

Integrated assessment model with agricultural impact

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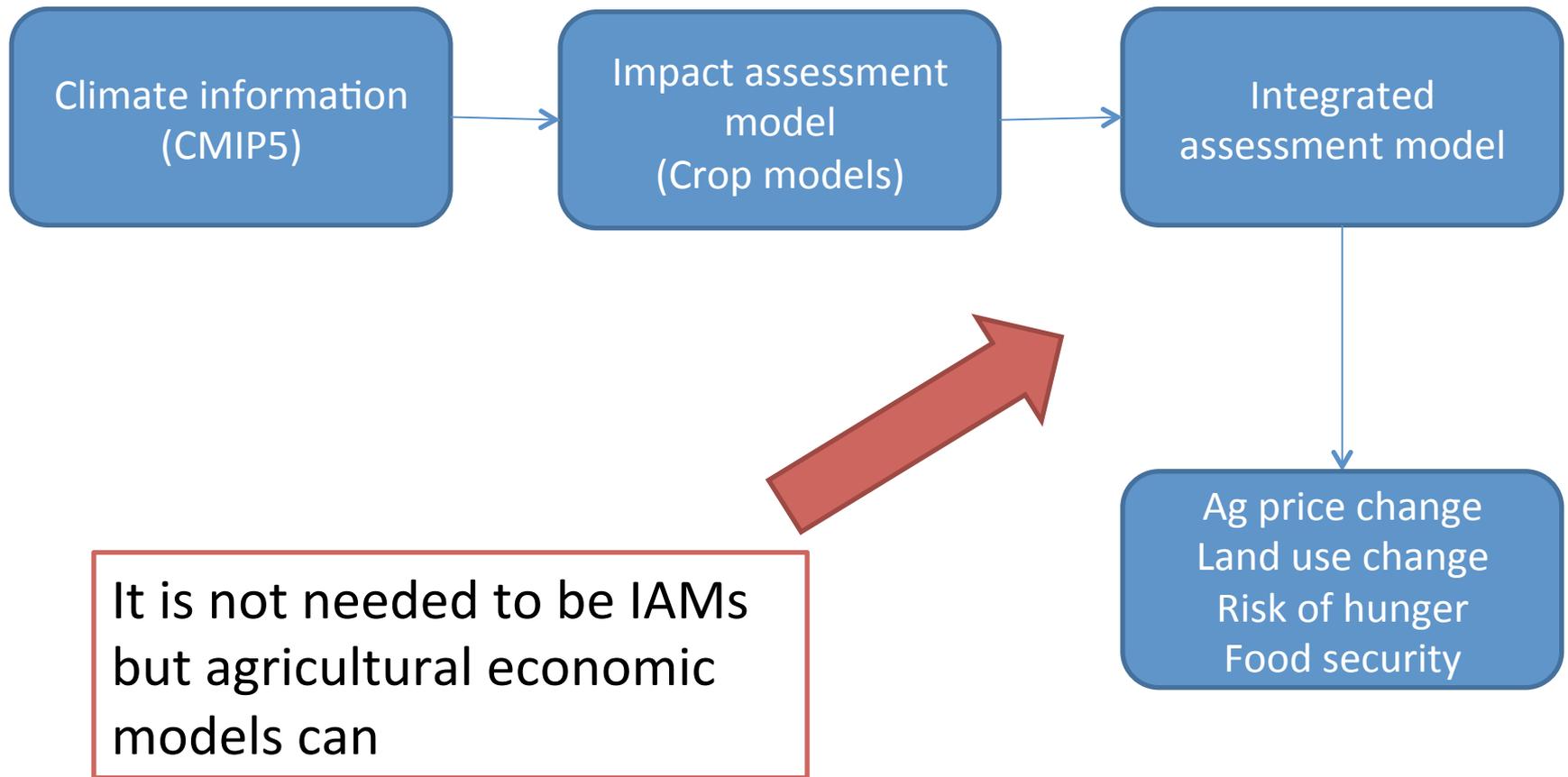
Discussion topics

- Aren't we missing important factor for food security in the context of "real" IAM?
- What does change in the number of undernourished people mean in the economical sense?
- What is the main role of IAM in the agricultural sector?

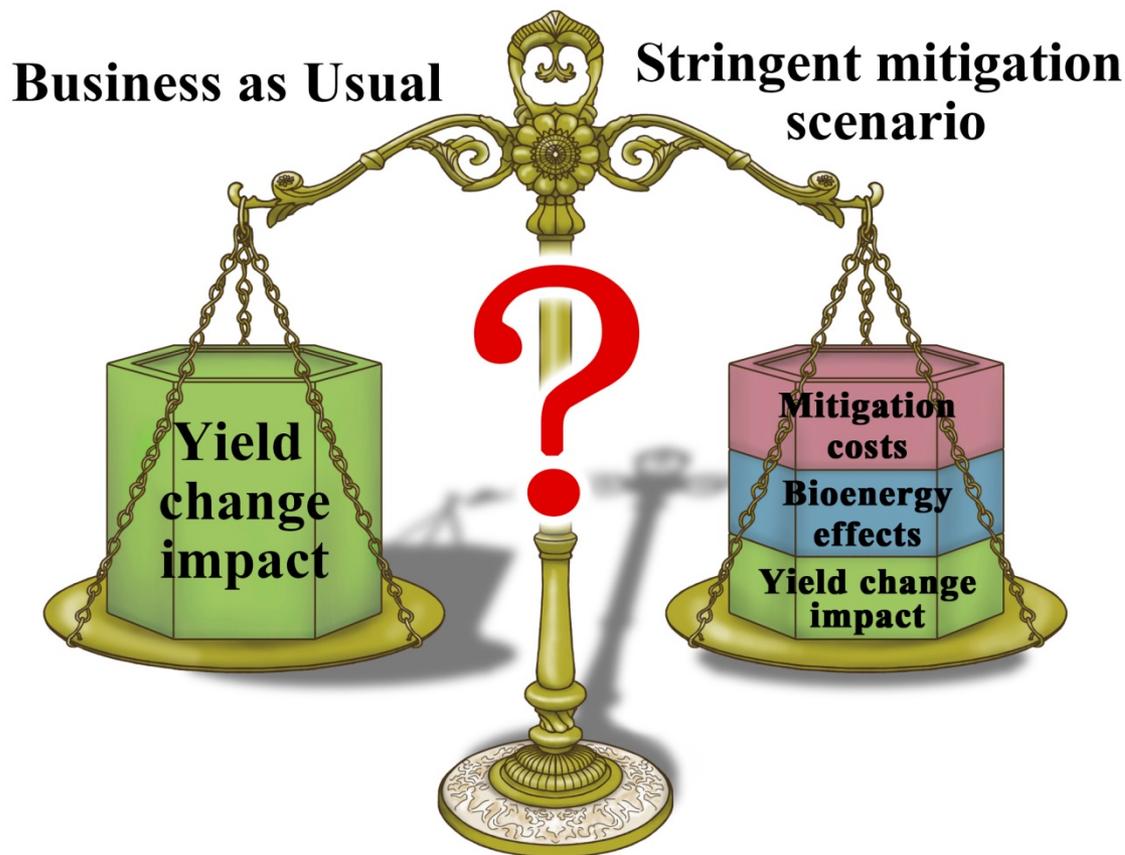
Yield change is important but...

- Yield change due to climate change is important
 - There are number of studies last couple of decades.
- Aren't IAMs missing important factor in the context of food security?
 - Mitigation does affect

Information exchange among models



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



Consequence of Climate Mitigation on the Risk of Hunger

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Supporting Information

ABSTRACT: Climate change and mitigation measures have three major impacts on food consumption and the risk of hunger: (1) changes in crop yields caused by climate change; (2) competition for land between food crops and energy crops driven by the use of bioenergy; and (3) costs associated with mitigation measures taken to meet an emissions reduction target that keeps the global average temperature increase to 2 °C. In this study, we combined a global computable general equilibrium model and a crop model (M-GAEZ), and we quantified the three impacts on risk of hunger through 2050 based on the uncertainty range associated with 12 climate models and one economic and demographic scenario. The strong mitigation measures aimed at attaining the 2 °C target reduce the negative effects of climate change on yields but have large negative impacts on the risk of hunger due to mitigation costs in the low-income countries. We also found that in a strongly carbon-constrained world, the change in food consumption resulting from mitigation measures depends more strongly on the change in incomes than the change in food prices.



INTRODUCTION

In general, climate change affects agricultural productivity negatively,¹ resulting in reduced food availability and increased risk of hunger. However, economic responses by both producers and consumers could alleviate some of this risk. Although mitigating greenhouse gases (GHGs) would reduce some of the negative productivity effects, mitigation may result in other effects that could increase the risk of hunger.

There are two key elements in understanding the consequences of climate mitigation. First, the use of bioenergy as a mitigation measure would increase bioenergy demand and thus also crop prices.² Heavy use of bioenergy would cause competition between food and energy crops due to limited land and water resources,²⁻⁷ and it would therefore increase land and crop prices. Second, there are costs associated with mitigation, which requires changes in technologies to achieve an emissions target. Under a strong emission reduction scenario, for example, aimed at maintaining the increase in mean global temperature at no more than 2 °C, drastic mitigation measures will require high mitigation costs, including additional capital cost for energy technologies that allow a shift to a low-emission industrial structure, which, in turn, will lead to gross domestic product (GDP) losses and decreased wages and household incomes. An example of a relative cost-changing technology is the introduction of carbon capture and storage.⁸ Adoption of this mitigation measure raises the cost of electricity generation that relies on fossil fuels and the products that rely

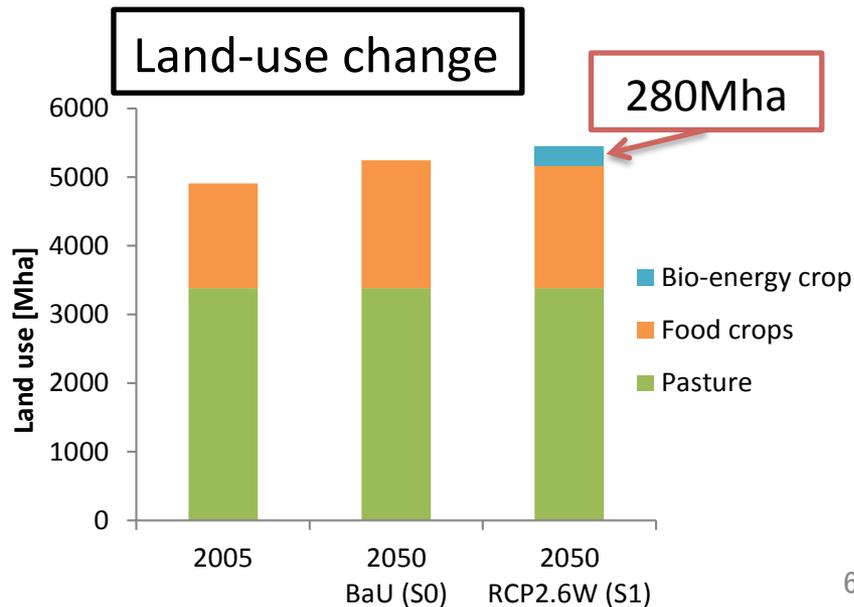
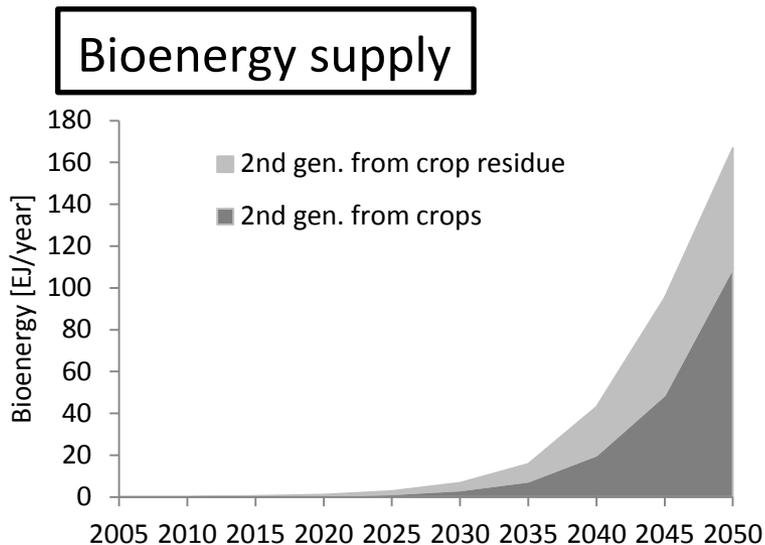
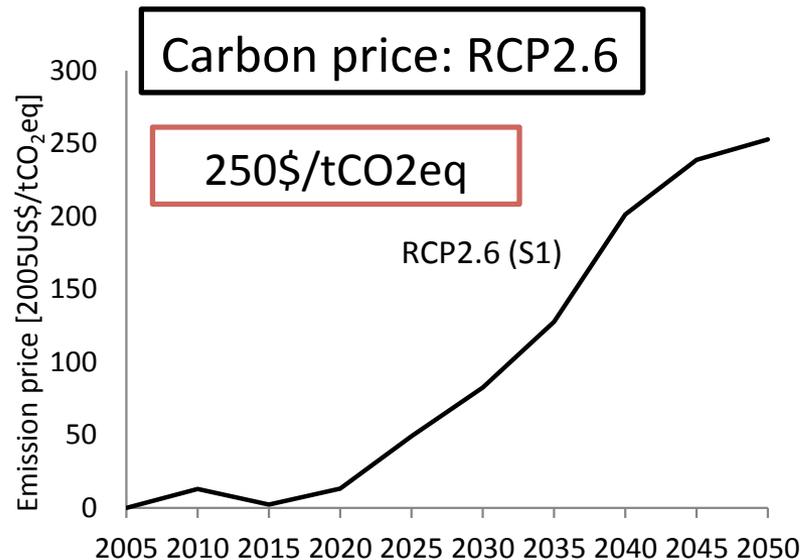
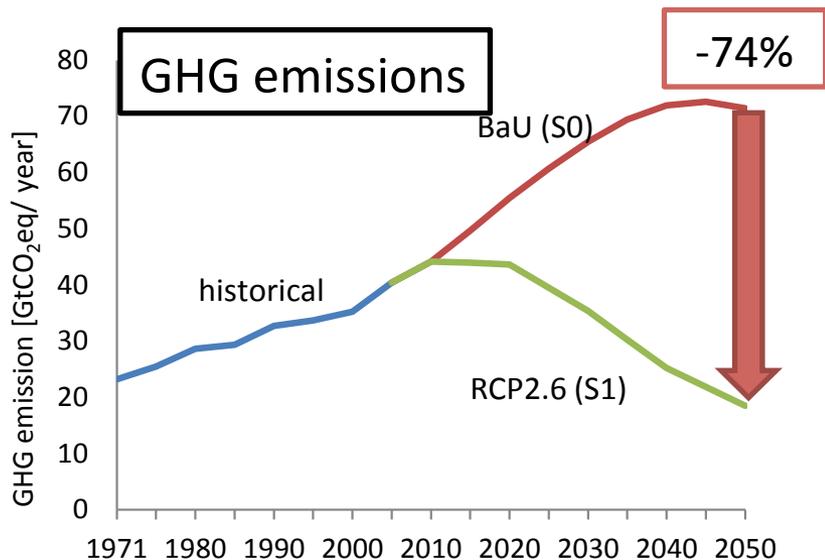
on electricity. This, in turn, lowers real income and causes consumers to switch to products that are less intensive in electricity use.

The increased use of bioenergy and higher mitigation costs to lower GHG emissions both have effects on caloric intake and therefore the risk of hunger, in the first case via relative price effects and in the second case via real income effects. Although many studies have focused on impacts on the risk of hunger caused by climate change and high bioenergy demand,^{6,7,9-11} no studies have discussed the impacts of mitigation costs on the risk of hunger. In addition, none of the analyses of the effects of bioenergy use were based on consistent sets of GHG concentration pathways and climate conditions used to combine the effects of climate change and of land competition, even though these effects are related to each other.

In this study, we used a suite of models that can assess both the direct biophysical effects of climate change and the indirect effects of climate mitigation measures. The main aims of this study were to evaluate (1) how large the impact on the risk of hunger due to climate mitigation would be in a stringent mitigation scenario as compared to the impact of changes in crop yields without mitigation and (2) the economic factors in

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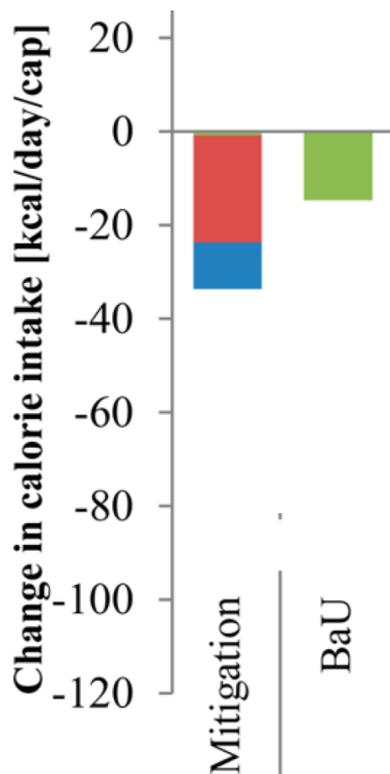
The World of RCP2.6





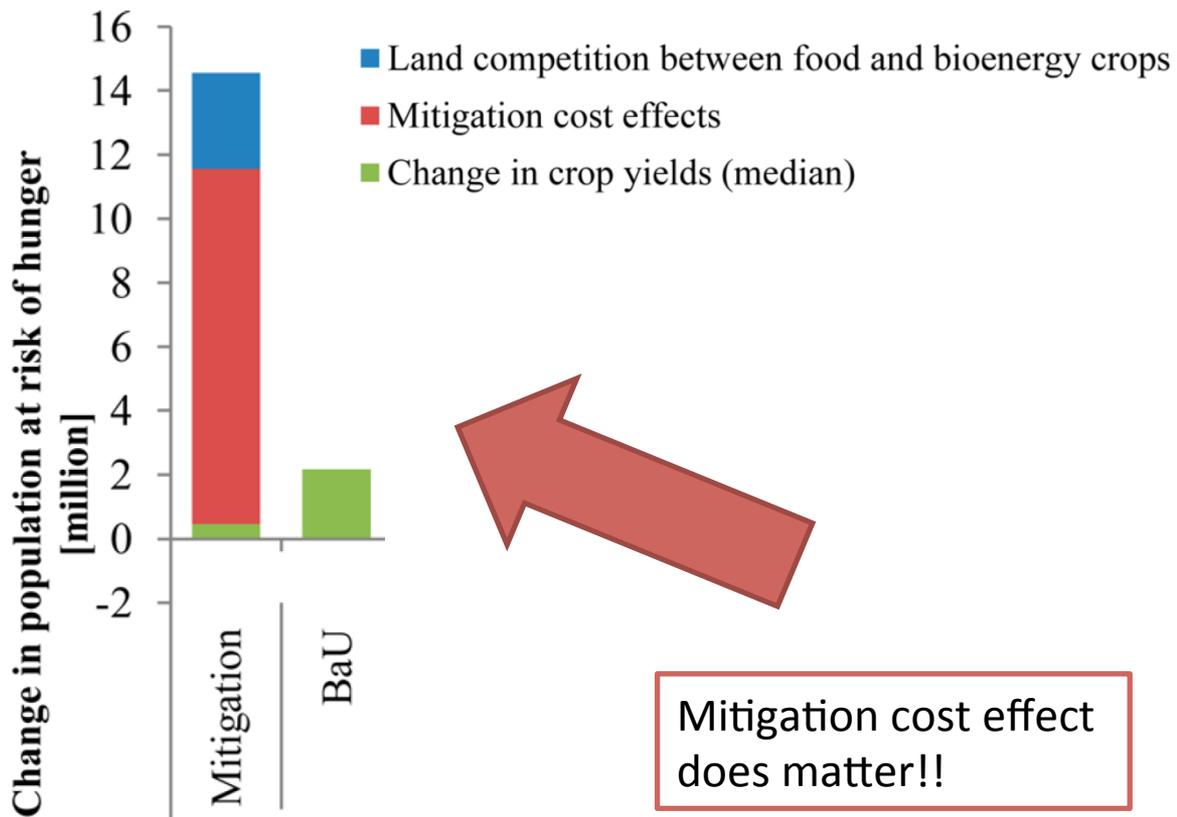
Global impacts on food security in 2050: BaU and Mitigation

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.

Mitigation cost effect
does matter!!

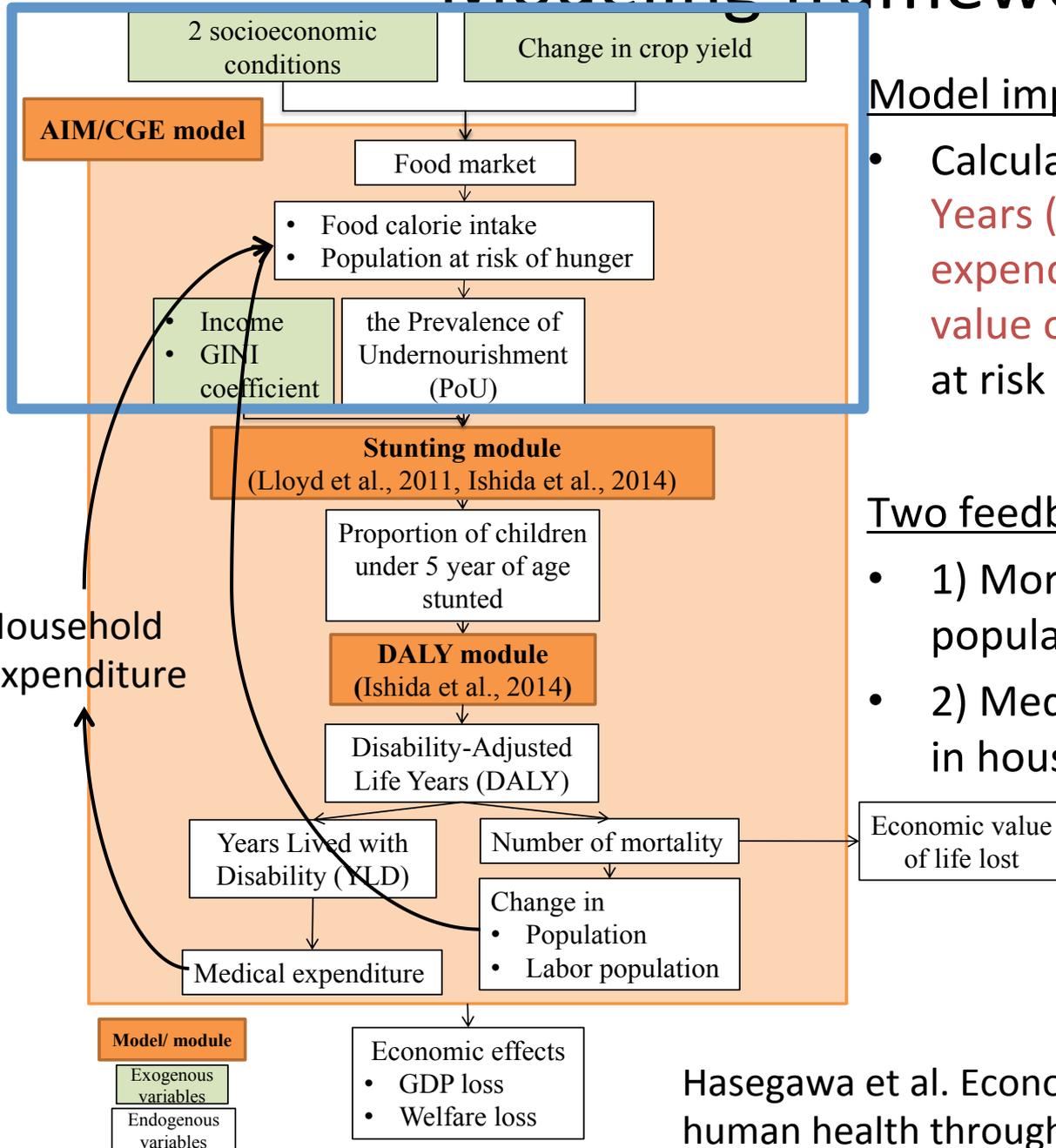
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Number of undernourished people; is it enough?

- After we could identify the change in the number of undernourished people, how can we digest that information?
 - Economic value
 - Macroeconomic impact

Modeling framework



Model improvements

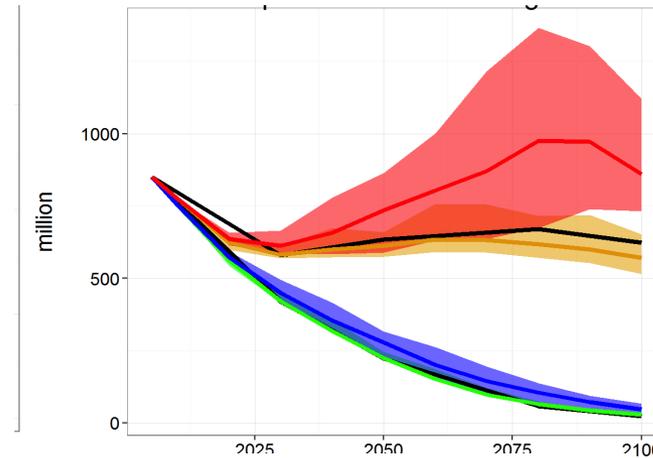
- Calculate Disability-Adjusted Life Years (DALY), Medical expenditure, mortality, Economic value of life lost from population at risk of hunger.

Two feedback

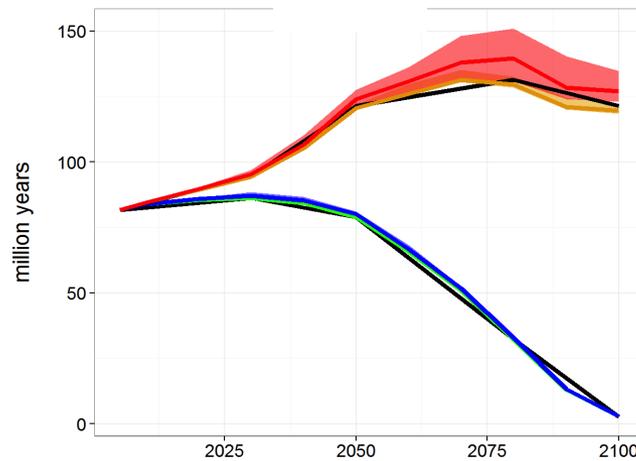
- 1) Mortality to changes in population and labor force
- 2) Medical expenditure to changes in household expenditure.

Effects of climate change to food and human health

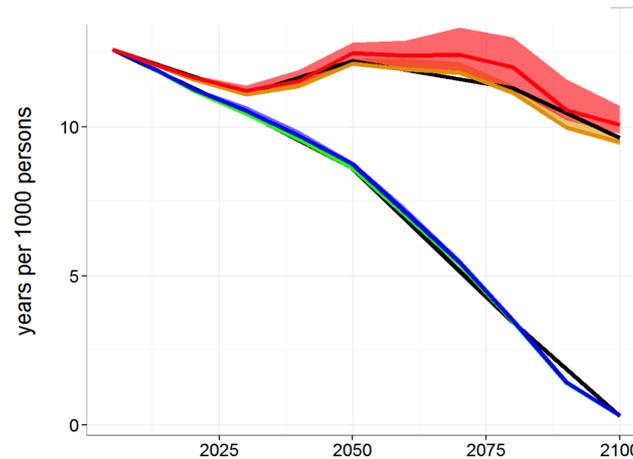
Prevalence of Undernourishment



DALY



DALYs per 1000 persons



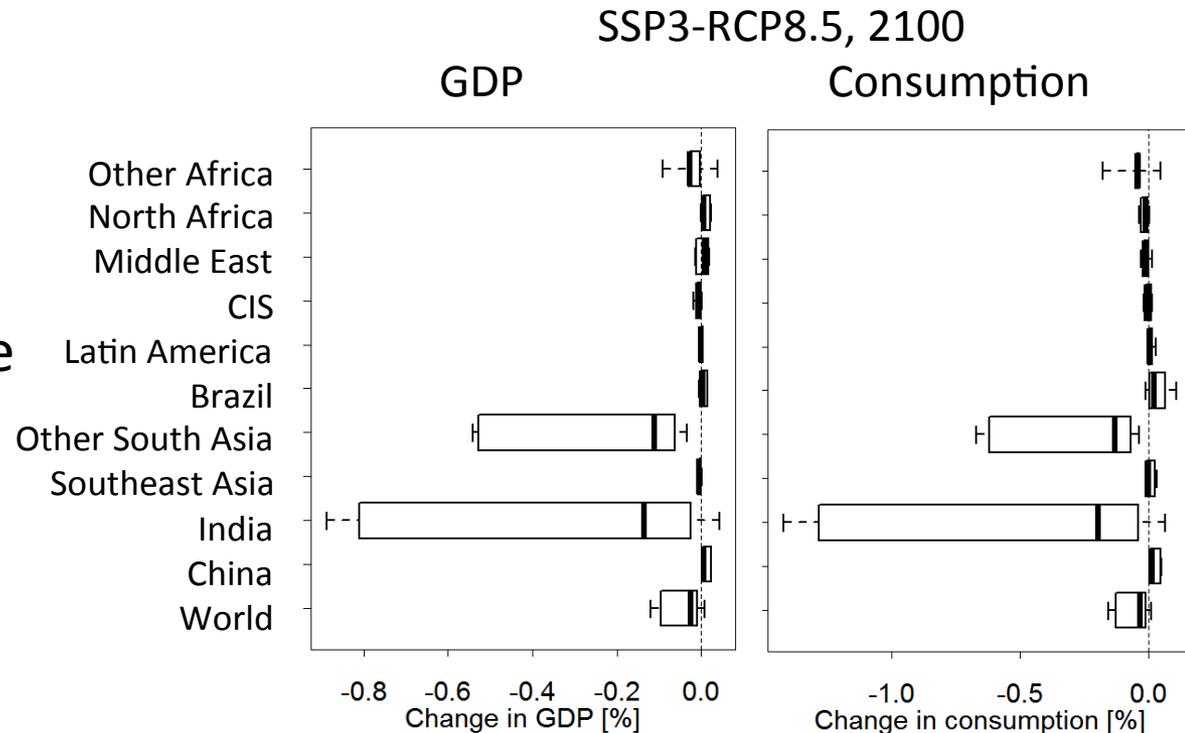
- Food consumption will decrease; PoU and DALY will increase in RCP8.5.
- The effects are small in RCP2.6.
- Future DALY depends on socioeconomic conditions rather than climate conditions. 11

Economic impacts of additional medical expenditure, decrease in population and labor force

- Global GDP change small
- Different in different regions

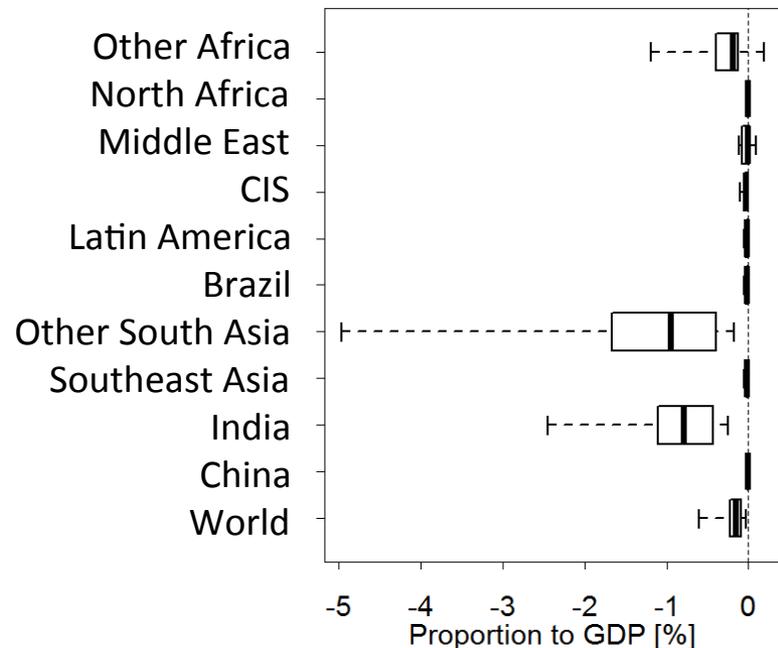
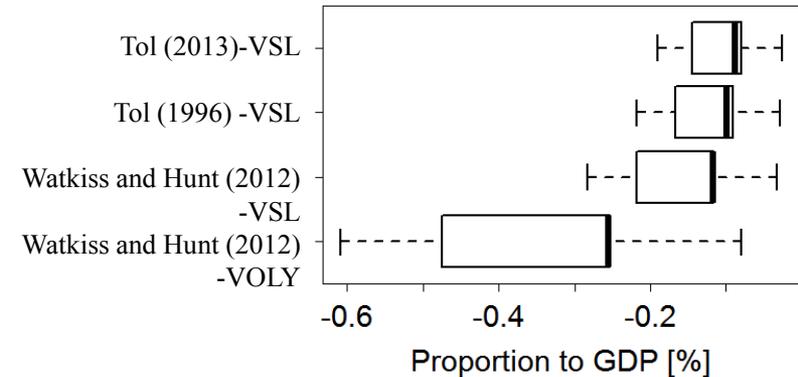
Reasons:

1. Proportion of healthy lives lost due to disease is small, with the majority of people suffering from disease dying prematurely.
2. Healthcare costs in low-income area are relatively low.



Economic value of lives lost due to undernourishment caused by climate change

- Global GDP changes -0.6~0.0%
- -5.0% of regional GDP at most
- Large impacts in South Asia
- This effect is much larger than the effects of additional health expenditure and decrease in labor force.



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The role of IAM

- Only IAMs can deal with mitigation analysis
 - How does mitigation interact with agricultural sector?
 - Land competition (bioenergy and afforestation)
 - GHG pricing drastically change the agricultural price
 - Economic loss due to mitigation matters
- “INTEGRATED” mitigation and adaptation assessment?
 - Adaptation in agricultural sector would help bioenergy crops expansion and enlarge afforestation space
- But keep in mind that integrating is not the objective

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

Economic value of Life lost as a result of Disability

Uncertainty in assessment of the value of a life is considered as possible by using several life valuation indexes based on the previous literature.

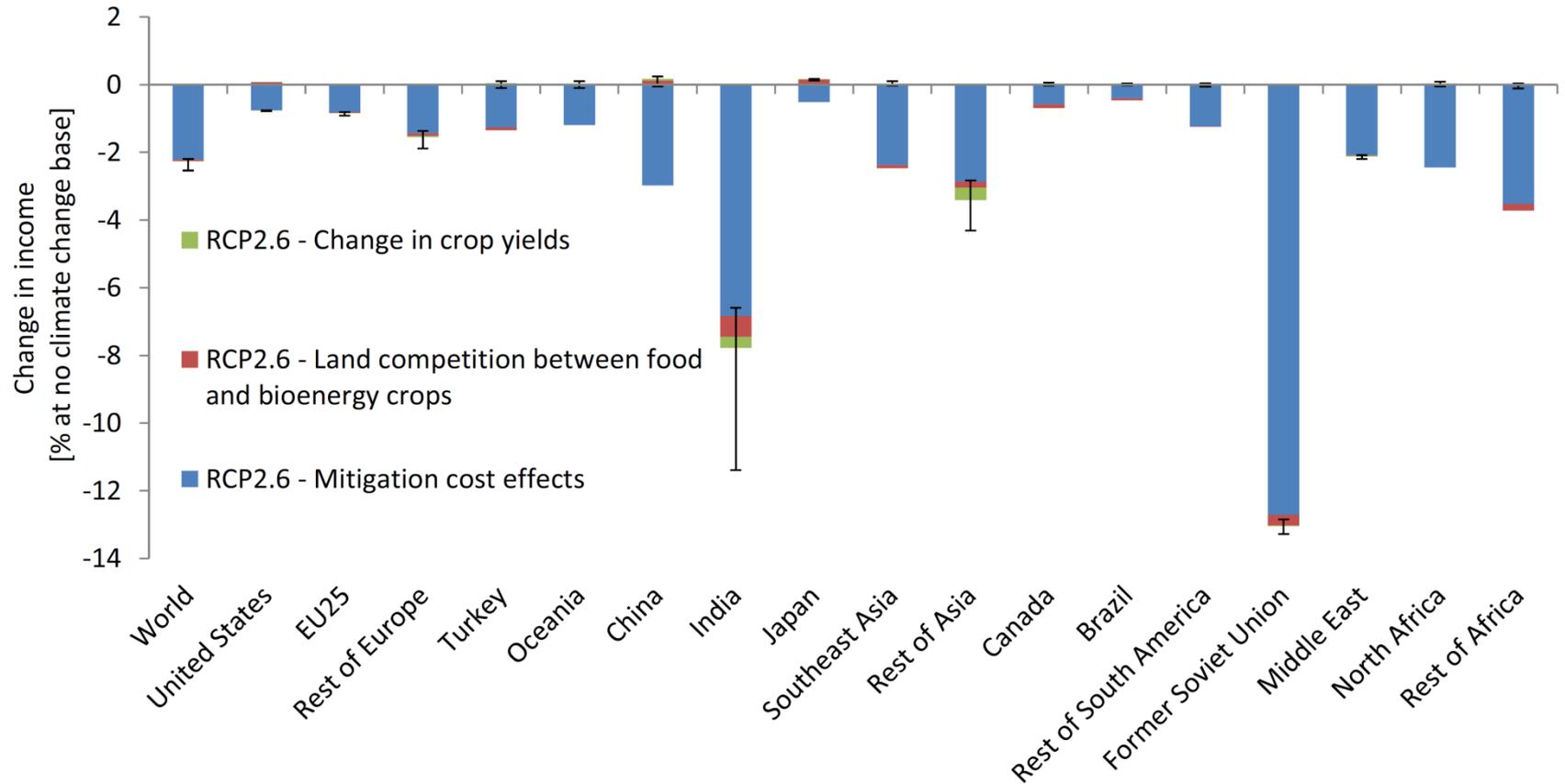
Two metrics

- the Value Of a Live Year(VOLY): an evaluation based on DALY According to the number of DALY (i.e. age of death).
- Value of Statistical Life (VSL): an evaluation based on the WTP to avoid the risk of death; Lost period (i.e., age at death) is not taken into account.

Four value of Life lost

- VOLY: 59,000 [€/DALY 1 year] (Watkiss and Hunt, 2012)
- VSL:
 - € 1,100,000/death (Watkiss and Hunt, 2012)
 - 200 times the annual income/death (Tol, 2013)
 - US \$250,000 + 175 times the annual income/death (Tol, 1996)

Income change



Main questions

- How much food consumption and population at risk of hunger in the world are improved by farmers' autonomous adaptations to climate change?
- How much is the magnitude of uncertainty associated with socioeconomic conditions, climate projections within the effects of the adaptations on food security?

Climate Change Impact and Adaptation Assessment on Food Consumption Utilizing a New Scenario Framework

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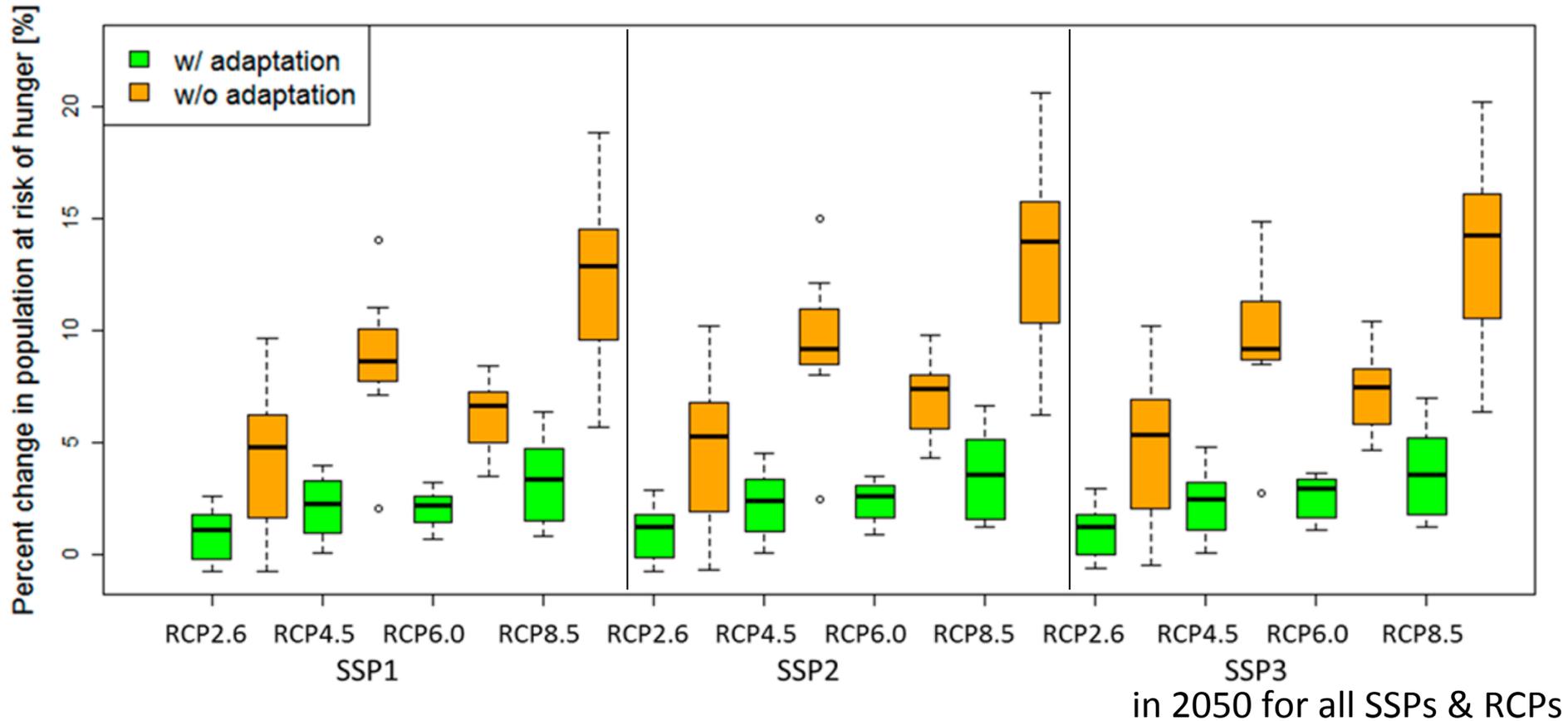
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Supporting Information

ABSTRACT: We assessed the impacts of climate change and agricultural autonomous adaptation measures (changes in crop variety and planting dates) on food consumption and risk of hunger considering uncertainties in socioeconomic and climate conditions by using a new scenario framework. We combined a global computable general equilibrium model and a crop model (M-GAEZ), and estimated the impacts through 2050 based on future assumptions of socioeconomic and climate conditions. We used three Shared Socioeconomic Pathways as future population and gross domestic products, four Representative Concentration Pathways as a greenhouse gas emissions constraint, and eight General Circulation Models to estimate climate conditions. We found that (i) the adaptation measures are expected to significantly lower the risk of hunger resulting from climate change under various socioeconomic and climate conditions. (ii) population and economic development had a greater impact than climate conditions for risk of hunger at least throughout 2050, but climate change was projected to have notable impacts, even in the strong emission mitigation scenarios. (iii) The impact on hunger risk varied across regions because levels of calorie intake, climate change impacts and land scarcity varied by region.



Global population at risk of hunger

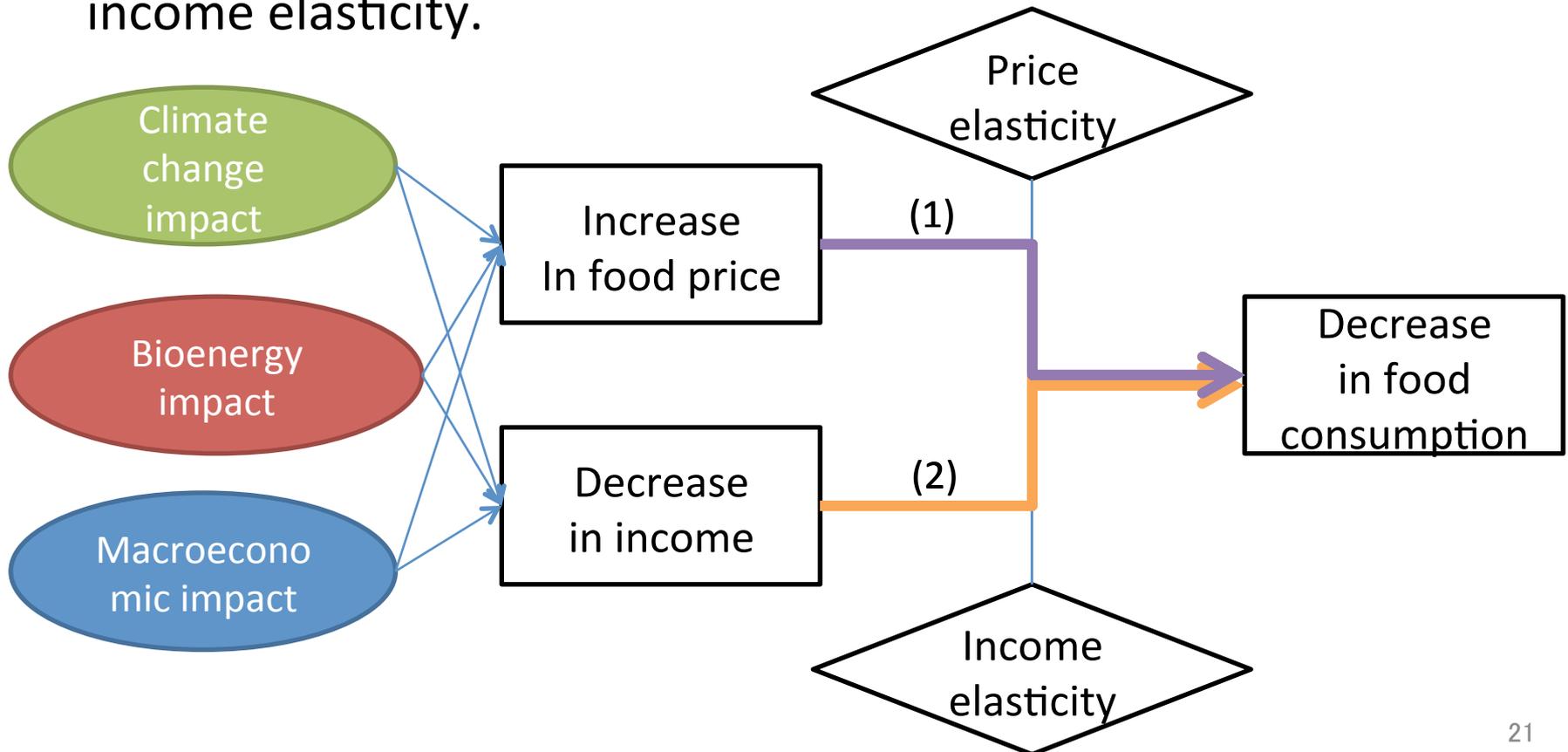


- % change becomes larger than calorie intake
- Adaptation seems working well to reduce risk of hunger

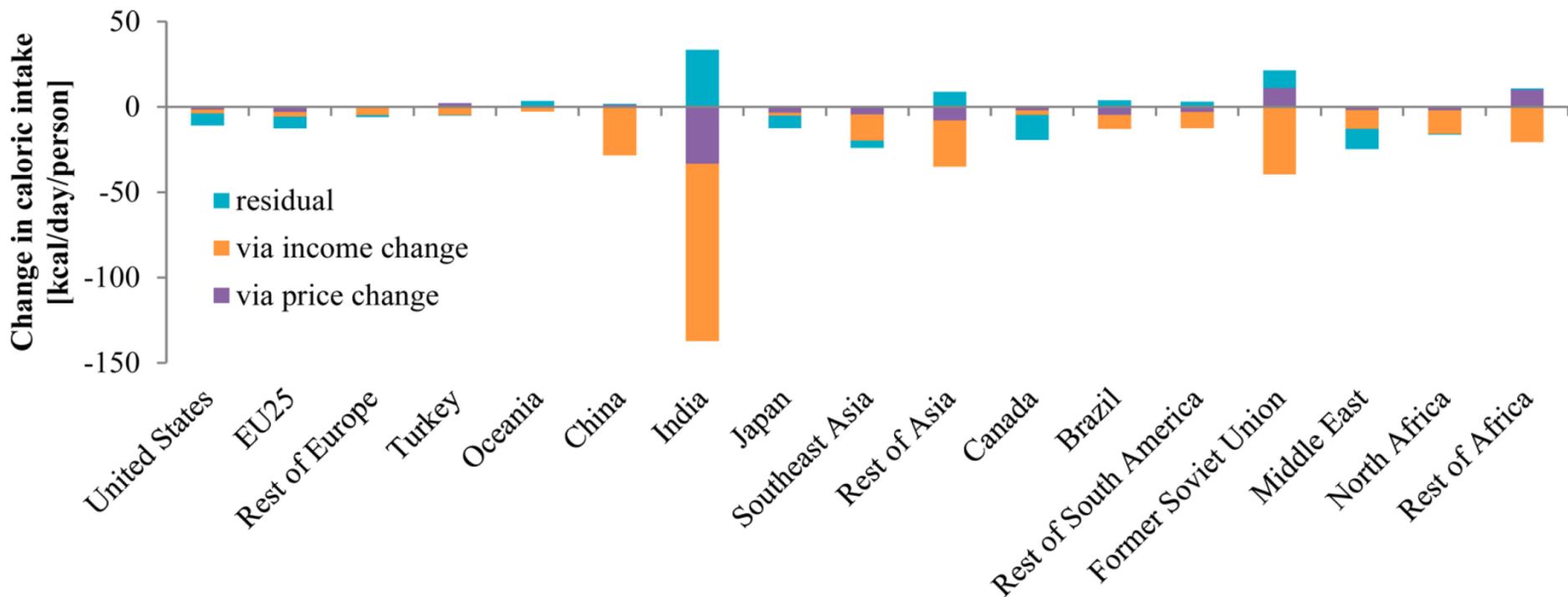
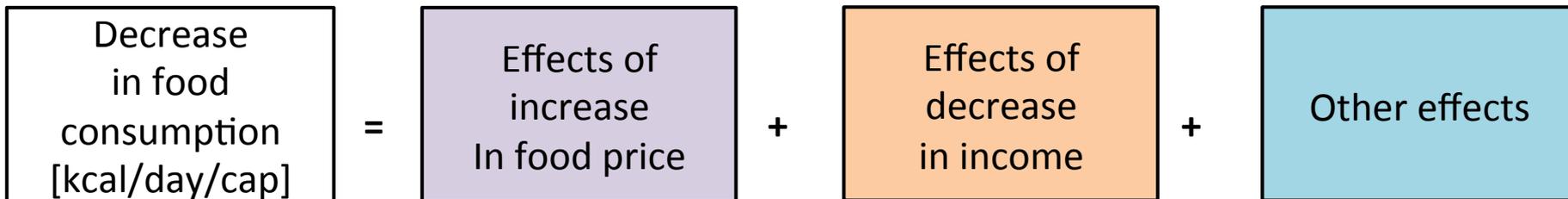
Two processes by which the three factors affect food consumption

(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



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