

# Climate change impacts on food supply and demand based on SSPs/CMIP5

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“CMIP5”: Coupled Model Intercomparison Project Phase 5  
“SSP”: Shared Socioeconomic Pathway

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# Background


- ▶ Crop yield can be affected by changes in temperature and precipitation in the future
- ▶ The impacts will vary in different regions
- ▶ Several approaches were taken in the assessment of climate change impact on agriculture and food supply so far.
- ▶ Existing researches
  - Not consider uncertainty of several factors
  - Not calculate effect of adaptations
  - Use SRES, not SSP

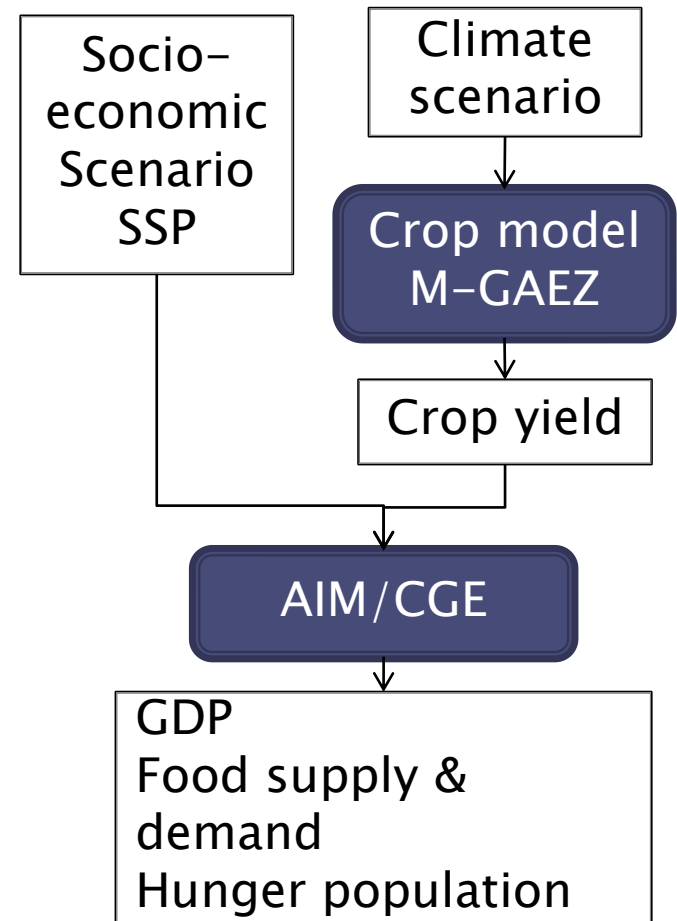
# Objectives

Aim to clarify

- ▶ Impacts of climate change and socioeconomic conditions on food consumption and risk of hunger
- ▶ Effects of adaptations on the climate change impacts

# Whole framework and models

- ▶ M-GAEZ
    - Calculate a crop potential yield in each 2.5' grid cell on the global scale considering biological conditions.
- 
- ▶ Global CGE model
    - Calculate amounts of production, consumption and trade in response to change in prices and factor availability



# Region and commodity

- ▶ 2005–2050
- ▶ 17 regions and countries
- ▶ 26 commodities (6 groups of crops, 3 groups of livestock products and fisheries)

Code	Regions	Code	Regions	Agricultural commodities	
JPN	Japan	TUR	Turkey	Rice	Meat cattle
CHN	China	CAN	Canada	Wheat	Dairy cattle
IND	India	USA	United States	Cereal grains nec	Other livestock
XSE	Southeast Asia	BRA	Brazil	Oil crops	Fishing
XSA	Rest of Asia	XLM	Rest of South America	Sugar crops	
XOC	Oceania	XME	Middle East	Crops nec	
EU25	EU25	XNF	North Africa		
XER	Rest of Europe	XAF	Rest of Africa		
CIS	Former Soviet Union				

# Future scenario

3 socioeconomic scenarios

5 climate scenarios		Optimistic SSP1	Middle SSP2	Pessimistic SSP3
No Climate change (NoCC)		Assume present climate condition in the future		
With climate change	RCP2.6	With adaptation in developing countries		Without adaptation in developing countries
	RCP4.5			
	RCP6.0			
	RCP8.5			

- ▶ Adaptation:
  - Change in crop variety and planting dates
  - Industrial & transition countries: available
  - Developing countries: available (SSP1&2) & restricted (SSP3)

	Population	GDP per-capita
SSP1	Low	High
SSP2	Mid.	Mid.
SSP3	High	Low

\* “RCP”: Representative Concentration Pathway

\* “SSP”: Shared Socioeconomic Pathway

# Multi-GCMs (General Circulation Model)

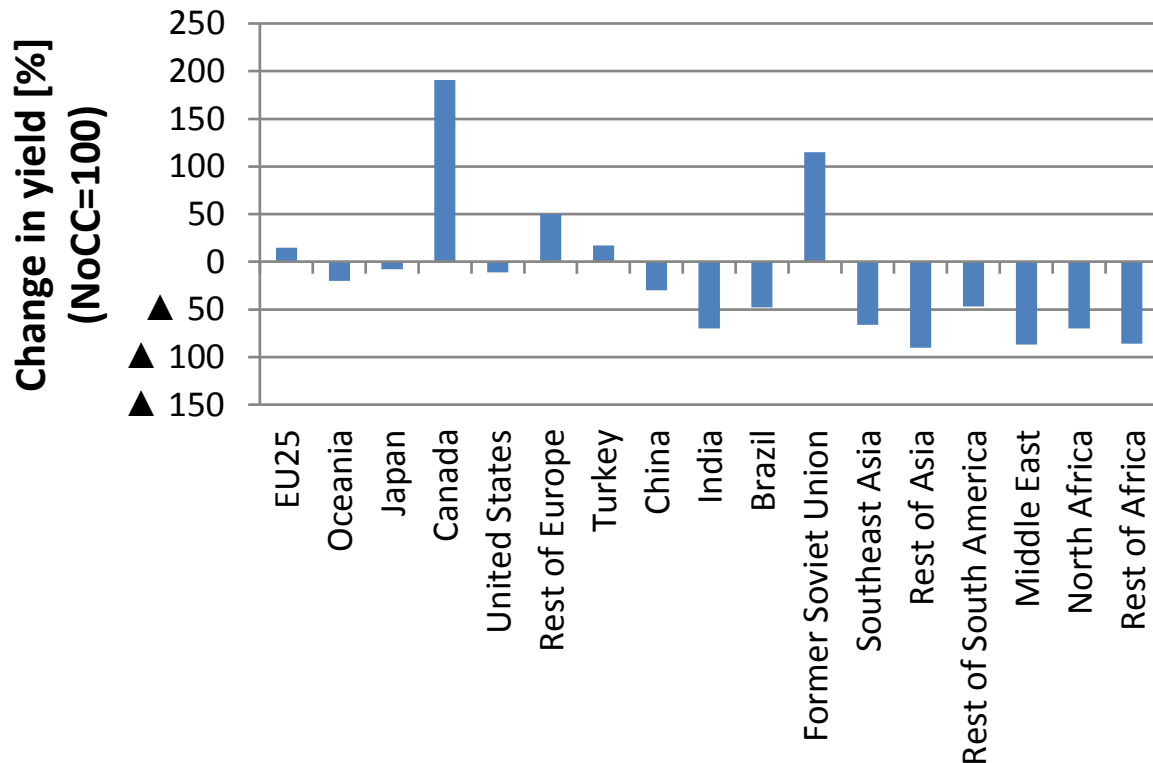
- ▶ To clarify uncertainty associated with different climate models, we used 12 GCMs which participated in CMIP5

GCM	RCP scenario				Grids Lon. × lat.	Grid length on the equator (km)
	2.6	4.5	6.0	8.5		
BCC-CSM1.1	✓	✓	×	✓	128 × 64	313
CanESM2	✓	✓	×	✓	128 × 64	313
CNRM-CM5	✓	✓	×	✓	256 × 128	156
GFDL-CM3	✓	✓	✓	✓	144 × 90	222
GFDL-ESM2G	✓	✓	✓	✓	144 × 90	222
GFDL-ESM2M	✓	✓	✓	✓	144 × 90	222
HadGEM2-ES	✓	✓	✓	✓	192 × 145	138
MIROC5	✓	✓	✓	✓	256 × 128	156
MIROC-ESM	✓	✓	✓	✓	128 × 64	313
MIROC-ESM-C	✓	✓	✓	✓	128 × 64	313
MRI-CGCM3	✓	✓	✓	✓	320 × 160	125
NorESM1-M	✓	✓	×	✓	144 × 96	208

# Assumption on crop yields

- ▶ NoCC: IMPACT
- ▶ CC: climate change impacts on crop yield calculated from M-GAEZ & LPJ

Change in crop yield caused by CC in 2050 (RCP8.5, HadGEM2ES)



“CC”: reflecting damages due to climate change in the future.  
“NoCC”: assuming present climate condition in the future.



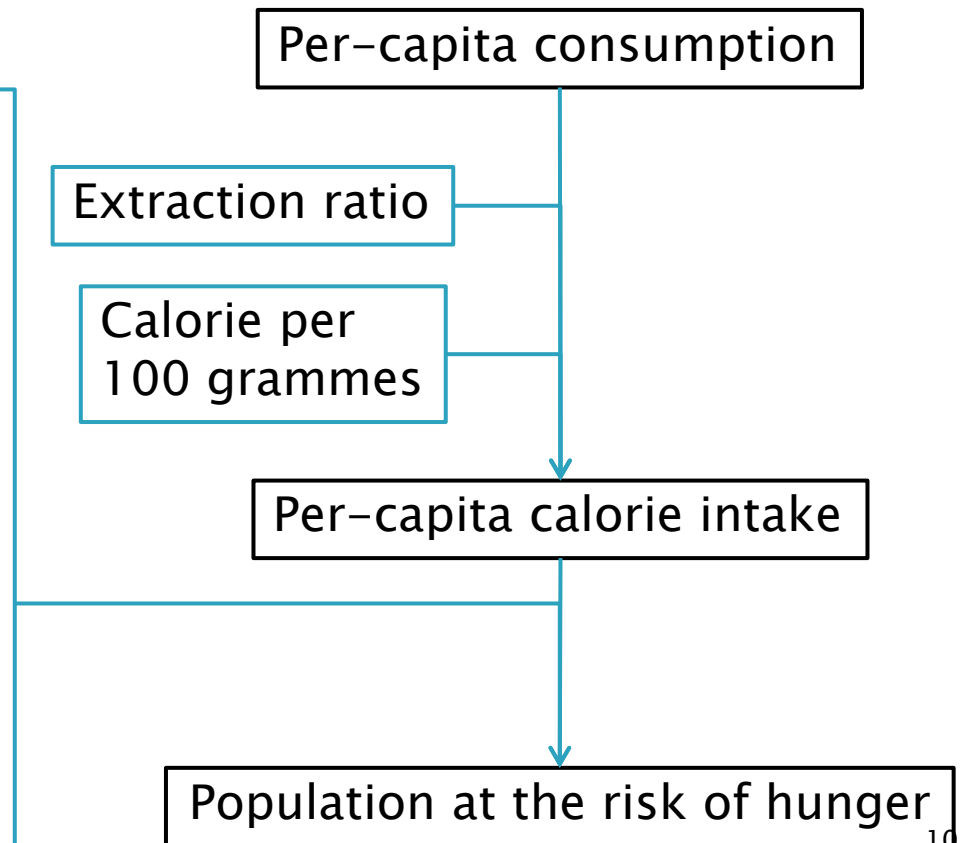
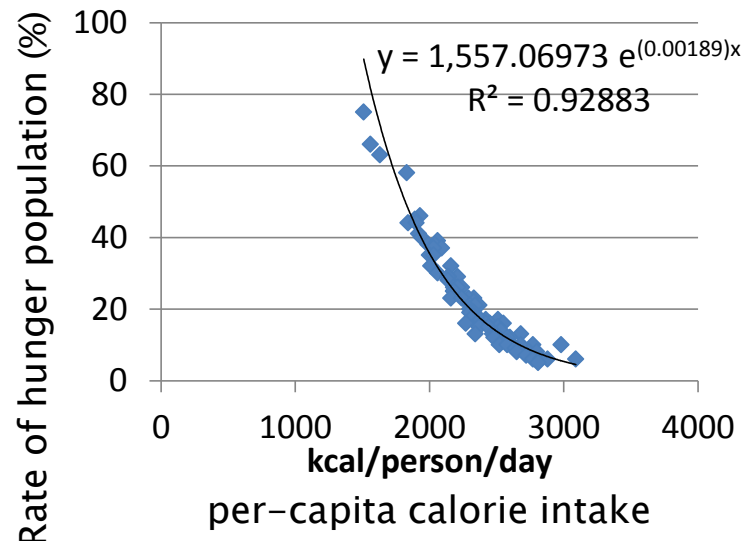
# Assumptions

- ▶ Per capita calorie intake
  - Income elasticity of food demand by regions and commodities is calculated based on Bruinsma et al, (2010)
- ▶ Bioenergy consumption
  - A ratio of bioenergy consumption to the total expenditure is assumed to be constant for the future

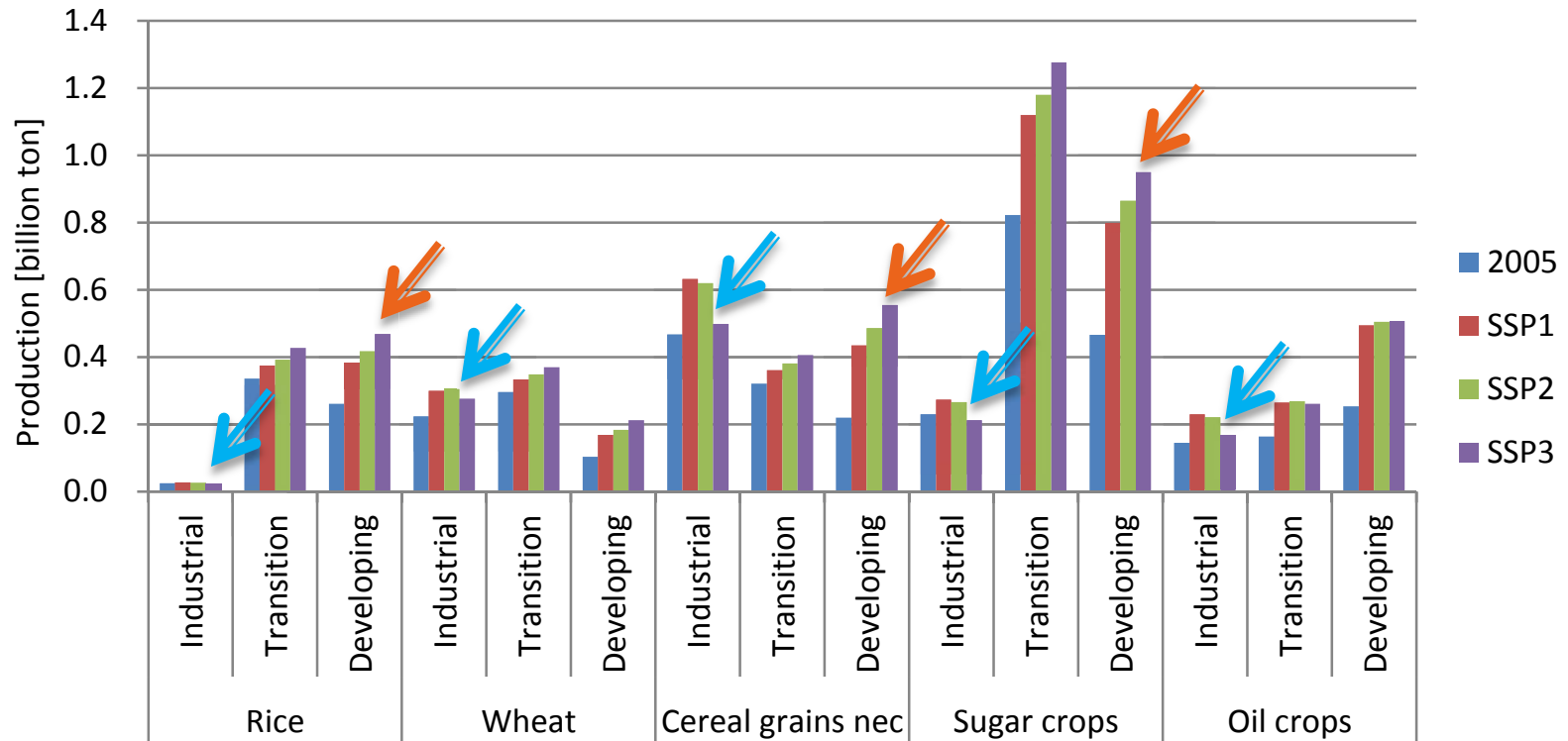
# Calorie-based consumption & population at the risk of hunger

- ▶ Calculate calorie intake from tonne-based consumption
- ▶ Calculate population at the risk of hunger from calorie intake

Relation between per-capita calorie intake and a ratio of population at the risk of hunger



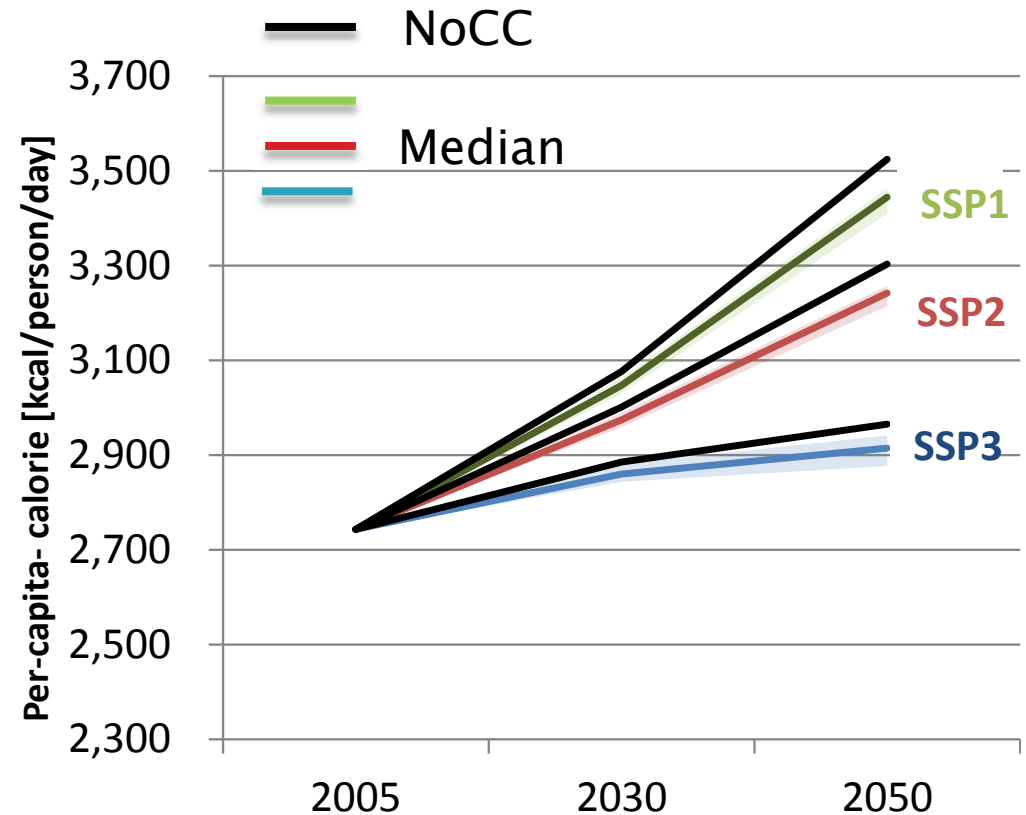
# Regional production in 2050 in 3SSPs with no climate change



- ▶ In industrial countries, production in SSP3 will be lowest among the SSP because population decreases in SSP3.
- ▶ In developing countries, production in SSP3 will be highest among the SSPs as a result of higher population growth and lower income improvement.
- ▶ Future low income improvement causes large per-capita consumption of crops rather than meat.

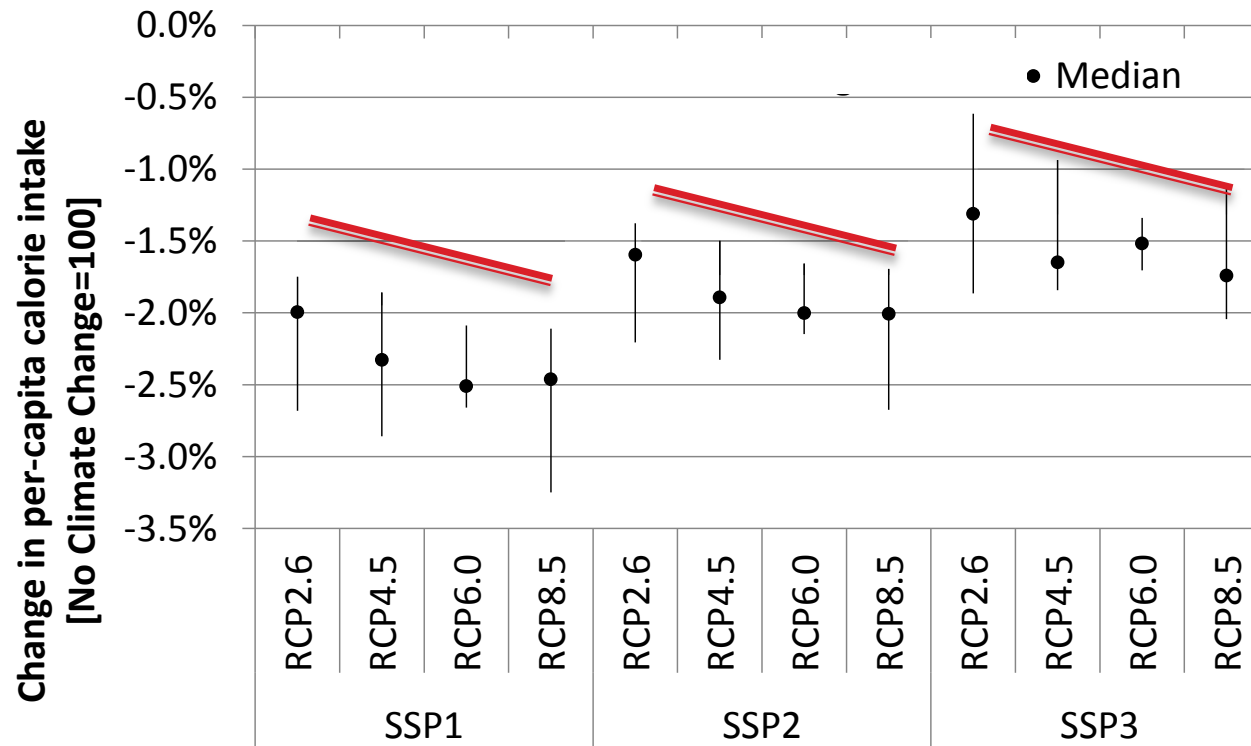
# Global per-capita food consumption

- ▶ Per-capita calorie intake has a large difference among the SSPs.
- ▶ Socioeconomic condition is a large factor in food consumption.



- Range: Uncertainty of multi-RCPs and multi-General Circulation Model (GCMs)

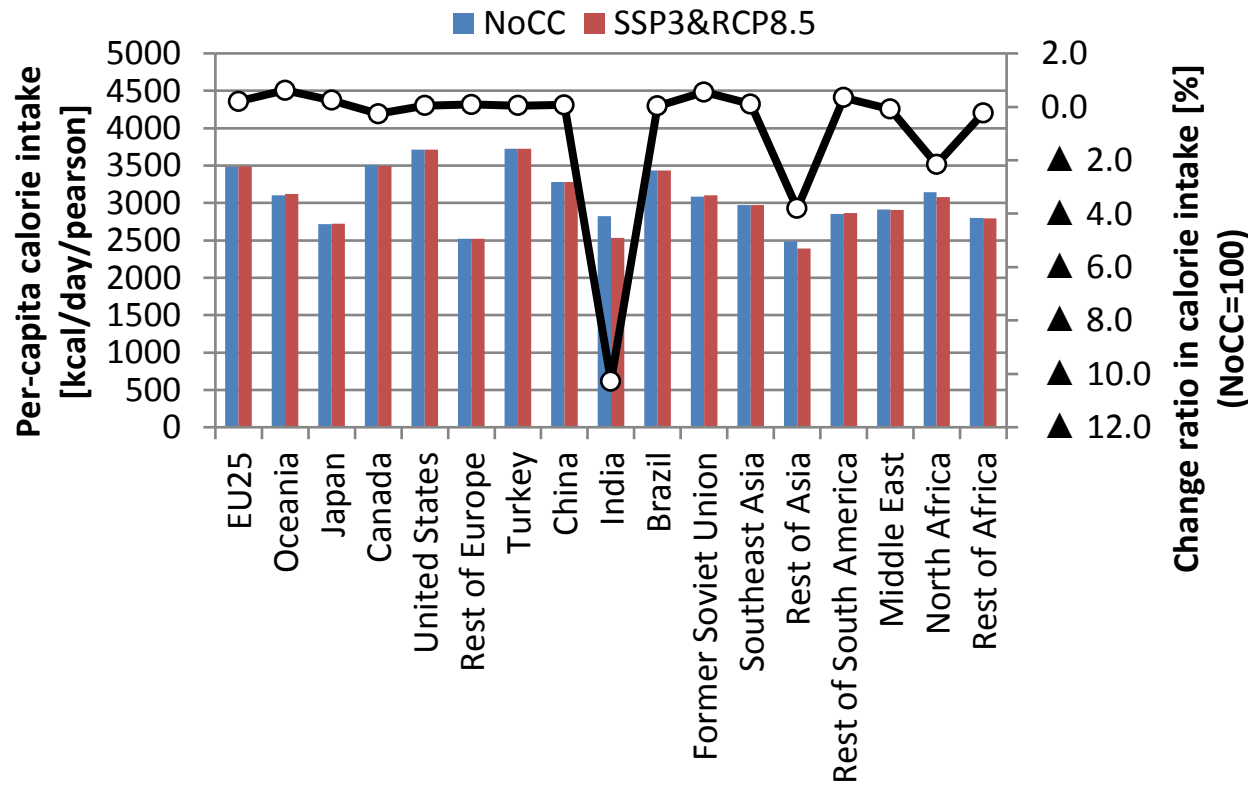
# Global per-capita calorie intake in 2050 for all SSPs & RCPs



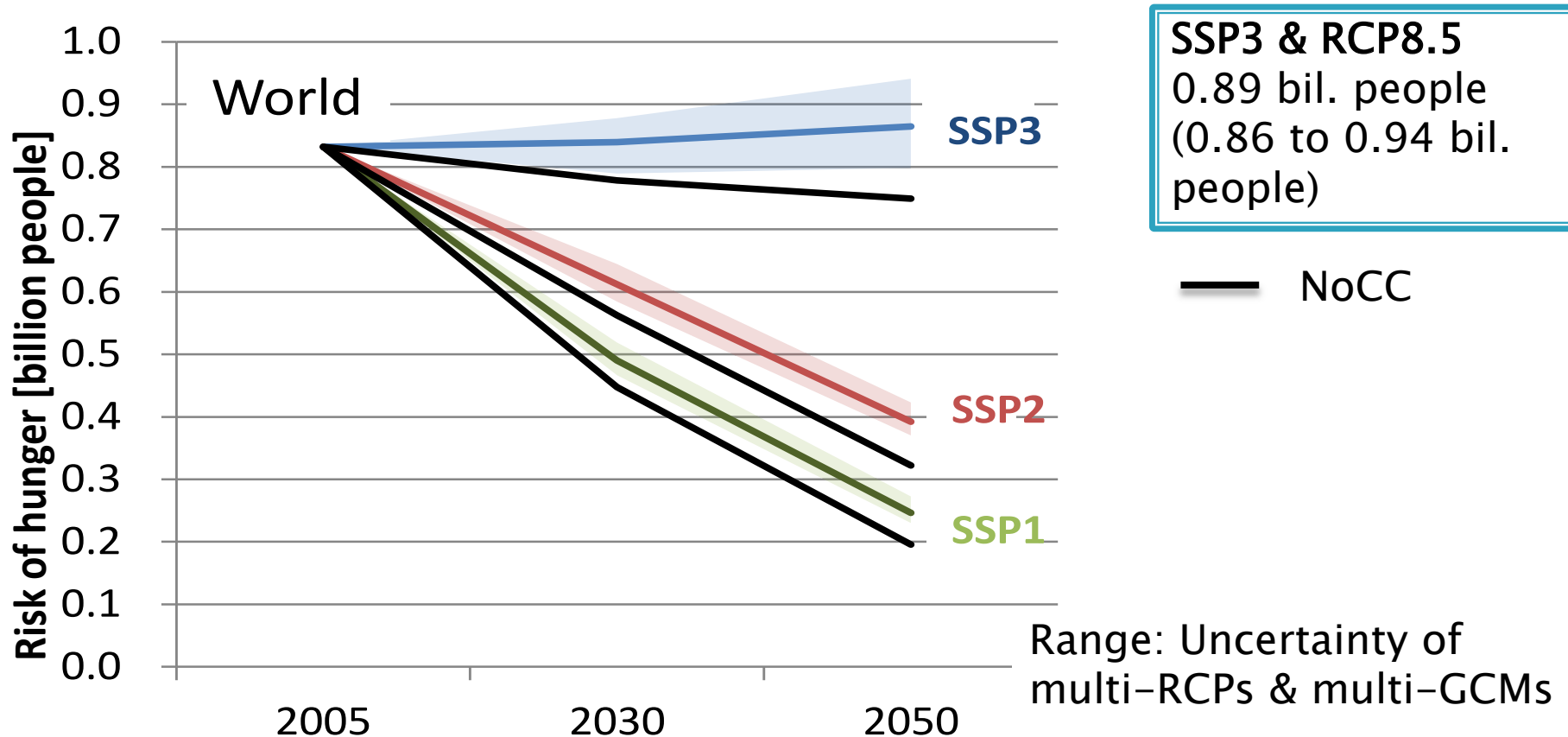
- ▶ A socioeconomic scenarios seems to be a strong factor in climate change impacts.
- ▶ Even in RCP 2.6 where mitigation challenges will be high, climate change will impact food consumption.
- ▶ In RCP 8.5, the calorie intake will be lower than RCP 2.6.
- ▶ Differences among RCPs are not as large as that among SSPs.

# Regional per-capita calorie intakes in 2050: SSP3-RCP8.5

- ▶ In India, Rest of Asia and Rest of Africa, 2.2% to 10% lower calorie intake than NoCC
- ▶ In India, 10% is a result of large climate change impacts and small amounts of extra arable land.
- ▶ This situation causes greater land scarcity, higher crop prices and less food consumption.



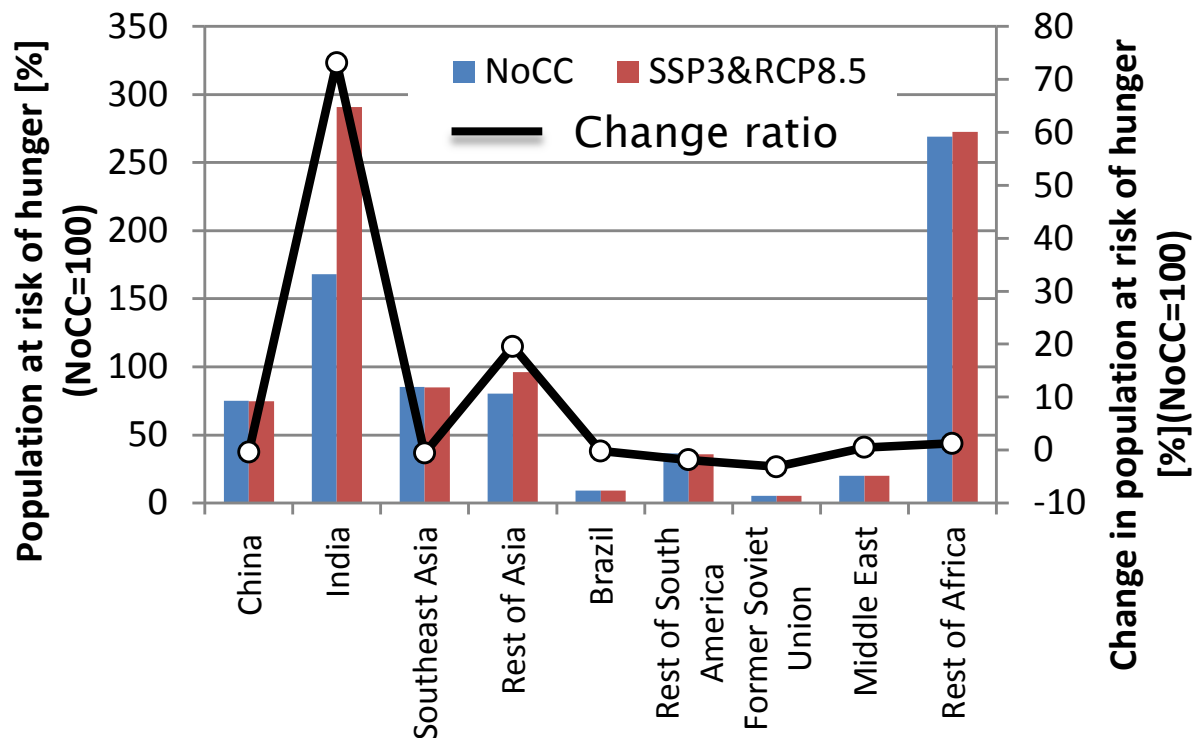
# Population at risk of hunger



- ▶ Future population at risk of hunger depends strongly on socioeconomic conditions.
- ▶ Increase in SSP3&RCP8.5 is caused partially by a higher ratio of population at risk of hunger due to lower per-capita calorie intakes and population increase.

# Population at risk of hunger in 2050: SSP3-RCP8.5

- ▶ In India, Rest of Asia and Rest of Africa, the populations are expected to be larger by 120 mil., 16 mil. and 3 mil people than those of NoCC.
- ▶ In contrast, in the Former Soviet Union, the population is less by 0.2 million people than those of NoCC.
- ▶ Climate change impact on risk of hunger is different among regions because levels of calorie intakes and climate change impacts on crop yield vary region by region.



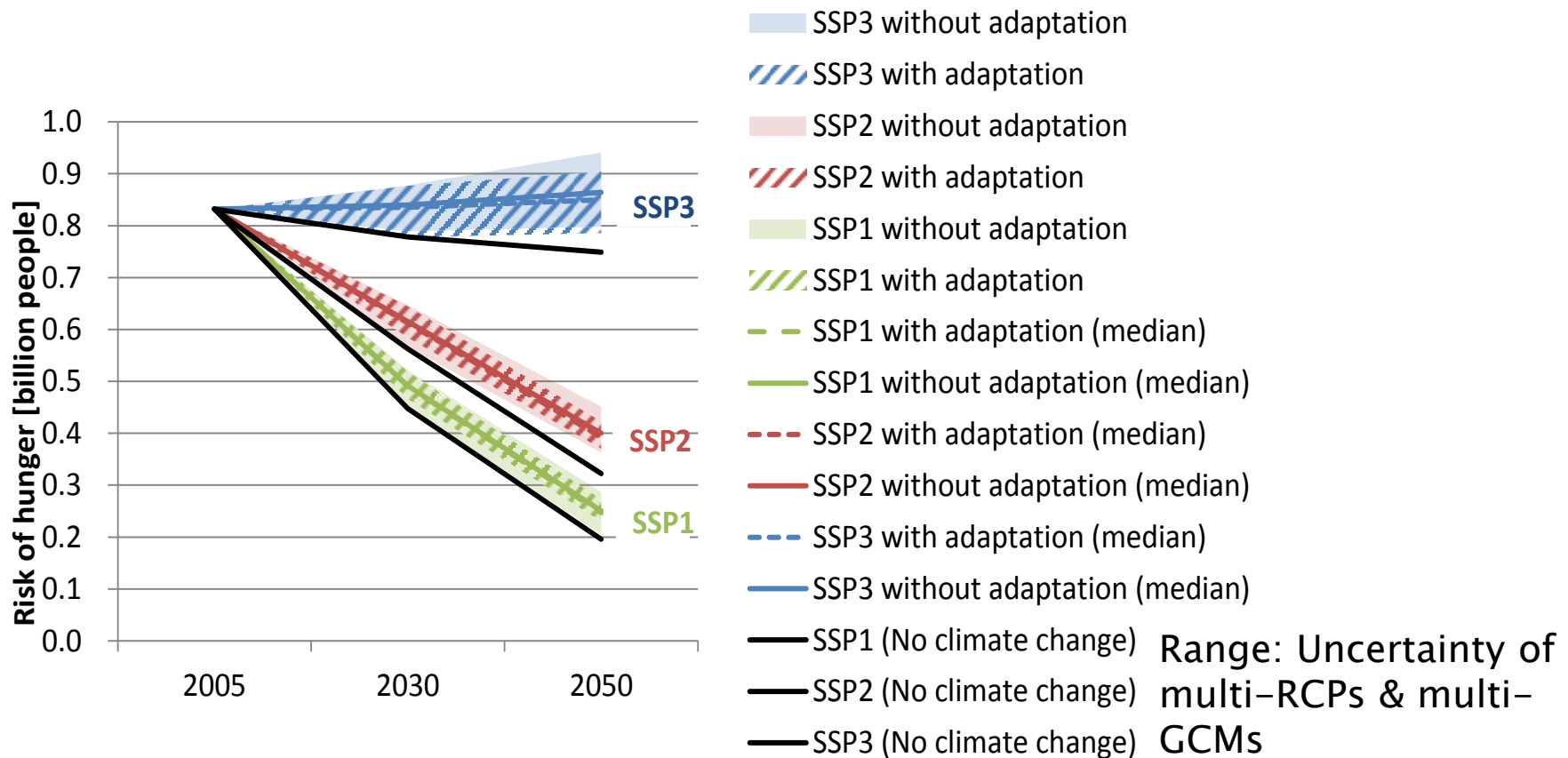


# Additional analysis on effects of adaptation

- ▶ Which is stronger factor to risk of hunger, socioeconomic or climate conditions?
- ▶ How much is the effect of adaptation measures?

		Population & GDP	
		SSP1 & SSP2	SSP3
With adaptation in developing countries			
Without adaptation in developing countries			

# Population at risk of hunger under different SSPs in the cases: with & without adaptation



Other adaptations such as irrigation implementation will be necessary to lower the increase in population at risk of hunger.

# Summary

We analyzed climate change impacts on food consumption and population at risk of hunger using 3SSPs, 4RCPs & 12GCMs

- ▶ Climate change impacts on food consumption and population at risk of hunger depends more strongly on socioeconomic conditions rather than climate conditions
- ▶ Even in the most optimistic scenarios: SSP1&RCP2.6, climate change is expected to make the impacts.
- ▶ Levels of the impacts will vary in different countries and regions
- ▶ Adaptation measures; changes in crop variety and planting dates do not contribute to lower risk of hunger, but contribute to narrow the range of future uncertainty of the risk caused by multi-GCMs.
- ▶ To lower the increase in risk of hunger due to climate change, other resource-intensive adaptation such as irrigation and further utilization of fertilizer will be necessary.

# Appendix

# Population & GDP of SSP

