Integrated Assessment Modeling Consortium

The Role of Integrated Assessment Models in Realizing Net Zero Societies
– From the Experience of AIM Model Development –

Mikiko Kainuma

Senior Research Advisor, Institute for Global Environmental Studies (IGES)

Secretary General, Leveraging Climate Neutral Sustainable Societies – Strategic Research Network (LCS-RNet)

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23 May 2023

AIM Asia-Pacific Integrated Model
http://www-iam.nies.go.jp/aim/index.html

LCS·R Net   LoCARNet

IAMC Lifetime Achievement Award

2018
John WEYANT

2019
William D. NORDHAUS

2020
Jae EDMONDS

2021
Nebojsa NAKICENOVIC

2022
Mikiko KAINUMA

Brief History of AIM and its application

Models

AIM/Enduse [Japan] and application to Asian countries
AIM/Enduse [Global]
AIM/CGE [Global]
AIM/CGE [Japan]
AIM/Air
Snapshot tool & ExSS
AIM/Climate
Impact assessment models

Outputs/ collaboration

Carbon tax policy assessemnt in Japan based on AIM/Enduse and CGE
Japan mid target / NDC
Long-term GHG emissions scenarios   IPCC SRES/ RCPs/ SSPs
EMF   IAMC   model comparison
UNEP/GEO
Eco-Asia   MA
Long-term LCS
LCS-RNet
LoCARNet

Realization of Sustainable Low/Zero Carbon Society

IPCC   FAR   SAR   SRES TAR   AR4   AR5   SR1.5   AR6

COP3   COP8   COP21

19 19 19 19 19 19 19 19 19 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20 20
90 91 92 93 94 95 96 97 98 99 00 01 02 03 04 05 06 07 08 09 10 11 12 13 14 15 16 17 18 19 20 21 22 23

20 20 20   21
30 40 50   00

AIM Project started in 1990

AIM International Workshop started in 1996

AIM Modeling/ Training Workshop started in 1997

Capacity Building Workshop at New Delhi in 2002

ASIA-PACIFIC INTEGRATED MODEL

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AIM Mission (Korea, China, India, Indonesia, 1995/6/20-7/1)

China
ERI: Zhou Dadi, **Hu Xiulian, Jiang Kejun,**
CISNAR: Sun Julin, Li Zehui
Agro-met Inst.: Lin Erda

Korea
KEEI: Hoesung Lee, **Tae-yong Jung, KETRI: Dong Kun Lee**

India
IIM: P.R.Shukla,
IGIDR: J. Parikh, V.K. Sharma

Indonesia
MoE: Aca Sugandhy

Beijing

Seoul

Ahmedabad

Jacarta

By Jun MORITA

Tsuneyuki MORITA

Yuzuru MATSUOKA

Hideo HARASAWA

4

AIM International Workshop

AIM: Asia-Pacific Integrated Assessment Model

The first AIM International Workshop (Feb. 1996)
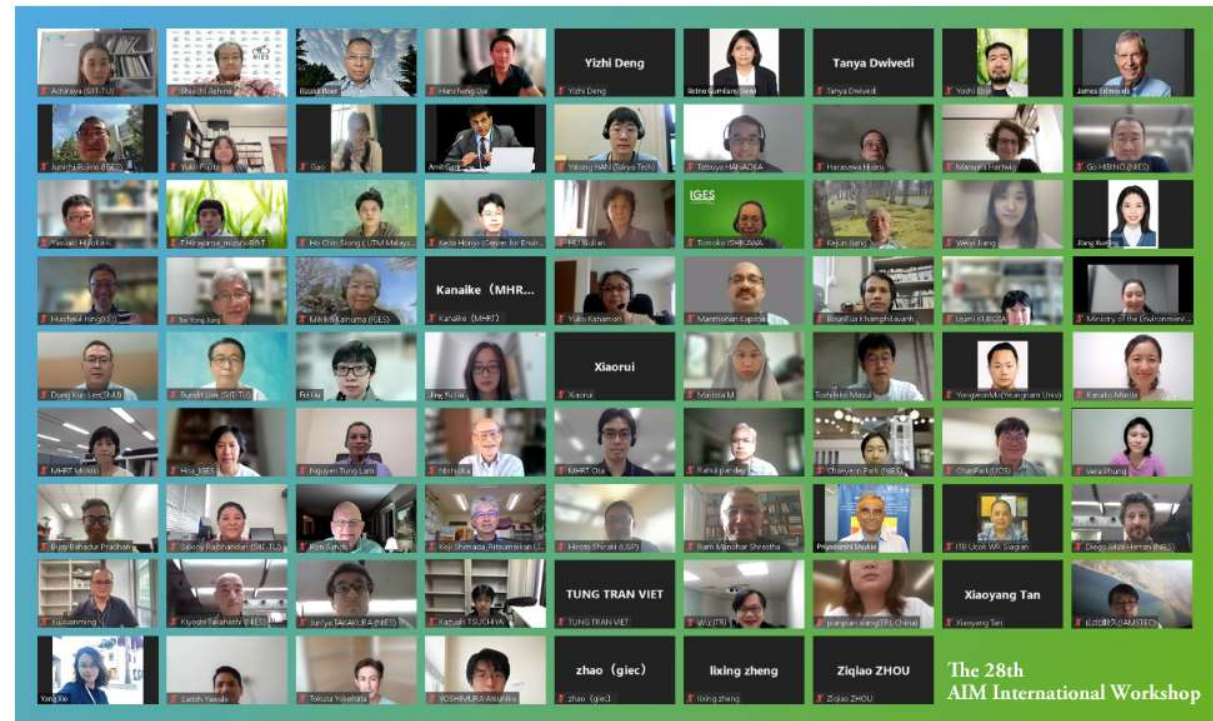
The 28th AIM International Workshp (Sep. 2022)

https://www-iam.nies.go.jp/aim/index_j.html [5]
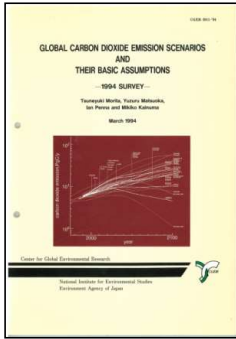
Overview of AIM (Asia-Pacific Integrated Model)

Mitigation Target, Climate Policy, Capacity building, ... **Real World**

Model World

Emission Model
- carbon tax
- IPCC/WG3
- 【Account model】(Snapshot tool)
- 【Enduse model】
- 【Economic model】
- 【Global】
- 【Country】
- 【Local/City】
- mid-term target
- 【sequential dynamics】↔【dynamic optimization】
- low carbon scenario
- future society

GHG emissions

long-term vision

AIM/Impact [Policy]

Simple Climate Model

temperature

feedback

Impact/Adaptation Model
- IPCC/WG2
- Agriculture
- Water
- Human health
- 【Global】↔【National/Local】
- adaptation

IPCC/integrated scenario

Other Models
- Population
- Transportation
- Residential
- AFOLU
- Stock-flow
- Life-style

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Steps to develop scenarios for a decarbonized society

- Area
- Base year
- Target year
- Covered sectors
- Actors/Players
- DCS target

1) Setting framework

Elements:
- Population
- Lifestyle
- Economy
- Industrial structure
- Building / Infrastructure
- Transport system
- Urban system
- Landuse
- Import/Export etc.

2) Description of socio-economic scenario

Mitigation option
- Low energy demand
- Electrification
- Renewables
- CCUS/BECCS
- Hydrogen
- Biofuel
- Sink Enhancement
- DAC etc.

3) Listing of mitigation options that contribute to achieving net zero emission

4) Identification of pathway to DCS with consistency across sectors

5) Design DCS Actions and Roadmaps from the analysis

DCS: decarbonized society

Source: Based on Hibino and Masui (2023)

Estimates of CO2 emissions varied widely

[94-MM3] Morita, Matsuoka, Penna, Kainuma; Global Carbon Dioxide Emission Scenarios and Their Basic Assumptions – 1994 Survey -, CGER-I011-'94, CGER, NIES, 75pp., 1994.

1994
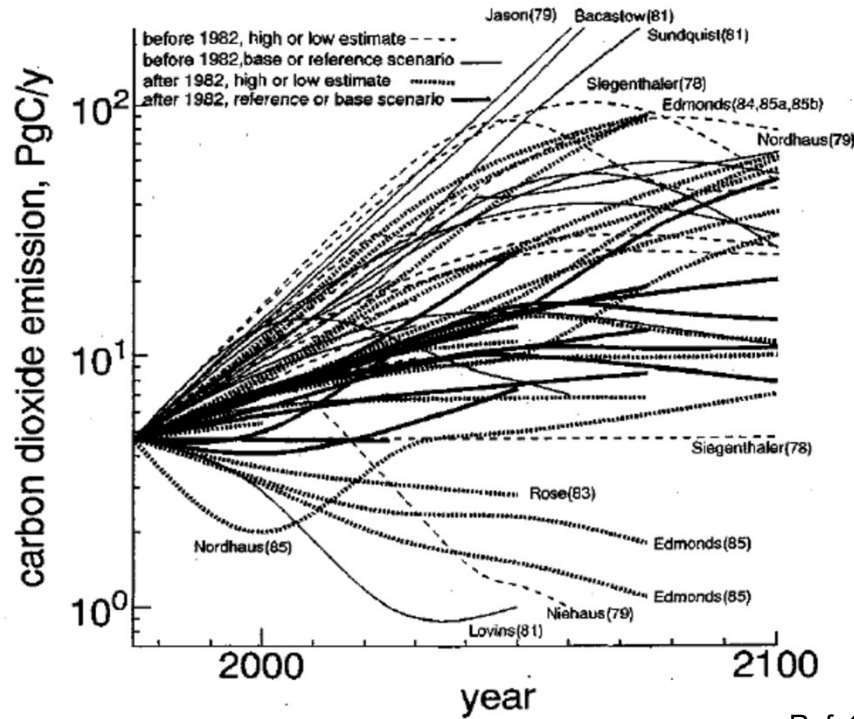
Global CO2 emissions

Ref: CO2 emissions in 2021: 37.9±3 CO2/y（GAP report）
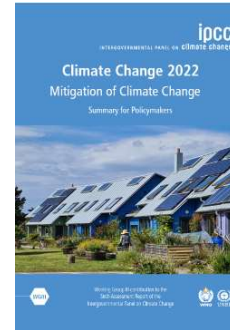
The challenge is how to achieve the 1.5°C target

Climate Change 2022: Mitigation of Climate Change. Working Group III Contribution to the IPCC Sixth Assessment Report

2022

a. Global GHG emissions

Current policies

2°C Target   1.5°C High Overshoot

1.5°C Target (no overshoot or low overshoot)

Global GHG emissions

8
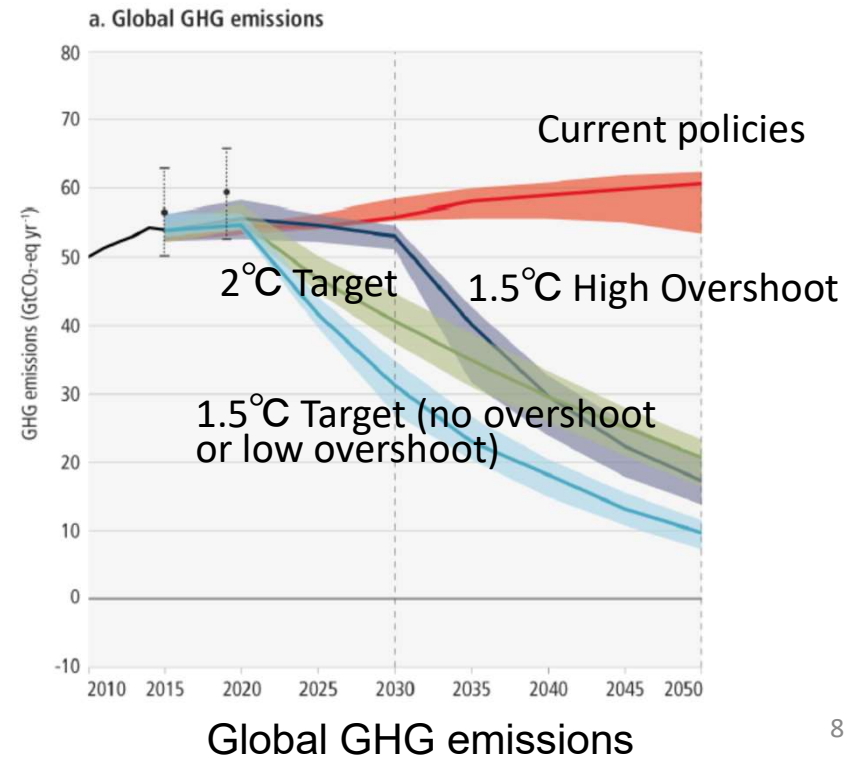
Report on Scenario Database

Environmental Economics and Policy Studies
Volume 7 Number 3 2006

- Nakicenovic, N., Kolp, P., Riahi, K. *et al.* (2006) Assessment of emissions scenarios revisited. *Environ Econ Policy Stud* **7**, 137–173. https://doi.org/10.1007/BF03353998

- Hanaoka, T., Kainuma, M., Kawase, R. *et al.(2006)* Emissions scenarios database and regional mitigation analysis: a review of post-TAR mitigation scenarios. *Environ Econ Policy Stud* **7**, 367–389. https://doi.org/10.1007/BF03354008
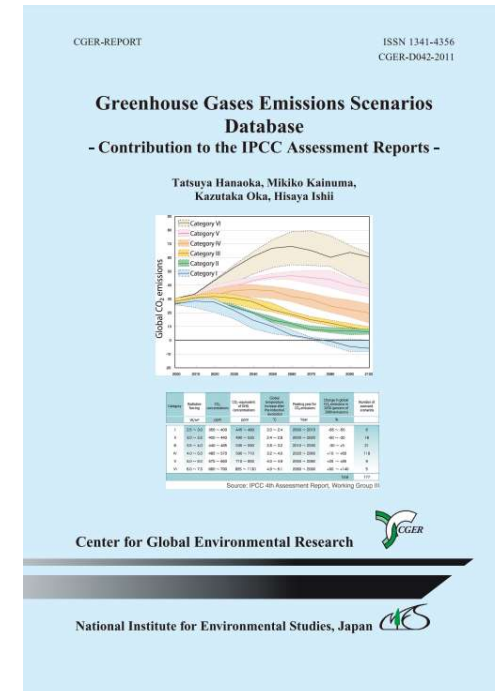
Hanaoka, t., Kainuma, M., Oka K., Ishii, H. (2011) Greenhouse Gases Emissions Scenarios Database -Contribution to the IPCC Assessment Reports -. CGER, NIES. https://www.cger.nies.go.jp/publications/report/d042/d042.pdf

RCP scenarios
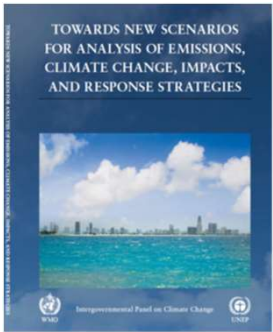
IPCC Expert meeting, 19–21 Sep. 2007 Noordwijkerhout, The Netherlands

International Institute for Applied Systems Analysis (IIASA)

- Asbjørn Aaheim
CICERO University of Oslo
- Keigo Akimoto
Research Institute of Innovative Technology for the Earth (RITE)
- Eduardo Calvo
- Patrick Criqui
Institut d'Economie et de Politique de l'Energie, IEPE-CNRS
- Francisco de la Chesnaye
US Environmental Protection Agency
- Jae Edmonds
Pacific Northwest National Laboratory
- Allen Fawcett
US Environmental Protection Agency
- Brian Fischer
CRA International
- Donald Hanson
Argonne National Laboratory
- Thomas Hertel
Purdue University
- Jean-Charles Hourcade
CIRED/CNRS/EHESS
- Maria E. Ibarrarán Viniegra
Universidad Iberoamericana Puebla
- Kejun Jiang
Energy Research Institute

Energy Modeling Forum (EMF) Stanford University

- Mikiko Kainuma
National Institute for Environment Studies
- Claudia Kemfert
DIW Berlin
- Atsushi Kurosawa
The Institute of Applied Energy
- Emilio Lèbre La Rovere
Programa de Planejamento Energético
PPE/COPPE/UFRJ
- Robert Lempert
RAND
- Bruce McCarl
Texas A&M University
- Nebojsa Nakicenovic
International Institute for Applied Systems Analysis (IIASA)
- Hom Pant
Australian Bureau of Agricultural and Resource Economics (ABARE)
- Hugh Pitcher
Pacific Northwest National Laboratory
- Keywan Riahi
International Institute for Applied Systems Analysis (IIASA)
- Richard Richels
Electric Power Research Institute (EPRI)
- Steven Rose
US Environmental Protection Agency

National Institute for Environmental Studies (NIES)

- Thomas Rutherford
Economist
- Ronald Sands
Joint Global Change Research Institute
- Priyadarshi Shukla
Indian Institute of Management
- Steve Smith
Pacific Northwest National Laboratory
- Brent Sohngen
Ohio State University
- Richard Tol
University of Hamburg and Economic and Social Research Institute (ESRI)
- Jose Eddy Torres
Universidad de Los Andes / Universidad Nacional de Colombia
- Detlef van Vuuren
The Netherlands Environmental Assessment Agency (MNP)
- Marc Vielle
CEA-LERNA
- Virginia Vilariño
Business Council for Sustainable Development – Argentina
- Robert Watson
Tyndall Center for Climate Change Research
- John Weyant
Energy Modeling Forum, Stanford University

IPCC Expert Meeting Report: Towards New Scenarios

IAMC
Integrated Assessment Modeling Consortium
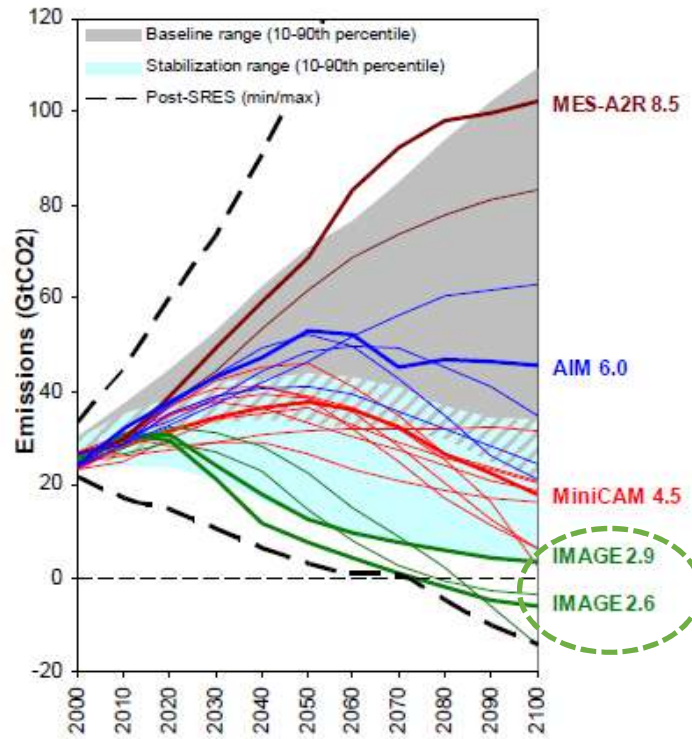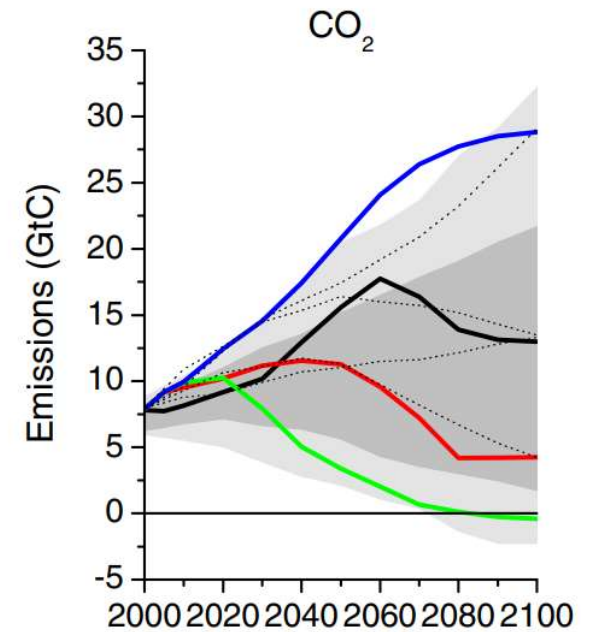Founded 2007

Figure III.2. Energy and industry CO_2 emissions and concentrations for RCP candidates (colored lines).

https://archive.ipcc.ch/pdf/supporting-material/expert-meeting-report-scenarios.pdf

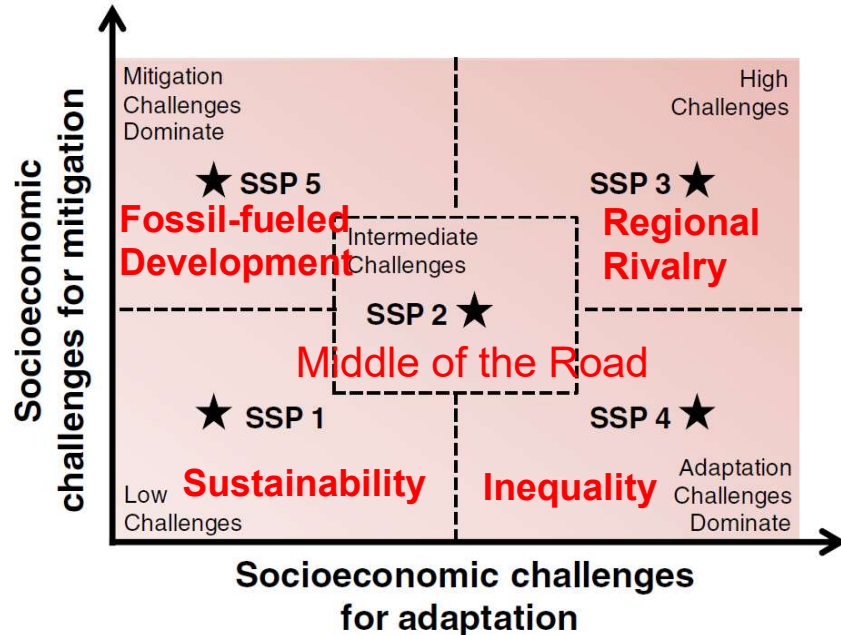RCP2.6 was accepted based on Report of 2.6 Versus 2.9 Watts/m2 RCPP Evaluation Panel.
https://archive.ipcc.ch/meetings/session30/inf6.pdf

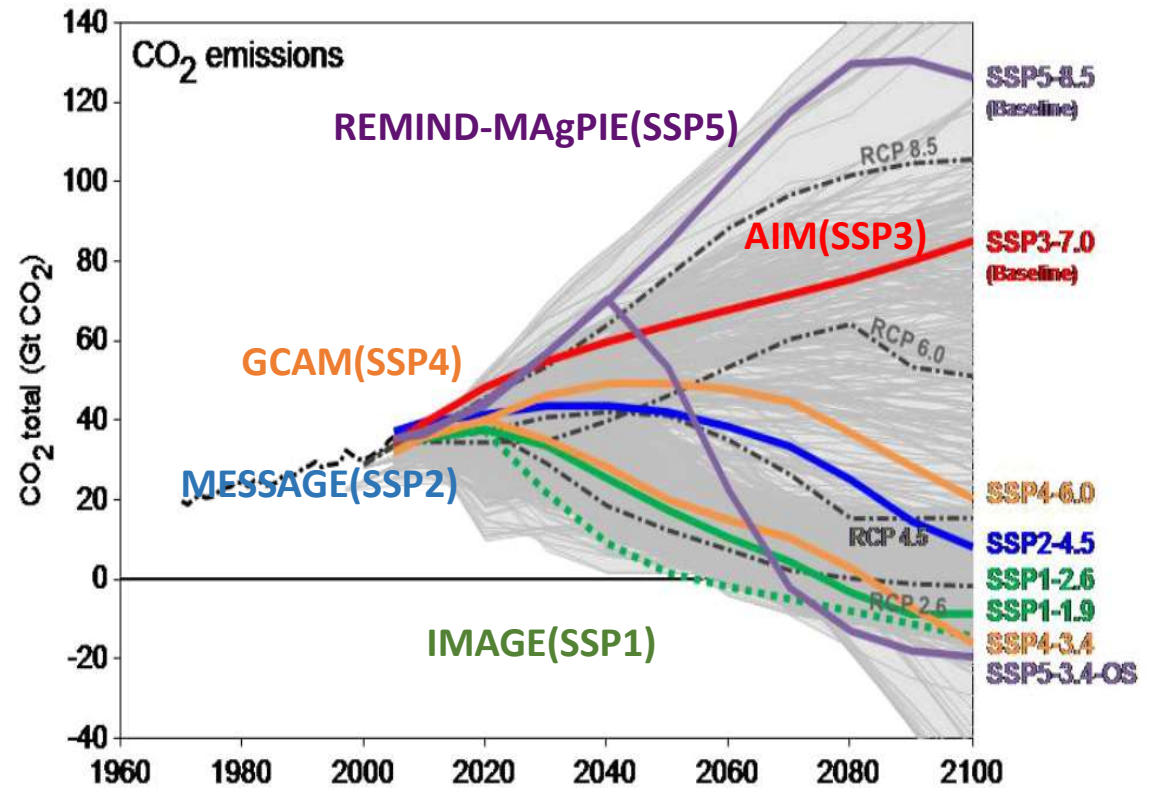van Vuuren, D.P., Edmonds, J., Kainuma, M. *et al.* (2011) The representative concentration pathways: an overview. *Climatic Change* **109**, 5. https://doi.org/10.1007/s10584-011-0148-z

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SSP–RCP scenarios

SSP scenarios

O'Neill BC, Kriegler E, Riahi K. *et al.* (2014) A new scenario framework for climate change research: the concept of shared socioeconomic pathways. *Climatic Change* **122**, 387–400. https://doi.org/10.1007/s10584-013-0905-2

Riahi K, van Vuuren DP Kriegler E et al. (2017) The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change Volume 42, January 2017, Pages 153-168 https://www.sciencedirect.com/science/article/pii/S0959378016300681

SSP–RCP scenarios

O'Neill B.C., Tebaldi, C., Detlef P. van Vuuren, D. (2016) The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6. https://gmd.copernicus.org/articles/9/3461/2016/gmd-9-3461-2016.pdf

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How to deploy our study to real world

Collaboration with stakeholders

Research activities

Collaboration for LCS scenario development and building roadmaps

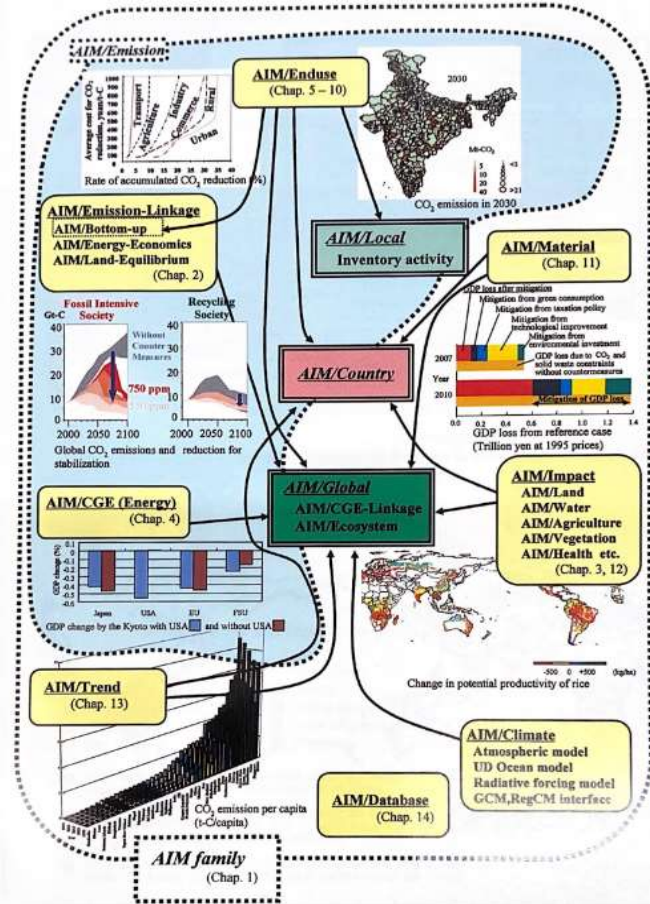*Request of more practical, realistic roadmaps and also tractable tools for real world*

Policy makers
National/ subnational government
Development agencies
NGOs

Each country's domestic/ local research institute

Core research members

Application and development to actual LCS processes

Development and maintenance of study tools/models

Nepal
Bhutan
Laos
Cambodia
Korea
China
Bangladesh
Vietnam
India
Thailand
Philippines
Japan
Malaysia
Indonesia

https://www.apn-gcr.org/wp-content/uploads/2020/09/b91737449ea1e94822f6c17da5131a59.pdf

http://2050.nies.go.jp/LCS

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AIM Books

Kainuma., M., Matsuoka, Y., Morita, T. (eds) (2002, printed in 2003)

This book was produced for a capacity building workshop held in New Delhi on the occasion of COP8 in 2002.
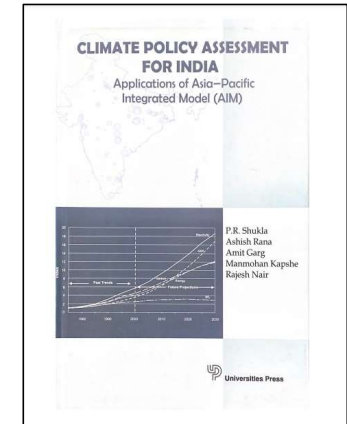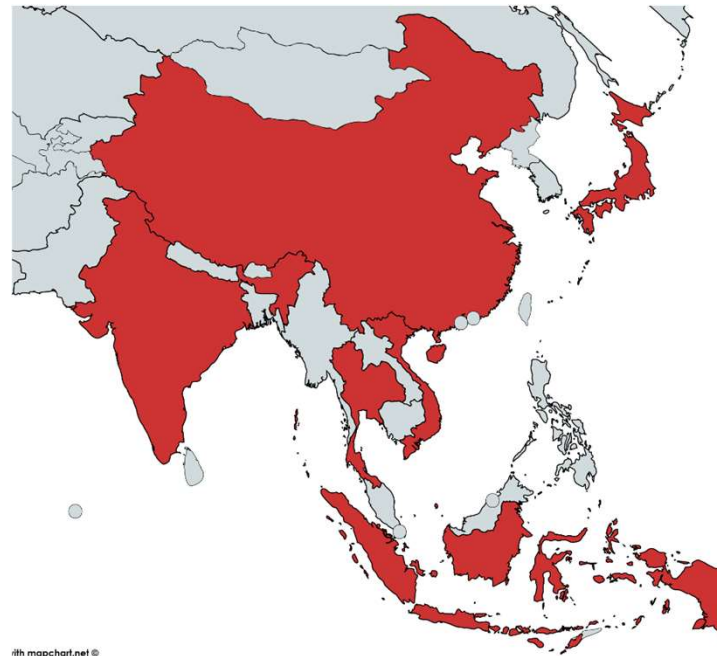

Shukla, P.R. et al. (March 2004) Climate Policy Assessment for India. AIM

- Climate policy assessment provides endues models for **China, India, Korea, Vietnam and Japan**

Paris Agreement assessment for Global and Asian countries

Shinichiro Fujimori · Mikiko Kainuma
Toshihiko Masui *Editors*

Post-2020
Climate
Action

Global and Asian Perspectives

Springer
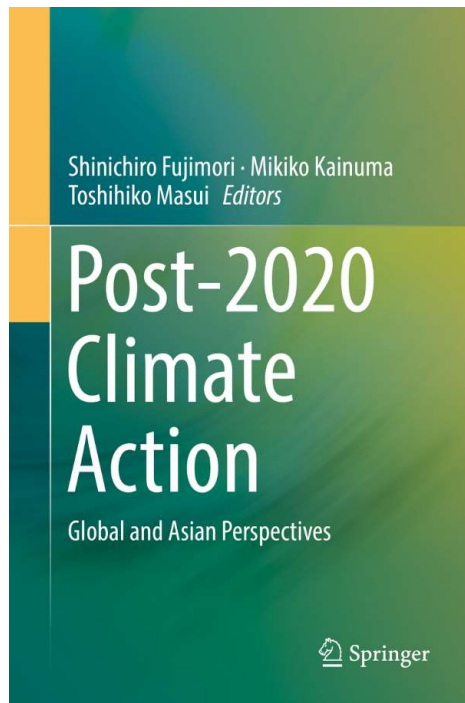
Published in
September 2017

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

- 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

Networking: LCS-Rnet (Low Carbon Society Research Network/ Leveraging Climate Neutral Society Research Network and LoCARNet (Low carbon Asia Research Network)

The 13th Annual Meeting of LCS-RNet, Online, December 2022

The 11th LCS-Rnet Annual, Online March 2023

First Annual Meeting of LCS-RNet, BOLOGNA 12-13 October 2009

J. Skea
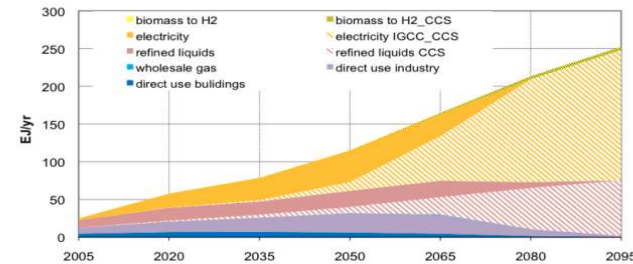
Discussed the 2°C target
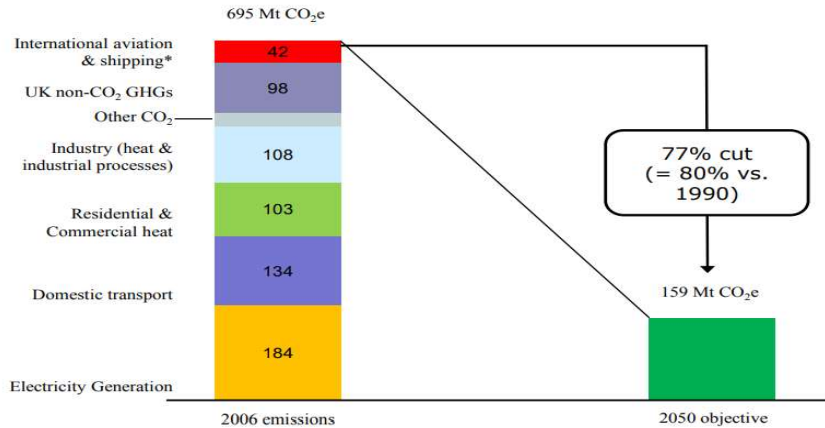
J. Edmonds

Biomass Consumption by use 450ppm Advanced Technology (with CCS)

► About 170 EJ in Electricity, and 73 EJ in refined liquids
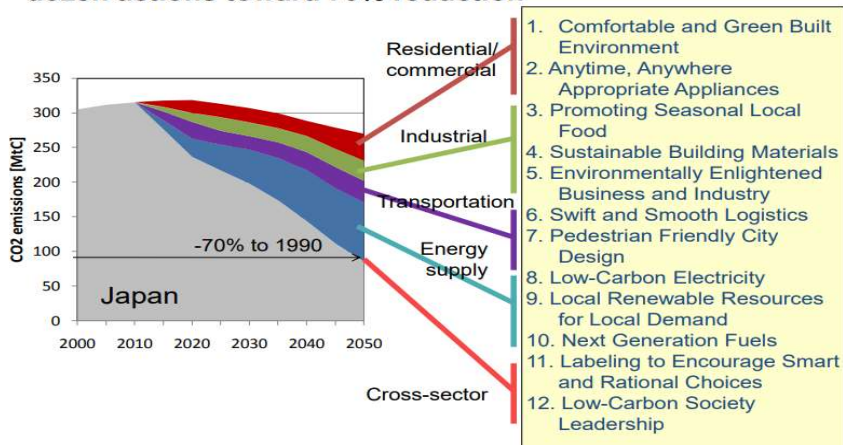► CCS is used heavily with high CO_2 prices in later years

M. Kainuma & J. Fujino

CO2 emission projections based on a dozen actions toward 70% reduction

AIM/LCS

A Dozen Actions

1. Comfortable and Green Built Environment
2. Anytime, Anywhere Appropriate Appliances
3. Promoting Seasonal Local Food
4. Sustainable Building Materials
5. Environmentally Enlightened Business and Industry
6. Swift and Smooth Logistics
7. Pedestrian Friendly City Design
8. Low-Carbon Electricity
9. Local Renewable Resources for Local Demand
10. Next Generation Fuels
11. Labeling to Encourage Smart and Rational Choices
12. Low-Carbon Society Leadership

P.R. Shukla

INDIA: Carbon Emissions

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Assessment of pathways of the net zero GHG emission consistent with **the 1.5 degrees** target

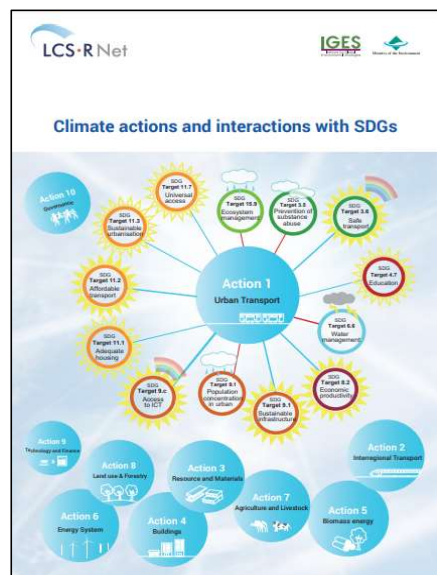Carbon Management
Volume 9, 2018 - Issue 5
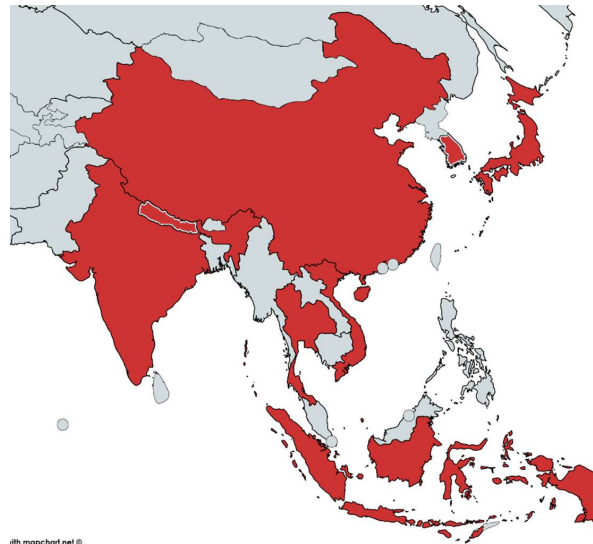
+ Global, Germany, Brazil

- India
- China
- Japan
- Korea
- Thailand
- Nepal
- Germany
- Brazil
- Global

- Assessment of climate policies with 1.5 degrees target

https://www.tandfonline.com/toc/tcmt20/9/5

Domestic priorities related to climate change policies

M. Kainuma, R. Pandey, M. Kamei, S. Nishioka, T. Ishikawa (2017) Climate actions and interactions with SDGs. IGES. http://lcs-rnet.org/archive/pdf/publications/climate_actions.pdf

Country	Domestic priorities
Cambodia	• Energy access • Sustainable Forest management • Food security
China	• Air pollution • Energy access • Increase of exports of clean technologies
India	• Air pollution • Job creation • Food security • Sustainable development • Resource efficiency

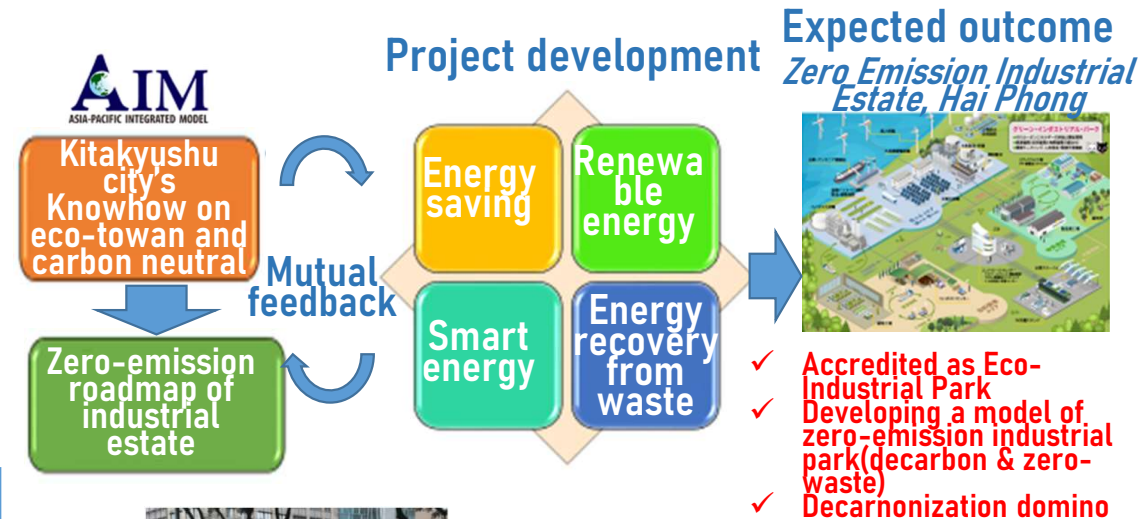| Country	Domestic priorities
Indonesia	• Sustainable forest management • Food security • Energy security
Japan	• Energy security • Food security
Thailand	• Avoid impacts of climate change • Job creation • Food security
Vietnam	• Energy access • Forest management • Food security • Avoid impacts of climate change • Air pollution

Source: Kainuma et al. (2017) and Ishikawa (2017) Climate Actions and Interactions with SDGs. Integrated Air Pollution and Climate Change Policies in Asia. Presented at Japan Pavilion, COP 23.

AIM/LoCARNet Activities in FY2021 (Commissioned Work by MOEJ)

LCS·R·Net

Project Outline

National Level

Viet Nam (Simulation of accelerated peak-out years, Long-term Strategy (LCS))

Thailand (LTS development)

Indonesia (LTS development)

Malaysia (Carbon Neutral (CN) scenario development, Science-Policy dialogue)

Subnational / City Level

Jakarta (Contribution to LC transport policy)

West Java (Interlinkage analysis - Climate and SDGs)

Hai Phong (Zero-emission Type Industrial Estate for CN)

Luang Prabang (CN scenario development)

(Kuala Lumpur(City-to-city collaboration by MOEJ))

Project development

Expected outcome
Zero Emission Industrial Estate, Hai Phong

AIM ASIA-PACIFIC INTEGRATED MODEL

Kitakyushu city's Knowhow on eco-towan and carbon neutral

Mutual feedback

Zero-emission roadmap of industrial estate

Energy saving

Renewable energy

Smart energy

Energy recovery from waste

✓ Accredited as Eco-Industrial Park
✓ Developing a model of zero-emission industrial park(decarbon & zero-waste)
✓ Decarnonization domino

Jakarta Climate Resilient City
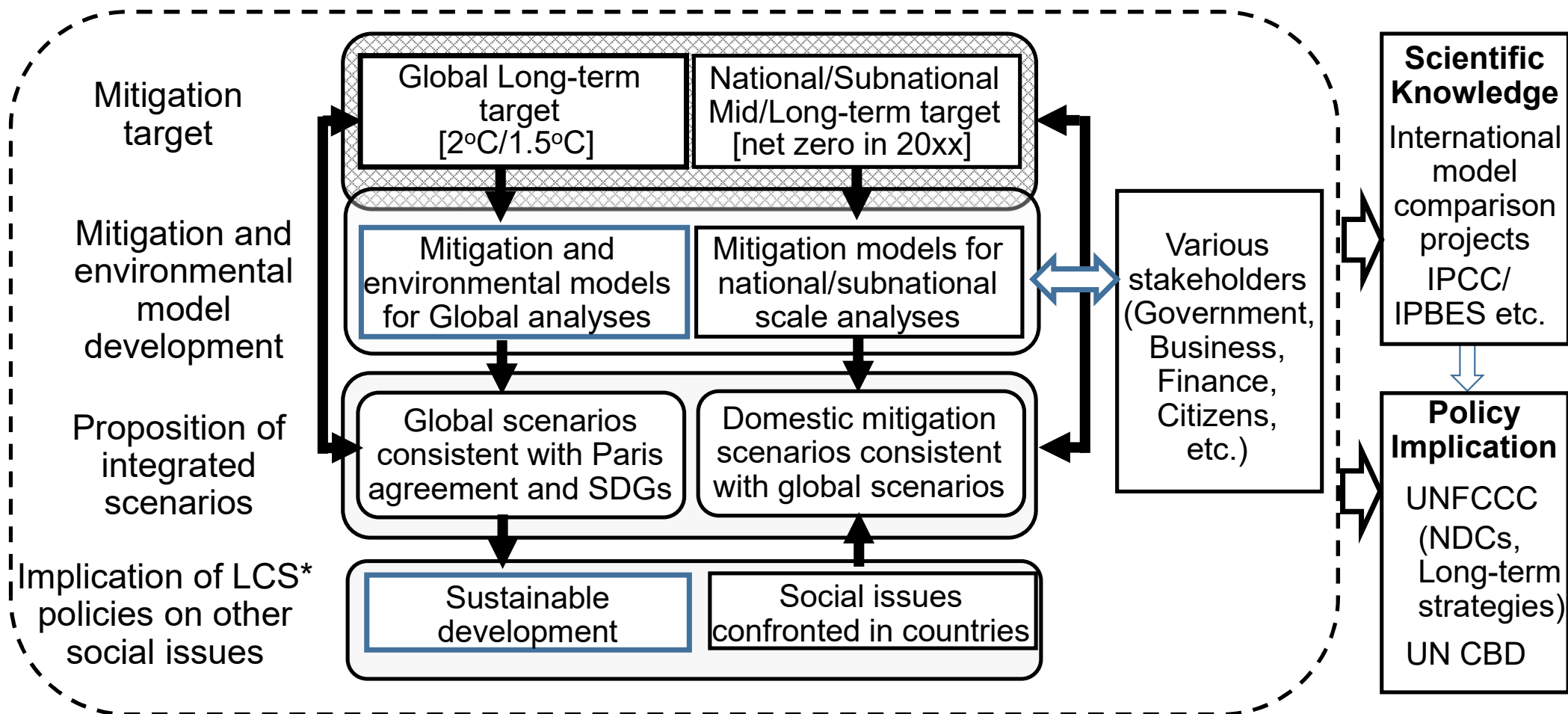Best Practices Compilation 2021
Jakarta

Long-term strategy to achieve DKI Jakarta's Low Carbon Society 2050

The development of a low carbon society scenario can be used to assist the mid- and long-term development planning or climate actions. Jakarta Government as a non-state actor is trying to formulate a strategy towards low carbon development.

Integrated Analyses of Climate Policies for Simultaneous Realization of the Paris Agreement and the SDGs

Mitigation target

Global Long-term target [2°C/1.5°C] | National/Subnational Mid/Long-term target [net zero in 20xx]

Mitigation and environmental model development

Mitigation and environmental models for Global analyses | Mitigation models for national/subnational scale analyses

Proposition of integrated scenarios

Global scenarios consistent with Paris agreement and SDGs | Domestic mitigation scenarios consistent with global scenarios

Implication of LCS* policies on other social issues

Sustainable development | Social issues confronted in countries

Various stakeholders (Government, Business, Finance, Citizens, etc.)

Scientific Knowledge

International model comparison projects IPCC/ IPBES etc.
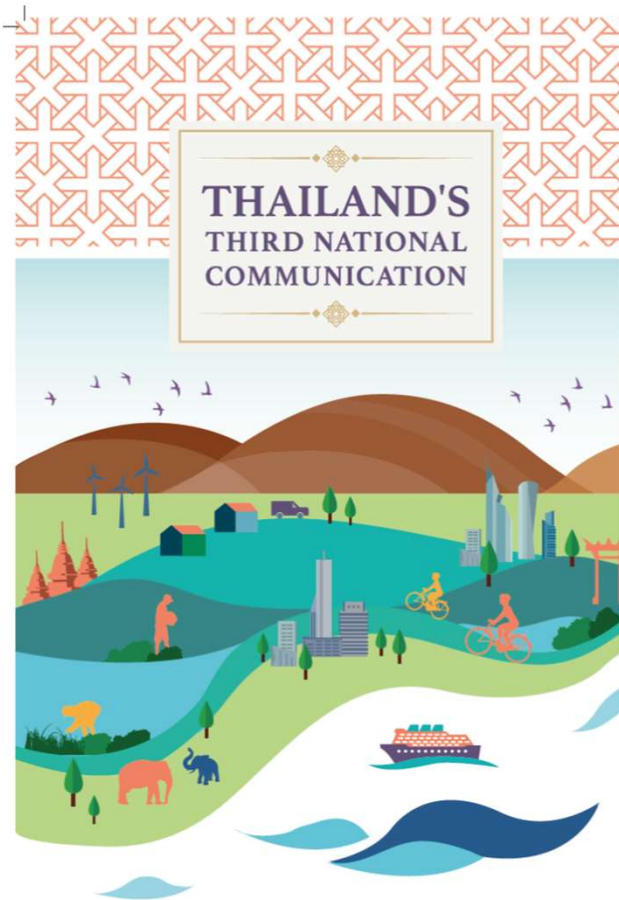
Policy Implication

UNFCCC (NDCs, Long-term strategies)

UN CBD

* LCS: Low carbon/ decarbonized Societies

** CBD: Convention on Biological Diversity

Examples of application of AIM in Thailand (1)

Developed by **Prof. Bundit Limmeechokchai**
(Sirindhorn International Institute of Technology, Thammasat University)

Thailand
Third National Communication

As mentioned, both Thailand's NAMAs and Thailand's NDC were developed on the basis of BAU (Figure 3-1). The BAU scenario was created by using the Asia-Pacific Integrated Assessment Model (AIM). The AIM model was developed in collaboration between the National Institute for Environmental Studies (NIES) Japan, Kyoto University, the Mizuho Information & Research Institute, and other Asian researchers including Thailand. The AIM model focuses on relevant policies to support low-carbon pathways.

https://unfccc.int/documents/181765

Source: Masui and Hibino (2021) Contribution of AIM to decarbonized society in Asia. LCA-RNet 12th Annual Meeting. https://lcs-rnet.org/lcsrnet_meetings/2021/10/2896

Examples of application of AIM in Thailand (2)

Thailand
Mid-century, Long-term Low Greenhouse Gas Emission Development Strategy

Developed by **Prof. Bundit Limmeechokchai** (Sirindhorn International Institute of Technology, Thammasat University)

3.1 Methodology for the Development of Long-term Low Greenhouse Gas Emission Pathways
3.1.1 Model for Low Greenhouse Gas Emission Pathways

Thailand's mid-century, long-term low greenhouse gas emission development strategy was developed based on the scenario of net-zero greenhouse gas emissions in the second half of this century, in line with science and the Paris Agreement. The BAU scenario was developed using input information of the current country's circumstances and status provided by related ministerial agencies into the Asia-Pacific Integrated Assessment Model (AIM) (Figure 3-2).

https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf
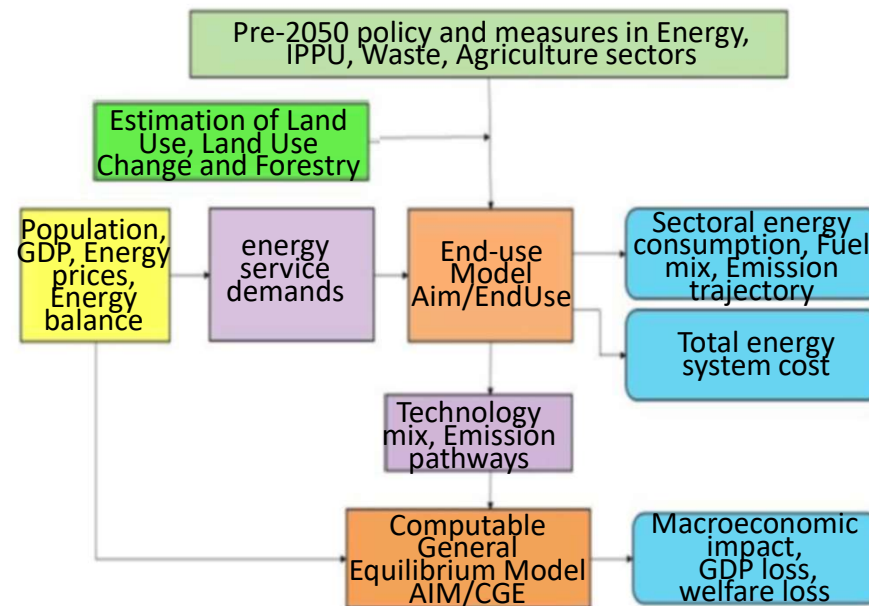
Figure 3-2: Framework of Thailand's LEDS Development

Pre-2050 policy and measures in Energy, IPPU, Waste, Agriculture sectors

Estimation of Land Use, Land Use Change and Forestry

Population, GDP, Energy prices, Energy balance

energy service demands

End-use Model Aim/EndUse

Sectoral energy consumption, Fuel mix, Emission trajectory

Total energy system cost

Technology mix, Emission pathways

Computable General Equilibrium Model AIM/CGE

Macroeconomic impact, GDP loss, welfare loss

Examples of application of AIM in Indonesia

Indonesia
Long-term strategy
for Low Carbon and
Climate Resilience
2050

Developed **by Prof. Rizaldi Boer** (Bogor Agricultural University**), Prof. Retno Gumilang Dewi** and **Dr. Ucok WR. Siagian** (Bandung Institute of Technology)

4.1. Scenario Development

4.1.1. Models for Mitigation Pathways

Indonesia used a set of models in developing the emission pathways with two stages of analysis. In the first stage, separate models were developed for modelling agriculture, forestry and other land uses (AFOLU), and energy. The AFOLU sector used AFOLU Dashboard (a spreadsheet model), meanwhile energy sector used AIM-EndUse and the AIM-ExSS (Extended Snapshoot). In both models, economic and population growth are the key drivers for changes in food and energy demand. In the second stage, the economic and economic impact of both AFOLU and energy sector mitigation are analysed by utilizing the Asia Pacific Integrated Model/Computable General Equilibrium (AIM/CGE)- Indonesia (see Figure 3).

https://unfccc.int/sites/default/files/resource/Indonesia_LTS-LCCR_2021.pdf

Figure 3. Models for developing emission pathways in Indonesia

Expected structure to support climate policy in Asian country

NDC (Nationally Determined Contributions)
LTS (long-term strategies)

MONRE*

Government

Agreement between countries

MOEJ, Japanese Embassy in Viet Nam, JICA Viet Nam

Government, Embassy, JICA

*MONRE: Ministry of Natural Resources and Environment

**ISPONRE: Institute of Strategy, Policy on Natural Resources and Environmennt

Policy needs & requests

Provision of numerical results
Policy support

Research requests

Other stake-holders

Research institute (AIM members)

ISPONRE**, Research institutes invited by MONRE

AIM team

NIES, MHRT***, E-Konzal, IGES

Other stake-holders

Research collaboration, Provision of AIM, Analysis support, Capacity development

*** MHRT: Mizuho Research & Technologies

【Asian country】　　　　【Japan】

Source: Dr. Masui's presentation at COP26 side-event, with light blue boxes added by Ms. Ishikawa
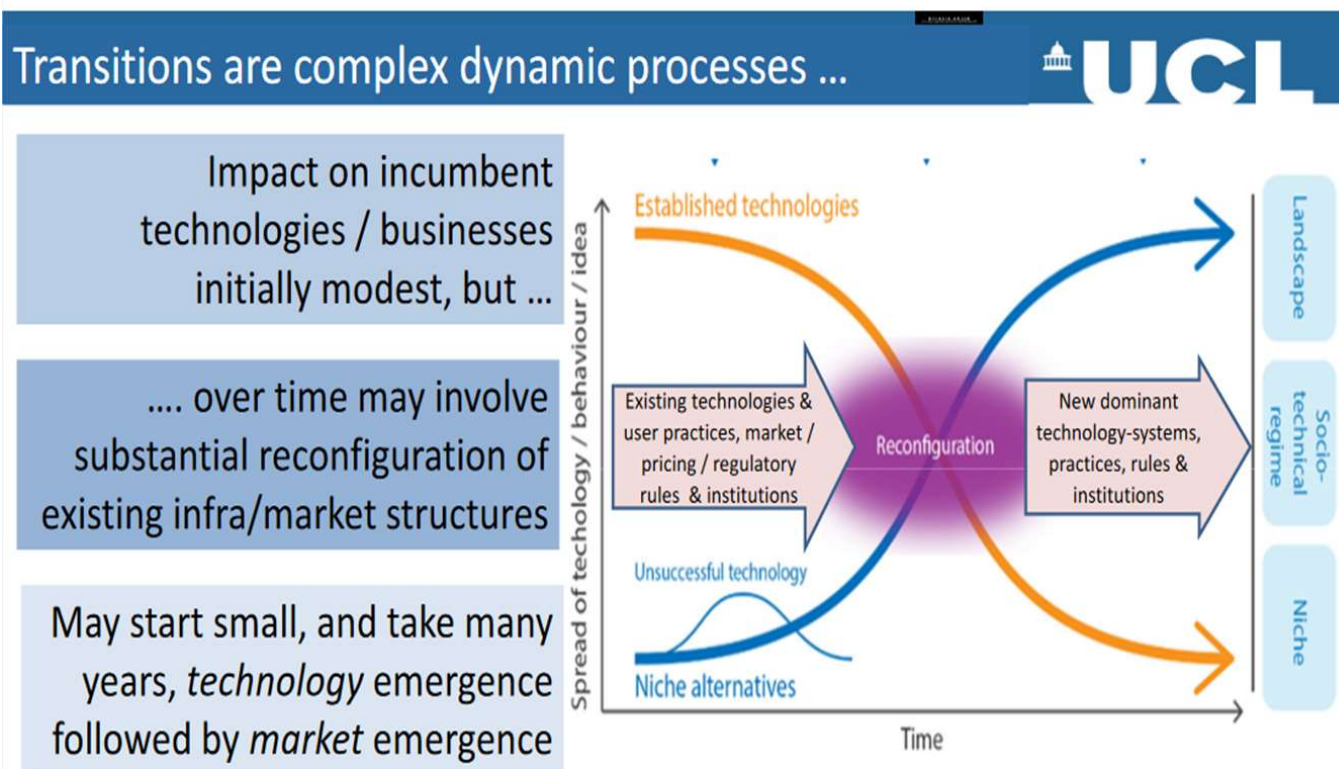
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Further studies: Transition dynamics
Just and sustainable transition

- Optimization within the existing systems increases the investments in them, and helps the current system to continue, which does not lead to a decarbonaized society.

- There are so many technologies and social innovations that provide the basis for a much more systemic and transformative shift to <mark>a nature positive economy</mark>. Question is how we can empower the most radical possible transitions.

D. Loorbach (2021) Mobilizing research and design for sustainability transitions. Presentation at LCS-RNet 12th Annual Meeting – Accelerating Actions for Leveraging a Climate-Neutral, Sustainable Society. https://lcs-rnet.org/en/meeting/2022/10/3756

The 14th Annual Meeting will be held on **18-19th Dec. 2023, Online**

Transitions are complex dynamic processes ... UCL

Impact on incumbent technologies / businesses initially modest, but ...

.... over time may involve substantial reconfiguration of existing infra/market structures

May start small, and take many years, *technology* emergence followed by *market* emergence

Source: IPCC Sixth Assessment Report – Mitigation (Chapter 1 / Technical Summary)

Michael Grubb (2022) The Economics of Innovation & Transition. Lessons and principles for policymaking. Presentation to LCS-RNet 13th Annual Meeting New Scientific Challenges for Strengthening Actions Based on IPCC AR6. https://lcs-rnet.org/en/meeting/2022/12/4166

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Further studies: City level collaboration

Science Policy Dialogue in Bangkok, Mar. 2023.

Presentation by C.Chanyam

Consultation Workshop on Low Carbon Development Scenario for Luang Prabang City, Lao, May 2022.

Presentation by H. Nyugen & B. Khamphilavanh.
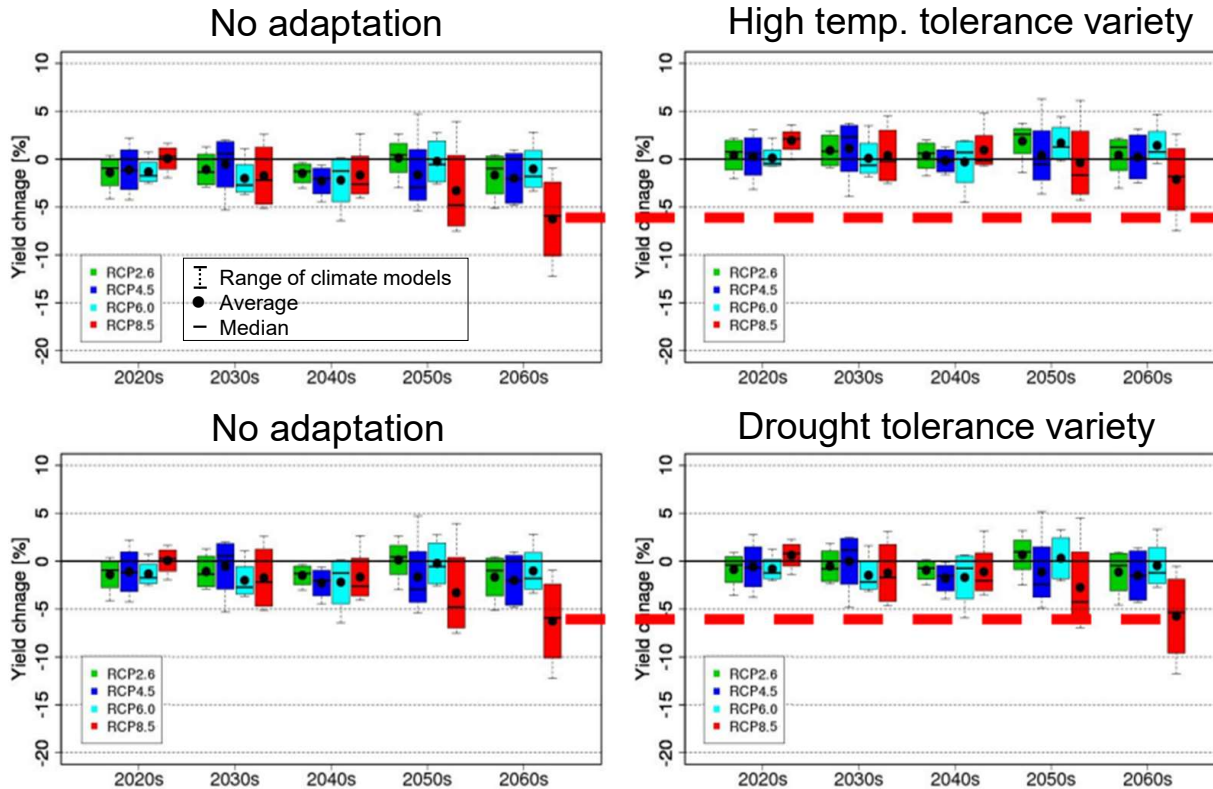
At the 11th LoCARNet Annual Meeting, 2023. https://lcs-rnet.org/en/feature/2023/05/4456

AIM teams' collaboration at cities levels to develop their low/zero emission scenarios

Year	City
2007	Shiga | Japan
2009	Iskandar | Malaysia
	Ahmedabad | India
	Jilin | China
	Kyoto | Japan
2011	Bhopal | India
	Cyberjaya | Malaysia
2012	Putrajaya | Malaysia
	Gyeonggi Province | Korea
2013	Guang Zhou | China
	Khon Kaen | Thailand
2014	Ho Chi Minh City (HCMC) | Vietnam
	Kyoto | Japan

Year	City
2015	Danang | Vietnam
2016	Hai Phong | Vietnam
	Kuala Lumpur | Malaysia
2017	Can Tho | Vietnam
	Pengerang | Malaysia
	Phnom Penh | Cambodia
	Semarang | Indonesia
2018	Hanoi | Vietnam
	Quezon City | Philippine
2019	Ho Chi Minh City (HCMC) | Vietnam
	Kyoto | Japan
2020	Kuala Lumpur | Malaysia
	Shiga | Japan

Y. Ochi: Asia-Pacific Integrated Model (AIM) Scenario for Net-Zero Emission. The 14th March 2023, Bangkok.

Scenarios are found at https://2050.nies.go.jp/LCS/eng/list.html

Further studies: Mitigation and adaptation

Case in Vietnam: Change of rice yield

Adaptation (HIT vs IRR)

No adaptation

High temp. tolerance variety

No adaptation

Drought tolerance variety

Masutomi (2020) Impact and adaptation assessment on rice yields in Vietnam. The 26th. AIM-WS. https://www-iam.nies.go.jp/aim/aim_workshop/aimws_26/presentation/S3_06_Masutomi.pdf
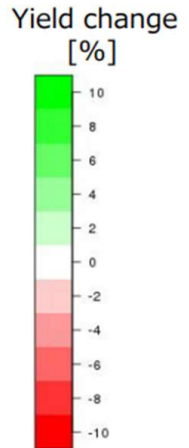
. HIT: High temp. tolerant variety
. IRR: Irrigation system

- Effects of adaptations are different among provinces. It is necessary to identify and take effective adaptative options by provinces.

Case in Japan: Masutomi, Y. et al (2023) Breeding targets for heat-tolerant rice varieties in Japan in a warming climate. *Mitig Adapt Strateg Glob Change* **28**. https://doi.org/10.1007/s11027-022-10027-4 27
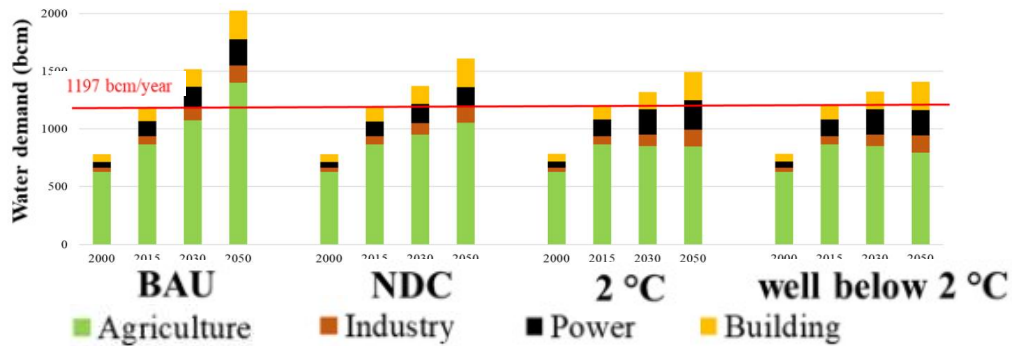
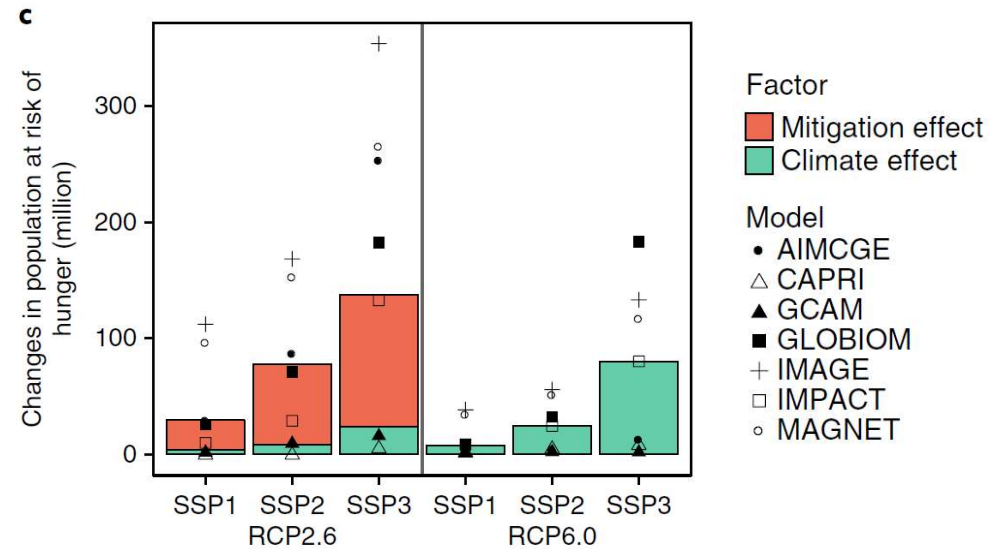# Further studies: Co-benefits and Trade-offs

Mortality (Air quality)
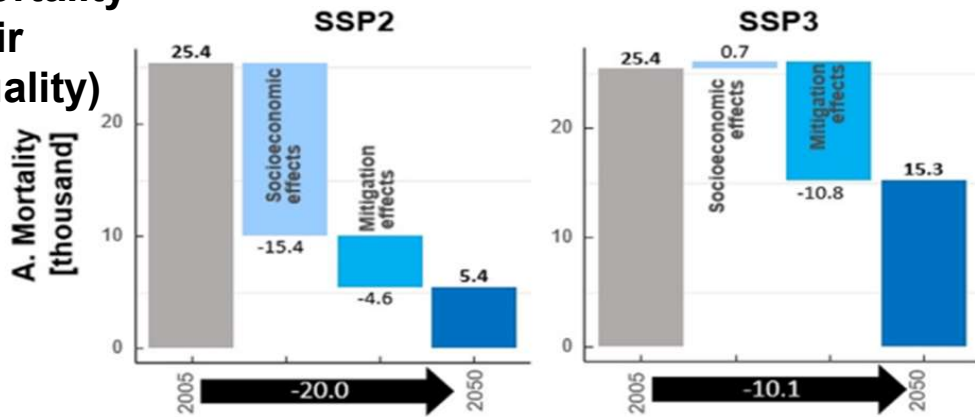
Kim ES, Xie Y, Dai H, Fujimori S et al. (2020) Air quality co-benefits from climate mitigation for human health in South Korea. Environment international. https://repository.kulib.kyoto-u.ac.jp/dspace/bitstream/2433/255849/1/j.envint.2020.105507.pdf

Food security

Hasegawa T, Fujimori S, Havlik P et al. (2018) Risk of increased food insecurity under stringent global climate change mitigation policy. Nature Climate. https://www.nature.com/articles/s41558-018-0230-x

Water demand

Vishwanathan et al. (2021) SDG implications of water-energy system transitions in India, for NDC, 2 °C, and well below 2 °C scenarios. https://iopscience.iop.org/article/10.1088/1748-9326/ac08bf/pdf

Further studies: How can we involve citizens?

Climate Citizens' assemblies are held across Europe to enable the public to learn, discuss and make policy recommendations. Narrative scenarios are used in the UK assembly and Oxford assembly.

Climate citizens' assemblies in Europe

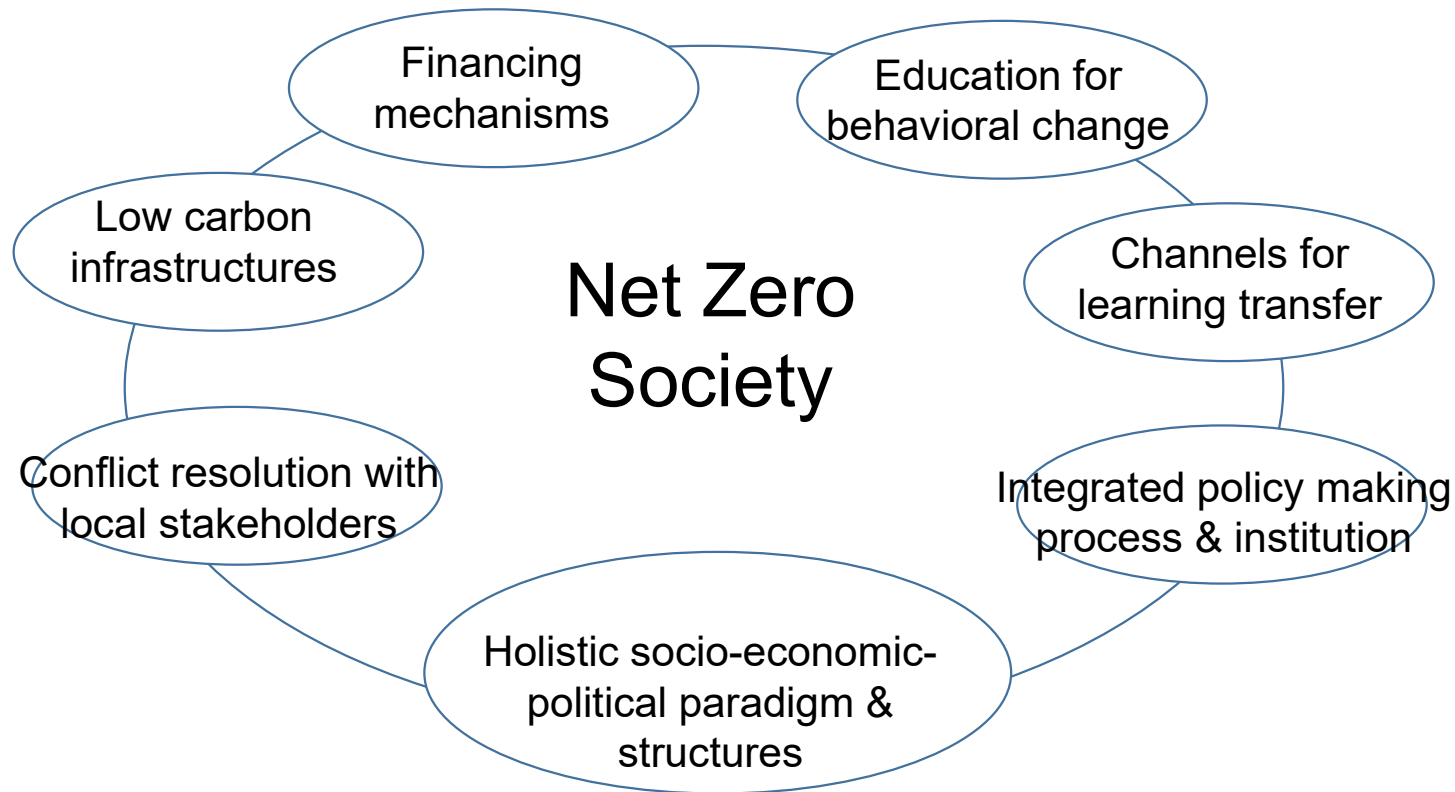Source: Climate Assemblies. https://knoca.eu/

- UK Assembly* prepared several qualitative scenarios for discussion for move, in the house, buy/ landuse/ food/ agriculture, energy/ CCS.
- Oxford assembly** used qualitative scenarios for voting (current and three net zero scenarios for 5 themes: waste, buildings, transport, biodiversity and offsetting, renewable energy,).
- About 30 local level assemblies*** have been held in the UK. These cities declared net zero emissions.

*https://www.climateassembly.uk/report/;
**https://www.ipsos.com/en-uk/oxford-citizens-assembly-climate-change;
***https://www.buergerrat.de/en/citizens-assemblies/citizens-assemblies-worldwide/

Changes needed in structures, institutions, processes and mechanisms for net zero societies

M. Kainuma (2015) Modeling approach to bridge the climate change and SDGs. presentation at the 21th AIM Workshop. https://www-iam.nies.go.jp/aim/aim_workshop/aimws_21/presentation/s07_03_kainuma.pdf

Thank you for your attention!

The12th Annual Meeting at Tsukuba (2019)

No time to waste