AIM modeling and recent on-going research activities

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National Institute for Environmental Studies

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FEEM seminar @Millan, Italy

AIM
ASIA-PACIFIC INTEGRATED MODEL

NIES JAPAN

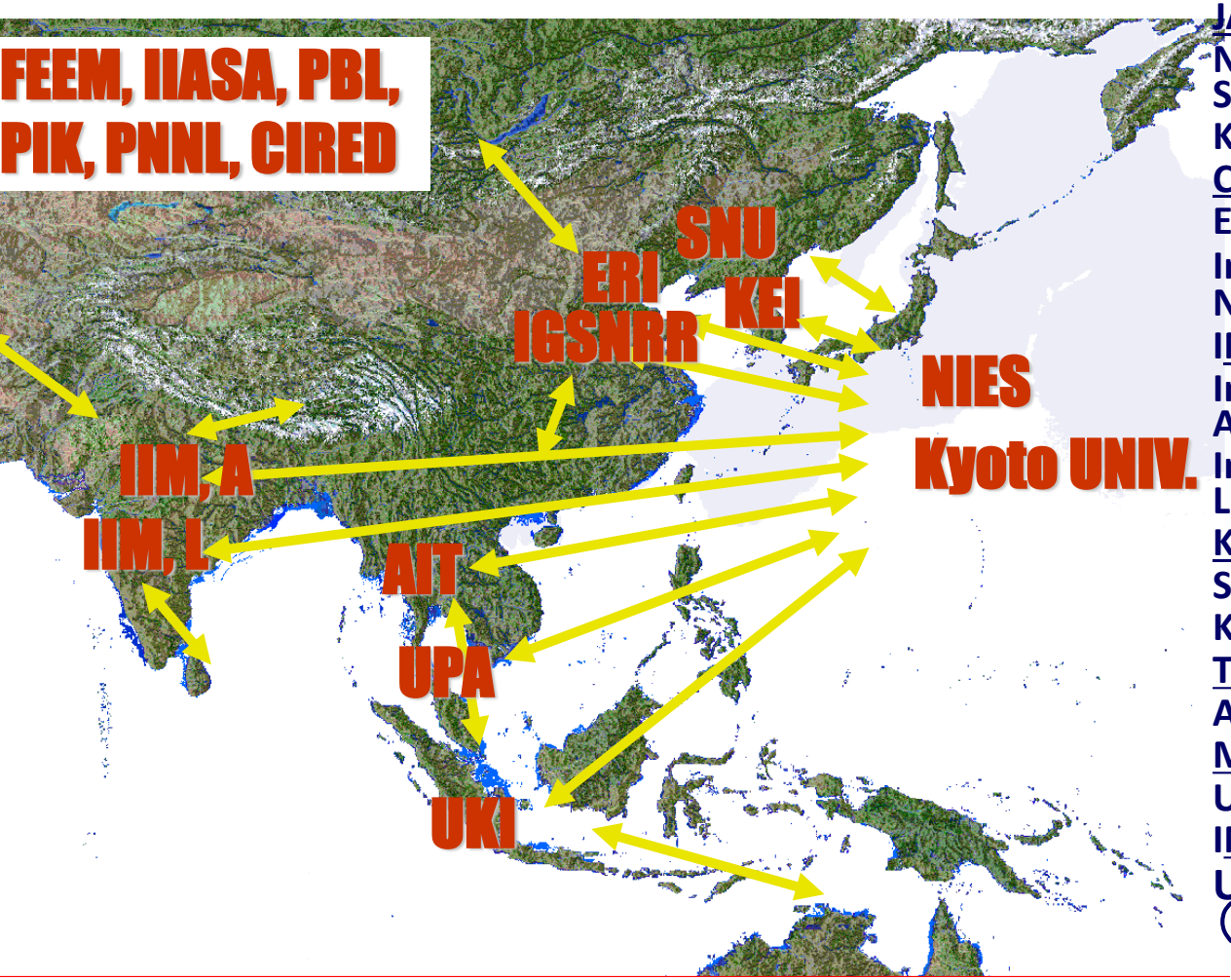
Outline

- AIM modeling team
  - ✓ History of AIM
  - ✓ Team organization
- Recent activities
  - ✓ Asian climate mitigation policy assessment
  - ✓ Climate change impact economics
  - ✓ Global land use and agricultural modeling in AIM

AIM modeling team

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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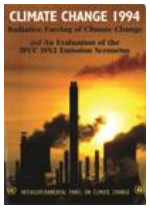
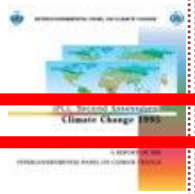
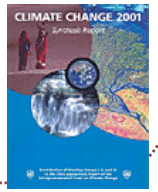
AIM brief history (1)

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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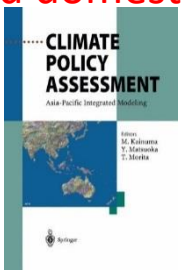
AIM brief history (2)

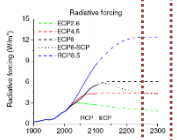
Play significant roles in Int' and domestic policy

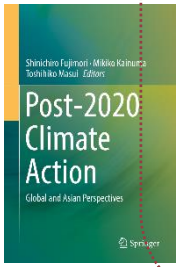
		International activity	National activity
2002	AIM book published Ecosystem model development	• GEO3	
2004		• UNEP MA	• Japan LCS project
2005	First COP side event		
		• IPCC AR4	• Japanese med-term target
2009			• Asian LCS project

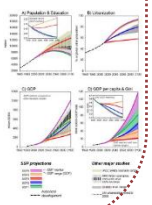
Diversified and intensified in many research area

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	







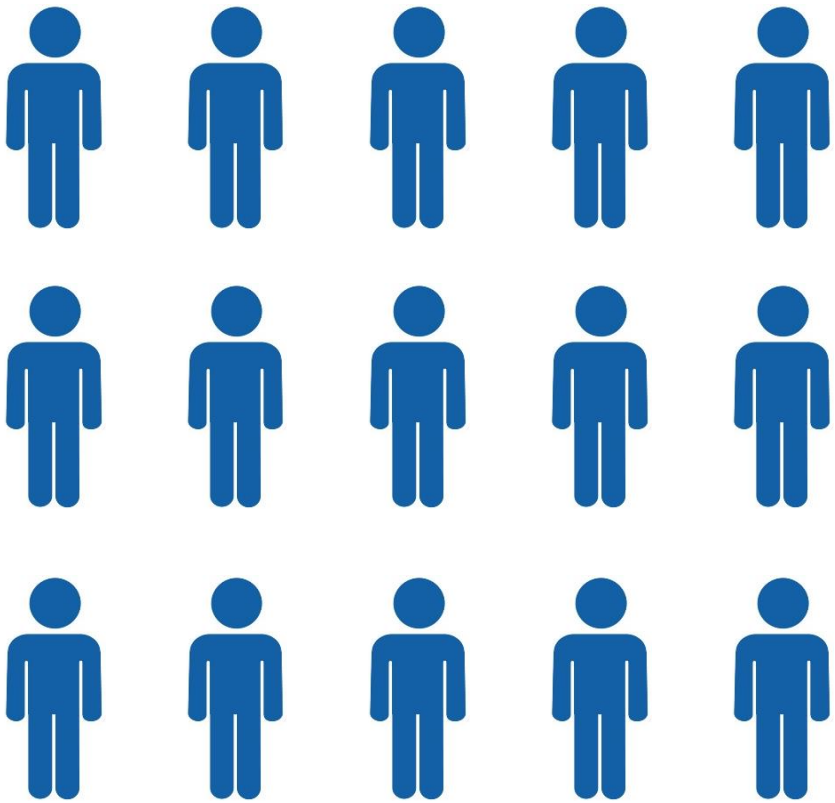


Training workshop at NIES 2015

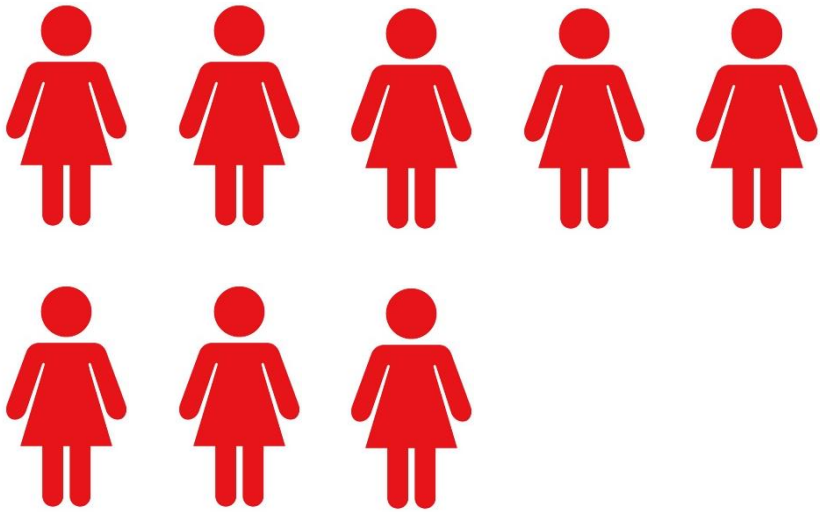
Who we are

- Core institution
  - ✓ NIES
  - ✓ Kyoto University
  - ✓ MHIR (consultant company)
- NIES
  - ✓ 23 researchers (including postdoc)
  - ✓ Internal and external funding from Ministry of Environment Japan
  - ✓ Current main externally funded projects
    - ➢ Climate mitigation and SDGs long-term scenario
    - ➢ Climate change impact economic assessment
    - ➢ Short lived climate pollutants assessment
    - ➢ Local low carbon scenario development

Gender balance



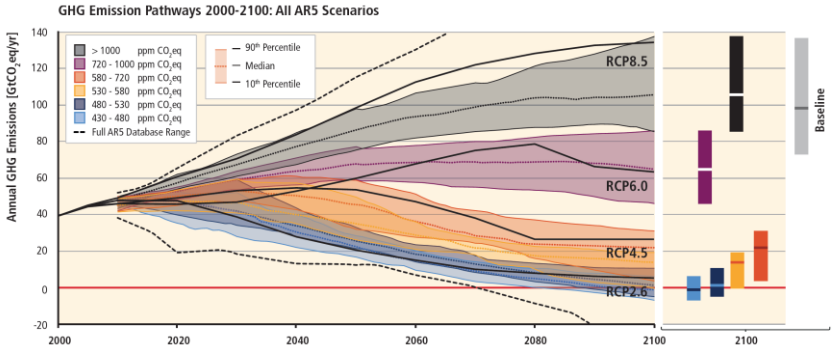
Male (15)

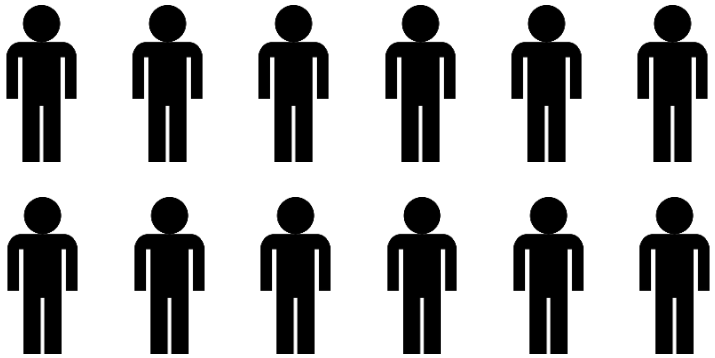


Female (8)

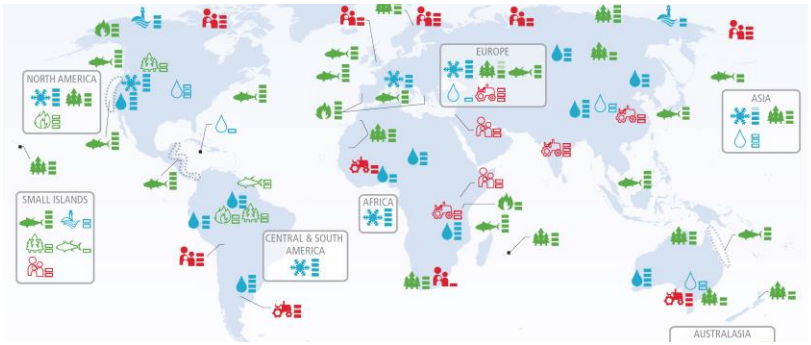
Discipline

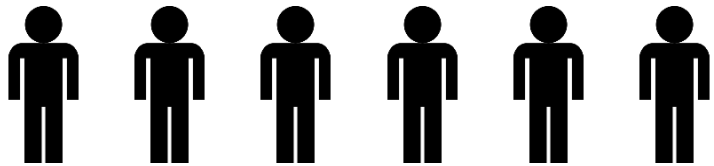
Mitigation (10)





Impact and adaptation (6)





Both of them (5)

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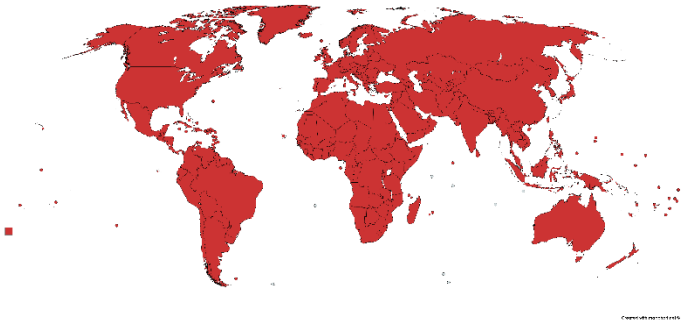
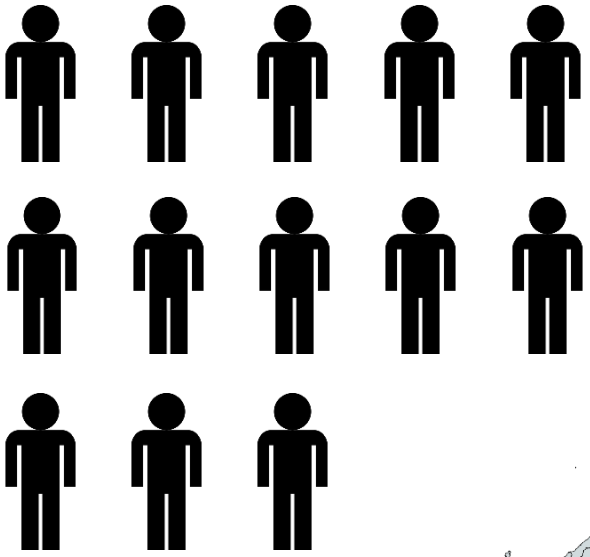
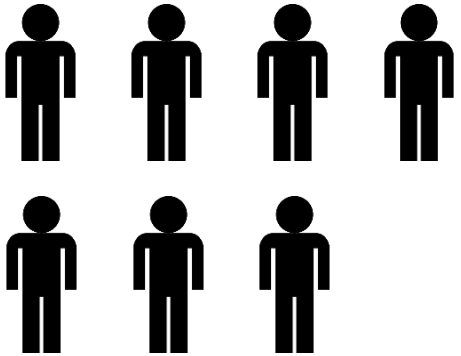
Research area

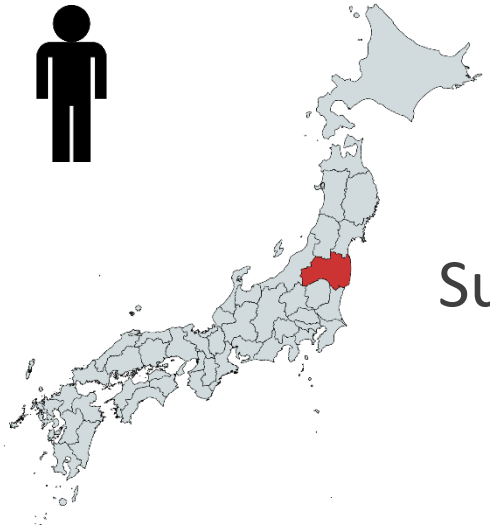
Global (13)





National (7)





Subnational (3)

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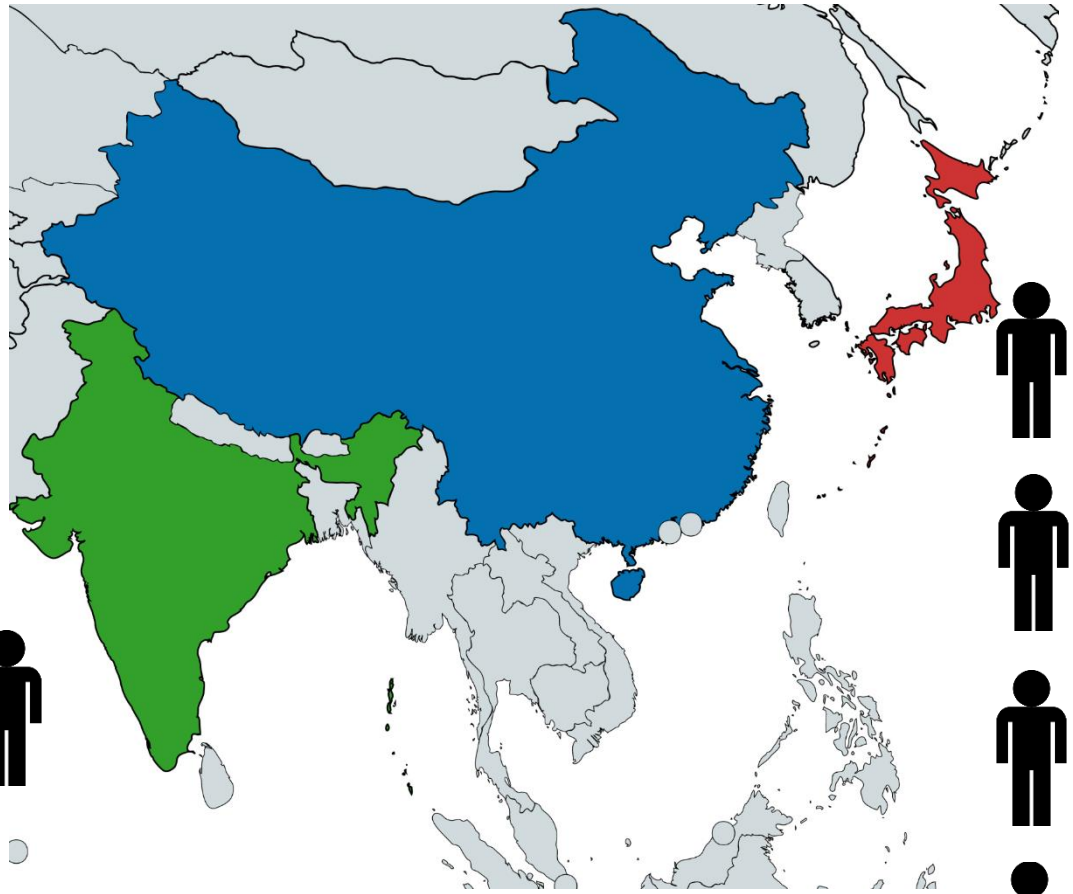
Nationality

China (6)



India (1)

Japan (16)

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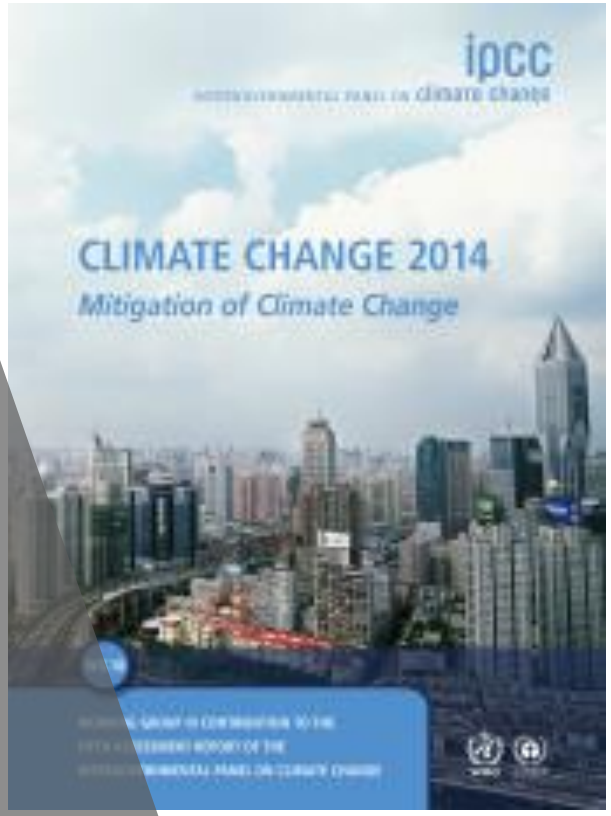
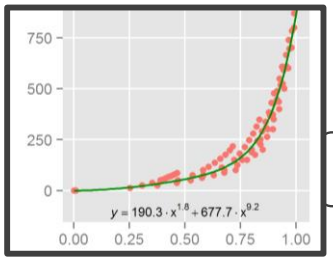
Climate change mitigation study



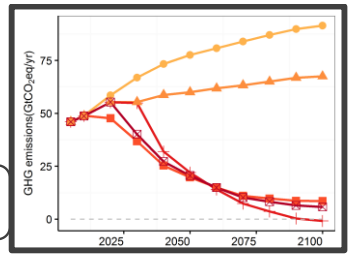
AIM modeling (Mitigation)



MAC curve

DICE type optimization model AIM/Dynamic

GHG emissions pathway



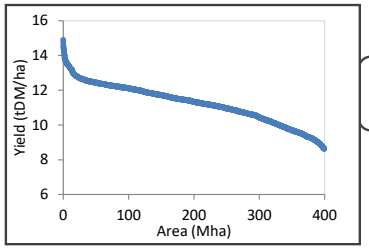
Recursive Dynamic Economic model AIM/CGE

Activity

AIM/AFOLU

MAC and land use

Enduse information



Biomass supply curve

Transport and energy demand

Land use and agriculture price

Energy and carbon price

Transport model AIM/Transport

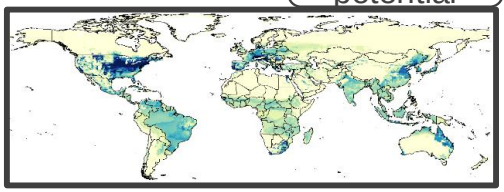
Gridded land use

Land allocation model AIM/PLUM

Energy production and consumption

GHG and air pollutant emissions

Biophysical potential

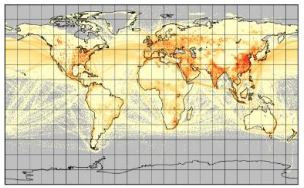


Simplified climate MAGICC

Emissions downscaling AIM/DS

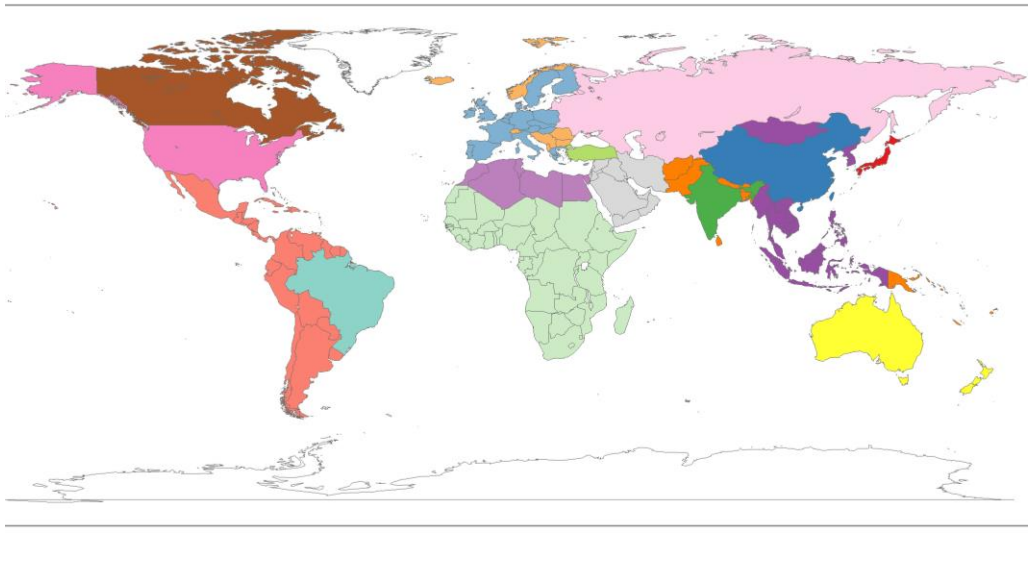
Global mean temperature

Gridded emissions



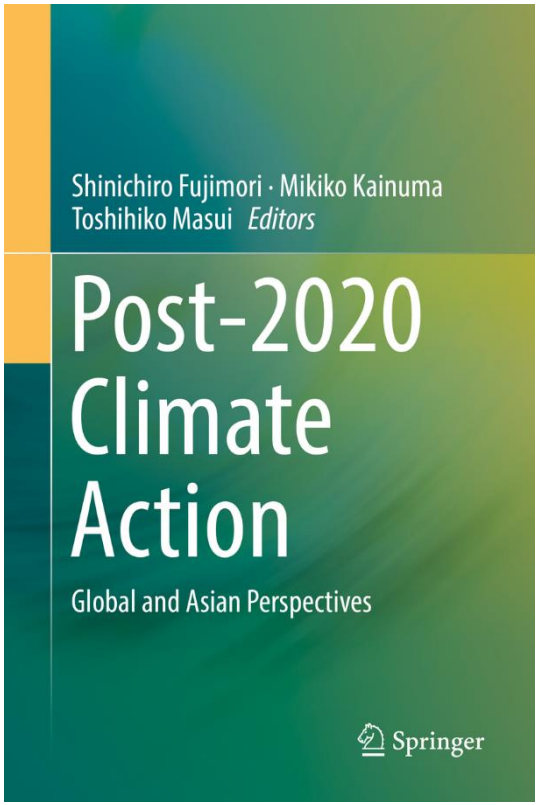
AIM/CGE

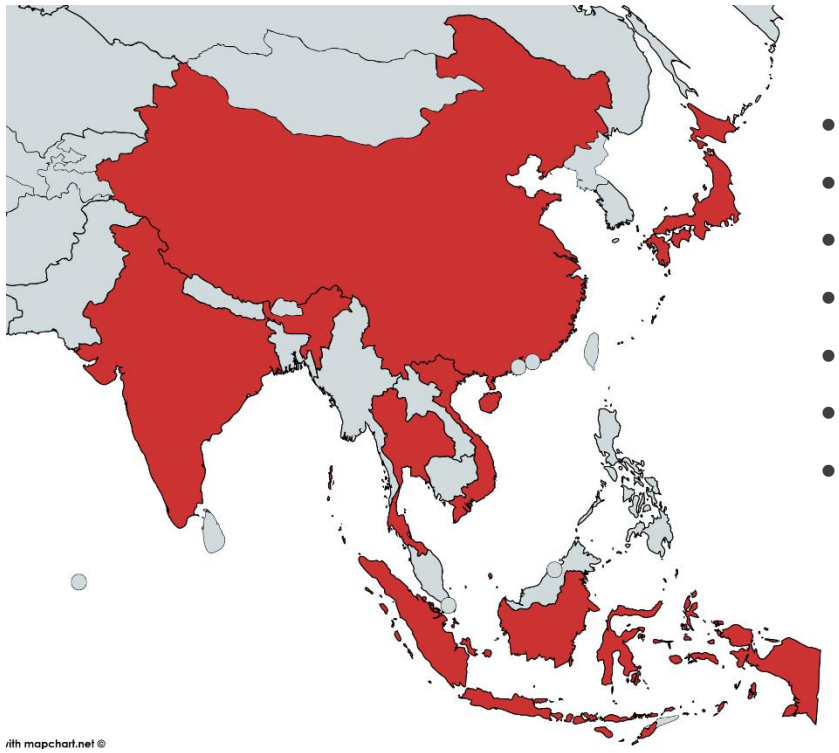
- General equilibrium global economic model
- 43 industrial sectors (Energy and agriculture are highly disaggregated) and 17 region.
- Recursive dynamic
- Domestic and international market is assumed



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

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

energies

Article

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

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Academic Editor: Bin Chen
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Indonesia land use

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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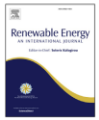

Renewable energy achievements in CO_2 mitigation in Thailand's NDCs

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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

Jing-Yu Liu[1,3], **Shinichiro Fujimori**[1,2] **and Toshihiko Masui**[1]

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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

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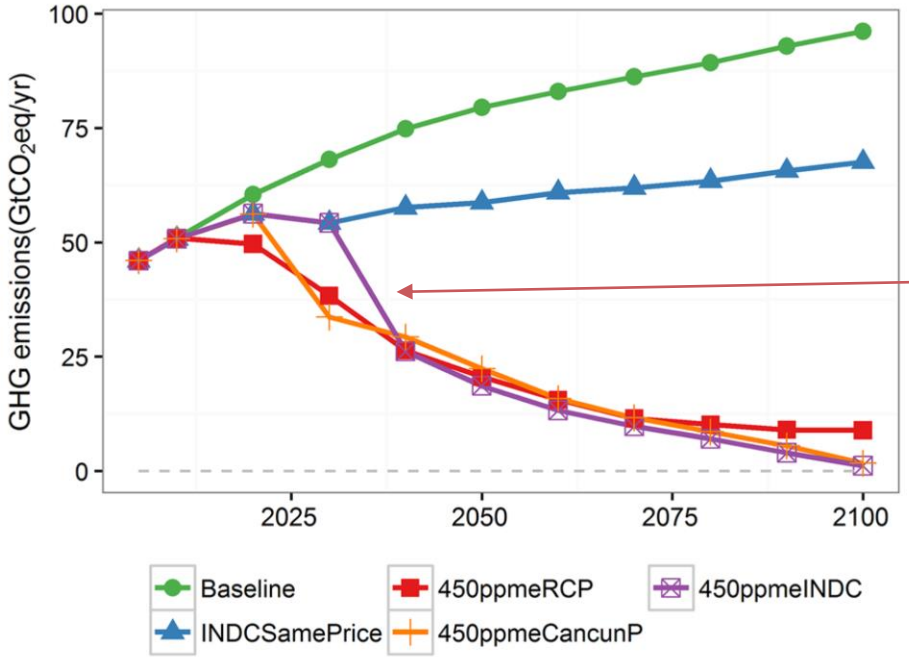
Scenarios

Table 1 List of scenarios

Scenario name	GHG emissions reduction		
	2015–2020	2020–2030	2030–2100
Baseline	None		
INDCSamePrice	Cancun pledge	INDCs	Same carbon price in 2030
450ppmeRCP	Same as RCP2.6 emissions pathway		
450ppmeCancuunP	Cancun pledge	Equivalent to cumulative emissions in 450ppmeRCP	
450ppmeINDC	Cancun pledge	INDCs	Equivalent to cumulative emissions in 450ppmeRCP



Speed of he reduction is one of the keys

Fig. 2 Global total greenhouse gas (GHG) emissions

GDP loss and carbon price

- GDP loss rates differ in the near-term (-2030) and the end of century
- The delayed action effect
- Carbon price is similar
  - ✓ Room for reduction is limited

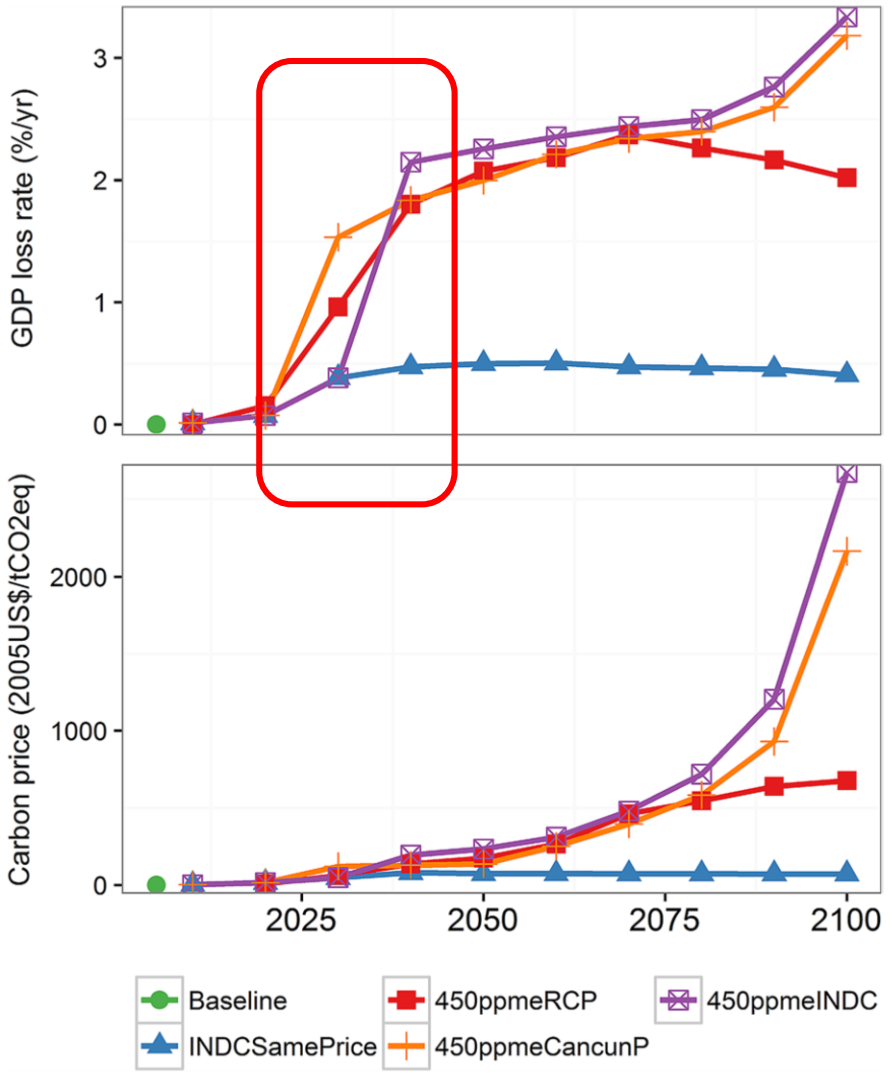


Fig. 6 Global gross domestic product (GDP) loss rate and carbon prices

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GHG emissions in 2100

- Our immediate reduction scenario does not go negative CO2
- INDC and Cancun scenarios are almost same at the end of century.
  - ✓ Total GHG emissions in 2100

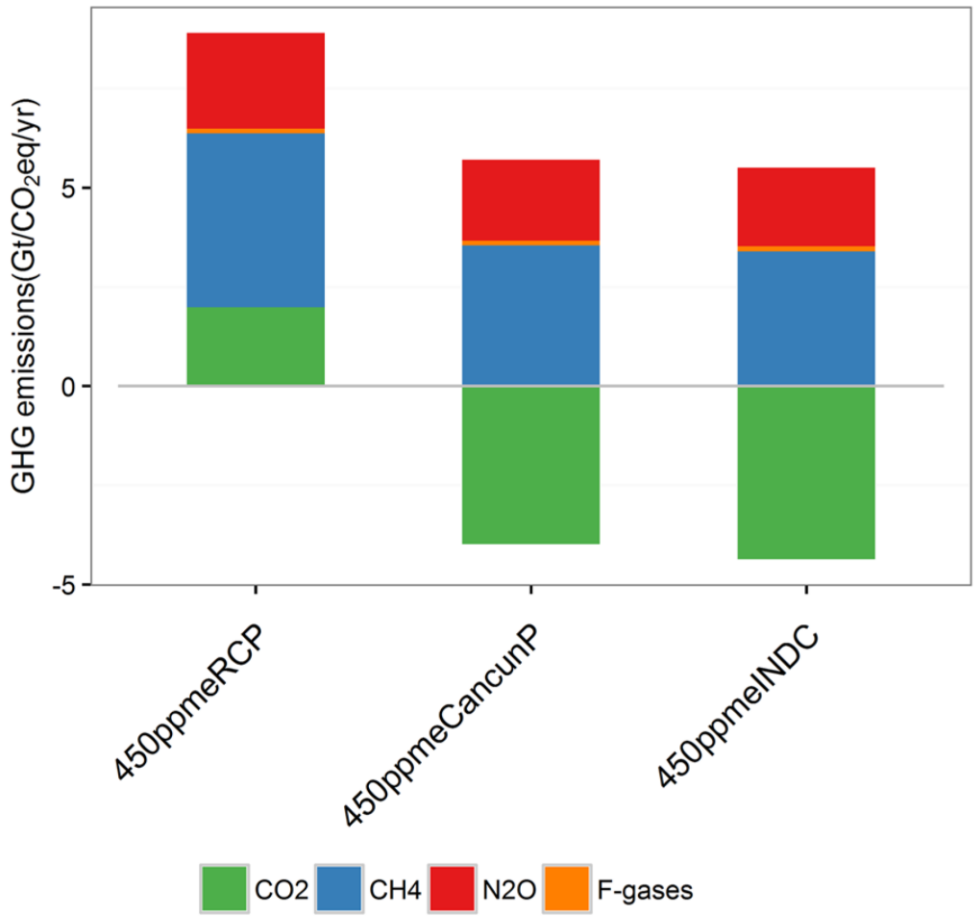

Fig. 7 Greenhouse gas (GHG) emissions profile in 2100 for the 450 ppm stabilization scenarios

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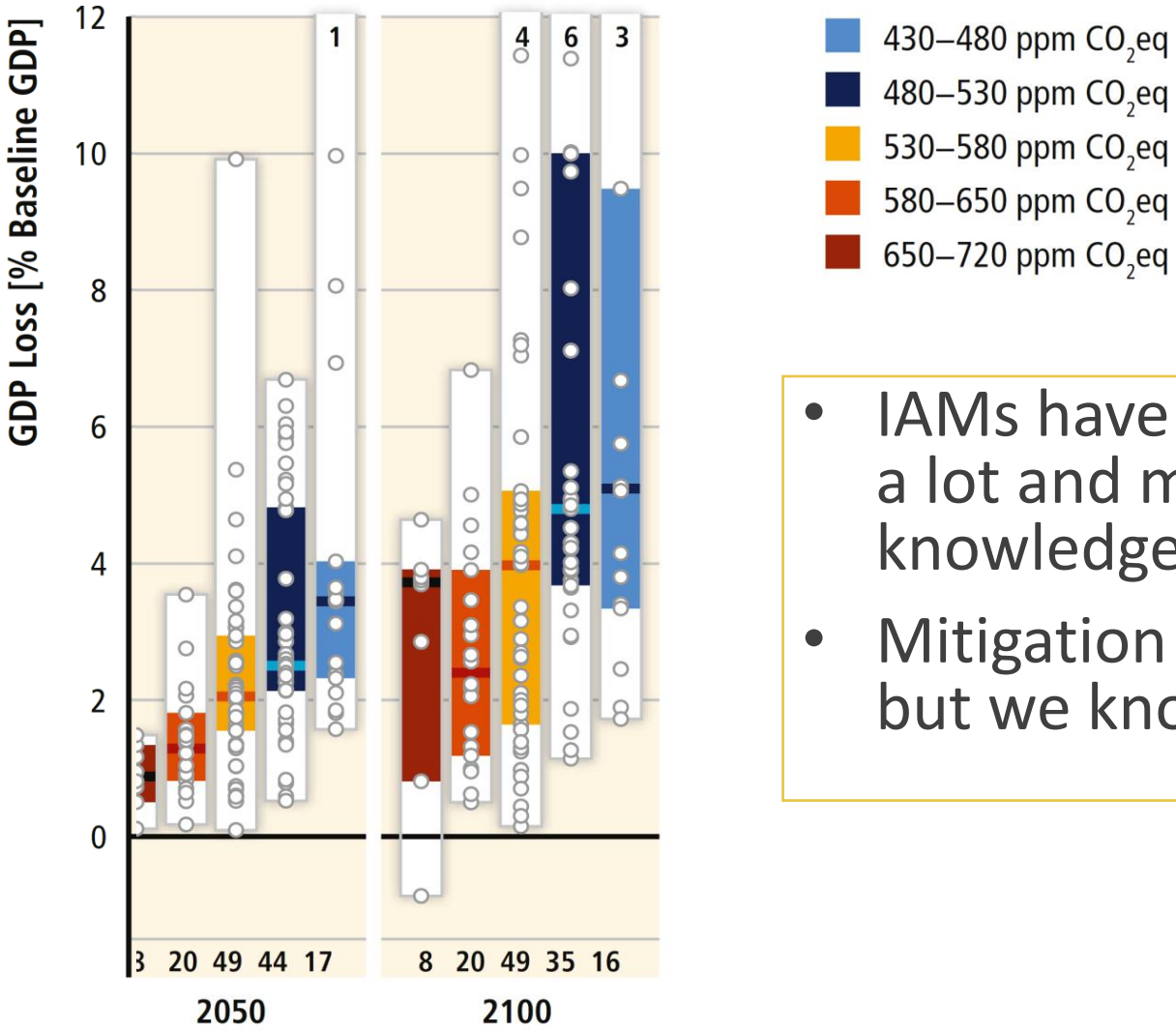
Remarks

- Near-term
  - ✓ Rapid emissions reduction
- Long-term
  - ✓ Negative emissions
  - ✓ Land competition

Climate change impact economics

Mitigation study is rich



- IAMs have been working a lot and much of knowledge
- Mitigation cost varies but we know about that.

AR5 WG3 Chap 6

Impact economics

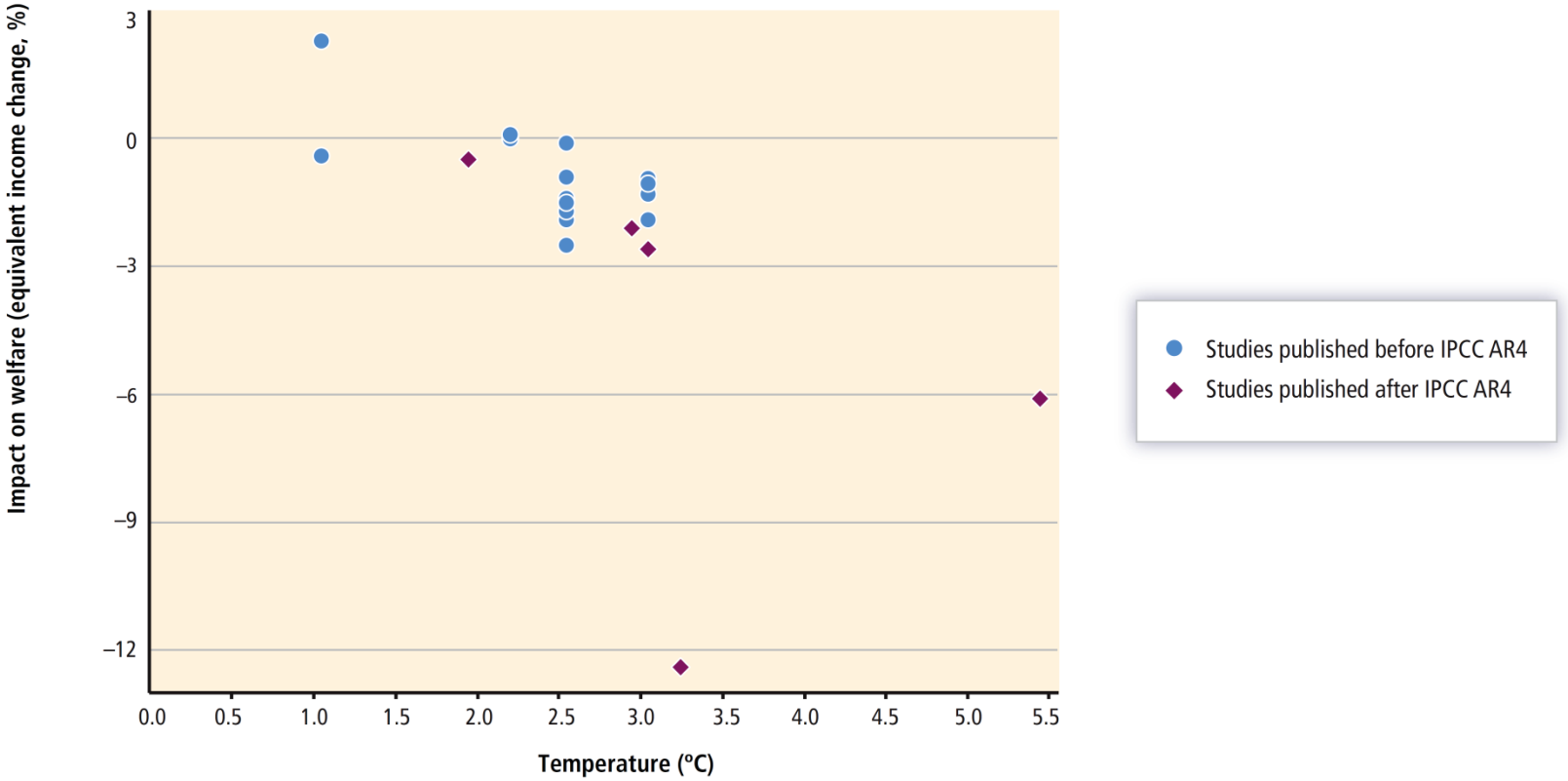


Figure 10-1 | Estimates of the total impact of climate change plotted against the assumed climate change (proxied by the increase in the global mean surface air temperature); studies published since IPCC AR4 are highlighted as diamonds; see Table SM10-1.

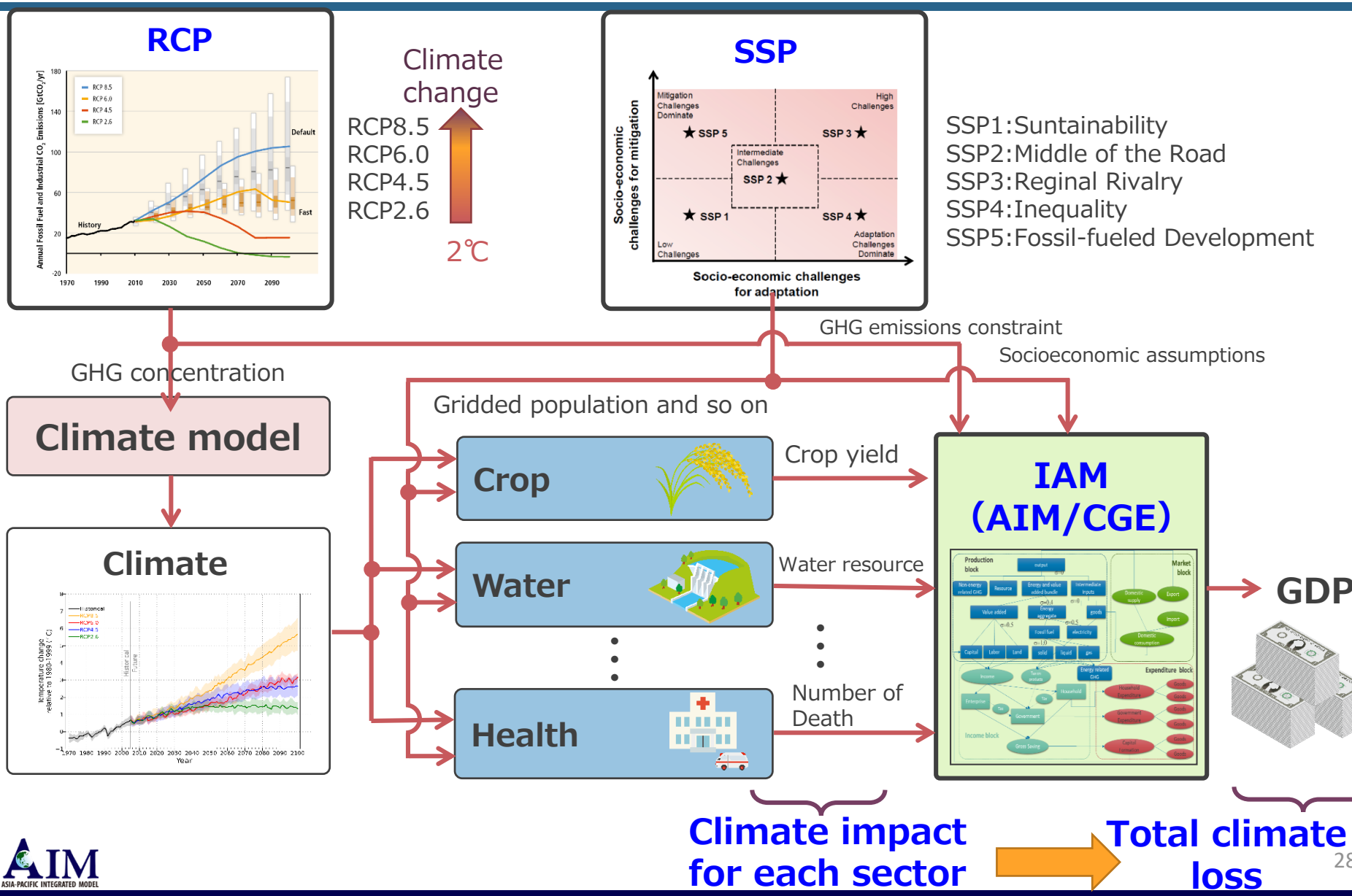
- Just 5 plots are added from AR4 to AR5
- The source data of damage function gets old.

Objective

Better information about impact economics

- Enrich the damage function information
- Global, multi-regional and multi-sectoral assessment
- RCP/SSP framework
- AIM/CGE + other sector models (0.5 degree or more detail)
  - ✓ Crop model (undernutrition and classical macro-economic shock)
  - ✓ Hydrology model (hydro and cooling water)
  - ✓ Flood model
  - ✓ Labor productivity
  - ✓ Energy demand
  - ✓ Coastal damage
  - ✓ Ecosystem

Overview of the study



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ARTICLE

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Quantifying the economic impact of changes in energy demand for space heating and cooling systems under varying climatic scenarios

Tomoko Hasegawa[1], Chan Park[2], Shinichiro Fujimori[1], Kiyoshi Takahashi[1], Yasuaki Hijioka[1] and Toshihiko Masui[1]

Energy demand

Methodology

- AIM/CGE coupled with an end-use type model
- In the model, energy demand is changed according HDD&CDD changes.

Socioeconomic conditions
- Population
- GDP

Gridded data
- Temperature
- Population

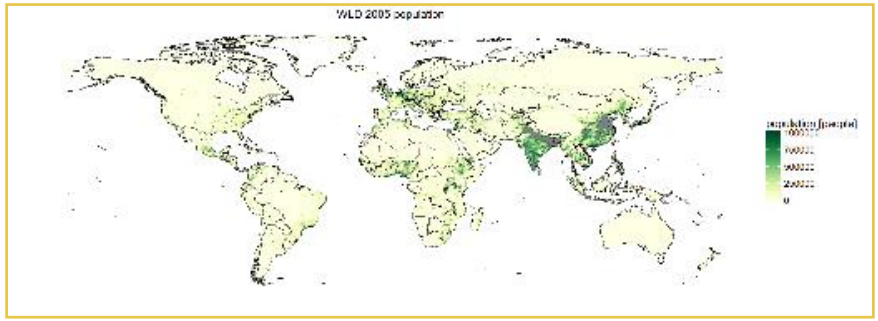
HDD & CDD

AIM/CGE model

Economic impact
- GDP loss
- Consumption loss

Energy supply & demand

Technology changes & costs



Cooling and Heating demand: Residential

(Energy service demand) =
(Population) *(floor area/cap)*(degree day)*(Device penetration rate)

- Population : SSP2
- Per capita floor area(McNeil et al)

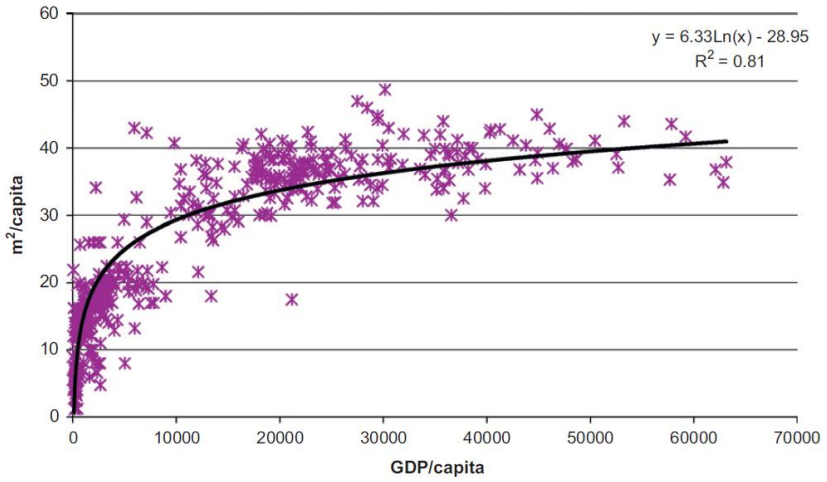
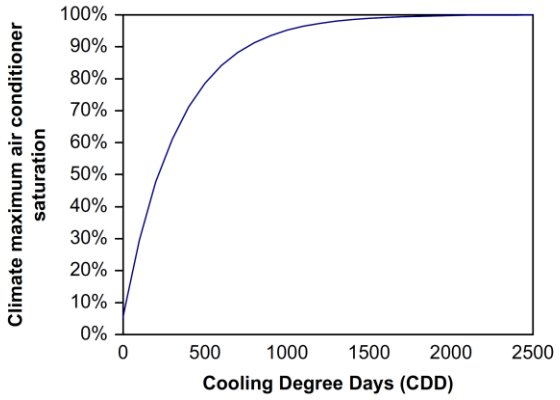
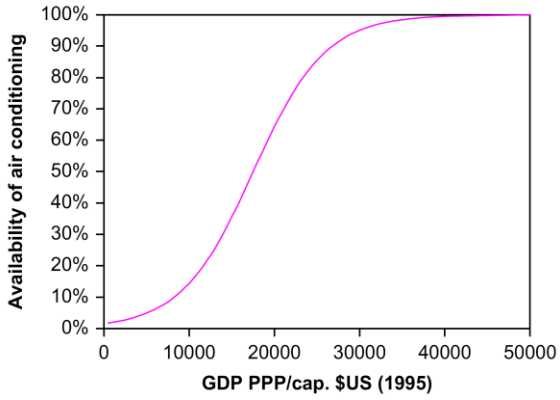


Fig. 1. Residential floor area per capita vs. GDP per capita: data points and fit to data.

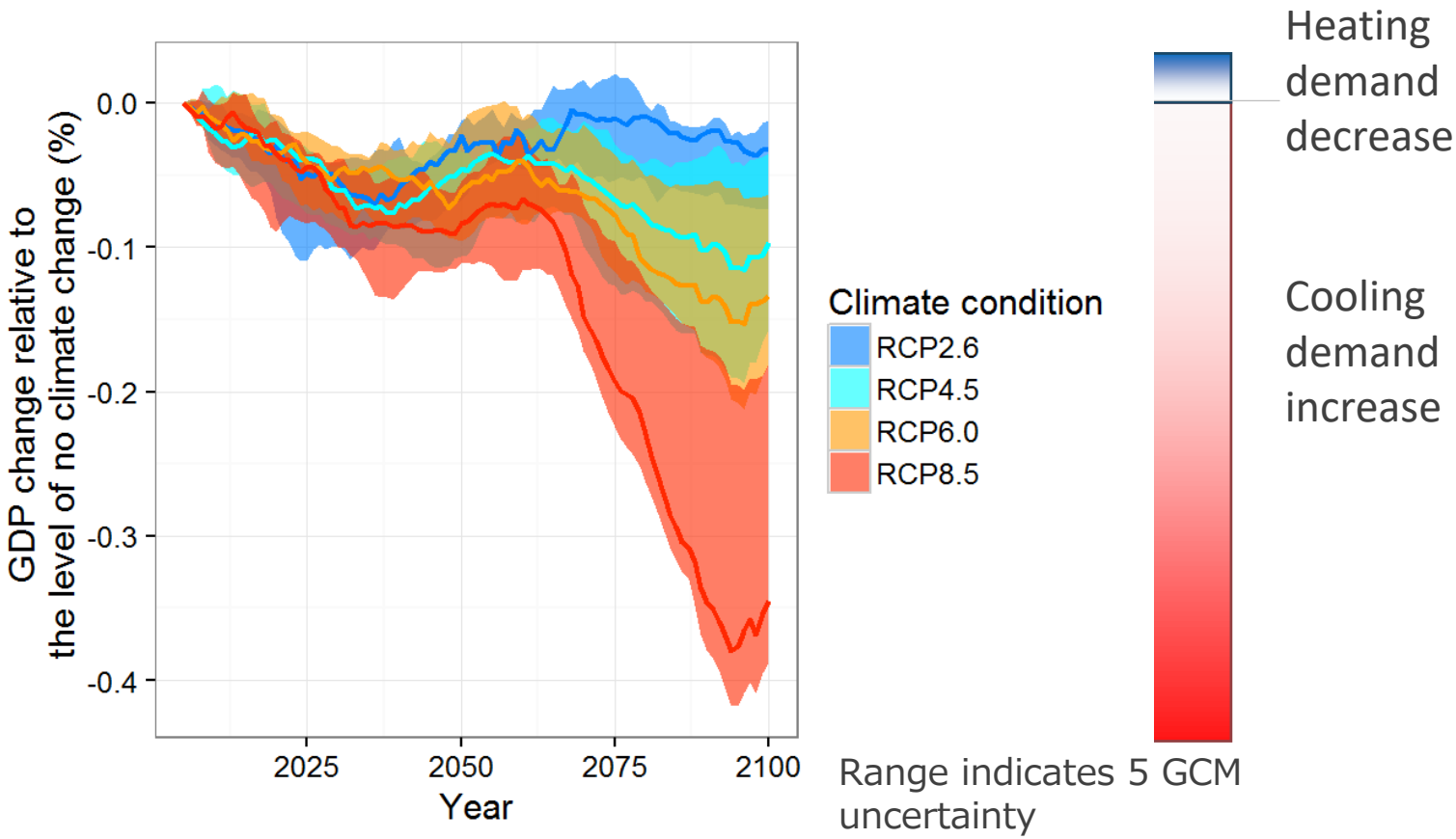
Device penetration= (climate condition) *(air conditioner availability)





(Isaac and van Vuuren, 2009)

SSP2 global total



- 0.43% GDP loss in RCP8.5
- <0.1% loss in low emissions scenarios
- The negative impact mainly comes from cooling demand increase

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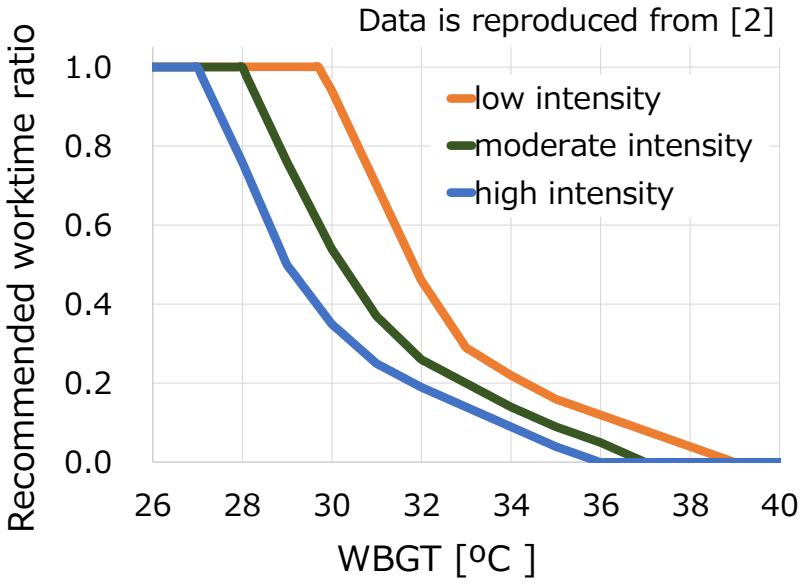
Cost of preventing workplace heat-related illness through worker breaks and the benefit of climate-change mitigation

Jun'ya Takakura[1,4], Shinichiro Fujimori[1,2], Kiyoshi Takahashi[1], Yasuaki Hijioka[1], Tomoko Hasegawa[1,2], Yasushi Honda[3] and Toshihiko Masui[1]

Labor productivity

Work time loss based on WBGT change (outside works)



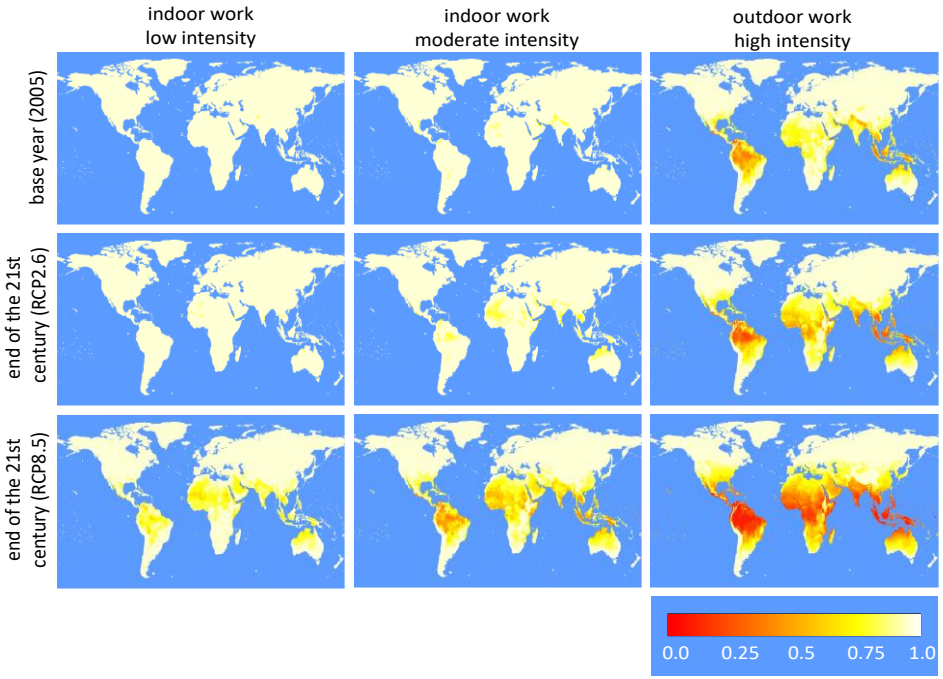
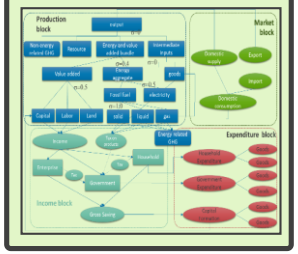


Fig.1 Relationship between recommended worktime and thermal condition

IAM (AIM/CGE)



Takakura et al. (2017)

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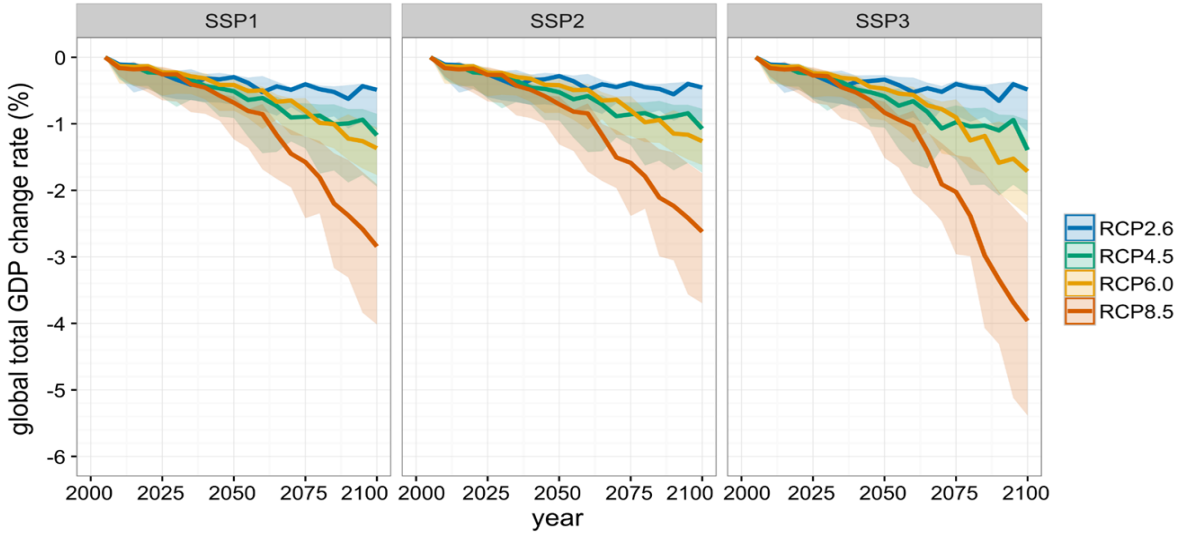
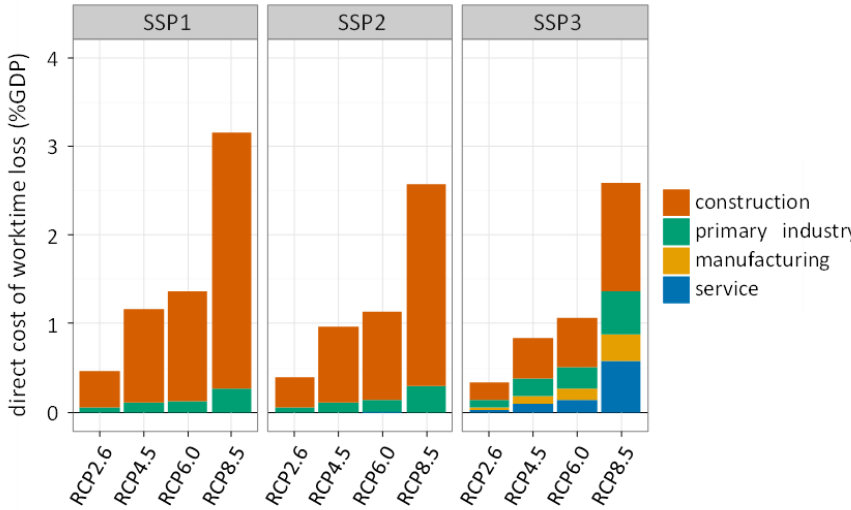
GDP loss associated with labor productivity loss



Range indicates 5 GCM uncertainty

- **Regardless socioeconomic conditions, economic loss is large (2.6~4.0% of GDP)**
- **Magnitude is comparable with climate mitigation cost**
- **Outdoor work (construction) is the major source**

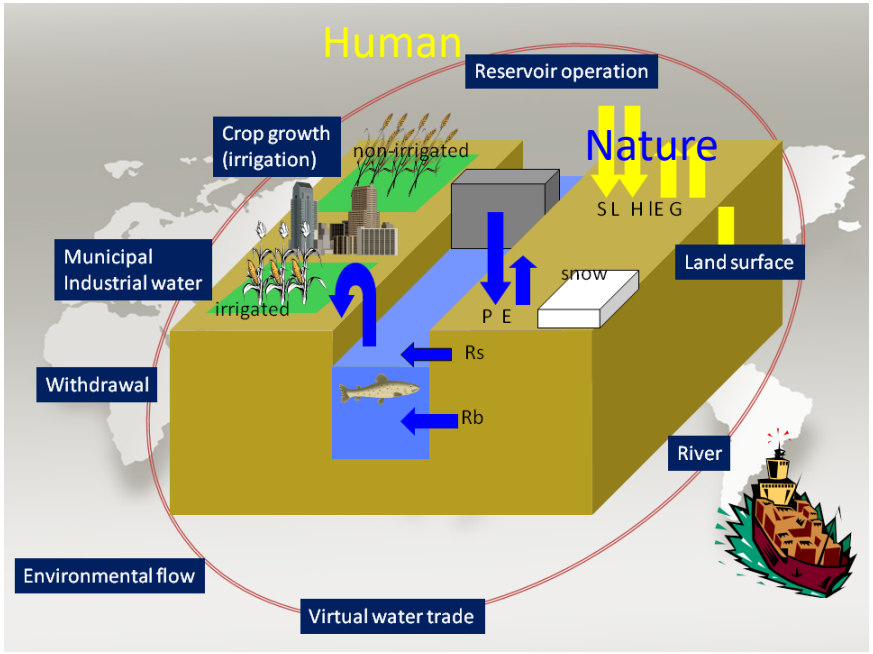


Takakura et al. (2017)

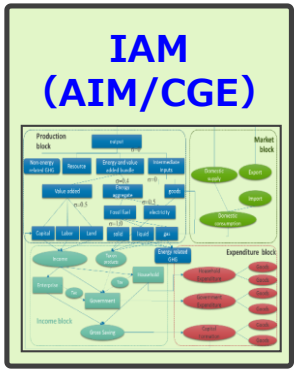
Hydropower

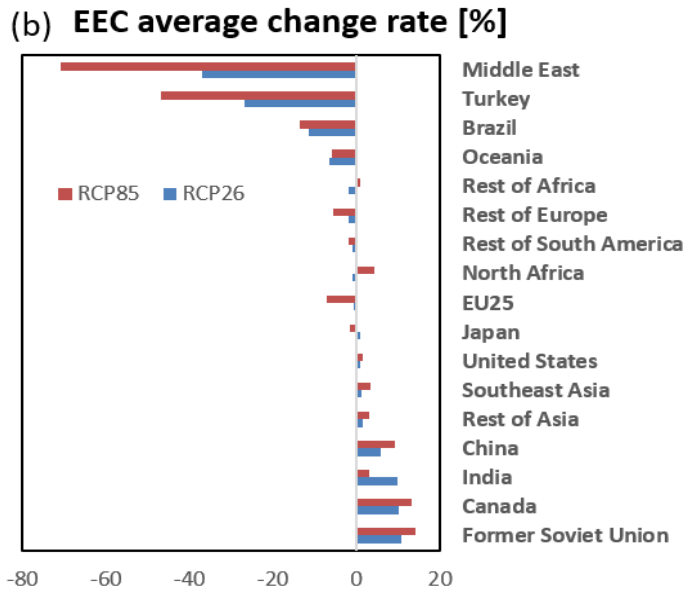
Q Zhou, N Hanasaki, S Fujimori, Y Masaki, K Takahashi, Y Hijioka, The economic consequences of global climate change and mitigation on future hydropower, Climatic Change, Under review

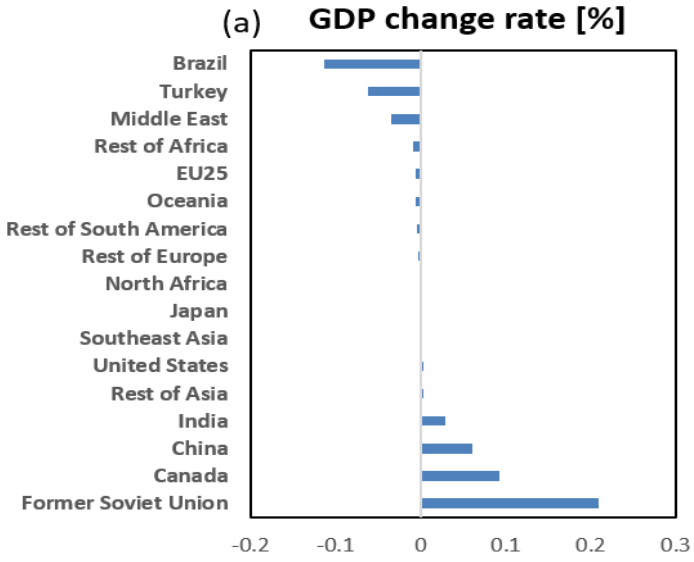
Economically Exploitable Capacity change



Hydrological model H08







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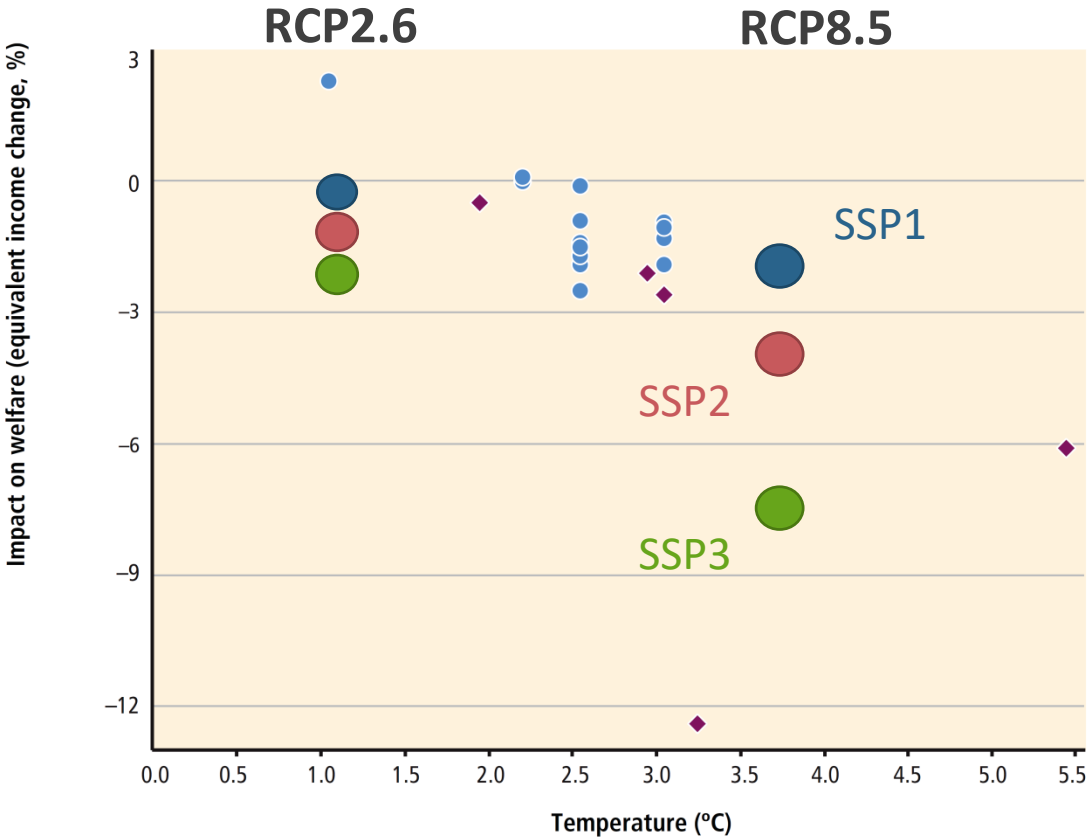
Preliminary results



- Included up to now
  - Energy demand,
  - Labor productivity
  - Crop yield change
  - Hydropower
  - Undernutrition
- Will be included
  - River Flood
  - Coastal damage

In AR4

Added after AR4

- The magnitude is almost similar or slightly bigger
- RCP8.5 should be avoided.
- Not easy to say which RCP level is best
- Extreme and catastrophic events are not

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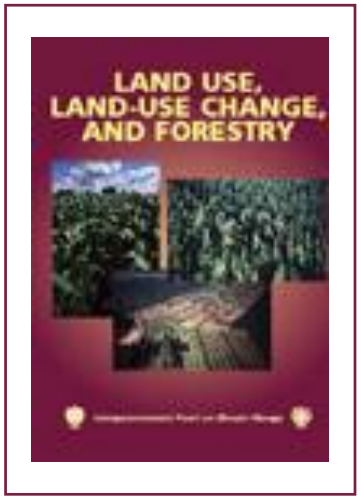
Discussion

- The need for considering regional variety
  - ✓ Offset issue
- Temporal and generation aggregation issue
- Extreme and catastrophic events



Global food, agriculture and land use in AIM

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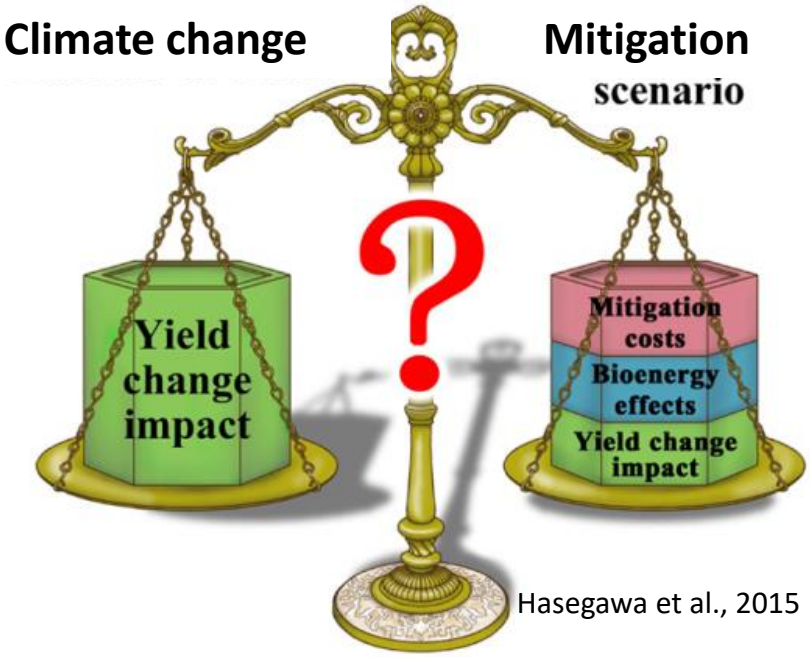
Recent studies

- Food security vs Climate Change
  - Effects of mitigation policies on food security
  - Model comparison in AgMIP
  - Health impacts caused by undernutrition
  - Extreme events

- Biodiversity loss vs Climate and Land-use Changes

Climate-induced undernourishment: Trade-offs between mitigation and food security



Hasegawa et al., 2015

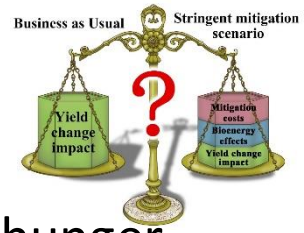
Yield change likely affects food consumption.

Land-based mitigation measures (e.g. bioenergy, afforestation) would compete with food production through land and water resources.

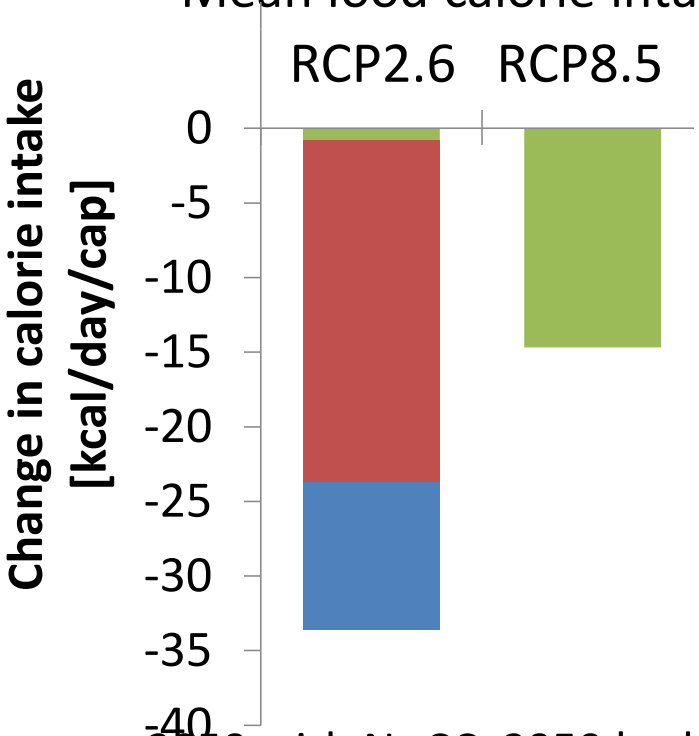
Macro-economic impact of the stringent mitigation aiming 2℃ target.

Which is better, baseline or mitigation worlds in terms of undernutrition?

Consequence of Climate Mitigation on the Risk of Hunger

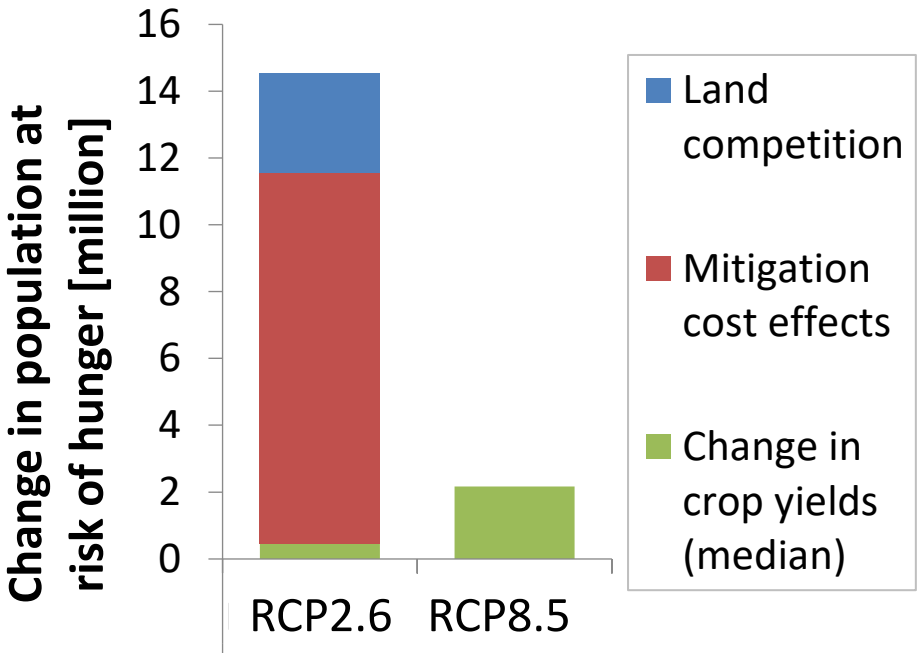


Mean food calorie intake



2050 with NoCC: 2950 kcal/cap/day
2005: 2680 kcal/cap/day

Global population at risk of hunger



2050 with NoCC: 90 mil.
2005: 830 mil.

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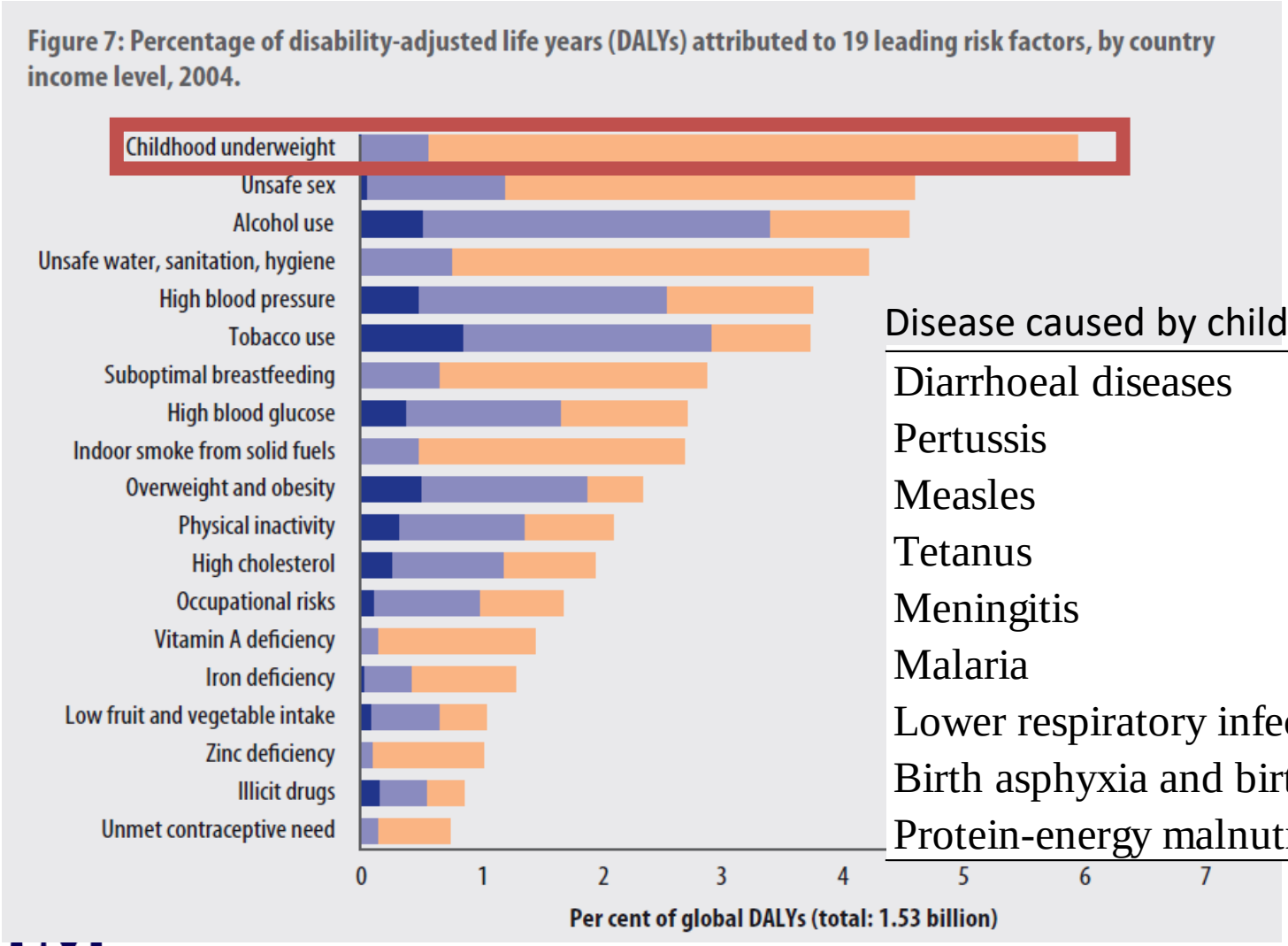
Hasegawa et al., 2015 EST

Health impacts caused by undernutrition

- Undernutrition brings serious disease due to childhood underweight.
- Childhood underweight is **the top risk factor** of disability in **low income regions**



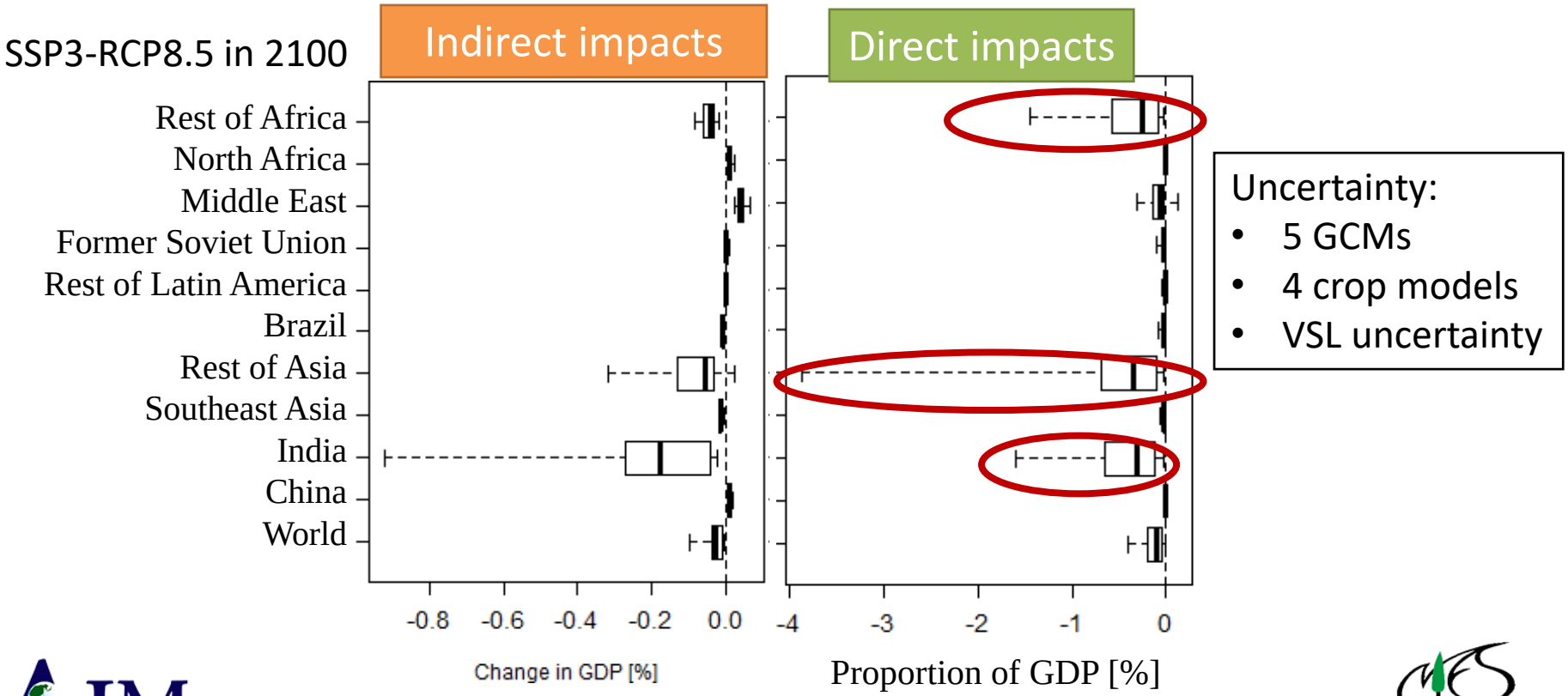
Disease caused by child underweight

- Diarrhoeal diseases
- Pertussis
- Measles
- Tetanus
- Meningitis
- Malaria
- Lower respiratory infections
- Birth asphyxia and birth trauma
- Protein-energy malnutrition

source: WHO 2009

How much climate change impact on undernutrition and economy?

- Effects of labor force & healthcare costs: -0.1–0.0% of Global GDP
- Effects of mortality (value of lives lost): -0.4-0.0% of Global GDP



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Hasegawa et al., 2016

Biodiversity loss vs Climate and Land-use Changes

Discussion

- The strict emissions cuts toward Paris Agreement could indirectly lead indirect impacts on food security and biodiversity loss.
- This risk doesn't negate need of climate mitigation.
- Highlight importance of careful design of climate mitigation and complementary measures to vulnerable groups or area.

- Next question is how much costs or food needs to be paid by whom.

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Summary

- AIM modeling team
  - ✓ History of AIM
  - ✓ Team organization
- Recent activities
  - ✓ Asian climate mitigation policy assessment
  - ✓ Climate change impact economics
  - ✓ Global land use and agricultural modeling in AIM

Grazie per l'attenzione

Illustrates sources
http://shigotogirai.hatenablog.jp/entry/2015/07/01/191247
https://pixabay.com/p-146843/?no_redirect