Climate mitigation assessment on food security by AIM modeling team

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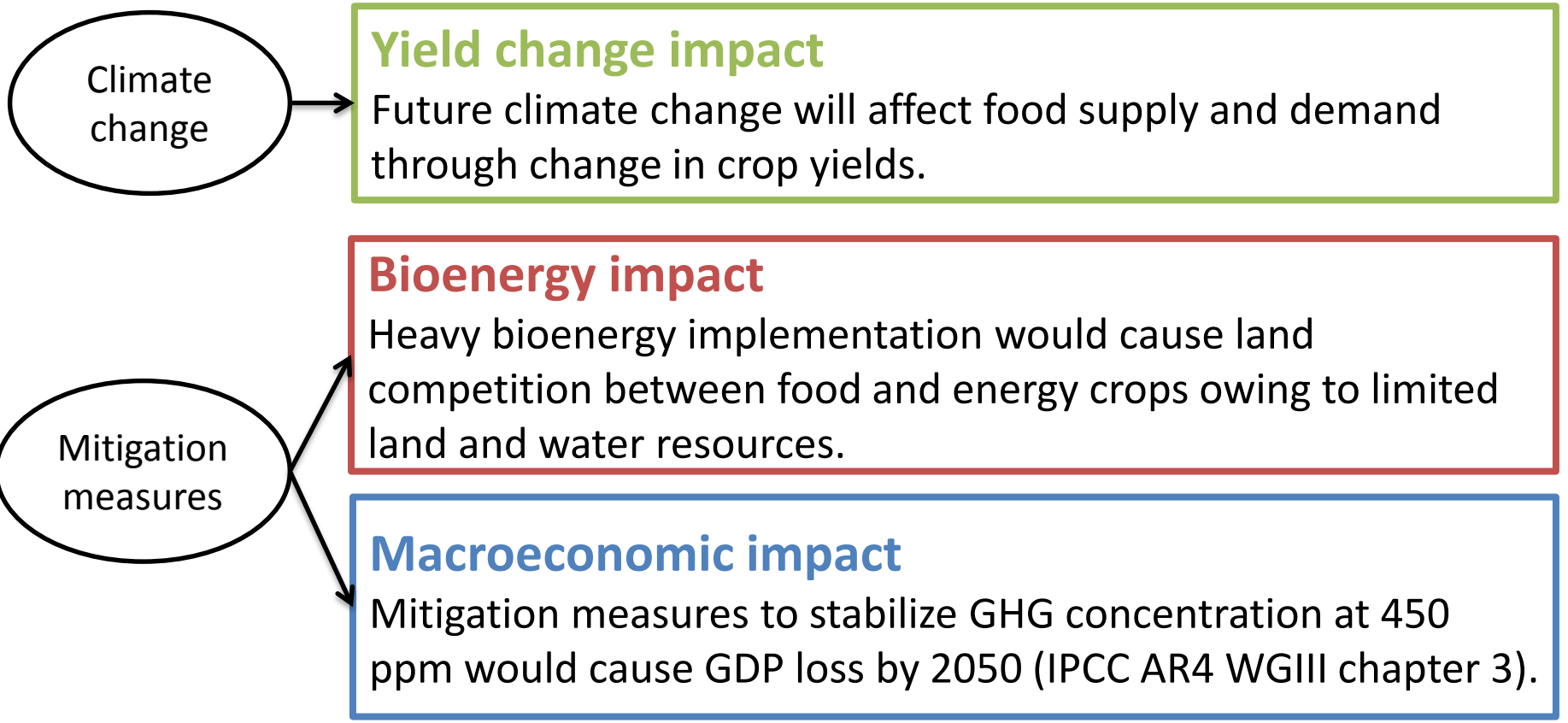
Hasegawa T., Fujimori S., Tanaka, A. Shin Y., Takahashi K., Masui T.,
The consequence of climate mitigation on food security, in review.

Snowmass Climate Change Impacts Workshop 2014, 21-25th, July, 2014

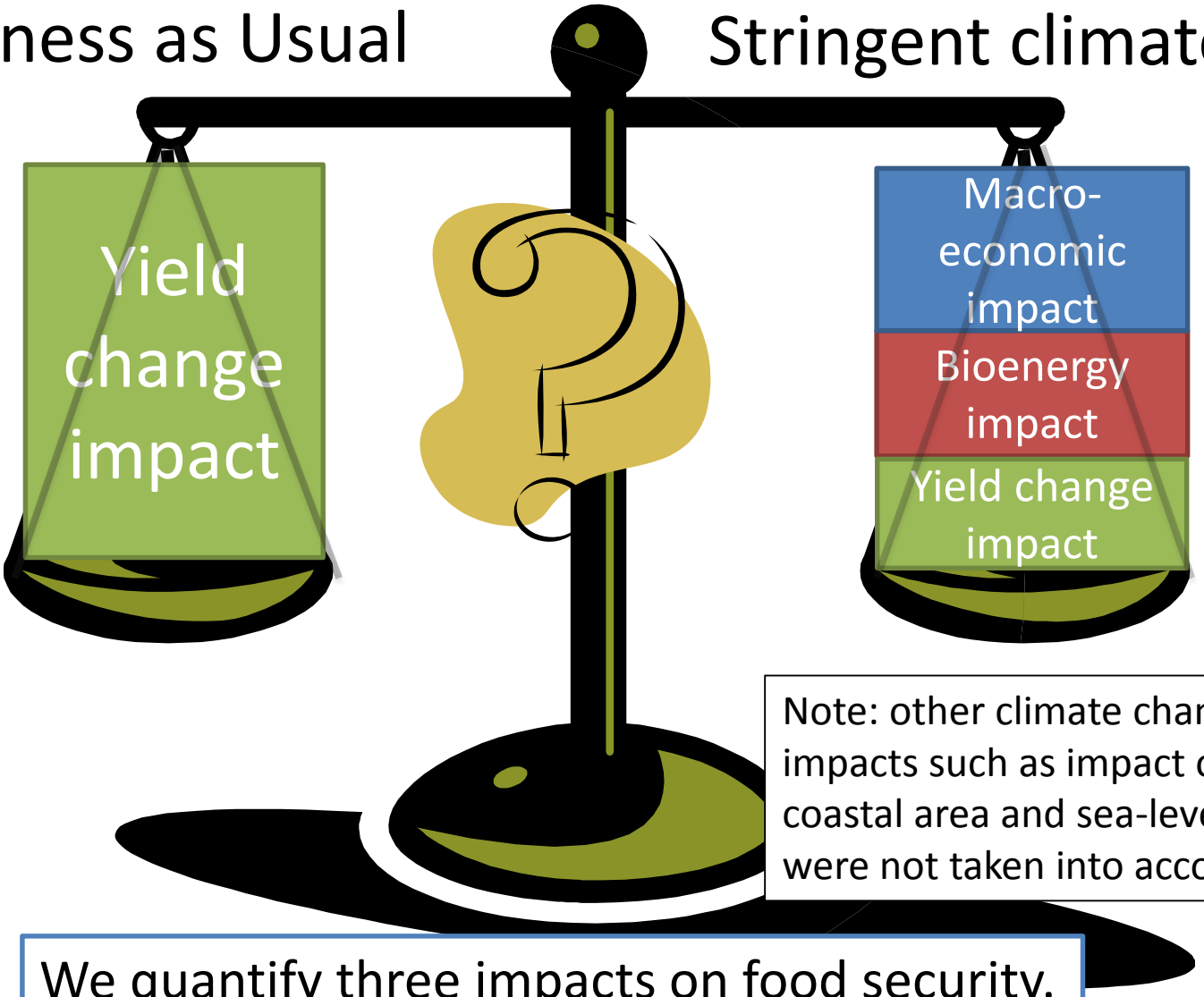
Three impacts of climate change and mitigation measures on food security



Trade-off between climate change and mitigation measures in food security

Business as Usual

Stringent climate policy



Note: other climate change impacts such as impact on health, coastal area and sea-level rise etc. were not taken into account.

We quantify three impacts on food security.

Aims

- Quantify the 3 impacts on food security
  - Yield change impact
  - Bioenergy impact
  - Macroeconomic impact
- Explore the possibility of reducing the negative impacts of mitigation measures by transferring funds.

- Shortcomings of previous studies:
  - No studies about macroeconomic effect on food consumption.
  - Inconsistency between GHG concentration pathway and climate conditions.

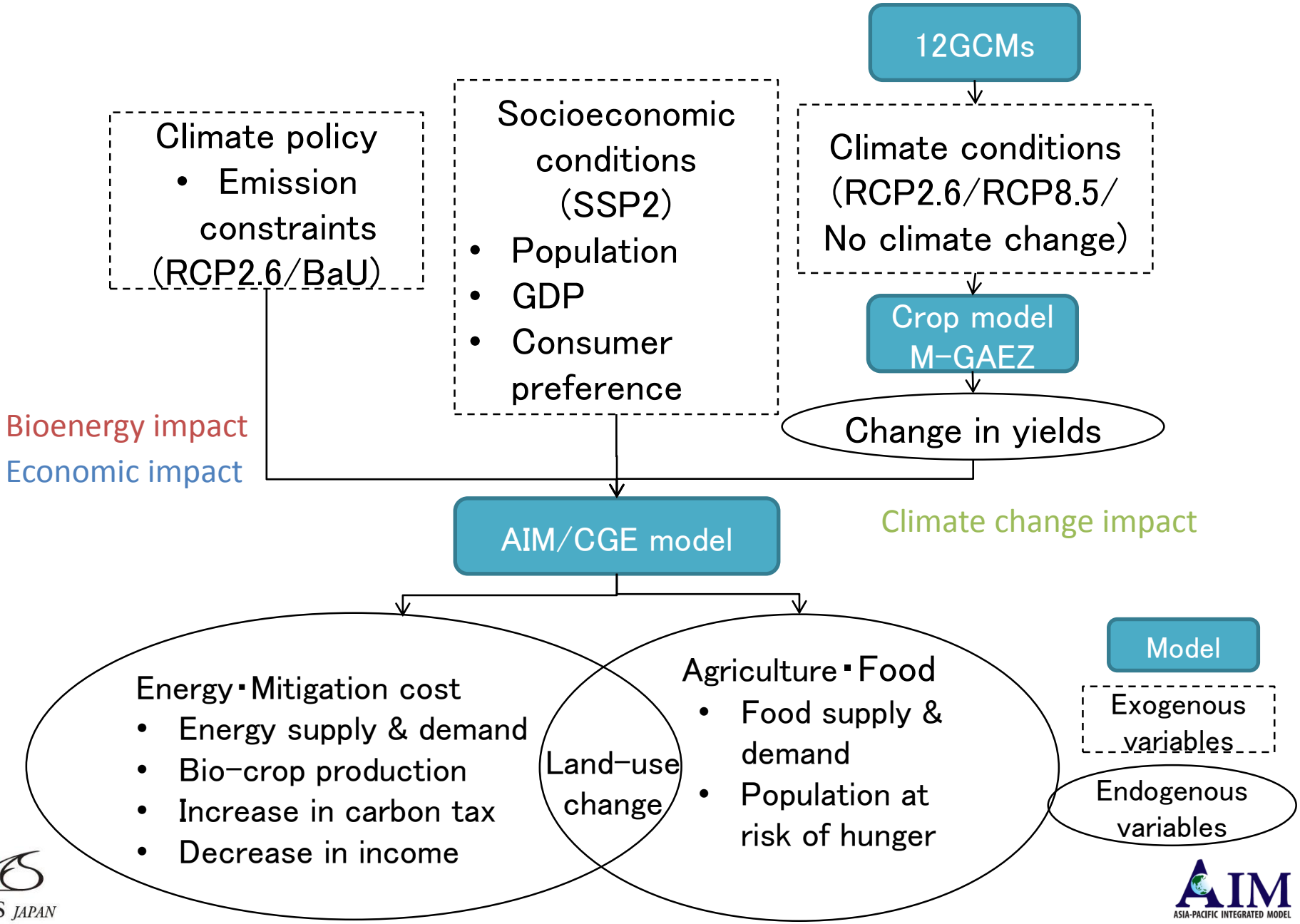
Framework

- 2 climate policy – emission constraints: RCP2.6/no constraint(BaU)
- 3 climate conditions: RCP2.6/RCP8.5/No ClimateChange(NoCC)
- 12 climate models (CMIP5)

- Key drivers
  - Population and GDP: SSP2
  - Exogenous crop yield growth: AgMIP assumption
- Models
  - crop model M-GAEZ: Yield change due to climate change
  - AIM/CGE model: Bioenergy and macroeconomic impacts

Method

Modeling framework



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AIM ASIA-PACIFIC INTEGRATED MODEL

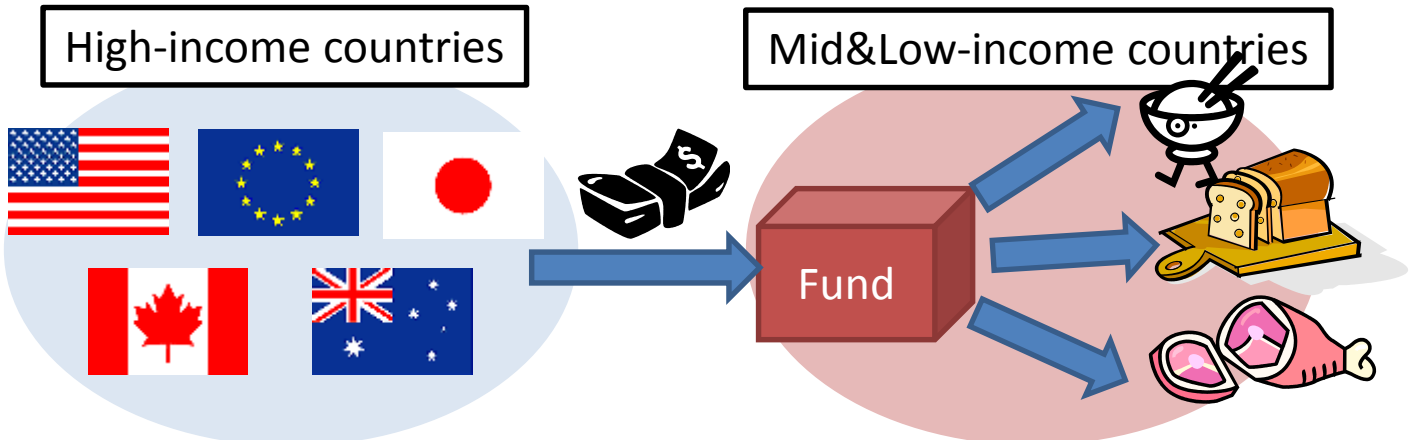
Scenario framework

Scenario	Climate conditions	GHG emission constraints	Other conditions	Issues to be analyzed
S0	No CC	BaU	-	-
S1	RCP2.6	RCP2.6	-	B + E + C impacts
S2	RCP2.6	BaU	-	C impact@RCP2.6
S3	No CC	RCP2.6	-	B + E impacts
S4	No CC	RCP2.6	No land input to bio-crop production	E impact
S5	No CC	RCP2.6	Fund transfer	Effects of fund transfer
S6	RCP8.5	BaU	-	C impact@RCP8.5

"NoCC": No Climate Change assuming present climate conditions.
"BaU" represents no emission constraints.
“B”: Bioenergy impact
“E”: Economic impact
“C”: Climate change impact

Assumptions in analysis on fund transfer

- High-income countries will provide funding to the countries strongly affected by implementing mitigation measures.
- Food consumption will keep at the same level as a reference scenario (S0) in mid&low-income countries.
- The funding burden among provider countries will be allocated in proportion to GDP.
- A hypothetical institution sector to manage fund within a receiving country.
  - Receive fund from provider countries and spend it for food consumption in a receiving country.



Limitations

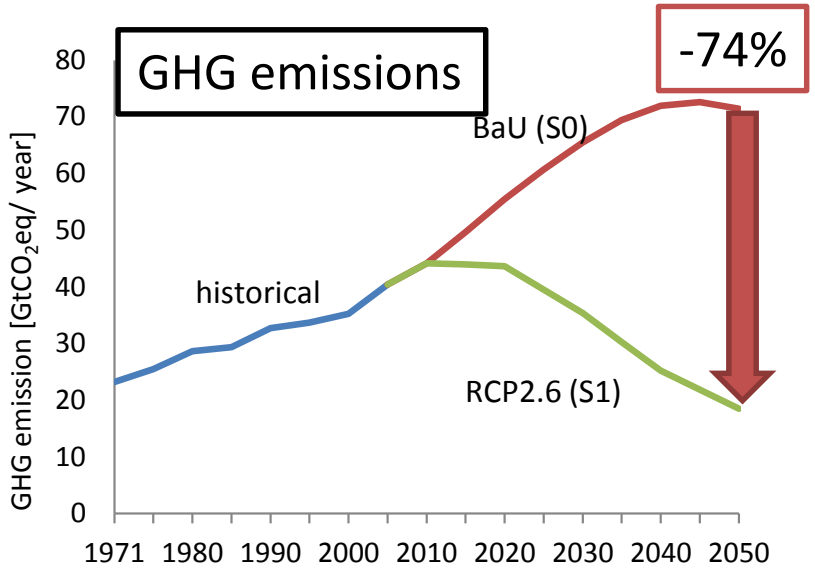
This study does NOT consider…

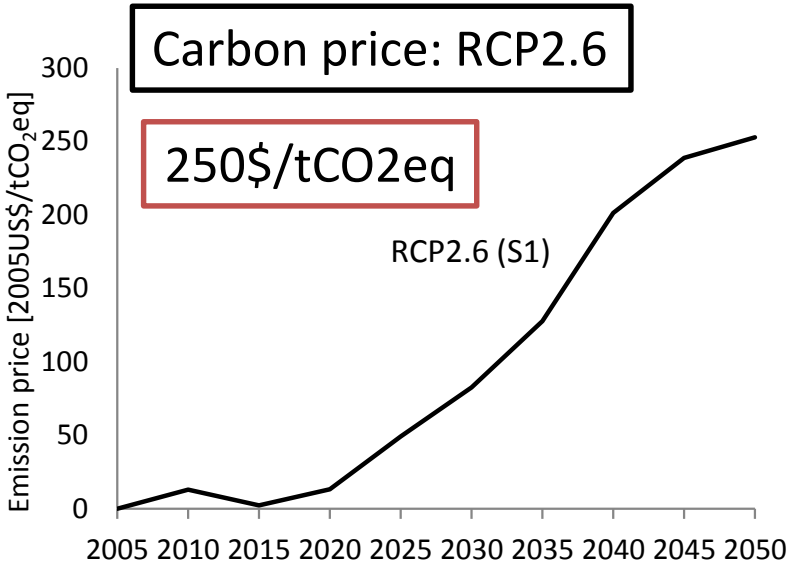
- Extreme event (i.e. drought, flood, heat waves)
- Competition between food and energy crops associated with ecosystem damage and water resources
- Spatial distributions at smaller regional scale.

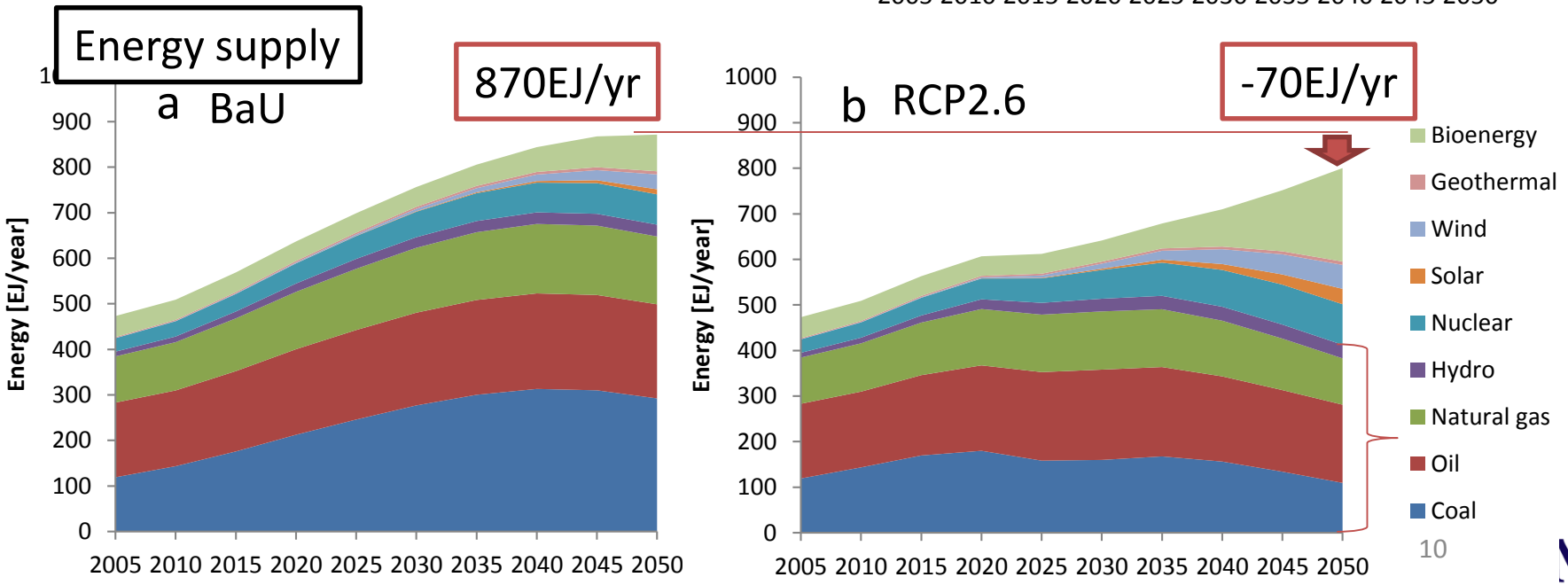
Strong assumptions

- Transfer and allocation mechanism of funding
- Agreements between donor countries

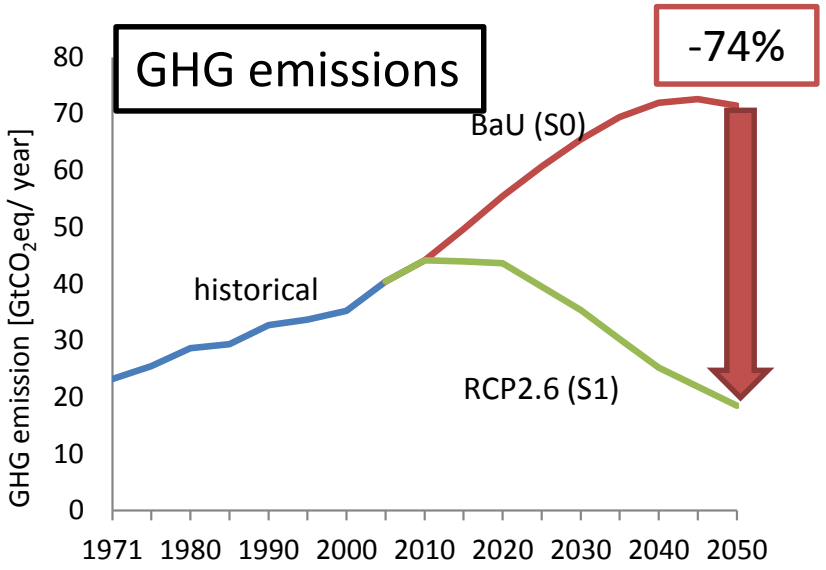
The World of RCP2.6

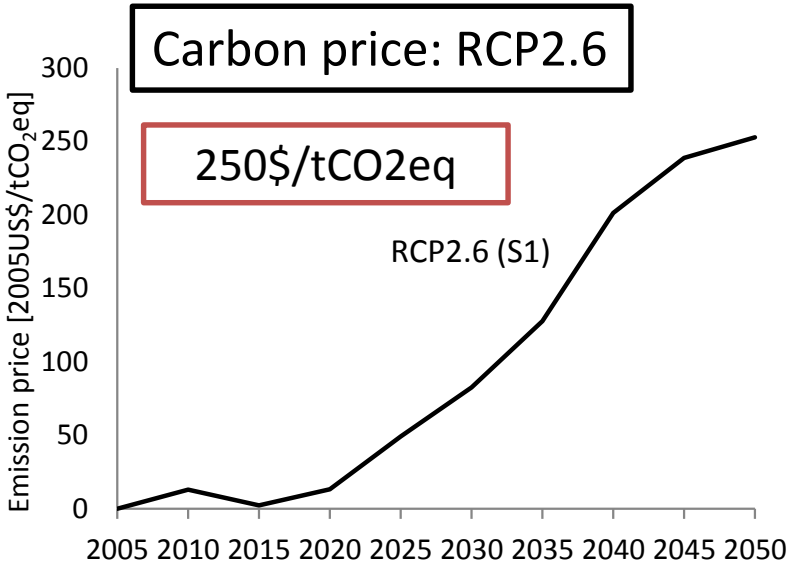


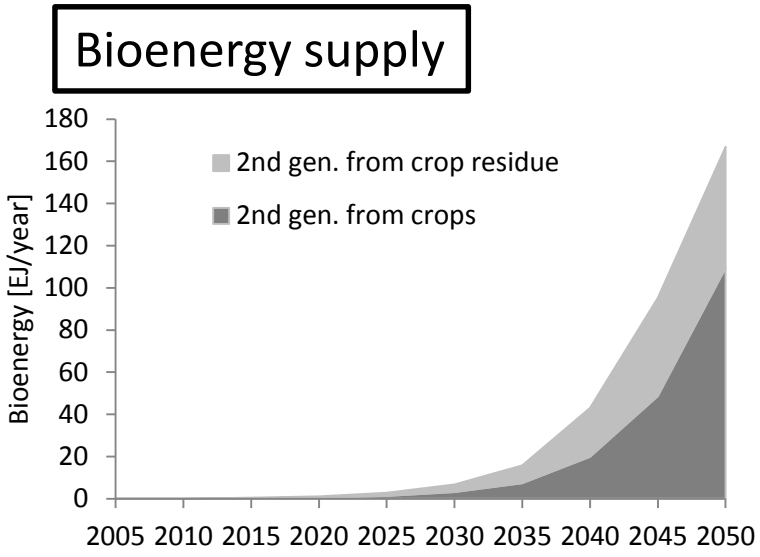


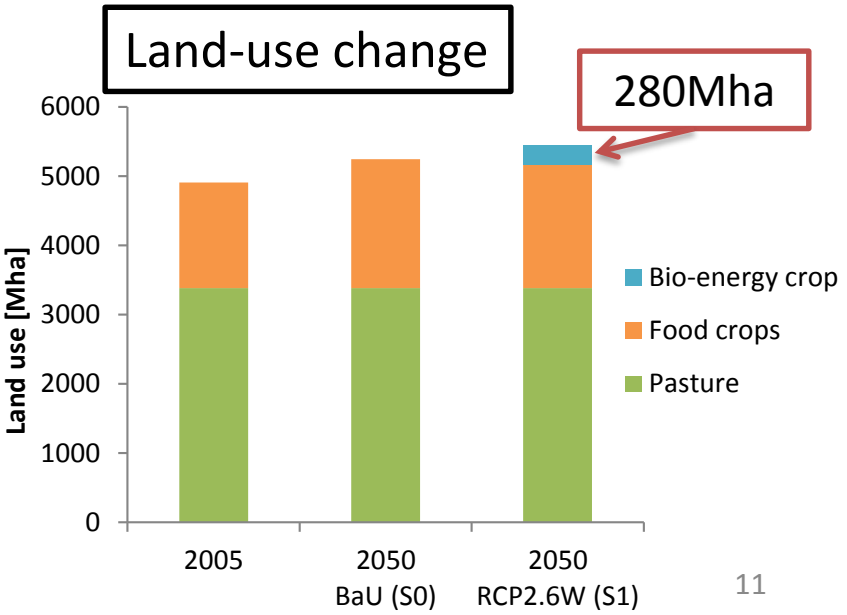


The World of RCP2.6



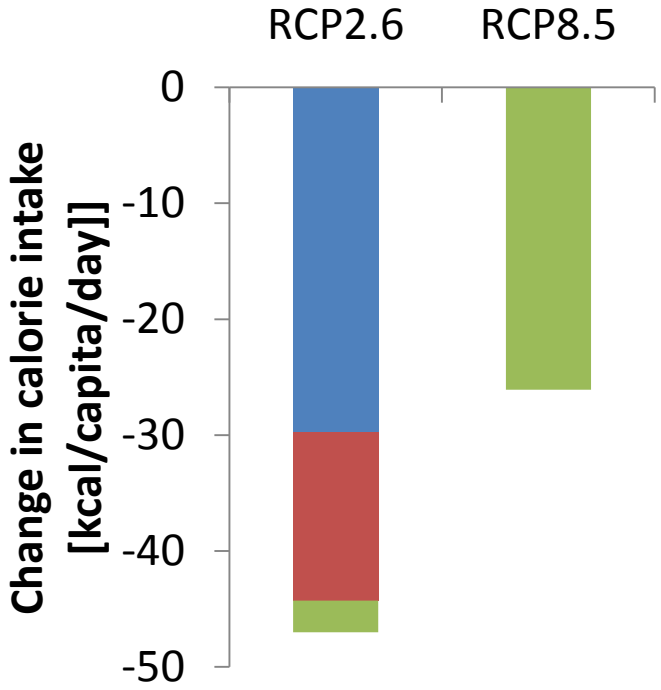






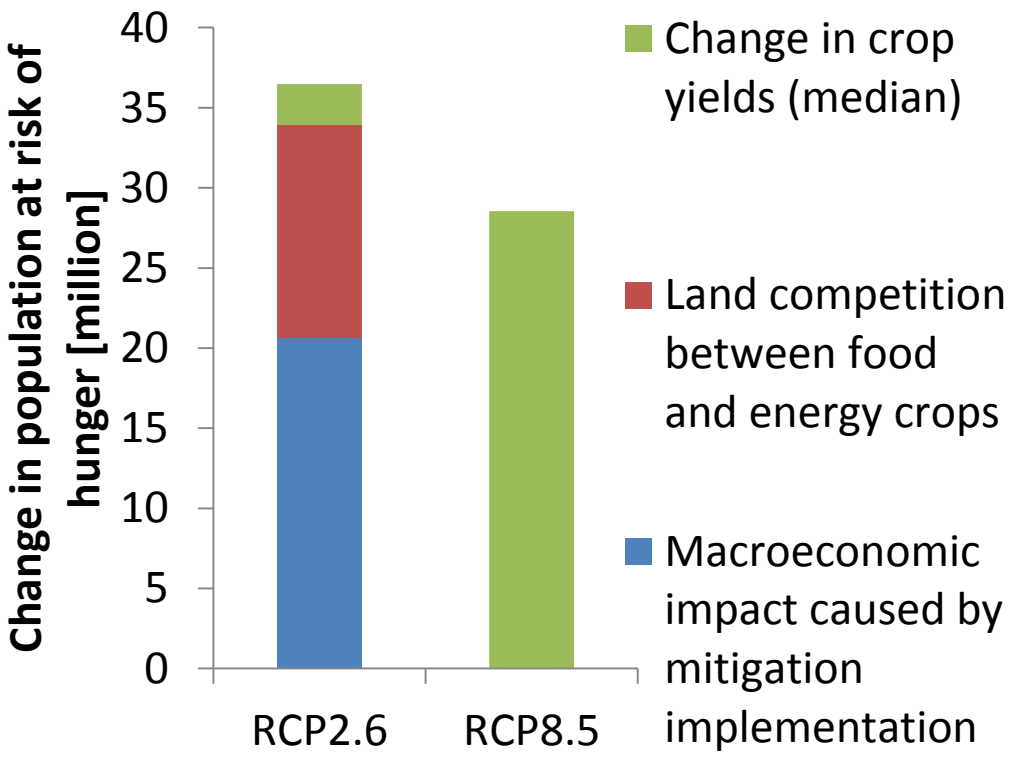
Global impacts on food security in 2050: RCP2.6 vs. RCP8.5 at NoCC level (S0) (median among 12 GCMs)

Mean food consumption



2005: 2680 kcal/cap/day
2050 with NoCC: 3256 kcal/cap/day

Global population at risk of hunger

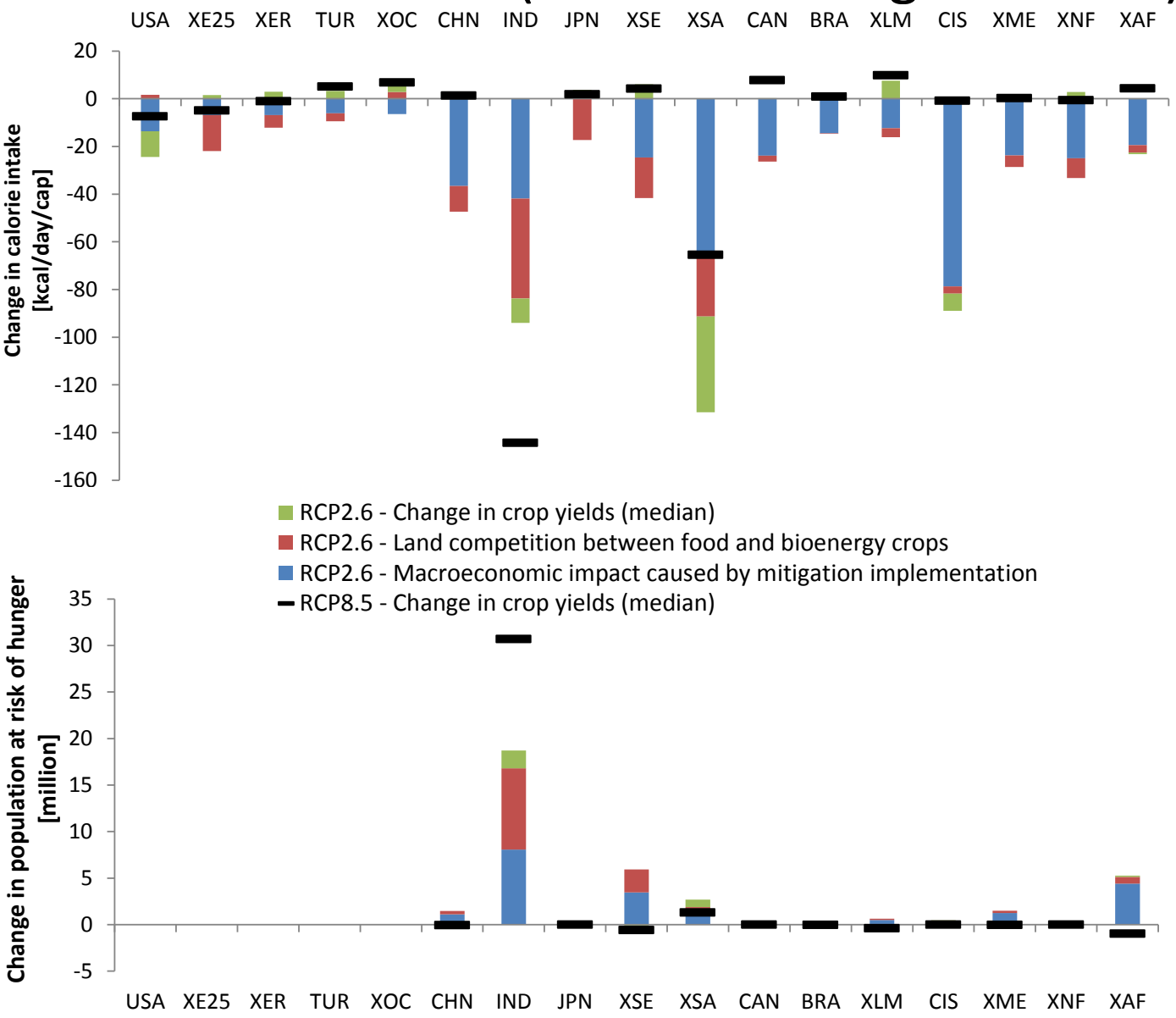


2005: 830 mil.
2050 with NoCC: 369 mil.

Hasegawa et al., in review

Results

Regional impacts on food security in 2050 : RCP2.6 vs. RCP8.5 (median among 12 GCMs)



Most of the world increase in risk of hunger would occur in India.

Macroeconomic impacts are seen in every countries.

Bioenergy impacts are seen in limited countries.

- Land competition occurs in a country with a limited land availability increasing land prices and crop producer prices.

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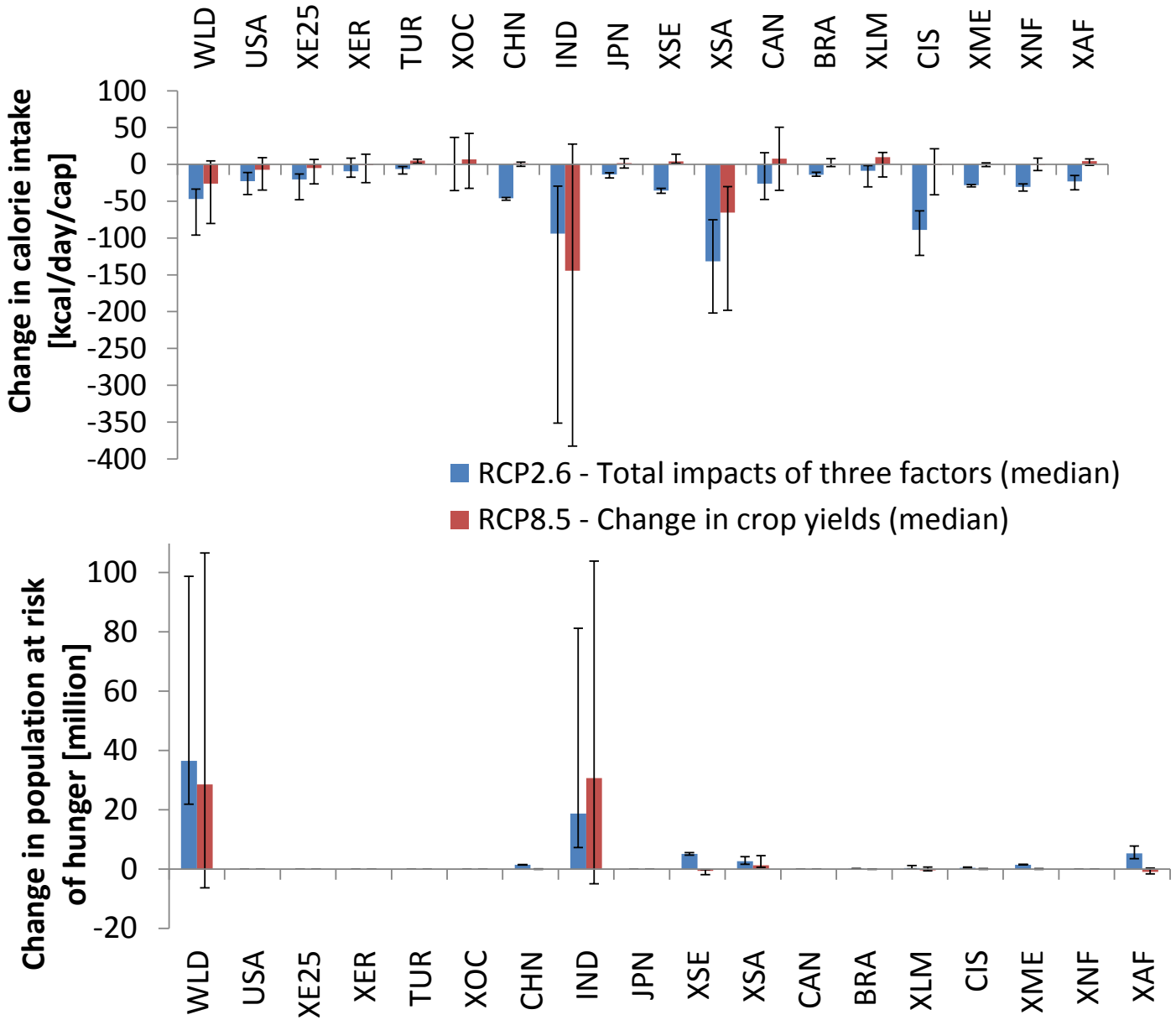
Regional impacts on food security in 2050 : RCP2.6 vs. RCP8.5 with multi-GCMs

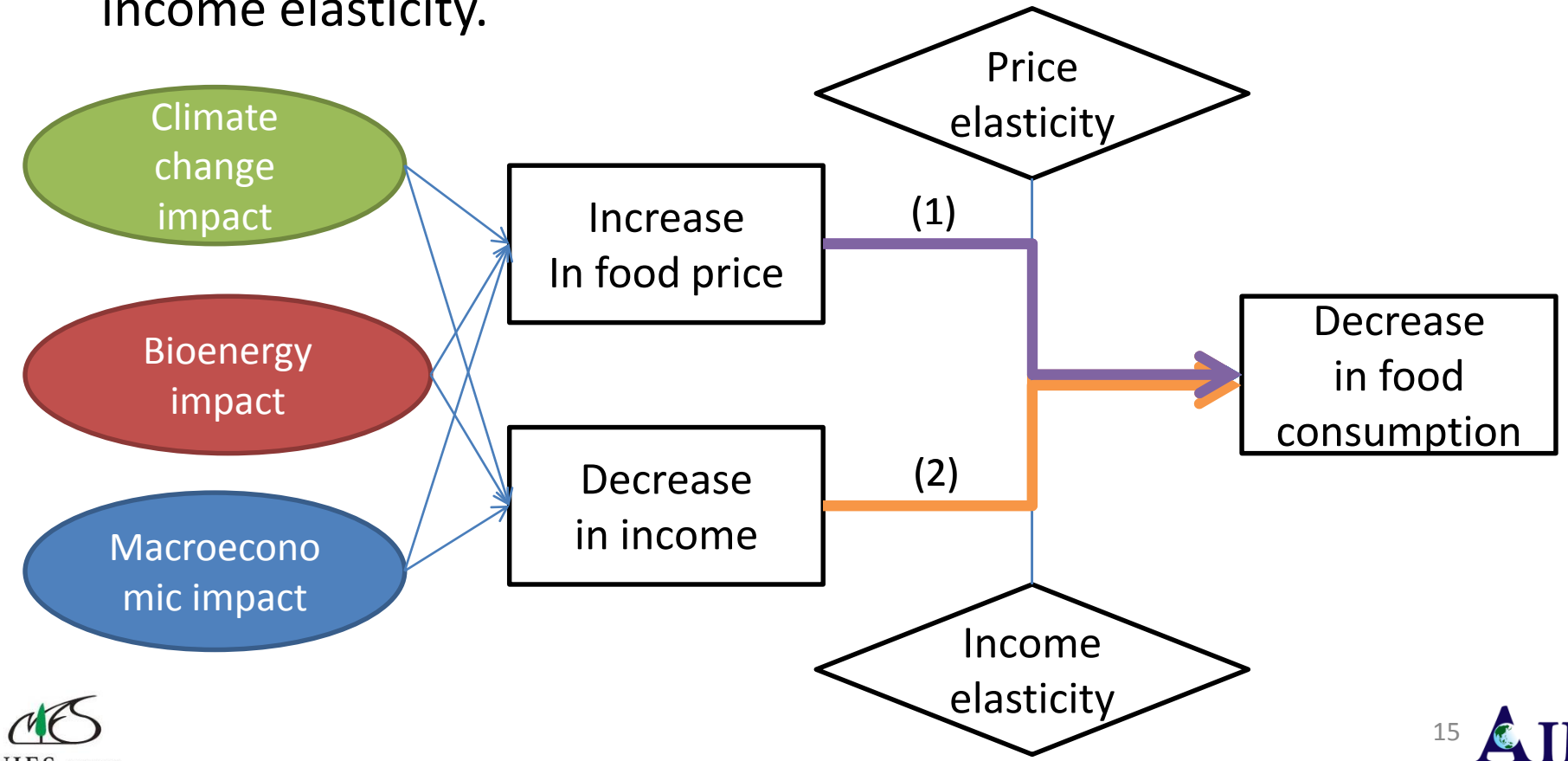


Results

Two processes by which the three factors affect food consumption

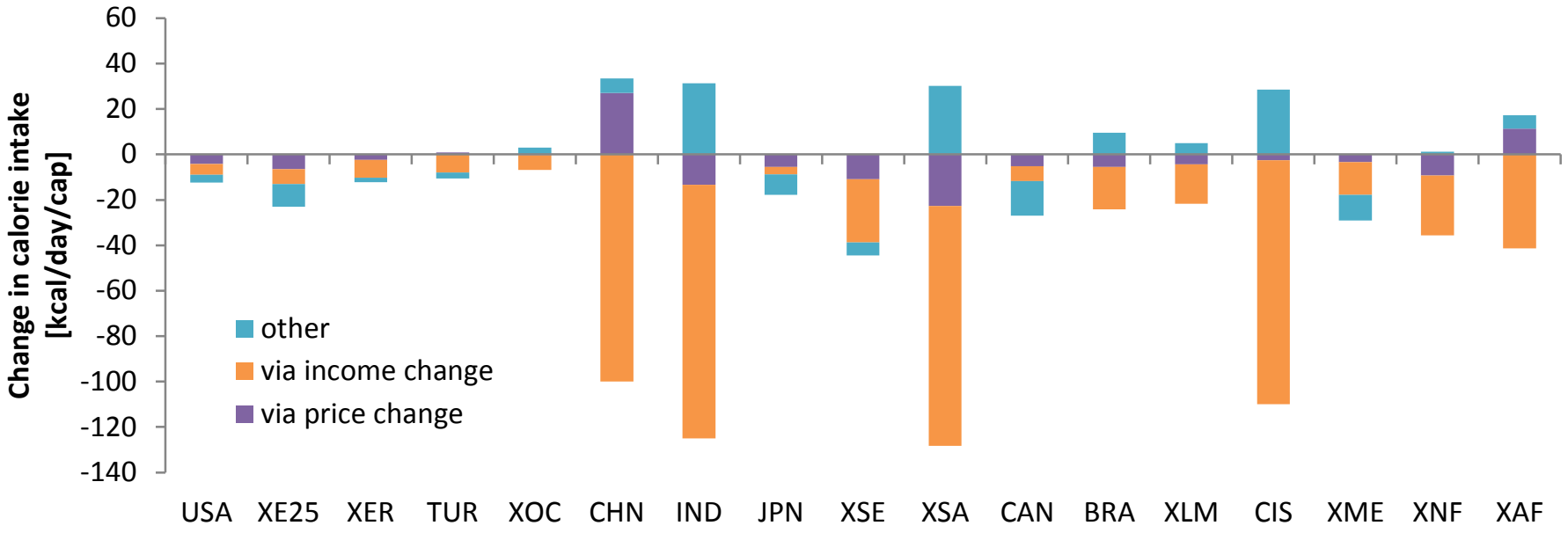
(1) Increase in food price reduces food consumption through price elasticity.

(2) Decrease in income reduces food consumption through income elasticity.



Decomposition analysis of change in food consumption

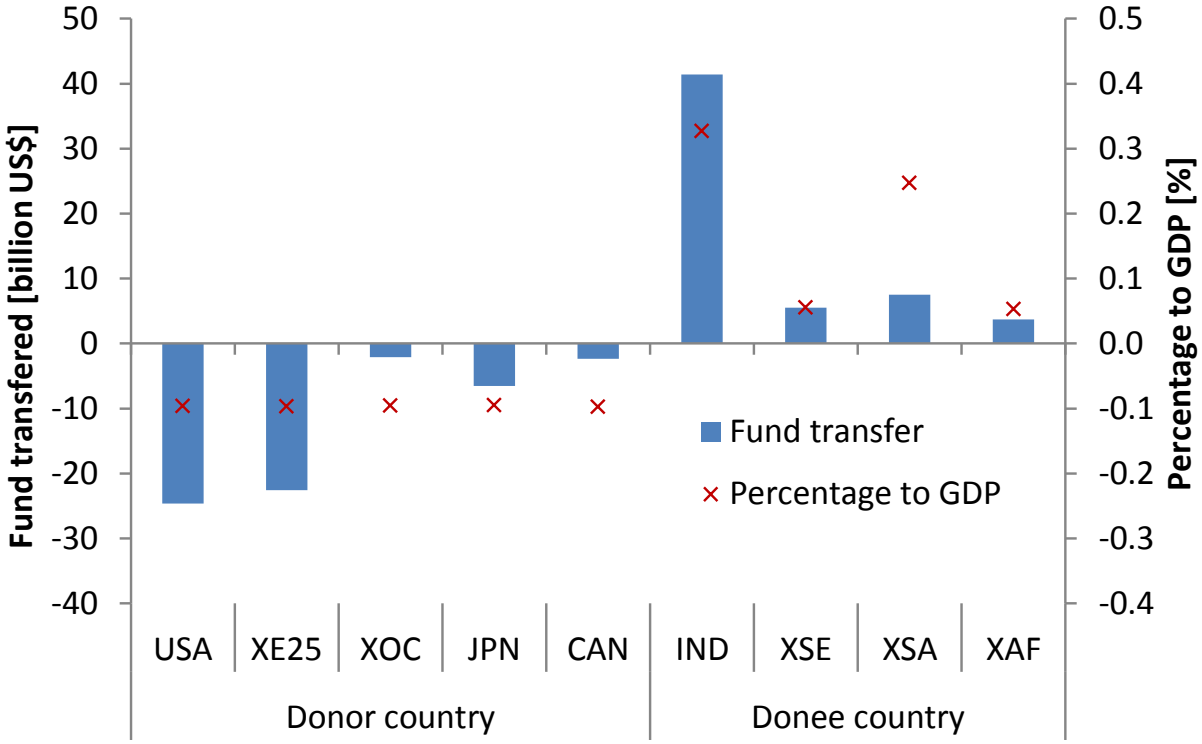
Decrease in food consumption [kcal/day/cap]	=	Effects of increase In food price	+	Effects of decrease in income	+	Other effects



Effects of the decrease in income >> Effects of an increase in food price

How much fund transfer will be needed to diminish the impacts of mitigation measures?

- Transfers totaling $58 billion in the world (0.04% of world GDP) could decrease the damage in food consumption.
- USA and Europe (XE25) would provide $47 billion (81% of the total).
- India (IND) would receive $41 billion followed by Rest of Asia (XSA).



Hasegawa et al., in review

Results & Discussion

- We quantified three impacts on food security; crop yields, bioenergy, macroeconomic impacts, resulting from climate change and the mitigation measures.
  - Per-capita food calorie intake: RCP2.6＜RCP8.5
  - The bioenergy and macroeconomic impacts in RCP2.6 would be comparable with climate change impacts in RCP8.5.
- Previous studies evaluated only the damage caused by climate change and the cost of mitigation measures.

- Necessary to take into account the negative impacts of mitigation measures and the remediation cost of the impacts.

- As such, this study provides a new perspective to evaluate future mitigation measures.

Future research

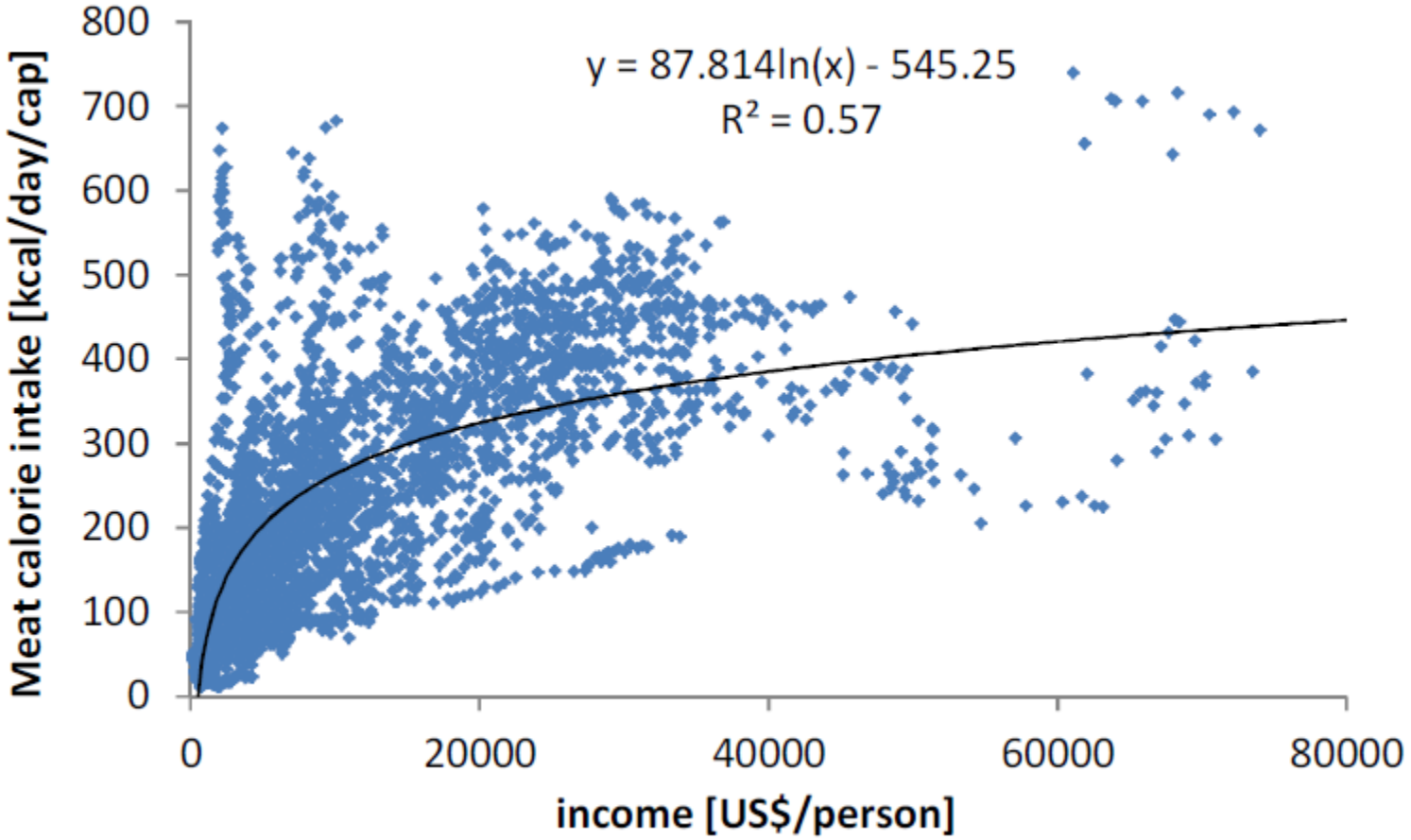
- Uncertainties of multiple socioeconomic conditions

- Extending the time period to 2100 would enable to find some different situation in the second half of the 21st century.

Thank you for your attention

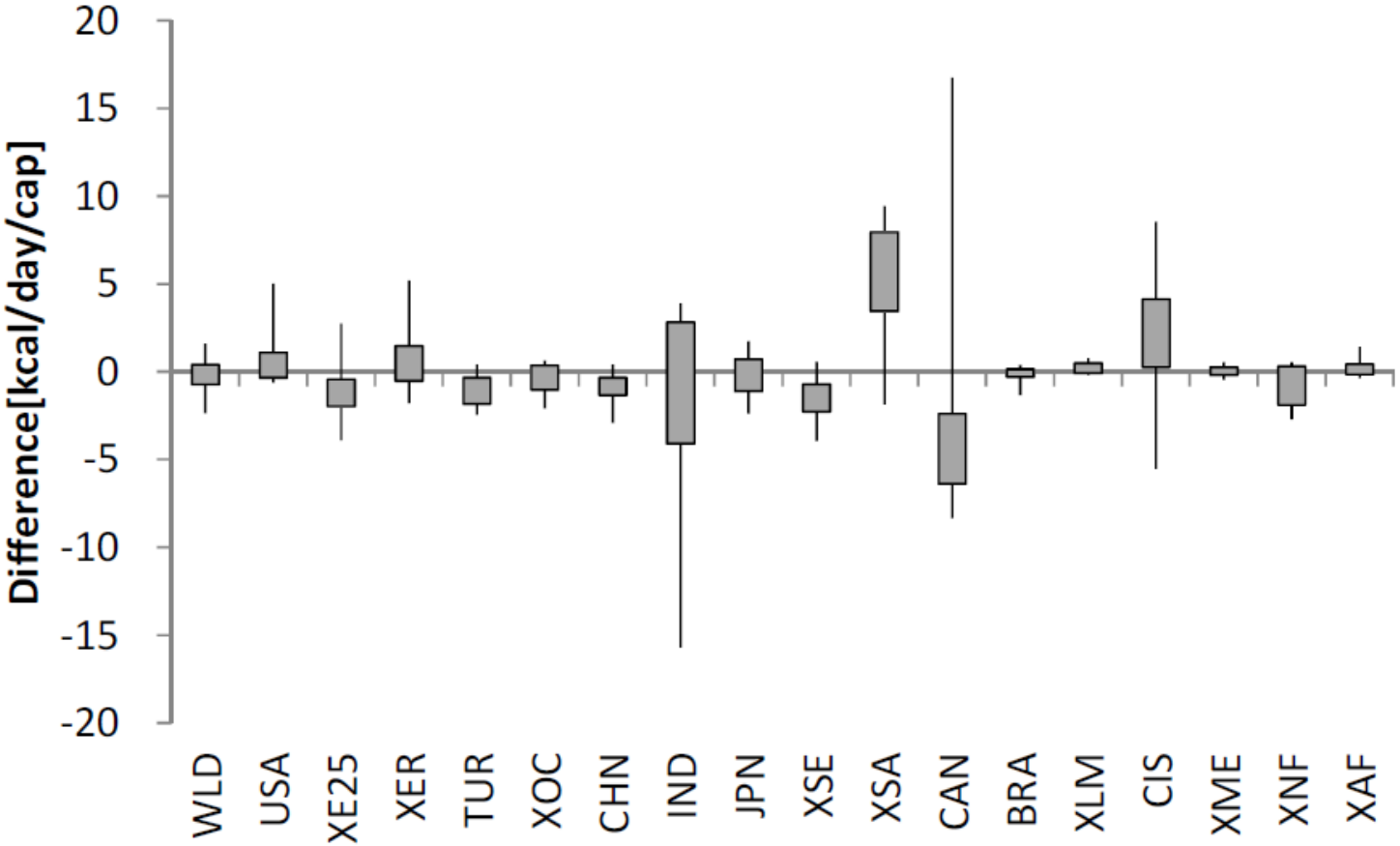
Supplementary

Time-series and cross-country relation between meat consumption and income

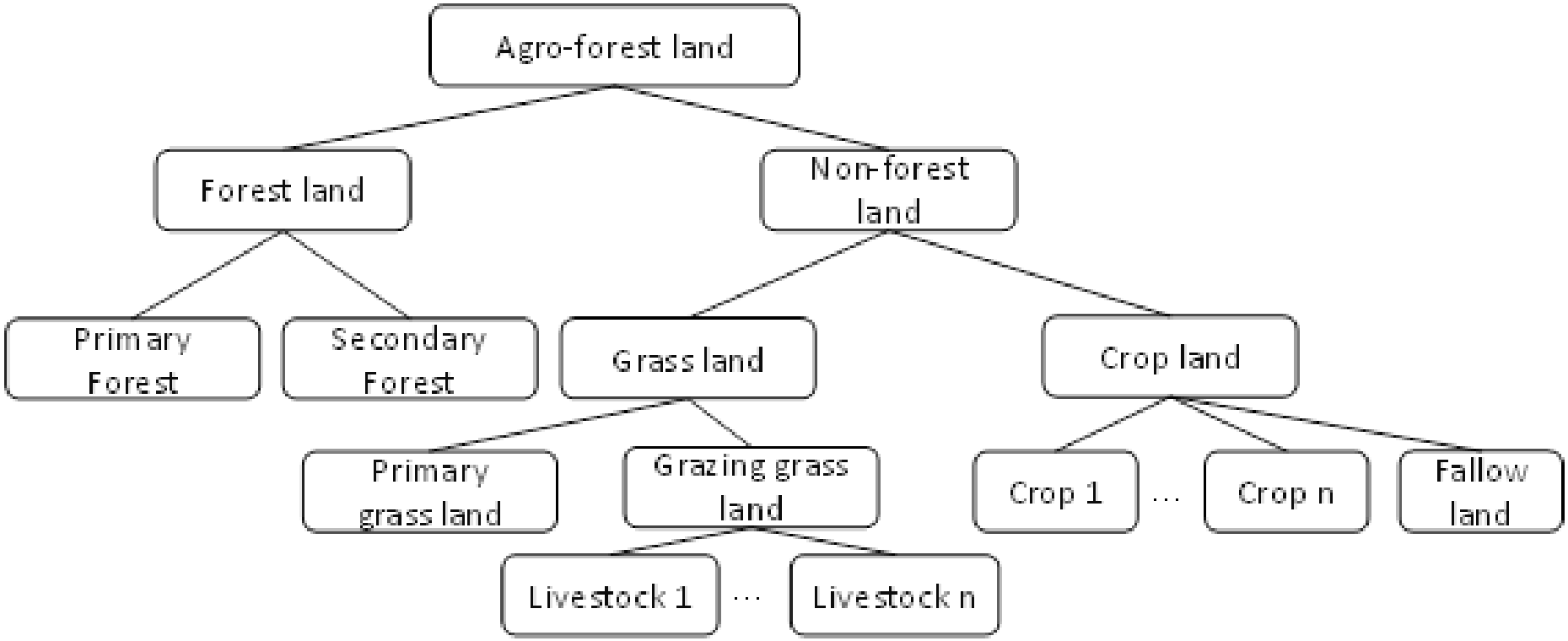


Confirmation of Crossover Effect

- The difference in the world is 0.6 kcal/day/person.
- Regional differences were all under 17 kcal/day/person.
- → No problem with this method.

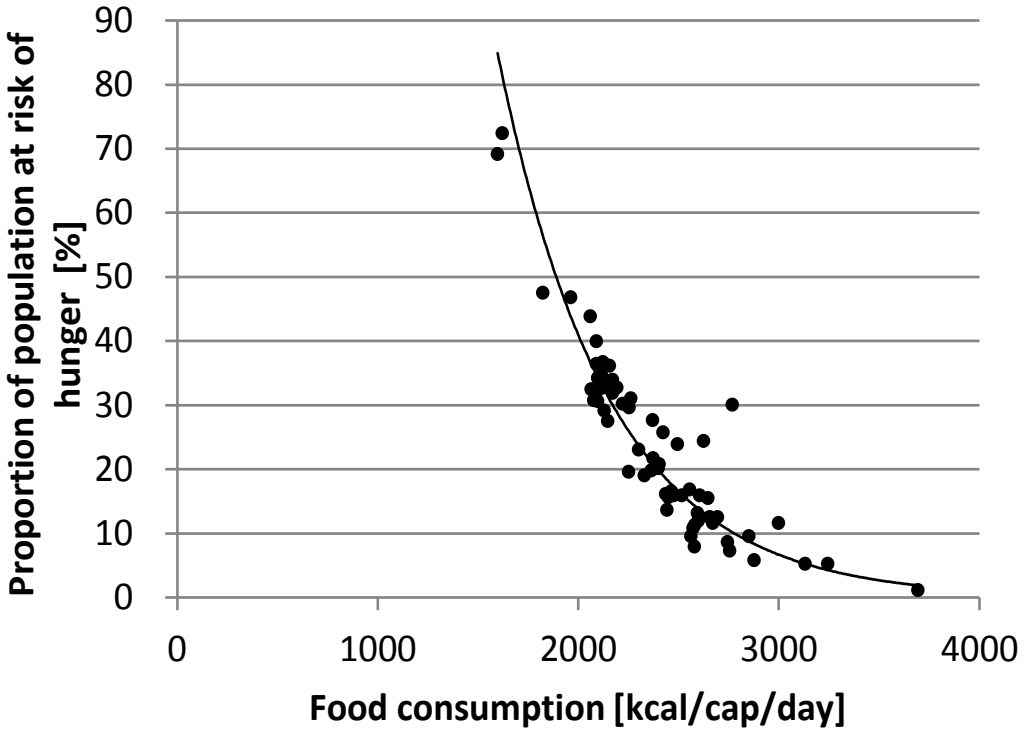


Land allocation tree within the AIM/CGE model

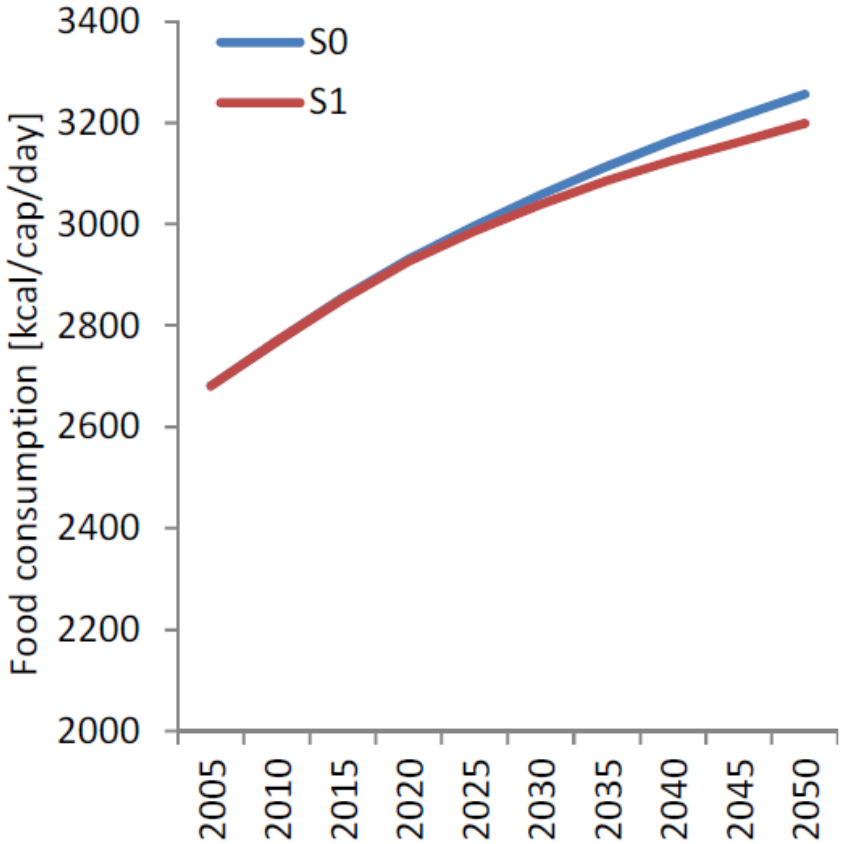


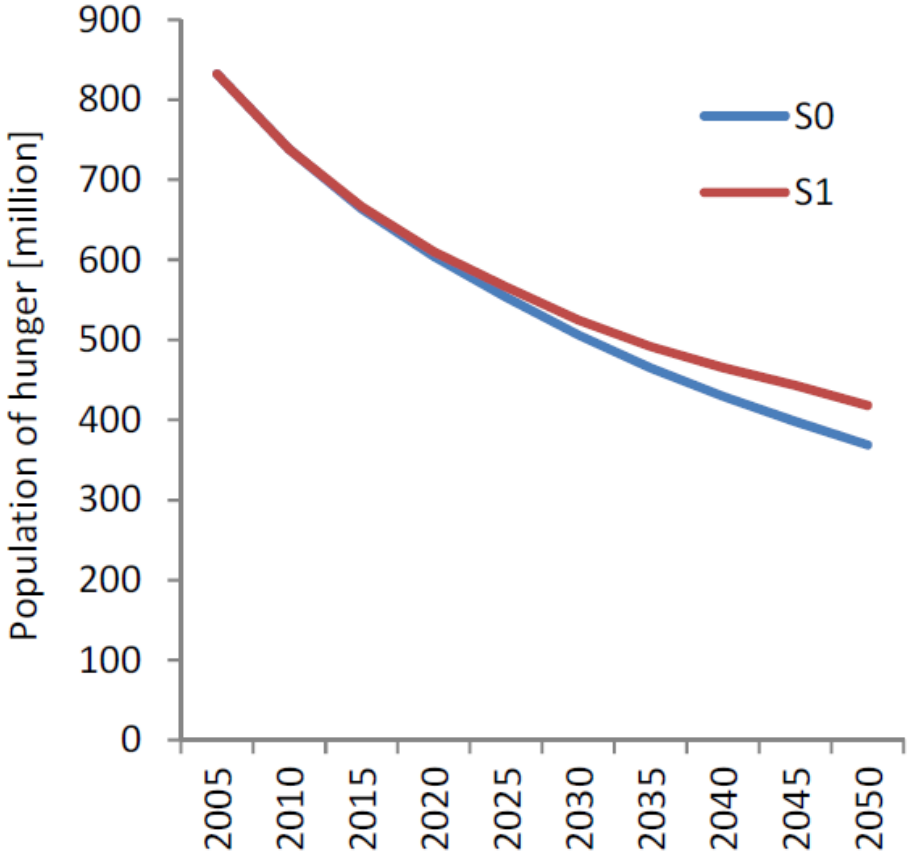
Relation between proportions of population at risk of hunger and Food consumption

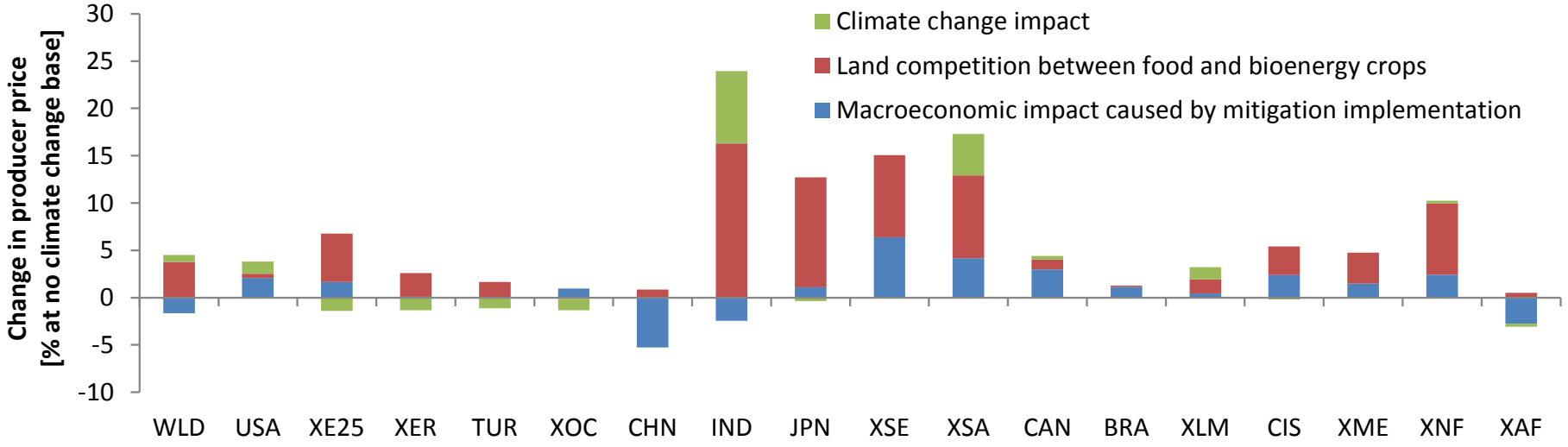
- Population at risk of hunger is refined as the population at "a state of energy deprivation lasting over a year" (FAO, 2012).

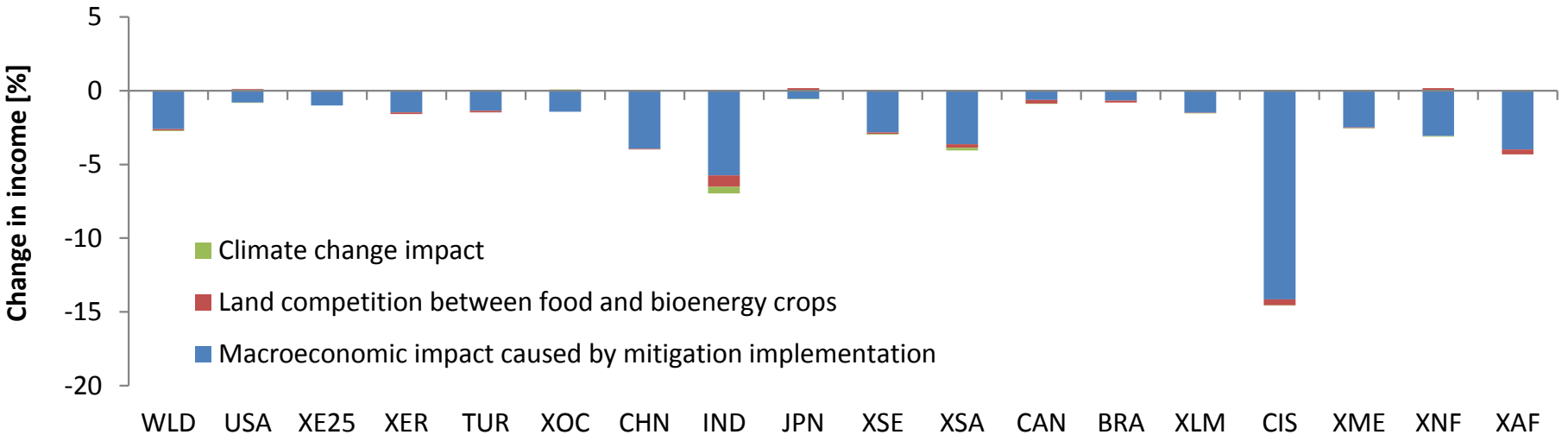


Global mean food consumption and population of hunger (BaU, RCP2.6)






Change in producer price
[% at no climate change base]
30
25
20
15
10
5
0
-5
-10
Climate change impact
Land competition between food and bioenergy crops
Macroeconomic impact caused by mitigation implementation
WLD
USA
XE25
XER
TUR
XOC
CHN
IND
JPN
XSE
XSA
CAN
BRA
XLM
CIS
XME
XNF
XAF


Change in income [%]
5
0
-5
-10
-15
-20
Climate change impact
Land competition between food and bioenergy crops
Macroeconomic impact caused by mitigation implementation
WLD
USA
XE25
XER
TUR
XOC
CHN
IND
JPN
XSE
XSA
CAN
BRA
XLM
CIS
XME
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