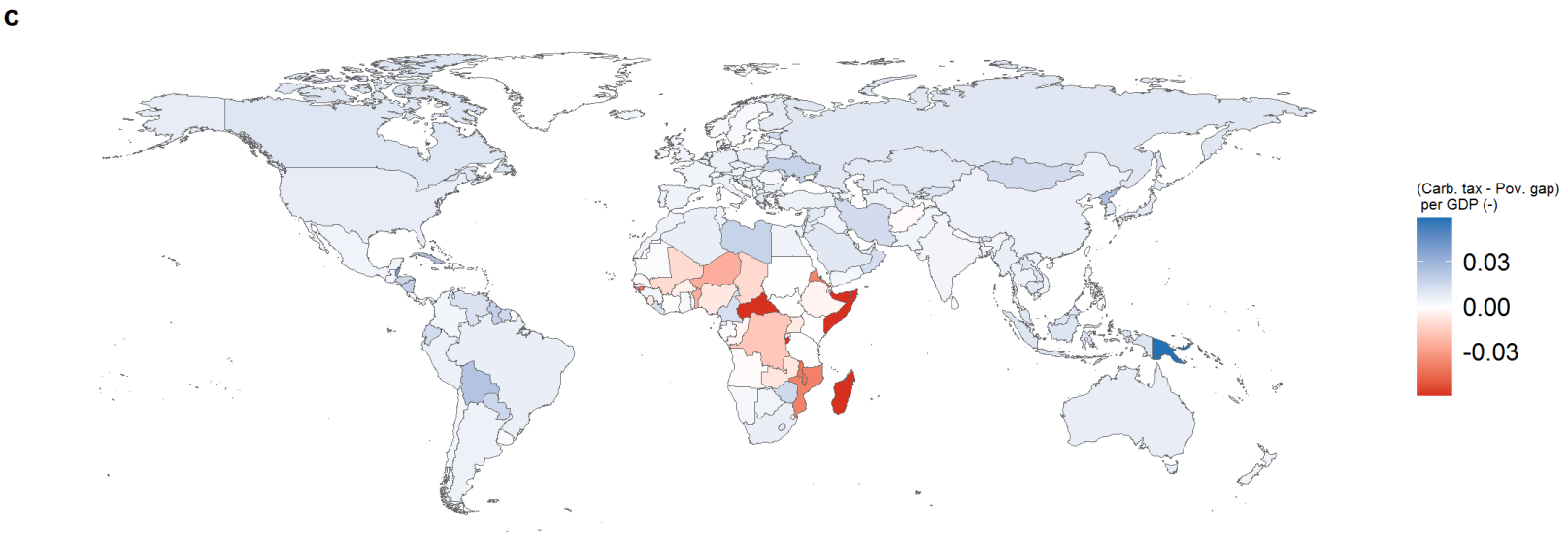


Country-wise poverty gap and carbon tax comparison (per GDP)



Carbon tax per GDP

Poverty gap per GDP



(Carbon tax – poverty gap) per GDP

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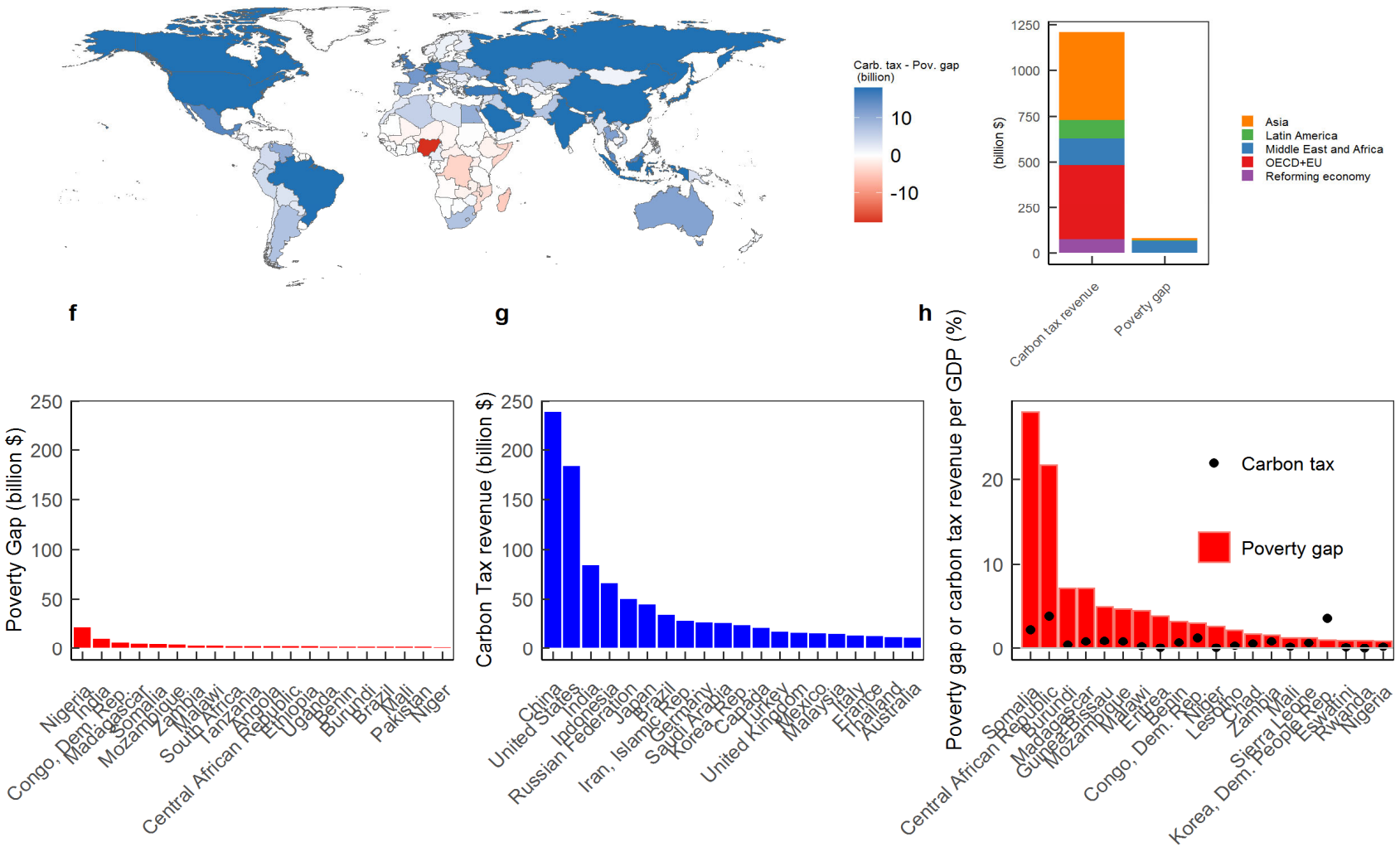
Country-wise poverty gap and carbon tax comparison (bil. $)



- Carbon tax is much larger than poverty gap
- Small potion of carbon tax via International transfer might help poverty eradication

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Implications

- Carbon tax revenue has a great potential to help eradicate poverty
- International cooperation is essential to filling the poverty gap
  - ✓ As carbon tax revenue is received primarily by high-income countries (e.g., the United States, Japan and Germany) and emerging countries (e.g., China)
  - ✓ A small fraction of the carbon tax revenues of high-income countries could be used to fill the overall global poverty gap.

nature climate change

LETTERS

https://doi.org/10.1038/s41558-019-0578-6

Dependence of economic impacts of climate change on anthropogenically directed pathways

Jun'ya Takakura[1*], Shinichiro Fujimori[2], Naota Hanasaki[3], Tomoko Hasegawa[4], Yukiko Hirabayashi[5], Yasushi Honda[6], Toshichika Iizumi[7], Naoko Kumano[8], Chan Park[9], Zhihong Shen[7], Kiyoshi Takahashi[1], Makoto Tamura[10], Masahiro Tanoue[5], Koujiro Tsuchida[11], Hiromune Yokoki[12], Qian Zhou[13], Taikan Oki[14,15] and Yasuaki Hijioka[3]

Climate change impact economics

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MiLAi Strategic Research on Global Mitigation and Local Adaptation to Climate Change [S-14]

CGE modelling approach in climate change impacts

- Computable General Equilibrium (CGE)
- Multi-sector and multi-region
- The parameters are normally calibrated in base year's social accounting matrix
  - ✓ Parameters in production and consumption functions are updated for the future scenario analysis (e.g. tech. and preference changes)
- Market driven interactions among multi-sectors and multi-regions can be considered.
- Widely used in environmental modeling
  - ✓ Intensively used in climate change communities

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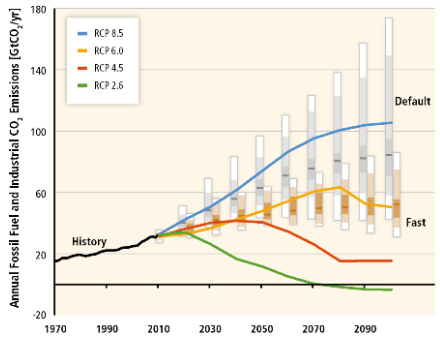
Overall method

Emission scenario

RCP



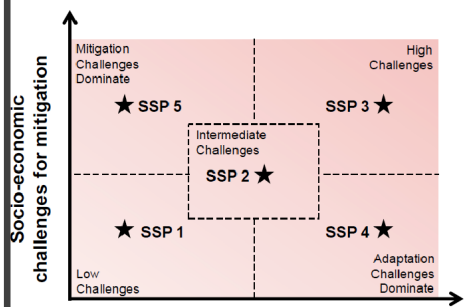
Climate change

RCP8.5
RCP6.0
RCP4.5
RCP2.6

2℃

Socioeconomic scenario

SSP



SSP1: Sustainability
SSP2: Middle of the Road
SSP3: Reginal Rivalry
SSP4: Inequality
SSP5: Fossil-fueled Development

GHG concentration

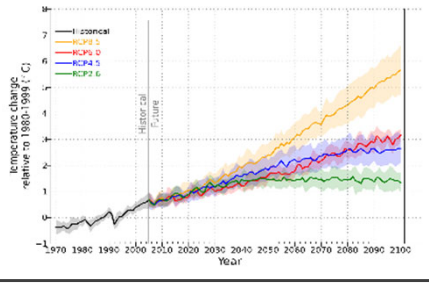
GHG emissions constraint

Socioeconomic assumptions

Gridded population and so on

Climate model

Climate



Crop model

Crop yield

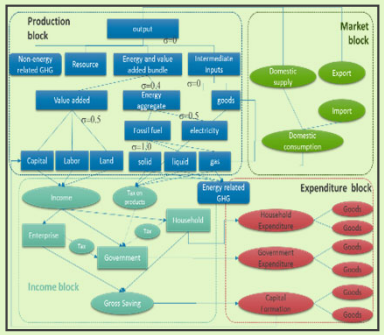
Water model

Water resource

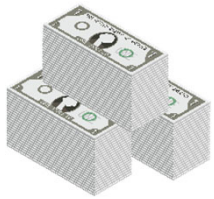
Health model

Number of Death

IAM (AIM/CGE)



GDP



Climate impact for each sector

Total climate loss

Scenarios

Socioeconomic pathways

Name	Description
SSP1	Sustainability (low vulnerability)
SSP2	Middle of the road (middle vulnerability)
SSP3	Regional rivalry (high vulnerability)
SSP4	Inequality
SSP5	Fossil-fueled Development

×

Emission pathways

Name	Temperature rise (median)
RCP2.6	+ 1.7 ℃
RCP4.5	+ 2.5 ℃
RCP6.0	+ 3.0 ℃
RCP8.5	+ 4.5 ℃

×

GCMs

Name
GFDL-ESM2M
HadGEM2-ES
IPSL-CM5A-LR
MIROC-ESM-CHEM
NorESM1-M

- We conducted 100 (5 × 4 × 5) scenario runs for each sector
- Part of the autonomous adaptations in each sector and market adjustment adaption were considered.
- Inter-sectoral interactions were not considered.

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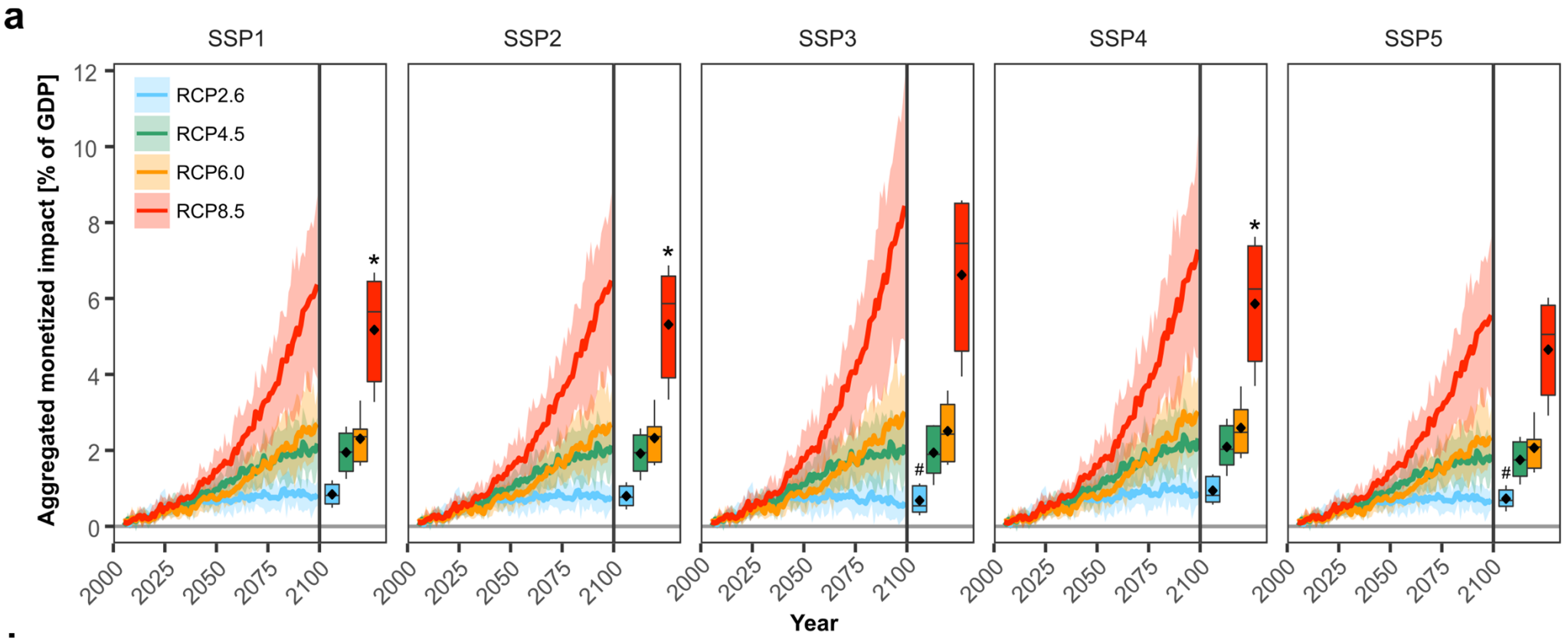
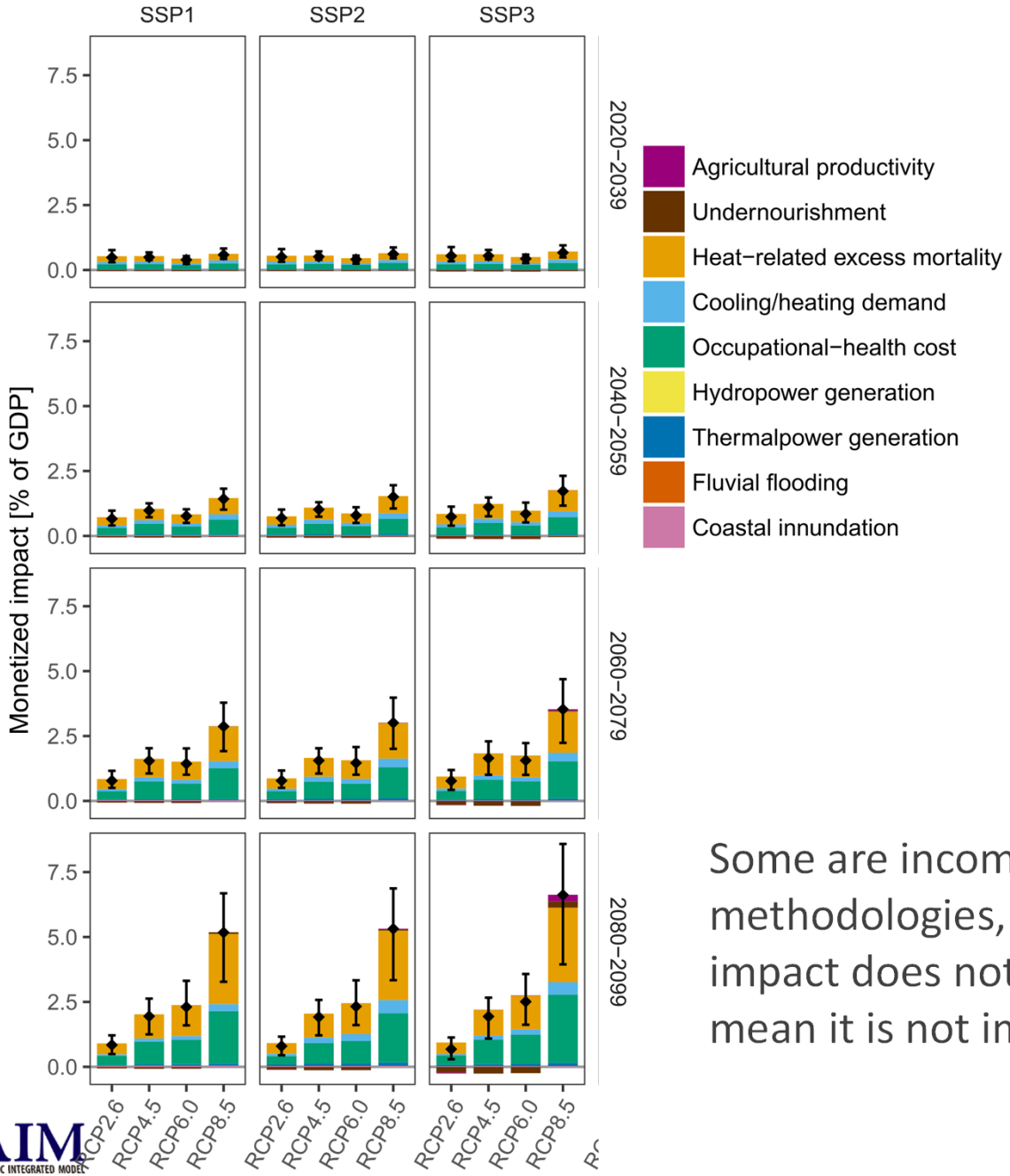
Results: total impacts over time



The impacts are expected to grow, but there is a large divergence from -0.4% to 9.3% (average in 2080-2099) depending on scenarios.

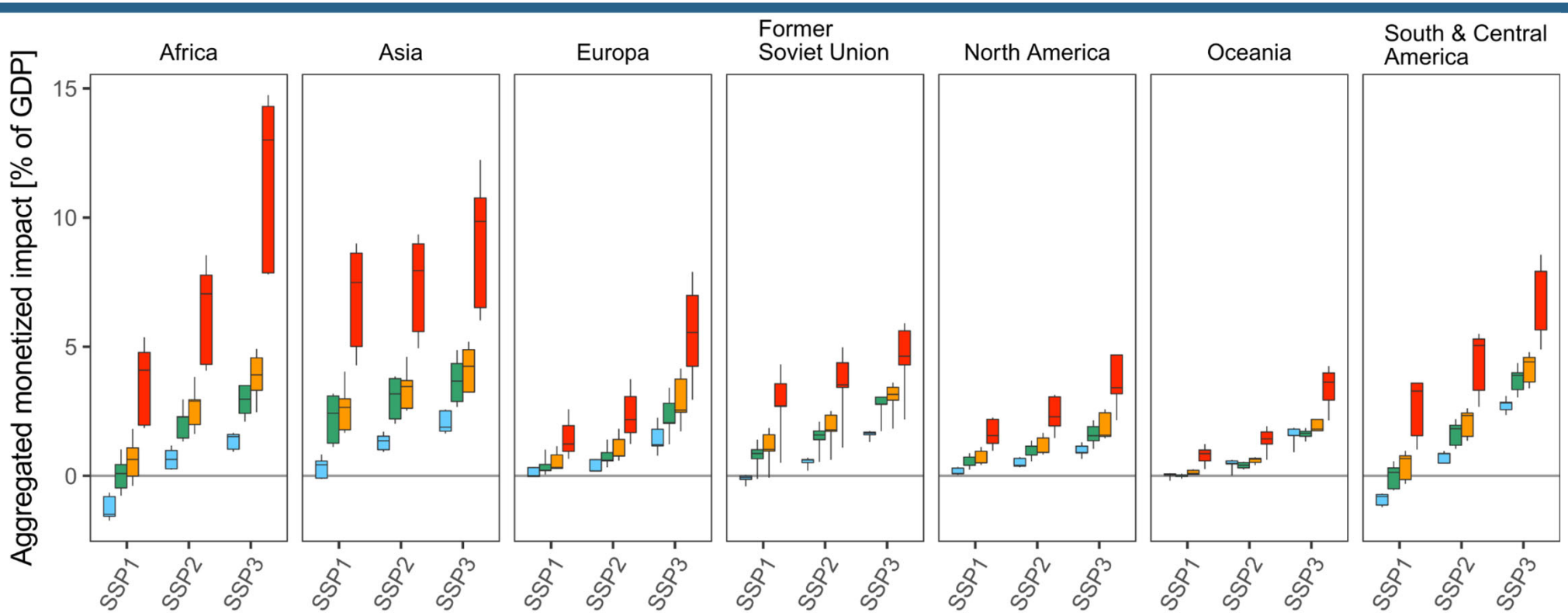
Results: impact of each sector



- Heat-related excess mortality
- Cooling/heating demand
- Occupational-health cost

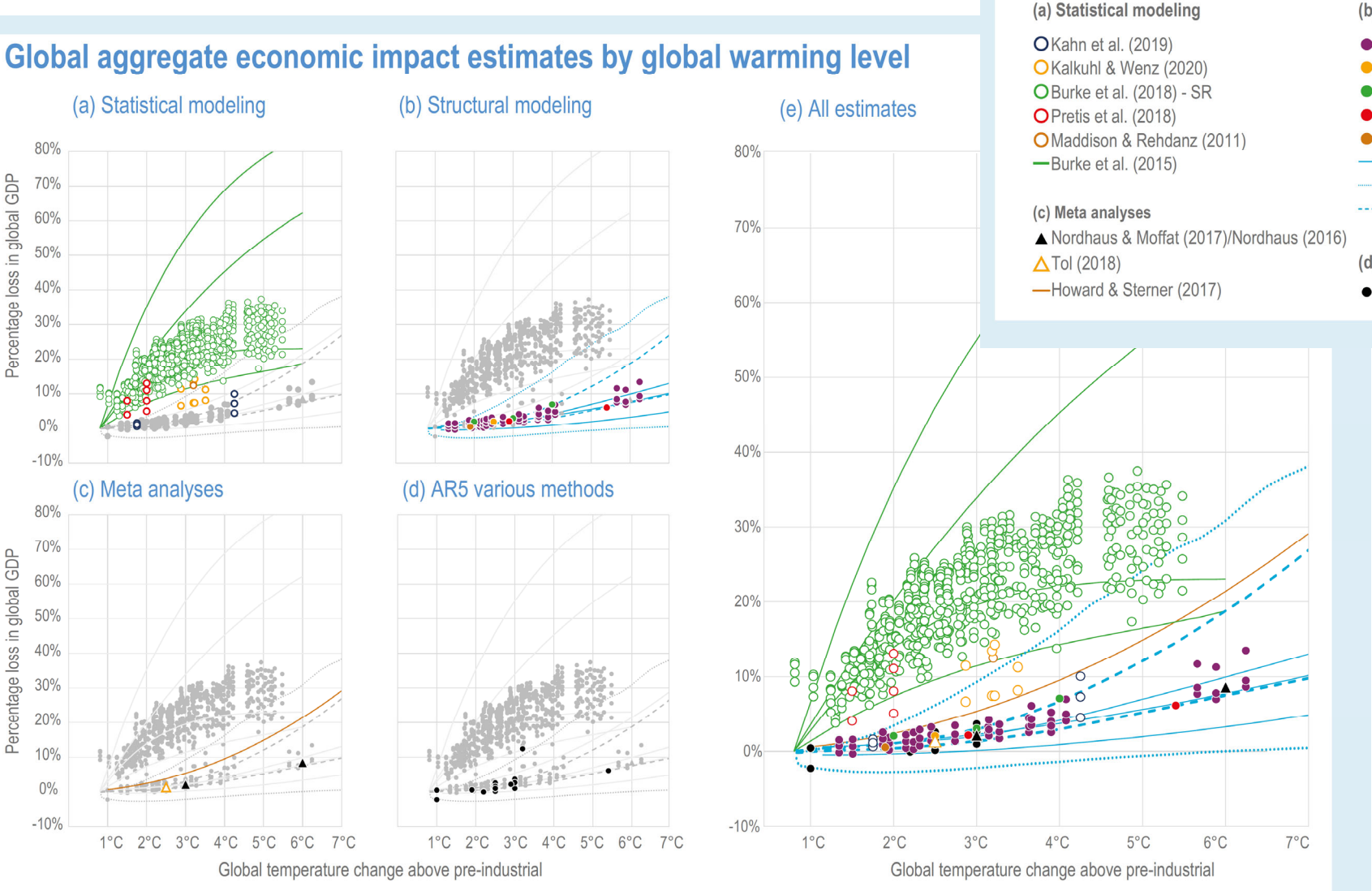
Some are incomparable because of different methodologies, and small economic impact does not necessarily mean it is not important.

Results: Regional results



- Expected impacts differ across regions.
- Large impacts are expected in Africa and Asia, particularly
- under SSP3 (less developed world).

IPCC AR6 WG2 Cross-chapter box



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Asian climate mitigation policy assessment

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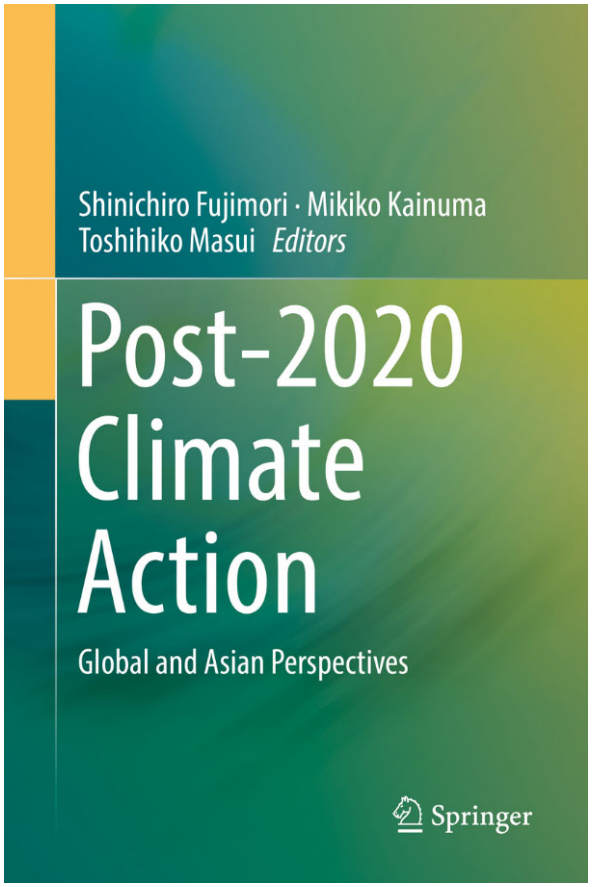
Paris Agreement assessment for Global and Asian countries



- China
- India
- Indonesia
- Thailand
- Vietnam
- Japan
- Global

Just published in September 2017

- Assessment of 2030 emissions reduction targets by AIM/CGE **global** and **national** model
  - Considering each country national policy
  - Led by individual national team members under AIM umbrella

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Indonesia energy

Indonesia land use

energies

Article

Low-Carbon Energy Development in Indonesia in Alignment with Intended Nationally Determined Contribution (INDC) by 2030

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MI sustainability

MDPI

Article

Land-Based Mitigation Strategies under the Mid-Term Carbon Reduction Targets in Indonesia

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Thailand

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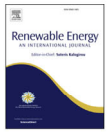

Renewable energy achievements in CO_2 mitigation in Thailand's NDCs

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ABSTRACT

Thailand had summited its Intended Nationally Determined Contributions (INDCs) in 2015 and ratified the Paris Agreement in September 2016. Its INDCs stated that by 2030 GHG emissions will be reduced by 20–25% when compared to the business-*as*-usual (BAU) scenario by using mainly domestic renewable

Vietnam

energies

MDPI

Article

Realizing the Intended Nationally Determined Contribution: The Role of Renewable Energies in Vietnam

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Environmental Research Letters

Global studies

LETTER

Will international emissions trading help achieve the objectives of the Paris Agreement?

Shinichiro Fujimori[1,2], **Izumi Kubota**[1], **Hancheng Dai**[1], **Kiyoshi Takahashi**[1], **Tomoko Hasegawa**[1,2], **Jing-Yu Liu**[1], **Yasuaki Hijioka**[1], **Toshihiko Masui**[1] **and Maho Takimi**[3]

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Keywords: emissions trading, Paris Agreement, computable general equilibrium model, welfare change

Supplementary material for this article is available online

Environmental Research Letters

LETTER

Temporal and spatial distribution of global mitigation cost: INDCs and equity

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Keywords: Paris Agreement, INDC, climate change, equity, mitigation cost, CGE

Supplementary material for this article is available online

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RESEARCH Open Access

Implication of Paris Agreement in the context of long-term climate mitigation goals

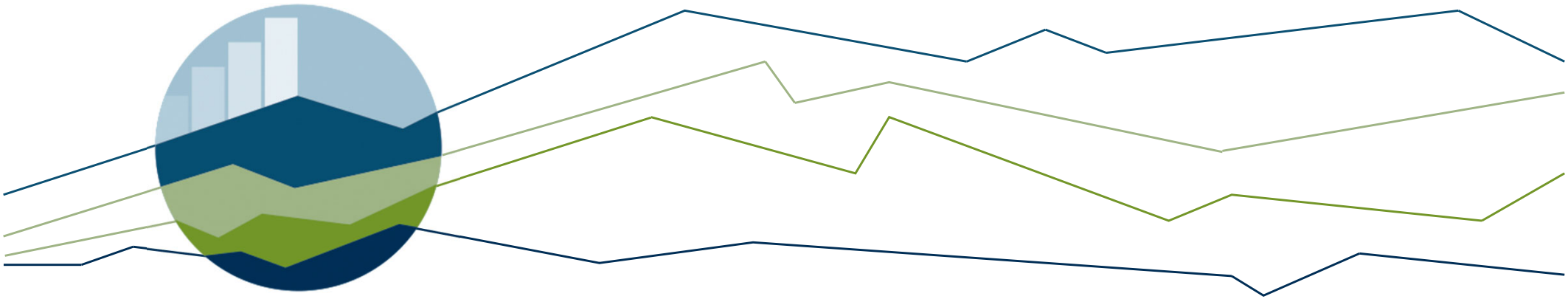
Shinichiro Fujimori[1,2*], Xuanming Su[1], Jing-Yu Liu[1], Tomoko Hasegawa[1,2], Kiyoshi Takahashi[1], Toshihiko Masui[1] and Maho Takimi[3]

Abstract

The Paris Agreement confirmed the global aim to achieve a long-term climate goal, in which the global increase in mean temperature is kept below 2 °C compared to the preindustrial level. We investigated the implications of the near-term emissions targets (for around the year 2030) in the context of the long-term climate mitigation goal using the Asia-Pacific Integrated Model framework. To achieve the 2 °C goal, a large greenhouse gas emissions reduction is required, either in the early or latter half of this century. In the mid-term (from 2030 to 2050), it may be necessary to consider rapid changes to the existing energy or socioeconomic systems, while long-term measures (after 2050) will rely on the substantial use of biomass combined with carbon capture and storage technology or afforestation, which will eventually realize so-called negative CO_2 emissions. With respect to the policy context, two suggestions are provided here. The first is the review and revision of the nationally determined contributions (NDCs) in 2020, with an additional reduction target to the current NDCs being one workable alternative. The second suggestion is a concrete and numerical mid-term emissions reduction target, for example to be met by 2040 or 2050, which could also help to achieve the long-term climate goal.

Keywords: AIM, Integrated assessment model, Land use, Climate change mitigation

Fujimori et al., (2016) SpringerPlus



IAMC – Integrated Assessment Modeling Consortium

SWG on National Scenarios

Shinichiro Fujimori and Roberto Schaeffer

IAMC Advisory Council, 10th March 2022

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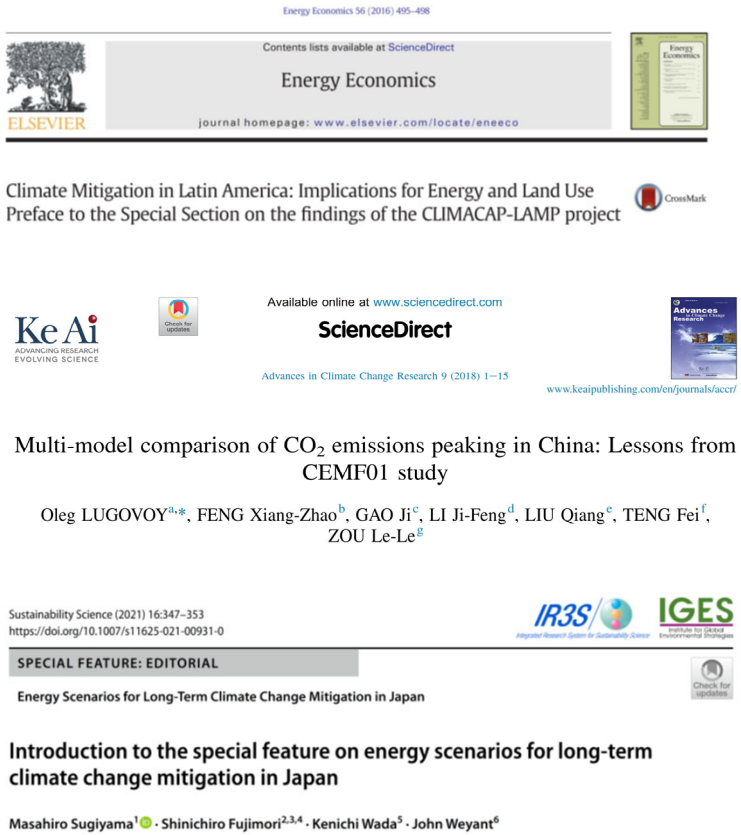
KYOTO UNIVERSITY
KYOTO JAPAN
FOUNDED 1897

Background on global IAM scenarios

- Model-based scenarios are essential pieces of climate mitigation policies
- Global scenarios have been greatly contributing to international climate policy formulation, COPs, IPCC…
- Well-coordinated model inter-comparisons are the main sources for IPCC scenarios databases
  - ✓ AR6 (EMF30, EMF33, ENGAGE, CD-LINKS etc.)
  - ✓ SR1.5 (EMF33, CD-LINKS)
  - ✓ AR5 (EMF23, EMF27, AMPERE, LIMITS etc.)

Background on national IAM scenarios (1)

- National scenarios play similar roles as global ones
- The importance of, and needs for, national scenarios are increasing
  - ✓ Paris Agreement
    - ➢ NDCs and updated NDCs
    - ➢ Long-term strategies
    - ➢ Periodic reviews and revisions of national strategies
- What is the situation of national scenarios?
  - ✓ Individual modeling teams have generated national scenarios individually
  - ✓ Individual national MIPs (China, India, Japan, US)
  - ✓ Continental level MIPs (Asia, EU, Latin America)
  - ✓ Cross-national comparisons (CD-LINKS, COMMIT, ENGAGE, NAVIGATE)
    - ➢ -> Basically take global scenarios and use them as boundary conditions
    - ➢ Uniform carbon prices
  - ✓ IPCC WG3 chapter 4 collected the existing national scenarios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Climate Mitigation in Latin America: Implications for Energy and Land Use
Preface to the Special Section on the findings of the CLIMACAP-LAMP project

Available online at www.sciencedirect.com

ScienceDirect

Advances in Climate Change Research 9 (2018) 1–15

www.keaipublishing.com/en/journals/accr/

Multi-model comparison of CO_2 emissions peaking in China: Lessons from CEMF01 study

Oleg LUGOVOY[a,*], FENG Xiang-Zhao[b], GAO Ji[c], LI Ji-Feng[d], LIU Qiang[e], TENG Fei[f], ZOU Le-Le[g]

Sustainability Science (2021) 16:347–353
https://doi.org/10.1007/s11625-021-00931-0

SPECIAL FEATURE: EDITORIAL

Energy Scenarios for Long-Term Climate Change Mitigation in Japan

Introduction to the special feature on energy scenarios for long-term climate change mitigation in Japan

Masahiro Sugiyama[1] · Shinichiro Fujimori[2,3,4] · Kenichi Wada[5] · John Weyant[6]

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Background on national IAM scenarios (2)

- No communities or organizations have centrally collected information on national scenarios
- Comparability between scenarios are expected but …
- How should we design national scenarios that are consistent with global scenarios?
- How to deal with uncertainties?
  - ✓ Climate policies are revised and launched periodically (and frequently)
  - ✓ National circumstances can change drastically over time
  - ✓ Global scenarios are also revised based on WG3 and WG1 state-of-the-art knowledge

There should be many things that IAMC can resolve and provide

Objective of the SWG on national scenarios

- Promote some standardization among national scenario development activities to increase comparability and use in assessment of international climate policy
  - ✓ This can include linkages to common reporting databases
- Facilitate the collection of national policies (existing and NDCs etc.), and translation/harmonization into modelling assumptions
- Link national activities to global activities
  - ✓ This can include the assessment of global and national/regional emissions, and climate consequences
- Provide a platform for sharing best practices, including the aim for capacity building

Expected outcomes

nature climate change

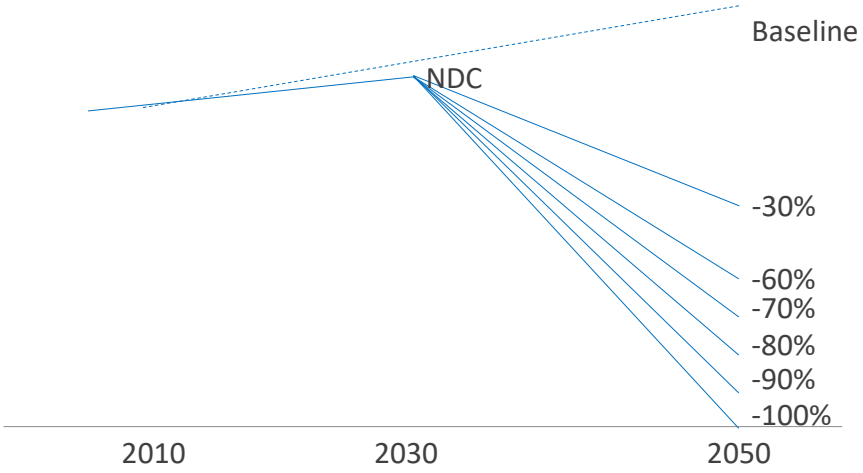
PERSPECTIVE

https://doi.org/10.1038/s41558-021-01048-z

Check for updates

A framework for national scenarios with varying emission reductions

Shinichiro Fujimori[1,2,3]✉, Volker Krey[3], Detlef van Vuuren[4,5], Ken Oshiro[1], Masahiro Sugiyama[6], Puttipong Chunark[7], Bundit Limmeechokchai[7], Shivika Mittal[8,9], Osamu Nishiura[1], Chan Park[10], Salony Rajbhandari[7], Diego Silva Herran[2,11], Tran Thanh Tu[12], Shiya Zhao[1], Yuki Ochi[13], Priyardarshi R. Shukla[9], Toshihiko Masui[2], Phuong V. H. Nguyen[14], Anique-Marie Cabardos[3] and Keywan Riahi[3,15]



- Implemented by six Asian countries and compared among them

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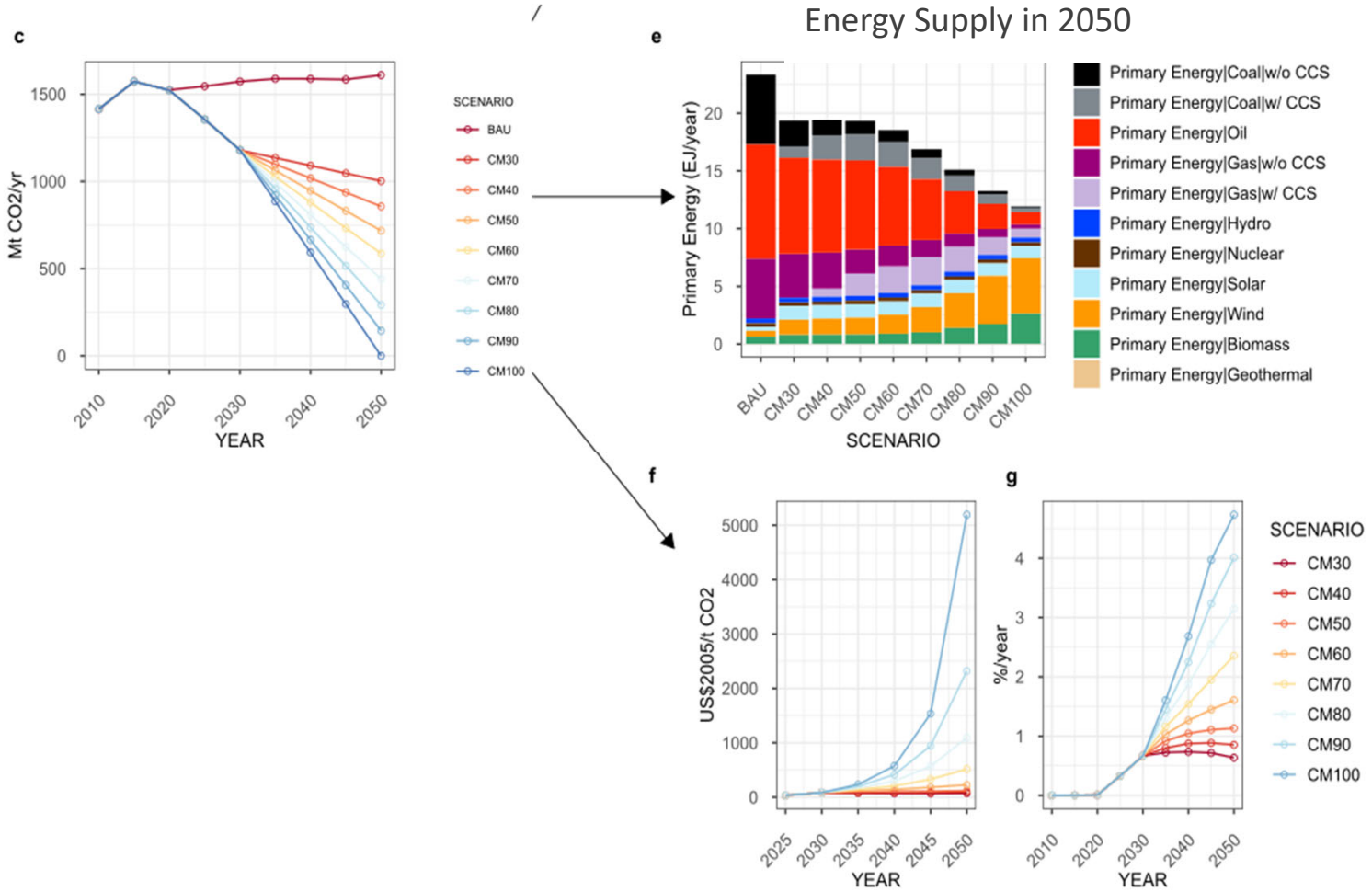
Japan example



Carbon price

Policy cost (GDP loss)

- Breaking point?
- Non-linearlity?

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Coordinating structure

Co-chairs

Shinichiro Fujimori
(KU, NIES)

Roberto Schaeffer
(COPPE)

Regional coordinators

- Asia
- Europe
- Latin America
- North America
- Africa

- The role of co-chairs is to lead the SWG and to coordinate overall relevant activities
- The role of regional coordinators is to collect national/regional scenario information to IAMC and to provide IAMC-SWG information for regional scenario exercises. Also, they can contribute to planning, developing and to advance the activities of this SWG
- If needed, co-chairs can organize meetings with regional coordinators

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Final remarks

- AIM modeling team
  - ✓ Long history from 1990
  - ✓ AIM has played significant roles in domestic policy and international research community
- Recent activities
  - ✓ Expansion of representation in socioeconomic aspects
  - ✓ Climate change impact economics
  - ✓ Asian climate mitigation policy assessment
- SWGs on national scenarios