Emission Projections using the Asia-Pacific Integrated Model (AIM): A Case Study on Indonesia's Sustainable Food Consumption

Annuri Rossita*, Toshihiko Masui

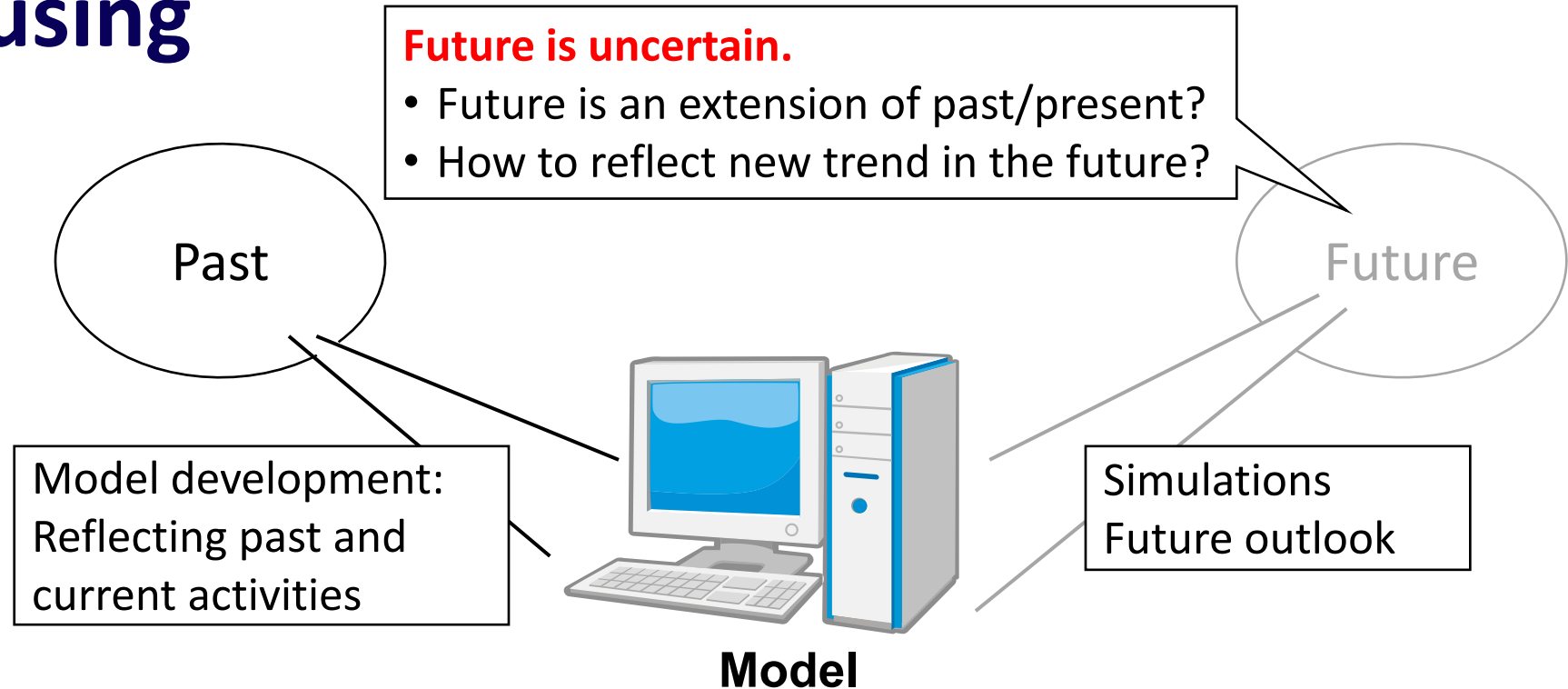National Institute for Environmental Studies (NIES), Tsukuba, Japan
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AIM ASIA-PACIFIC INTEGRATED MODEL

National Institute for Environmental Studies, Japan

How to assess the future using a model?

Future is uncertain.
- Future is an extension of past/present?
- How to reflect new trend in the future?

Past

Future

Model development:
Reflecting past and
current activities

Simulations
Future outlook

Model

- Model cannot predict the future,
  but only shows a result corresponding to a set of inputs.
- Model has both subjective and objective aspects.
- Model has both advantages and disadvantages.
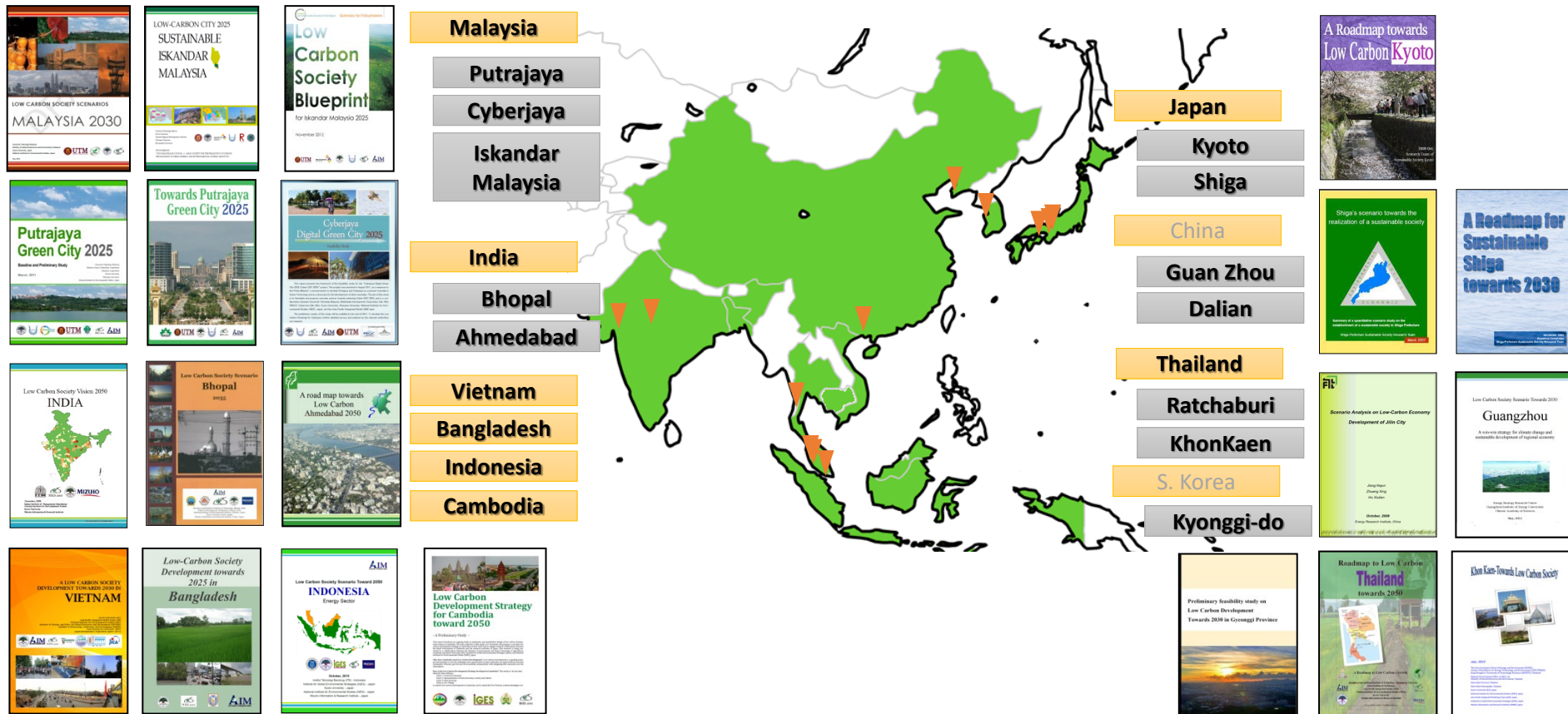- → We need to use model to meet a purpose.

International Network of AIM (Asia-Pacific Integrated Model)

The 30th AIM International Workshop
（Aug.28-29, 2024; Hybrid）
http://www-iam.nies.go.jp/aim/index.html
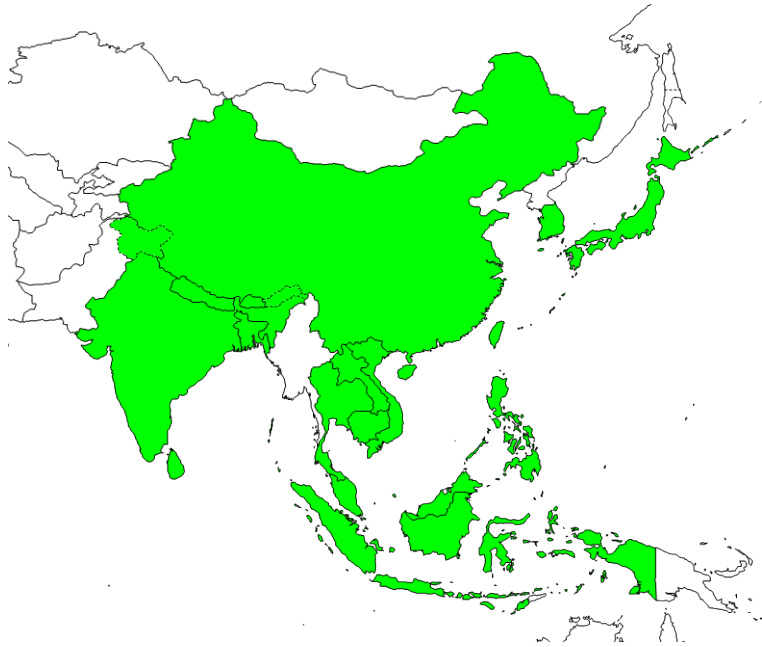
- AIM (Asia-Pacific Integrated Model) project started in 1990.
- Asian countries/regions will update their mitigation target and roadmap to achieve the 1.5/2 degree target reflecting their issues to be solved and the resources to be endowed.
- Model can be a collaboration tool between science and decision-making process. From the long-term viewpoint, each country/region will need the capacities to develop model and scenarios by itself.
- AIM has supported Asian countries/regions to develop the integrated assessment model (IAM) and their long-term low carbon/decarbonized scenarios.
- https://www-iam.nies.go.jp/aim/index.html

Examples of brochures introducing Asian Low Carbon Scenarios Communication and feedbacks of LCS study to real world

Malaysia
- Putrajaya
- Cyberjaya
- Iskandar Malaysia

India
- Bhopal
- Ahmedabad

Vietnam
Bangladesh
Indonesia
Cambodia

Japan
- Kyoto
- Shiga

China
- Guan Zhou
- Dalian

Thailand
- Ratchaburi
- KhonKaen

S. Korea
- Kyonggi-do

Not "low carbon society" but "zero carbon society" is needed now.
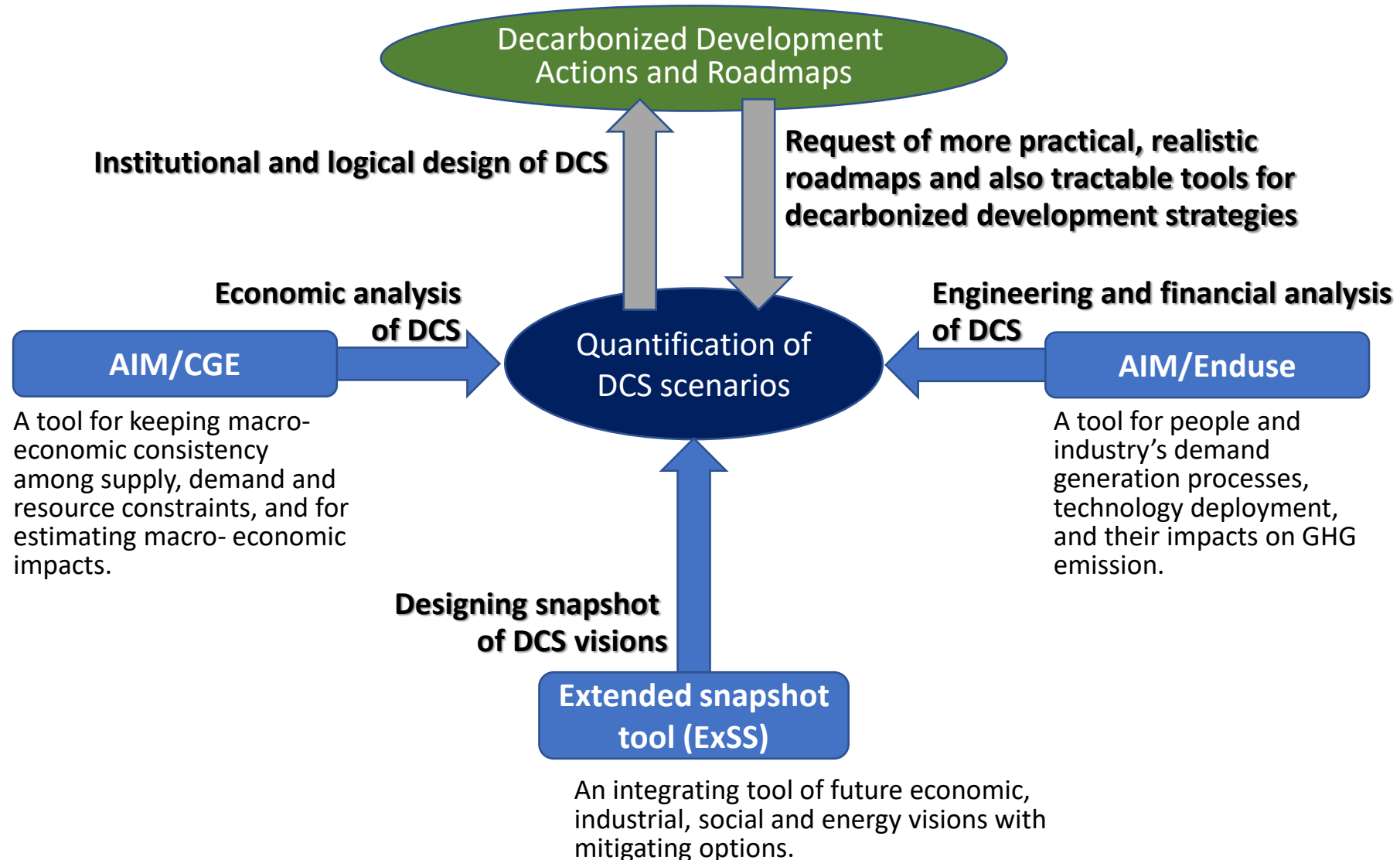
https://2050.nies.go.jp/

Toward sustainable decarbonized Asia

- Final goal is common among countries/regions;
  - SDGs (economy, society, environment)
  - GHG mitigation target (NDCs, long-term strategy, net-zero emission)
- But process/strategy may be different among countries/regions;
  - Viewpoint of economy and CO2
    - Japan, Korea, Taiwan: steady state economy with drastic CO2 reduction?
    - China, Thailand, Malaysia: strong decoupling between economic growth and CO2 reduction
    - Bhutan, India, Indonesia, Lao, Vietnam: economic growth with maintaining CO2 emissions
    - Cambodia, Nepal: First priority is economic growth, but soon CO2 reduction is needed.
    - In developing countries/regions: correction of disparities between urban and rural
  - Other viewpoints
    - Endowed resources
    - Social conditions such as aging, available technology, etc

  > "How to achieve the net-zero to meet each country" is an important issue.
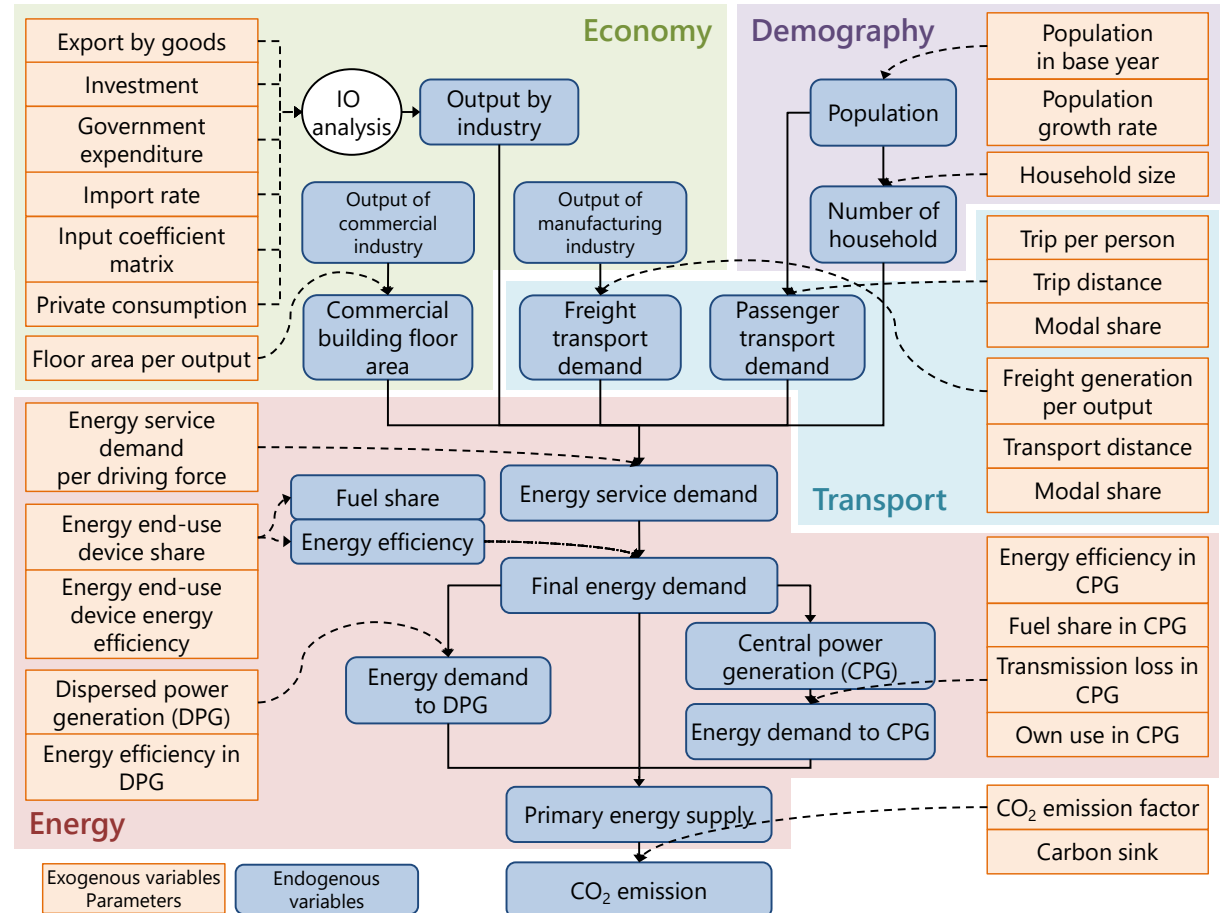

◯: 1990, ×: 2000, △: 2015
······▶ 1990-2015
——▶ 2015-2050
– –▶ 2050-

CO2 per capita [tCO2]

GDP per capita [US$ at 2010]
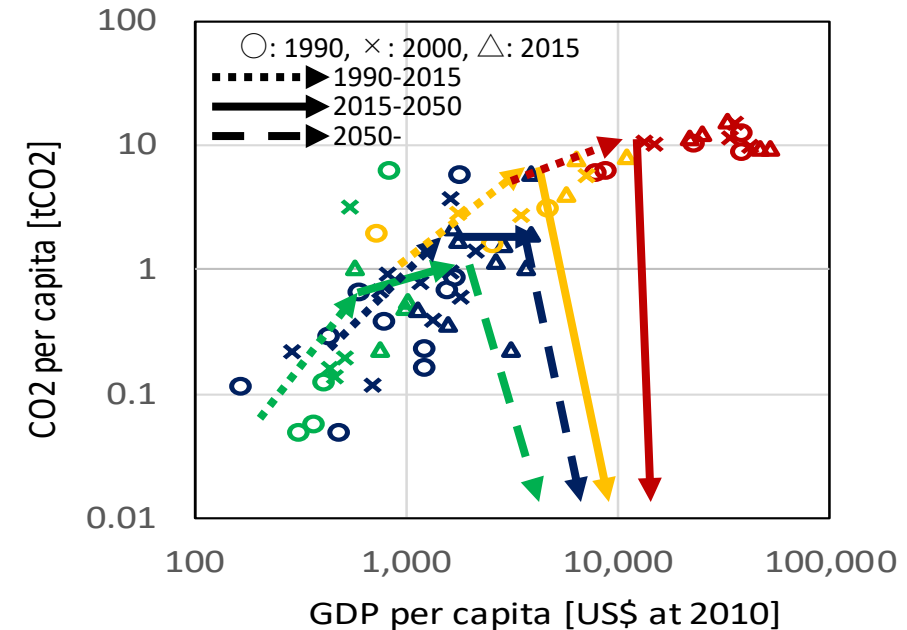
How to combine the tools in order to keep consistency and unity among socio-economic policies and DCS actions

Decarbonized Development Actions and Roadmaps

Institutional and logical design of DCS

Request of more practical, realistic roadmaps and also tractable tools for decarbonized development strategies

Economic analysis of DCS

Engineering and financial analysis of DCS

AIM/CGE

Quantification of DCS scenarios

AIM/Enduse

A tool for keeping macro-economic consistency among supply, demand and resource constraints, and for estimating macro- economic impacts.

A tool for people and industry's demand generation processes, technology deployment, and their impacts on GHG emission.

Designing snapshot of DCS visions

Extended snapshot tool (ExSS)

An integrating tool of future economic, industrial, social and energy visions with mitigating options.
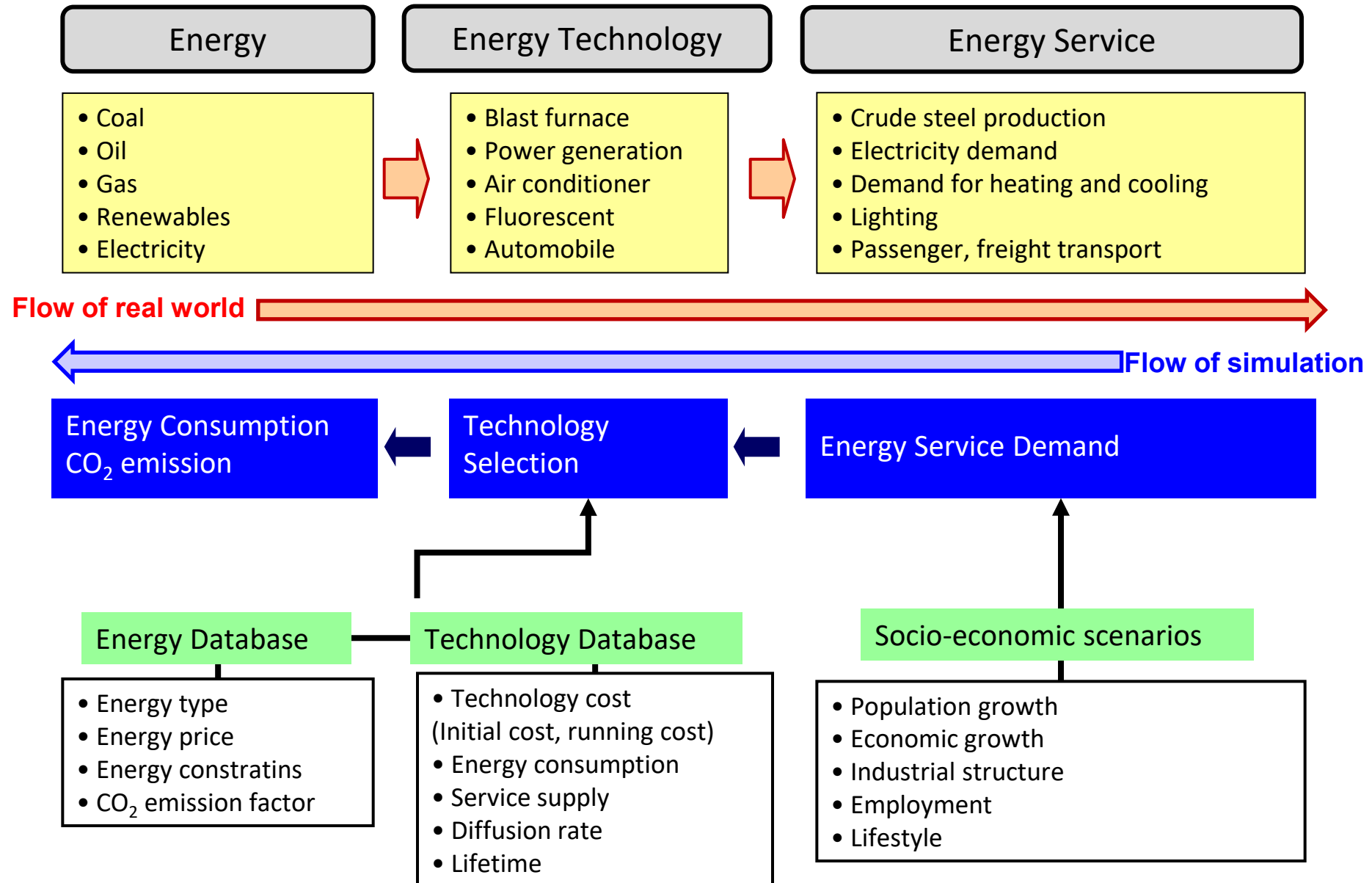
AIM
ASIA-PACIFIC INTEGRATED MODEL

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Extended Snapshot Tool (ExSS)

- Extended Snapshot Tool (ExSS) is an accounting type, static model consisting of simultaneous equations with about 6000 variables.
- It describes socio-economic activity, energy consumption, power generation, technology diffusion and GHG emissions in a future year.
- Coupled with waste and AFOLU model, it can show a comprehensive vision of a country or a region as a low-carbon society.
- Data requirement: Input-output table, energy balance table, demography, and transport data in a base year.

Overview of AIM/Enduse model

Energy	Energy Technology	Energy Service
• Coal • Oil • Gas • Renewables • Electricity	• Blast furnace • Power generation • Air conditioner • Fluorescent • Automobile	• Crude steel production • Electricity demand • Demand for heating and cooling • Lighting • Passenger, freight transport

Flow of real world →

← **Flow of simulation**

Energy Consumption CO_2 emission	←	Technology Selection	←	Energy Service Demand

Energy Database

• Energy type
• Energy price
• Energy constratins
• CO_2 emission factor

Technology Database

• Technology cost
(Initial cost, running cost)
• Energy consumption
• Service supply
• Diffusion rate
• Lifetime

Socio-economic scenarios

• Population growth
• Economic growth
• Industrial structure
• Employment
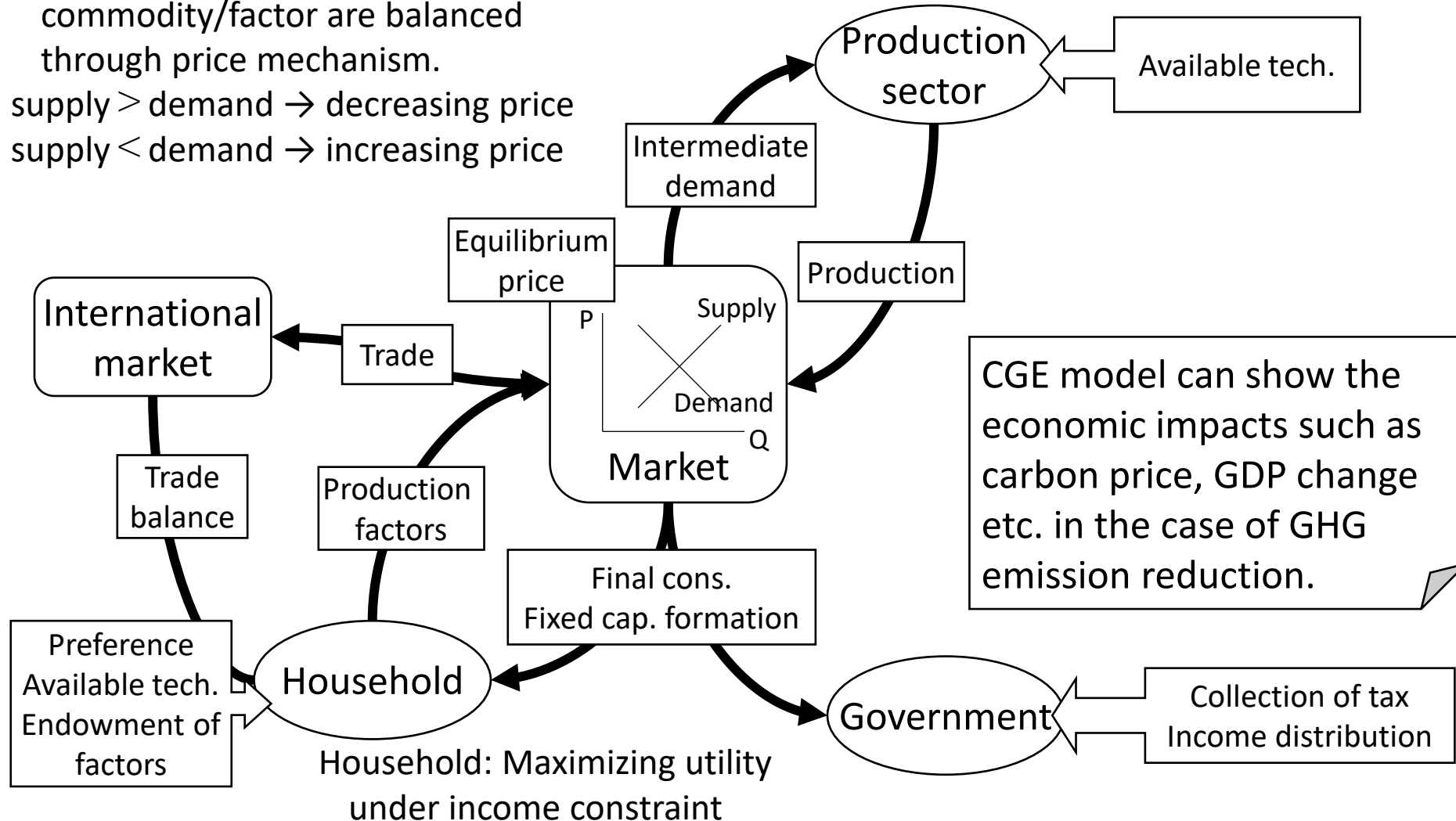• Lifestyle

AIM
ASIA-PACIFIC INTEGRATED MODEL

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Concept of AIM/CGE (Computable General Equilibrium)

Market: supply and demand of every commodity/factor are balanced through price mechanism.
supply ＞ demand → decreasing price
supply ＜ demand → increasing price

Production sector

Available tech.

Intermediate demand

Equilibrium price

Production

International market

Trade

P | Supply
Demand | Q

Market

CGE model can show the economic impacts such as carbon price, GDP change etc. in the case of GHG emission reduction.

Trade balance

Production factors

Preference
Available tech.
Endowment of factors

Household

Final cons.
Fixed cap. formation

Government

Collection of tax
Income distribution

Household: Maximizing utility under income constraint

Thailand
Fourth National Communication, First BTR, and Long-term Strategy

Prof. Bundit Limmeechokchai

(Sirindhorn International Institute of Technology, Thammasat University)

https://unfccc.int/documents/624738
https://unfccc.int/sites/default/files/resource/THAILAND%E2%80%99S%20BTR1.pdf

https://unfccc.int/sites/default/files/resource/Thailand_LTS1.pdf
https://unfccc.int/sites/default/files/resource/Thailand%20LT-LEDS%20%28Revised%20Version%29_08Nov2022.pdf

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

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

INDONESIA
Long-Term Strategy for Low Carbon
and Climate Resilience 2050

- 2021 -

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 Snapshot). 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).
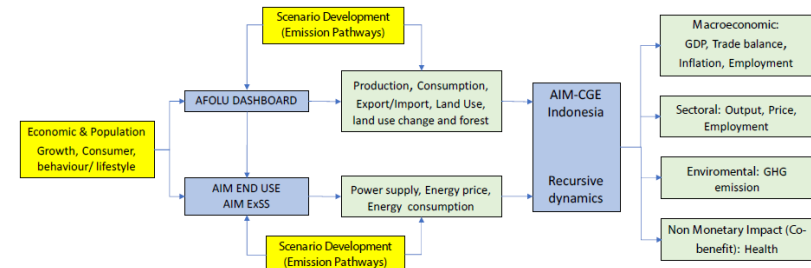

Figure 3. Models for developing emission pathways in Indonesia

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

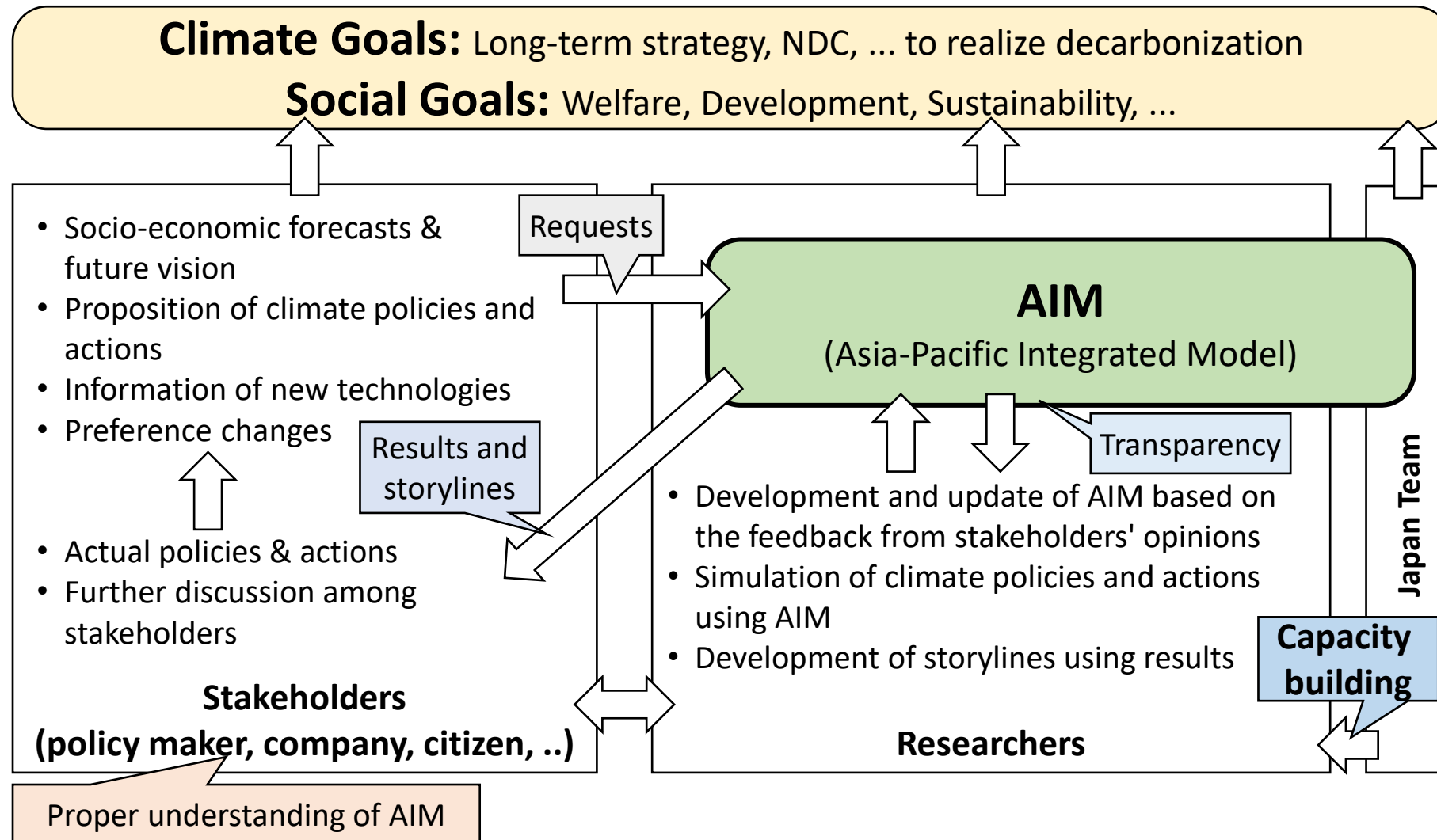# Training Workshop to introduce ExSS, Enduse and CGE

- Jan. 30-Feb. 1 2017, SIIT-TU, Thailand
- Bhutan, Cambodia, China, Indonesia, Korea, Malaysia, Nepal, Thailand, Vietnam
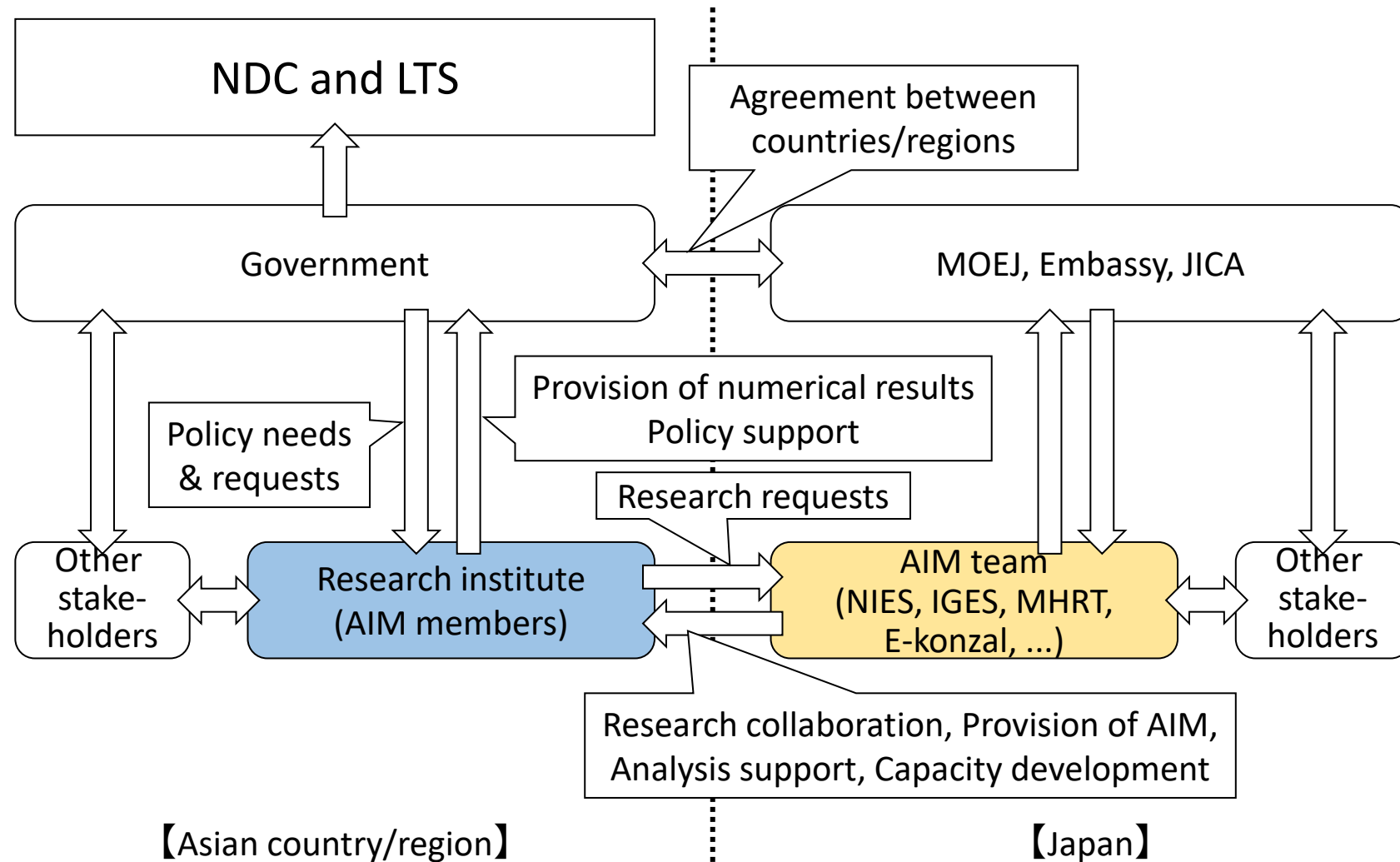
AIM and LoCARNet Peer-to-Peer Meeting for Sharing Experience and Lessons at NIES on August 27, 2024

How to realize decarbonized society and roles of the AIM?

Climate Goals: Long-term strategy, NDC, ... to realize decarbonization
Social Goals: Welfare, Development, Sustainability, ...

- Socio-economic forecasts & future vision
- Proposition of climate policies and actions
- Information of new technologies
- Preference changes

- Actual policies & actions
- Further discussion among stakeholders

Stakeholders
(policy maker, company, citizen, ..)

Requests

Results and storylines

AIM
(Asia-Pacific Integrated Model)

Transparency

- Development and update of AIM based on the feedback from stakeholders' opinions
- Simulation of climate policies and actions using AIM
- Development of storylines using results

Researchers

Japan Team

Capacity building

Proper understanding of AIM

Expected structure to support climate policy in Asian countries/regions

【Asian country/region】 【Japan】

NIES: National Institute for Environmental Studies
IGES: Institute for Global Environmental Strategies
MHRT: Mizuho Research & Technologies

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FY2025 Plan

- 22-23 July: The 31st AIM International Workshop (at Tsukuba, Japan, Hybrid)

  - About the previous workshops, please see the following site; https://www-iam.nies.go.jp/aim/aim_workshop/index.html

  - Registration: https://forms.gle/QJw7a6Gqfrdrb1Fy6

- 24 July: The 3rd AIM and LoCARNet Peer-to-Peer Meeting for Sharing Experience and Lessons (at Tsukuba, Japan, Hybrid)

Socioeconomic Impacts from Shifting to Sustainable Food Consumption Towards Indonesia's Net Zero Emission

Annuri Rossita*, Toshihiko Masui, Kazuaki Tsuchiya, Makiko Sekiyama

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National
Institute for
Environmental
Studies, Japan

Background and objectives of the study

To assess the environmental and socioeconomic impact of shifting food consumption preferences under Indonesia's Long-Term Strategy.

Map of Indonesia

- **Indonesia is still expecting increasing food consumption**

  With the current undernutrition issue and income growth, increasing food consumption per capita is the country`s main agenda.

- **The food sufficiency target could be a setback to the country`s Net Zero vision**

  Increasing food demand will trigger a more rapid agriculture GHG emission and land demand for agricultural expansion

- **Co-benefits from shifting food consumption have not yet been explored under the NZE**

Research flow and AIM/CGE model framework
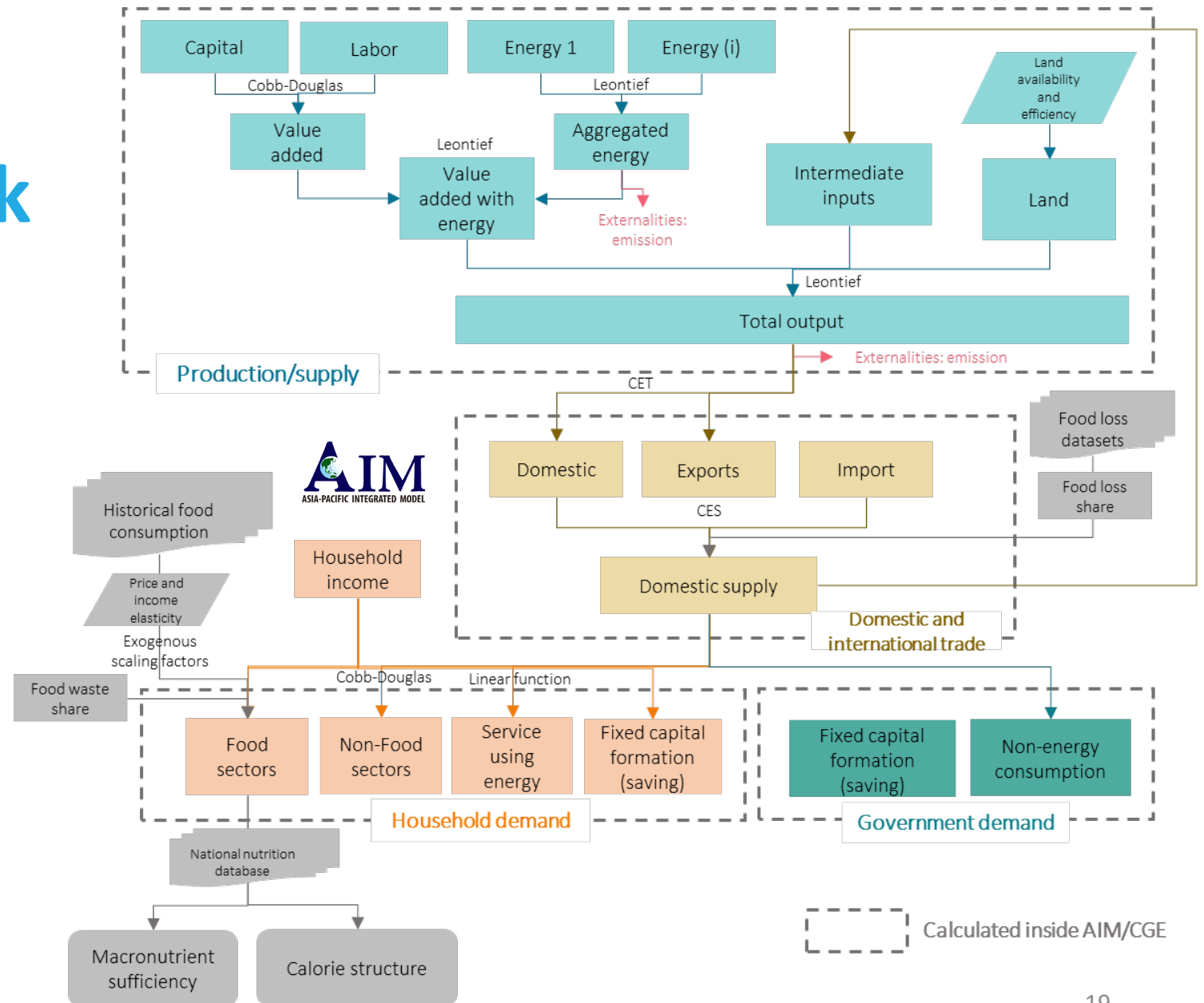
1. **Data preparation**
   Data collection to develop model structure, calibrate the model and execute model projection

2. **CGE simulation**
   We use the recursive dynamic of the Indonesia AIM/CGE model for the simulation time 2016-2060.

3. **Interpretation**
   Converting monetary to biophysics and analyzing model outputs

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Data input

No	Data	Details	Coverage	Purpose for analysis
1	Socioeconomic data	Input-Output (IO) table[1]	2016/national	Model input for economic structure
		Population and GDP growth[1]	2016-2060/national	Model input for socioeconomic projection
		Social Accounting Matrix[1]	2016/national	Ratio of household and government savings
		International prices for agricultural products[2]	2016-2032/ International	Setting international prices for food sectors
2	Food-related data	Historical Food consumption[1]	2005-2023/national	Food income elasticity calculation and conversion value for the model monetary outputs
		Food nutrition composition[3]	n.a./national	Macronutrient conversion value
		Food balance table[4]	2016-2023/national	Domestic production and international trade
		Food loss and food waste[5]	n.a./Asia region	Assumption setting for food loss and food waste
		National Desirable Dietary Pattern (DDP) [6]	n.a./national	Reference for healthy food consumption level

[1]Statistics Indonesia; [2]OECD & FAO, 2023; [3]Ministry of Health; [4]Ministry of Agriculture; [5](FAO, 2018) (Cederberg & Sonesson, 2011) ; [6]National Food Agency Law 11/2023

Data input

No	Data	Details	Coverage	Purpose for analysis
3	Land-related data	Land cover[1]	2016/national	Initial land use
		Land cover projection[2]	2016-2050/national	Projection of land use efficiency
		Agriculture production target[2]	2016-2050/national	Projection agricultural production
		Fertilizer demand for agriculture[3]	2016-2023/national	Assumptions on land management
4	GHG emission	GHG inventory[4]	2016/national	Emission factor for sectoral activity
		Emission factor for mitigation activities[1]	2016/national	Emission reduction from mitigation activities
		Mitigation activities for the agriculture sector[2]	2016-2050/national	Scale of mitigation activities

[1]Ministry of Environment and Forestry; [2](Government of Indonesia, 2021); [3]Indonesian Fertilizer Producers Association (APPI); [4](Government of Indonesia, 2018)

Scenario development

Features \ Scenario		Business as Usual (BaU)	Low Carbon Compatible with Paris Target (LCCP)	LCCP + Sustainable and Healthy Diet
Technology	Conventional technology	√	√	√
	New technology	×	√	√
Agriculture mitigation activities		×	√	√
Food-related assumptions	Food loss[1] reduction rate	Baseline rate	Sustainable rate	
	Food demand[2]	Conventional trajectory		Sustainable healthy consumption
	Food waste[3]	Increasing rate following the transition to a high-income country		

[1]Food loss between production stage and household; [2]Food demand was defined as the summation of actual food consumption and food waste; [3]Losses and waste at the household level.

Agriculture Mitigation Scenarios Following Indonesia's Long-Term Strategy (LTS)

Mitigation actions	Scale of implementation	Potential emission reduction	Supporting country-level regulations
Rice field			
a. Adoption of low-emission variety	1.96 Mha rice field in 2050 (~24% of total rice field)	Up to 58% of CH_4 emission reduction per ha[1]	Medium-Term National Development Plan, (Government of Indonesia, 2021; KLHK, 2019)
b. Improved water use efficiency	1.31 Mha of irrigated rice fields in 2050	Up to 45% of CH_4 emission reduction per ha[2]	
Livestock feed supplement	6.58 million head of livestock in 2050	Approx. 15% of CH_4 emission reduction per livestock head[3]	
Reduction of fertilizer use	Reduction of 65,697 tons of urea in 2050	Approx. 0.733 tCO_2e per 1-ton reduction of urea application[3]	Ministerial Law of Agriculture No.1/2024

[1]Under the assumption that the current widely used variety is *Cisadane* and the low-emission variety is *Dodokan*. [2]Emission reduction from intermittent flooding. [3](Government of Indonesia, 2021; KLHK, 2019).
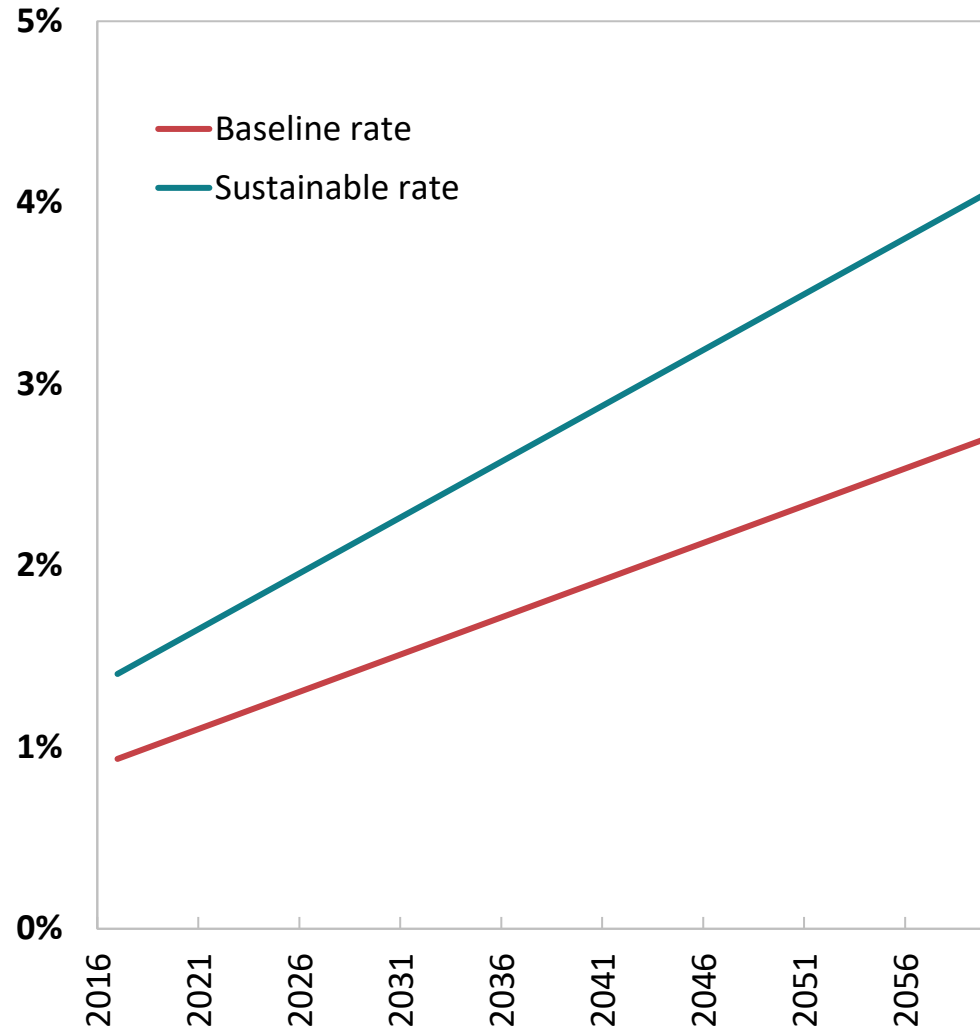
Scenario development: food demand

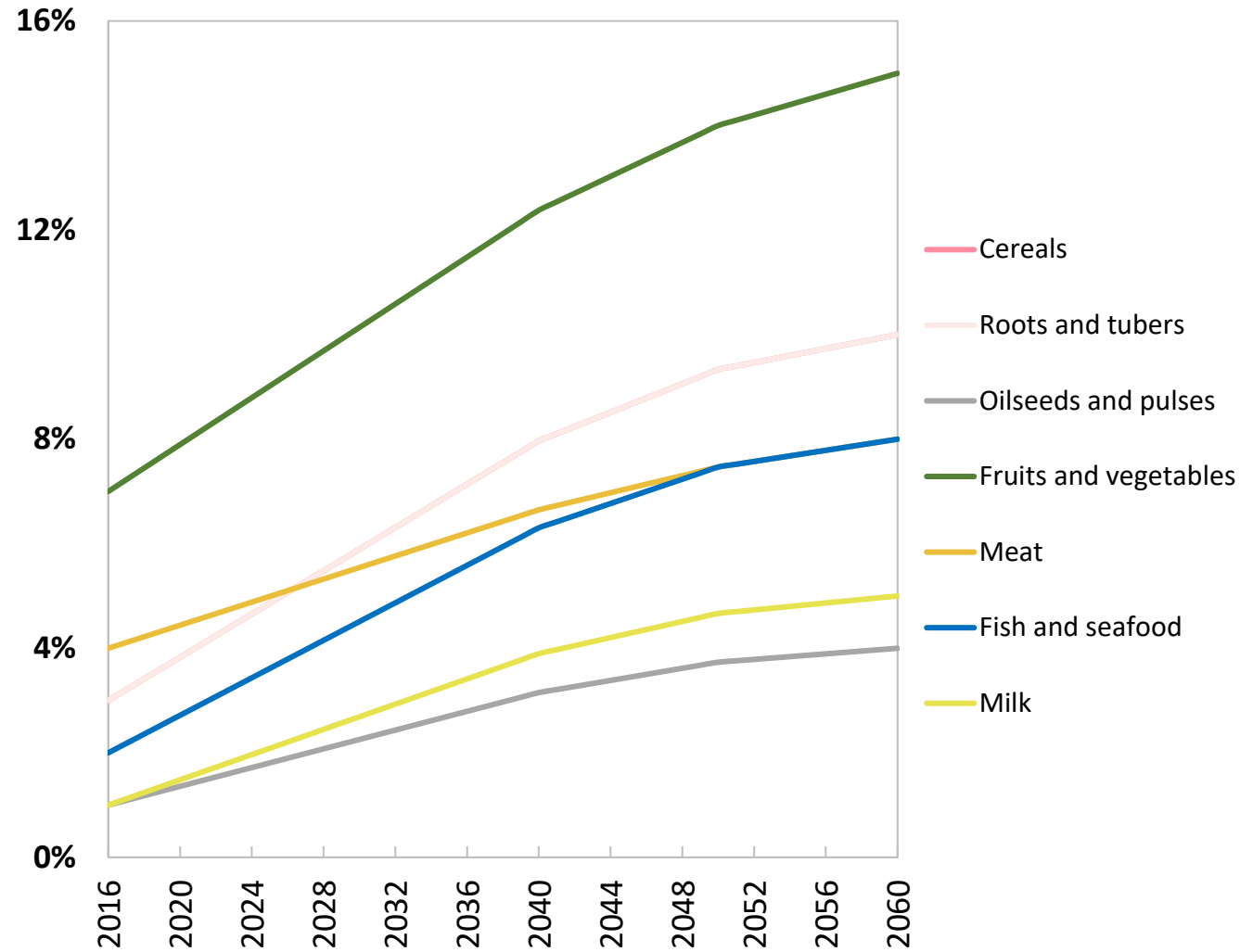|		Conventional Trajectory	Sustainable Healthy Diet[1]
Behavioral changes		Follow the historical trend with no behavioral changes	Healthy and environmentally mindful consumption
Total food demand		From 2,135 kcal/cap/day in 2016 to 2,924 kcal/cap/day in 2060	From 2,135 kcal/cap/day in 2016 to below 2,300 kcal/cap/day in 2060
Animal-source food		High demand for meat products following income growth	Slower growth according to the healthy level
Fruits and vegetables		Increase following historical trend	Slower growth according to the healthy level
Food type	Whole food	Declined along with increasing consumption of non-home cook	Increasing growth along with the declining of non-home cook
	Processed food	Increase to 322 kcal/cap/day in 2060	Increased only to 270 kcal/cap/day in 2060
	Restaurant and catering	Increase to 625 kcal/cap/day in 2060	Decreased to 325 kcal/cap/day in 2060

[1]Based on the ideal calorie structure and sufficiency level regulated under National Food Agency Law 11/2023

Scenario development: food loss and food waste
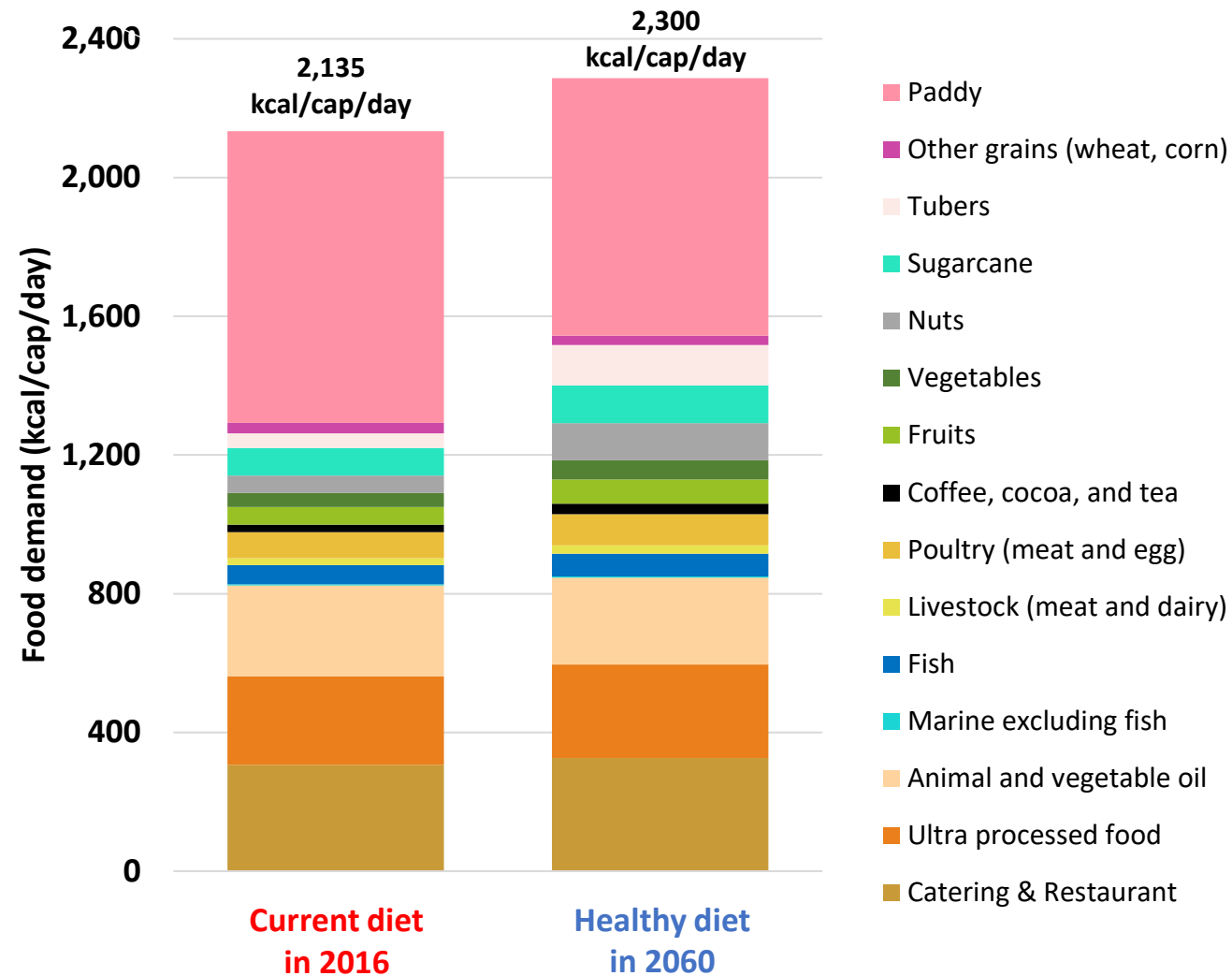
a. Food loss reduction rate

- Baseline rate
- Sustainable rate

b. Share of food waste to total food demand

- Cereals
- Roots and tubers
- Oilseeds and pulses
- Fruits and vegetables
- Meat
- Fish and seafood
- Milk

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Healthy diet profile

Food demand (kcal/cap/day)

2,135 kcal/cap/day — Current diet in 2016

2,300 kcal/cap/day — Healthy diet in 2060

Legend:
- Paddy
- Other grains (wheat, corn)
- Tubers
- Sugarcane
- Nuts
- Vegetables
- Fruits
- Coffee, cocoa, and tea
- Poultry (meat and egg)
- Livestock (meat and dairy)
- Fish
- Marine excluding fish
- Animal and vegetable oil
- Ultra processed food
- Catering & Restaurant

National Food Agency Law 11/2023 about "National Desirable Dietary Pattern (DDP)"

Energy substance:
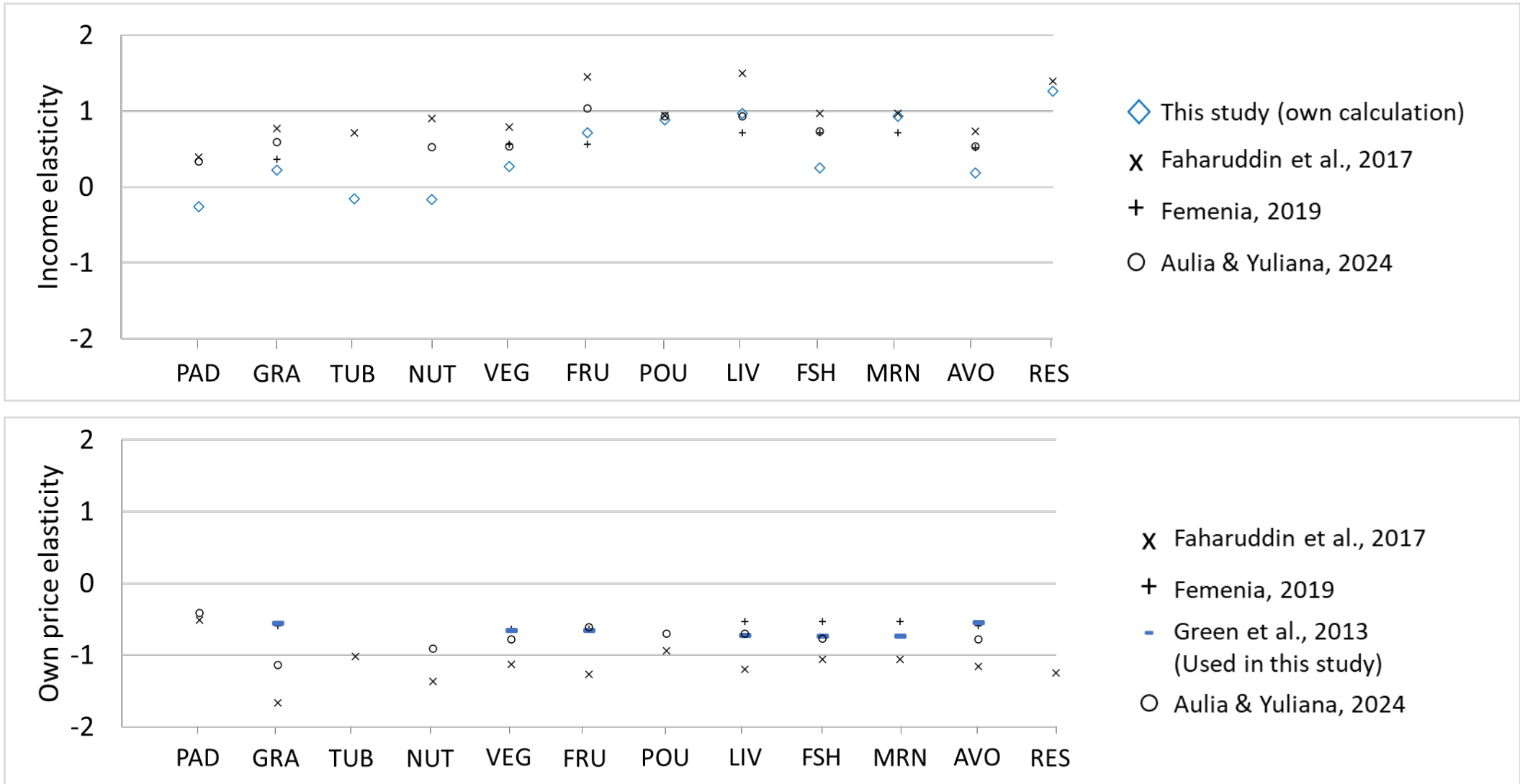A minimum 50% calorie share from grain groups

Protein substance:
A minimum 12% and 5% share from animal-based and plant-based protein, respectively

Regulating substance:
A minimum 6% calorie share from vegetables and fruits

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Food-income and food-price elasticities

PAD = paddy rice; GRA = other grains; TUB = tubers; NUT = nuts; VEG = vegetables; FRU = fruits; POU = poultry (meat and egg); LIV = livestock (meat and dairy); FSH = fish; MRN = marine; AVO = animal and vegetable oil; RES = restaurant
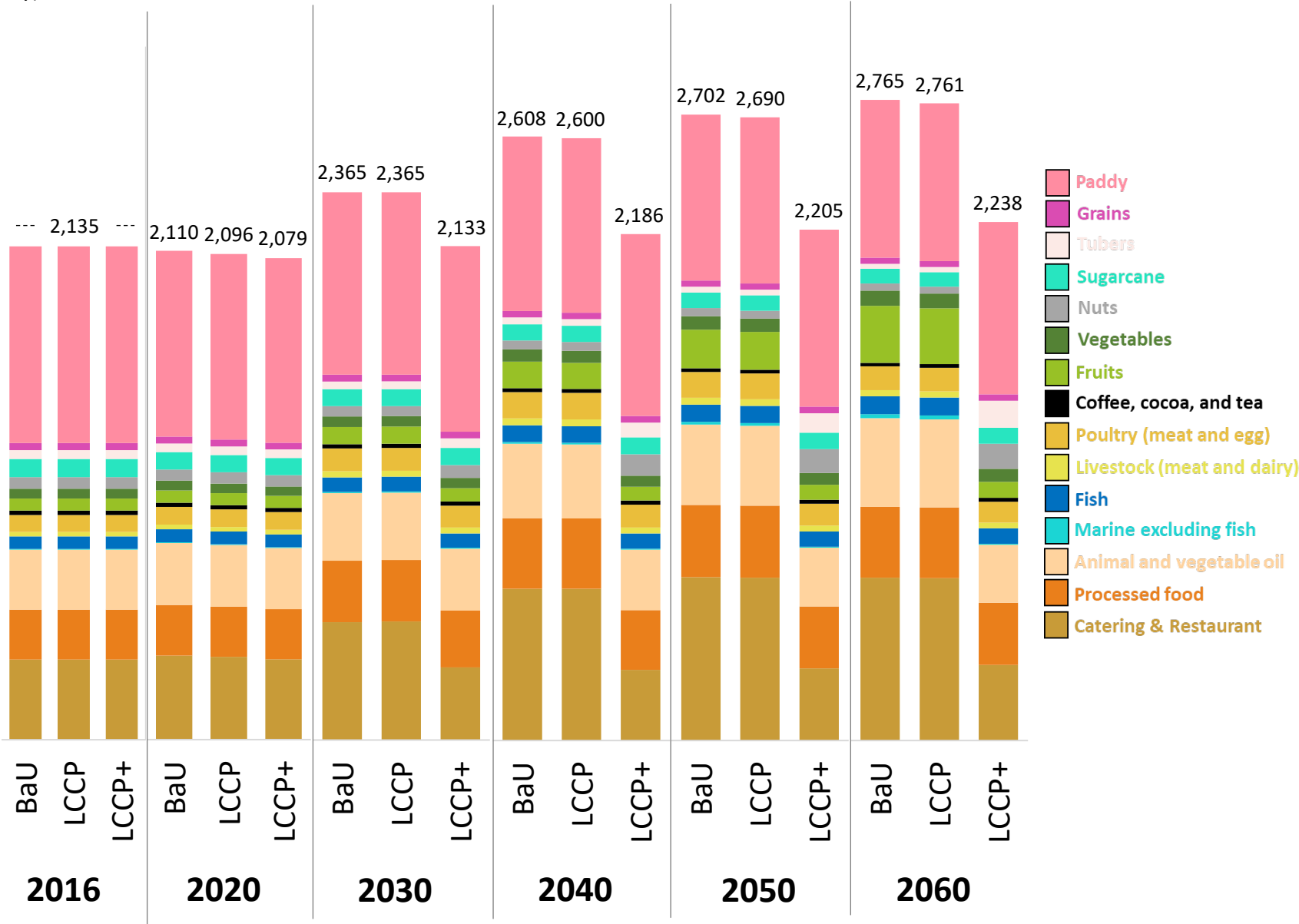
Food demand by scenarios

Food consumption (kcal/cap/day)

Shifting food demand (cal)

LCCP+ scenario offers ideal food proportion for carbohydrate source, protein source, and fiber source foods, and a lower consumption of non-home cook food.

In total, **LCCP+** scenario results in a **lower food demand**, as to avoid overconsumption and maintain the healthy level.

Legend:
- Paddy
- Grains
- Tubers
- Sugarcane
- Nuts
- Vegetables
- Fruits
- Coffee, cocoa, and tea
- Poultry (meat and egg)
- Livestock (meat and dairy)
- Fish
- Marine excluding fish
- Animal and vegetable oil
- Processed food
- Catering & Restaurant

Values shown: 2,135; 2,110; 2,096; 2,079; 2,365; 2,365; 2,133; 2,608; 2,600; 2,186; 2,702; 2,690; 2,205; 2,765; 2,761; 2,238

Categories per year group (BaU, LCCP, LCCP+): 2016, 2020, 2030, 2040, 2050, 2060

RESULTS: Socioeconomic implications

National GDP
(trillion IDR)

	2016	2020	2030	2040	2050	2060
BAU	12,273	13,901	22,882	38,594	60,455	95,225
LCCP	12,273	14,016	23,145	38,637	60,264	95,092
LCCP+	12,273	14,003	23,119	38,500	59,908	94,280
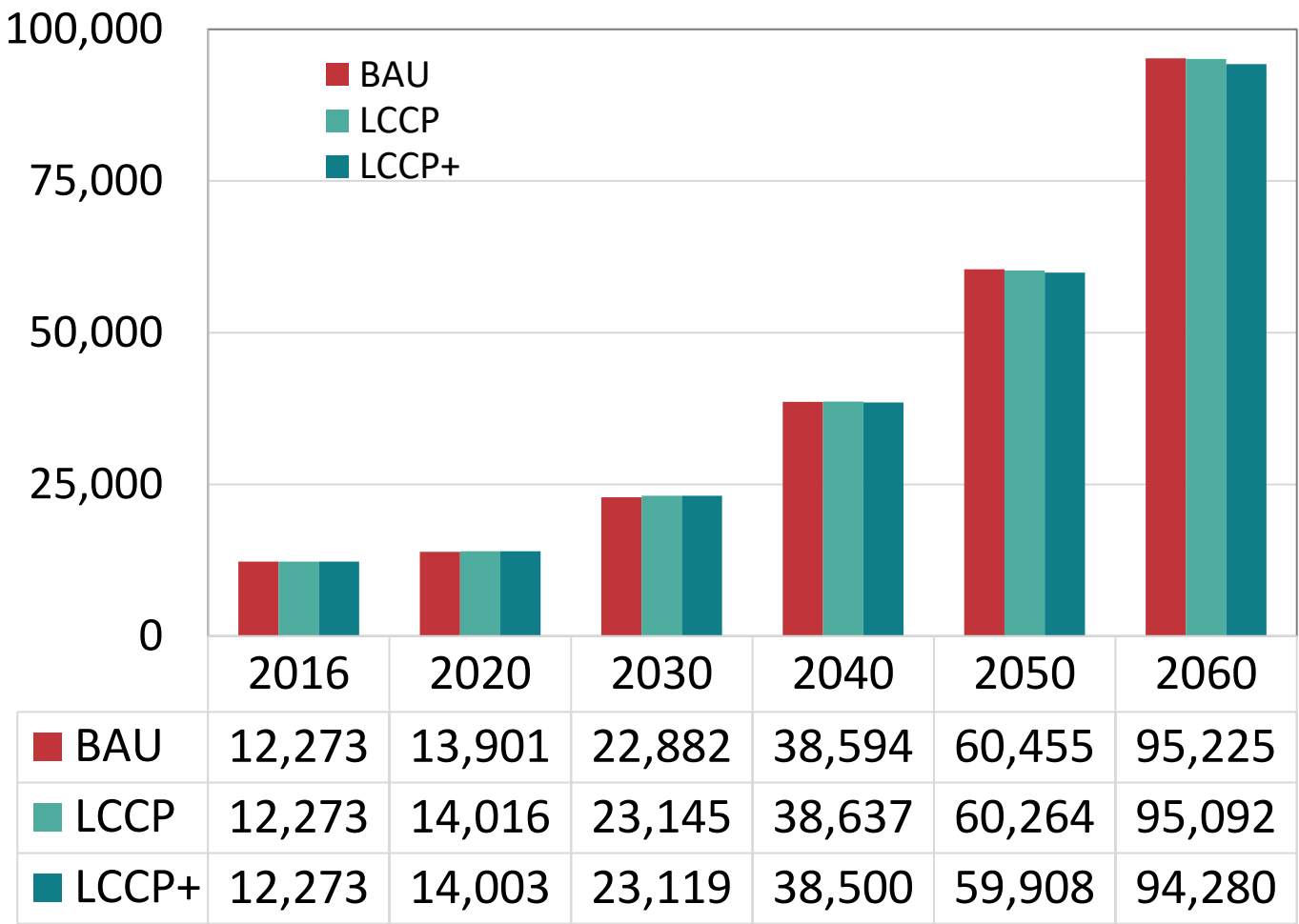
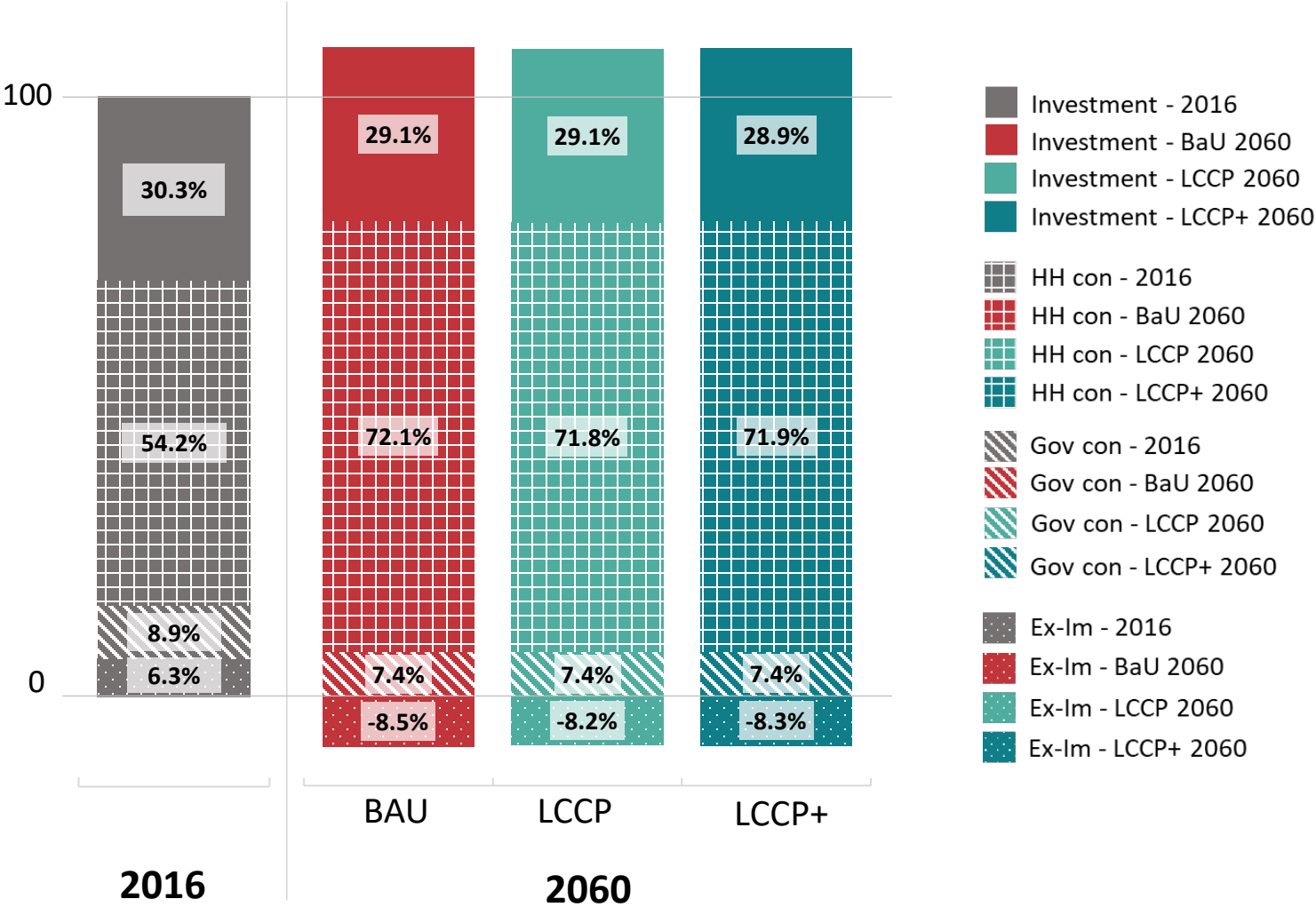## National GDP

Compared to the BaU, The **GDP loss** under the **LCCP** scenario reached **IDR 191 trillion (0.1%)** in 2060. A **higher** amount of GDP loss, amounting to IDR 945 trillion (1.0%) in 2060 was observed under the **LCCP+ scenario**.
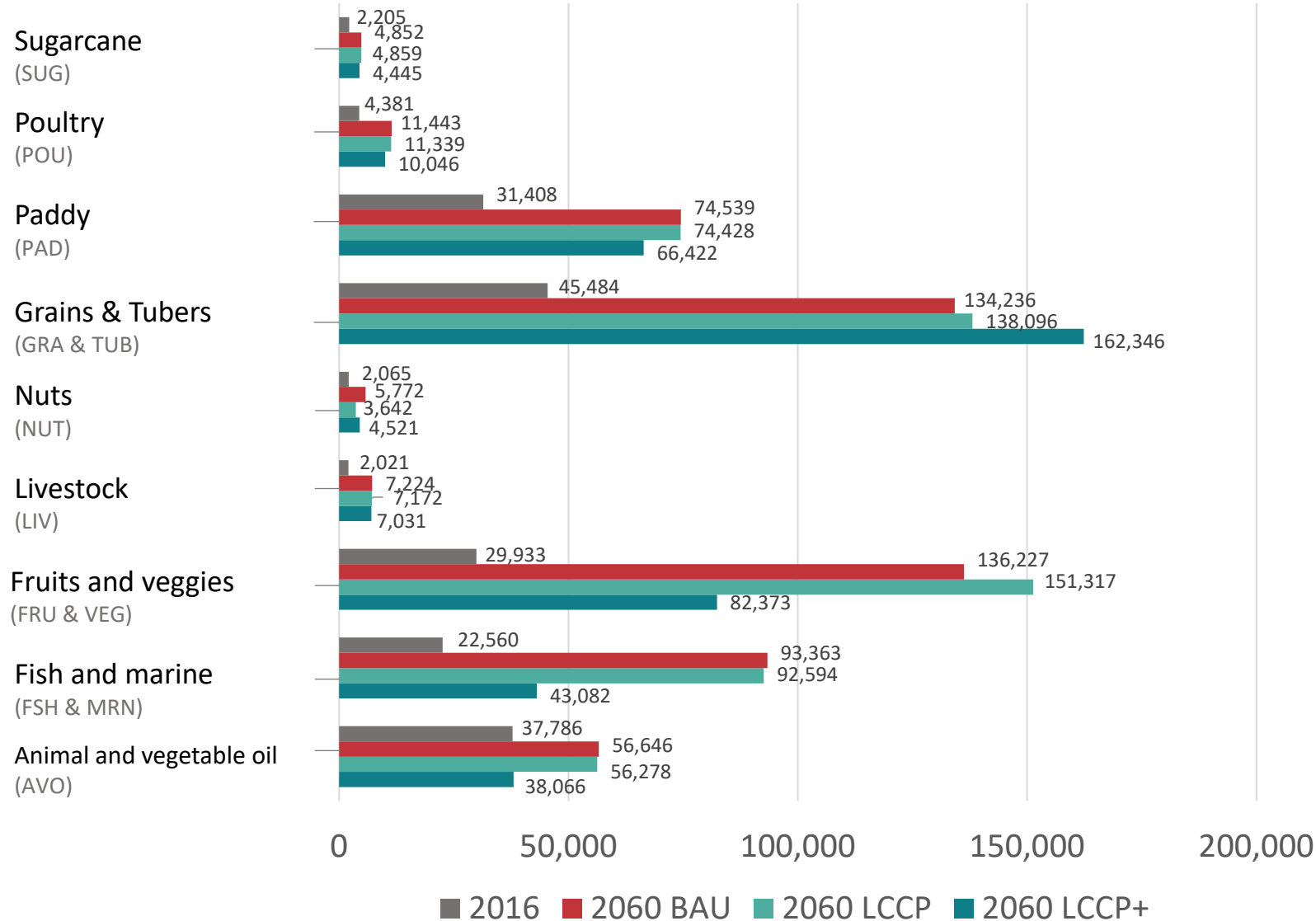
RESULTS: Socioeconomic implications

	Investment - 2016
	Investment - BaU 2060
	Investment - LCCP 2060
	Investment - LCCP+ 2060
	HH con - 2016
	HH con - BaU 2060
	HH con - LCCP 2060
	HH con - LCCP+ 2060
	Gov con - 2016
	Gov con - BaU 2060
	Gov con - LCCP 2060
	Gov con - LCCP+ 2060
	Ex-Im - 2016
	Ex-Im - BaU 2060
	Ex-Im - LCCP 2060
	Ex-Im - LCCP+ 2060

Chart values:

2016: Investment 30.3%, HH con 54.2%, Gov con 8.9%, Ex-Im 6.3%

BAU 2060: Investment 29.1%, HH con 72.1%, Gov con 7.4%, Ex-Im -8.5%

LCCP 2060: Investment 29.1%, HH con 71.8%, Gov con 7.4%, Ex-Im -8.2%

LCCP+ 2060: Investment 28.9%, HH con 71.9%, Gov con 7.4%, Ex-Im -8.3%

National GDP Component

Compared to the **BaU**, the **LCCP and LCCP+** scenarios produced **lower investment**.

A considerable reduction in household consumption was found under the **LCCP+ scenario**.

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RESULTS: Food sectoral activities

Food domestic production (000 ton)

Sugarcane (SUG)	2,205 / 4,852 / 4,859 / 4,445	
Poultry (POU)	4,381 / 11,443 / 11,339 / 10,046	
Paddy (PAD)	31,408 / 74,539 / 74,428 / 66,422	
Grains & Tubers (GRA & TUB)	45,484 / 134,236 / 138,096 / 162,346	
Nuts (NUT)	2,065 / 5,772 / 3,642 / 4,521	
Livestock (LIV)	2,021 / 7,224 / 7,172 / 7,031	
Fruits and veggies (FRU & VEG)	29,933 / 136,227 / 151,317 / 82,373	
Fish and marine (FSH & MRN)	22,560 / 93,363 / 92,594 / 43,082	
Animal and vegetable oil (AVO)	37,786 / 56,646 / 56,278 / 38,066	

Legend: ■ 2016   ■ 2060 BAU   ■ 2060 LCCP   ■ 2060 LCCP+

- The rise of sectoral outputs for food products in 2060 varied from 50% to 355% of the base year sectoral activities.

- Land mitigation policies enabled more efficient resource inputs for economic activities.

- Behavioral changes caused a reduction in food demand; hence, generated the least intensive food sectoral activities.

RESULTS: Agriculture GHG Emissions

- Under BaU scenario, GHG emission for agriculture sector will increase rapidly from 117 $MtCO_2e$ in 2016 to 313 $MtCO_2e$ in 2060.

- In 2060, LCCP and LCCP+ scenario will reach 265 $MtCO_2e$ and 235 $MtCO_2e$ of GHG emissions, respectively.

Agriculture GHG Emissions
(million tCO_2e)

- **48 $MtCO_2e$**
Mitigation policies and measures

- **30 $MtCO_2e$**
Behavioral changes in food demand
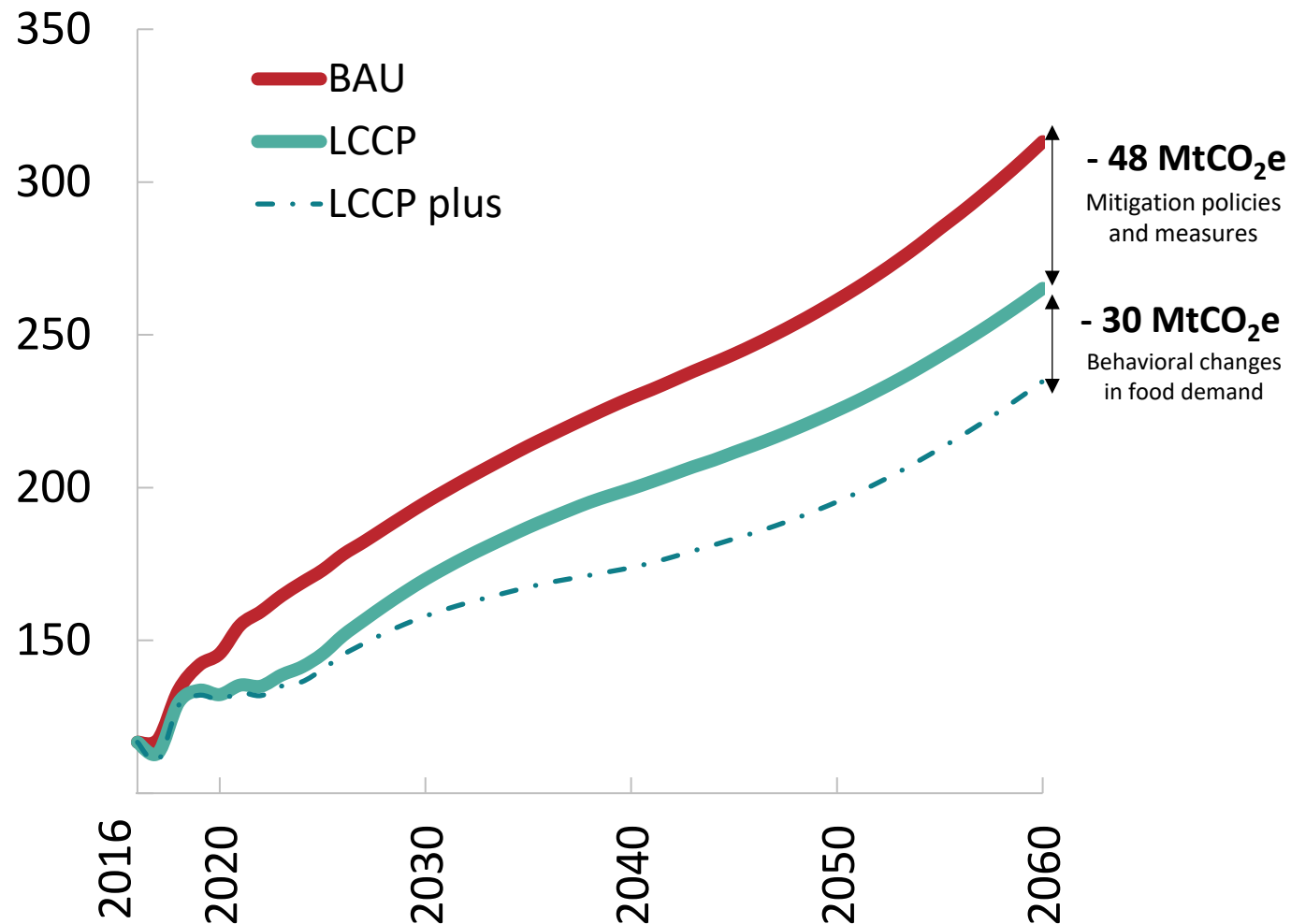
CONCLUSIONS

- Following the conventional trajectory of food consumption, there will be an increasing food demand in the future.

- Mitigation policies and measures potentially reduce 48 $MtCO_2e$ of emission reductions, with an additional 30 $MtCO_2e$ of emission reductions under behavioral changes in food demand.

- However, the GDP loss from the combination of mitigation policies and behavioral change on food demand under the LCCP+ scenario is higher (-1.0%) compared to merely mitigation policies under the LCCP scenario (-0.1%).

- To counter the potential negative impacts on socioeconomics, key policies aiming to increase income and regulate food prices in the market are necessary to make sustainable and healthy diets become more affordable and feasible.

End of presentation.
Thank you.

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