

Water-energy nexus studies by coupling  
the H08 global hydrological model and  
the AIM/CGE integrated assessment model

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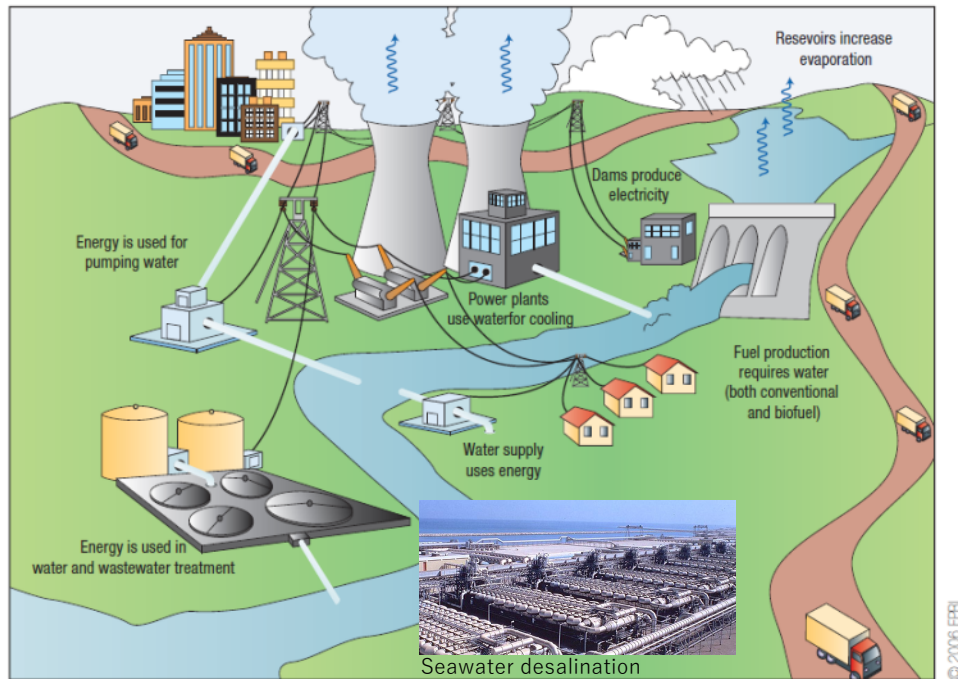
# Outline

- General introduction
  - Water-energy nexus
  - Coupling global hydrological and economic models
- Example
  - Climate change impact on global hydropower

*Zhou, Q., Hanasaki, N., et al.: Economic consequences of global climate change and mitigation on future hydropower generation, **Climatic Change**, 147, 77-90, 2018.*

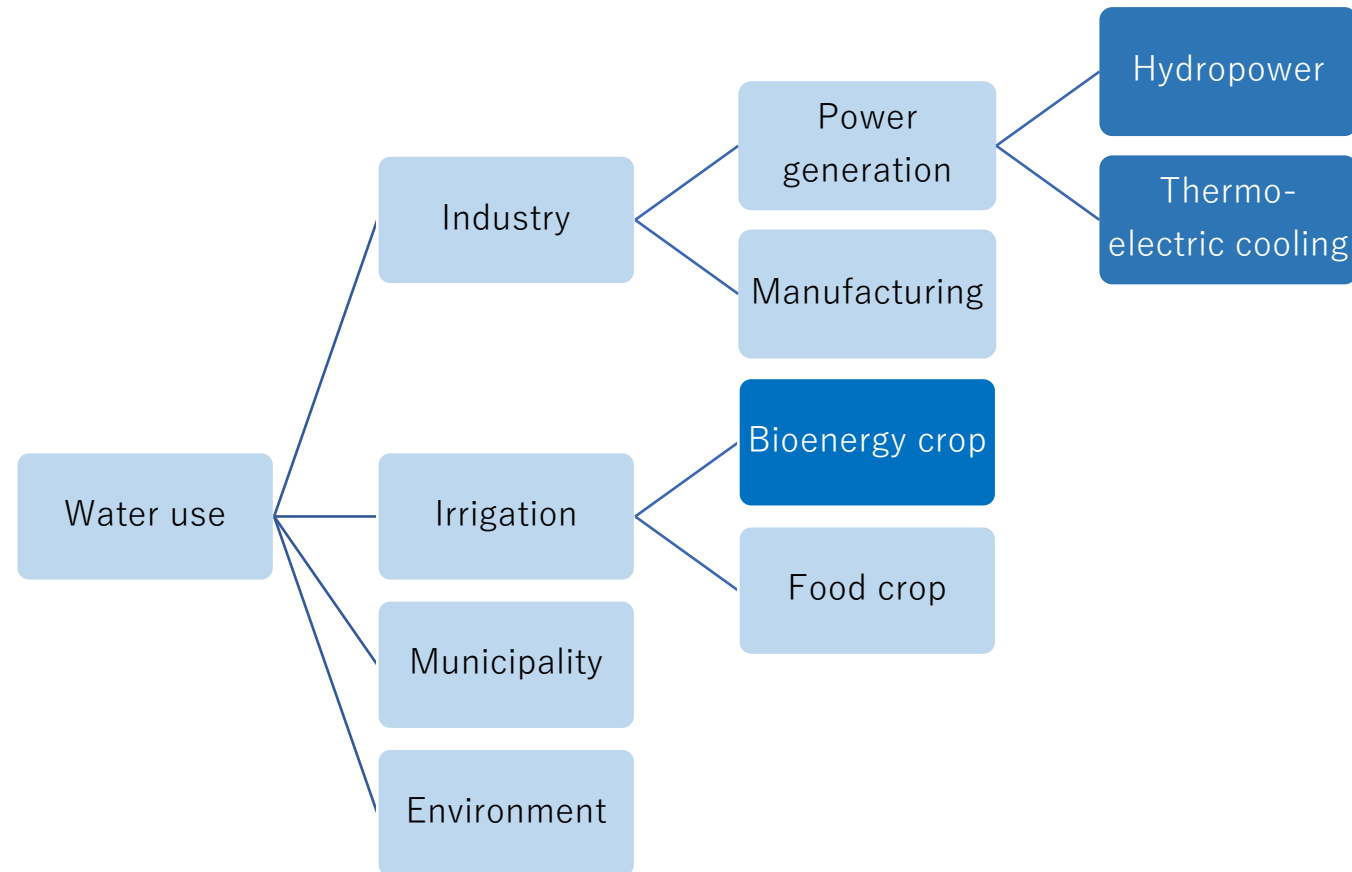
# Energy-Water Nexus

- Water for energy production
- Energy for water supply/treatment



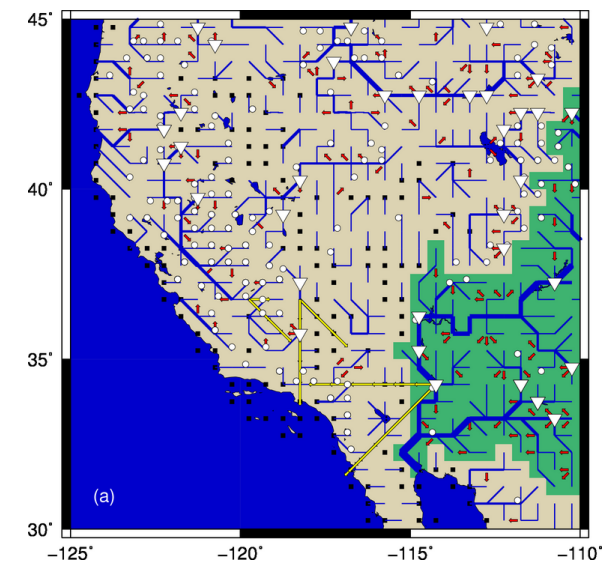
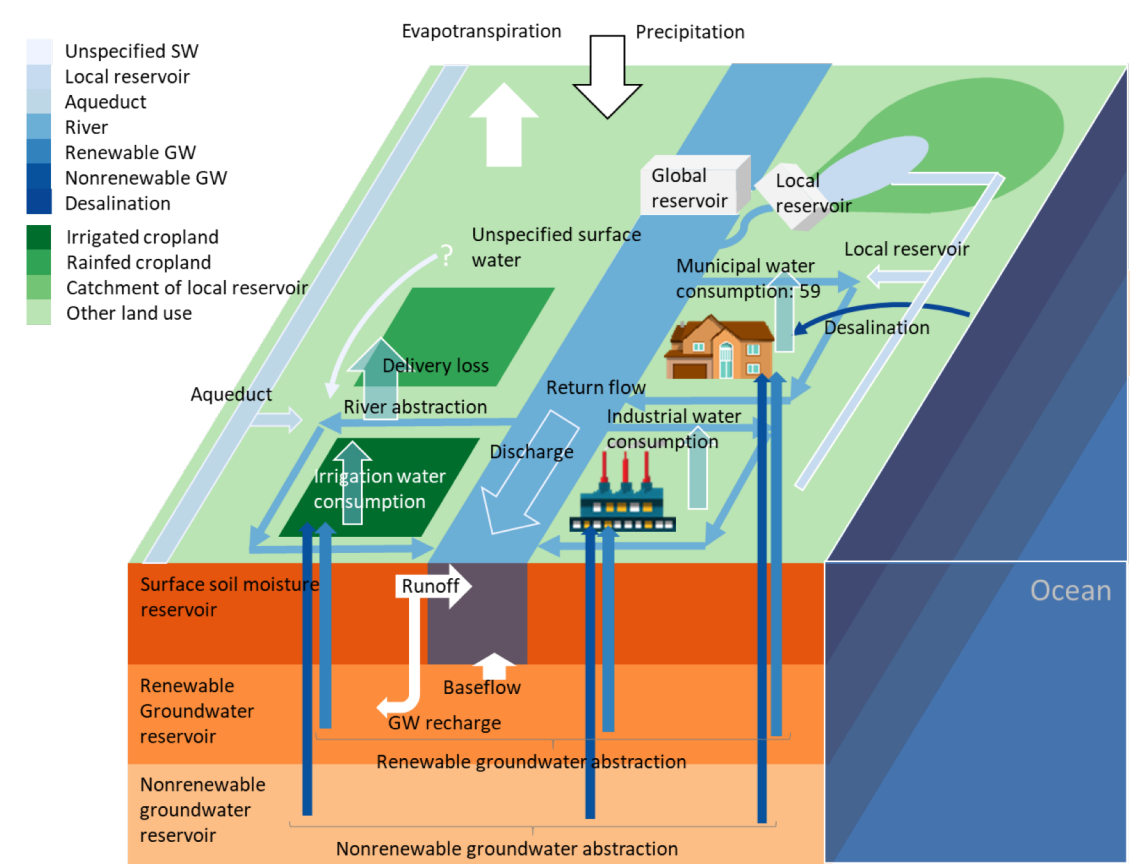
King et al., 2008

- Water use perspective
- +relevance to energy-economy



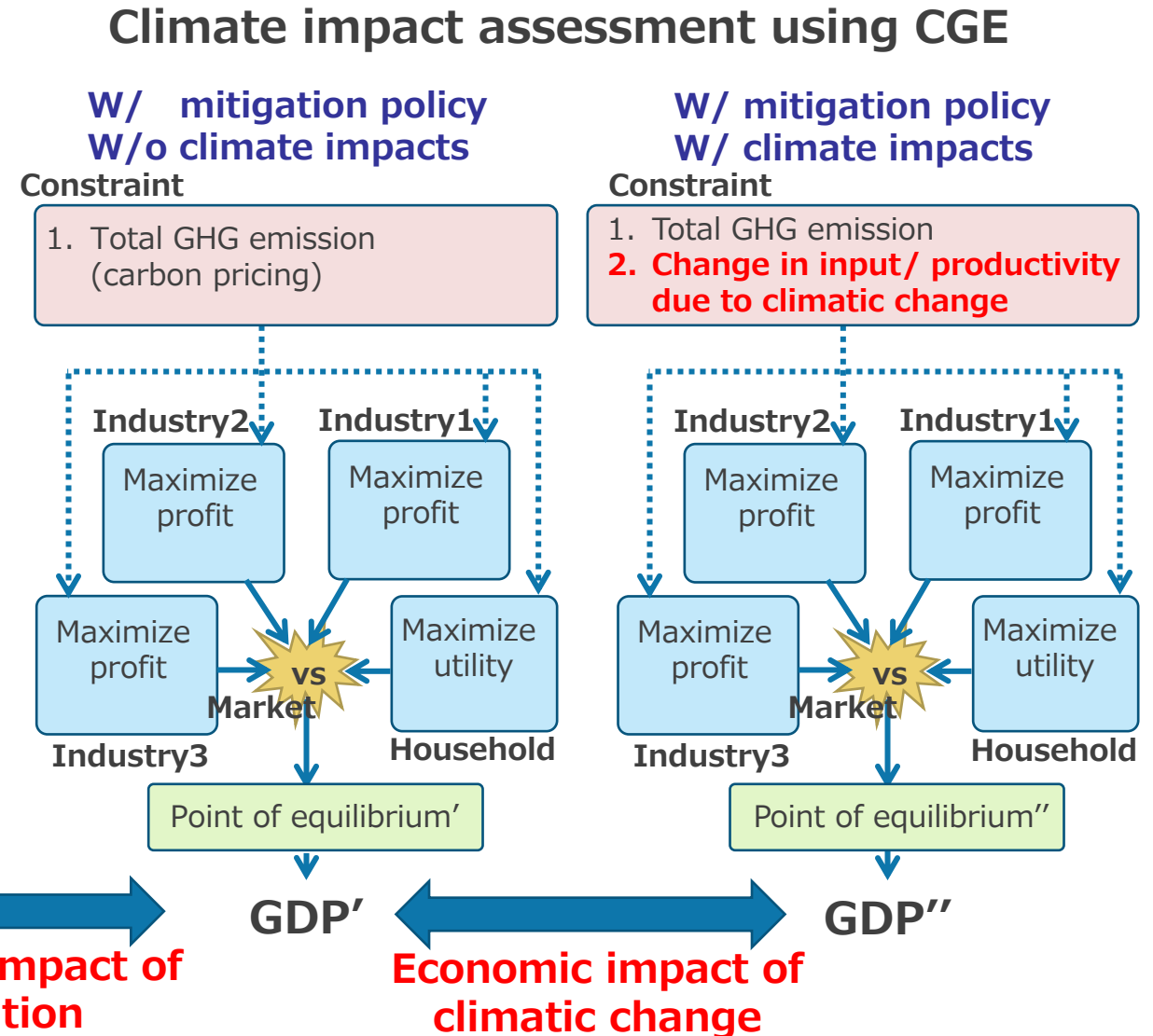
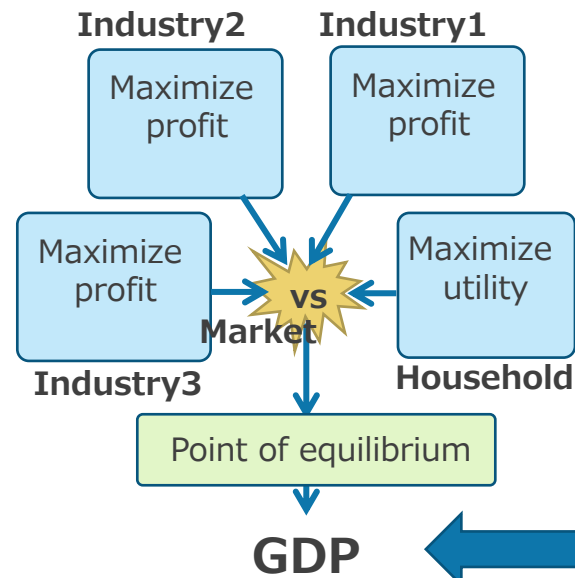
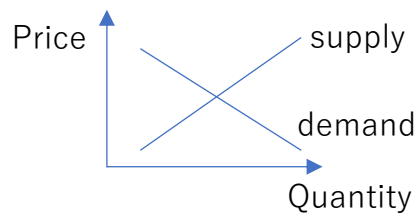
# H08

- Global hydrological model with human activities
- 4 water use sectors
  - Industry = manufacturing + cooling
- 7 water sources
  - 5 surface water
  - 2 groundwater
- Global  $0.5^\circ \times 0.5^\circ$
- Daily interval



# AIM/CGE

- Asia-Pacific Integrated Model  
Computable General Equilibrium
- Used to develop SRES A1B, SSP3
- 43 industrial sectors (incl. 11 electricity generation) + 3 household sectors
- Global 17 regions, yearly interval



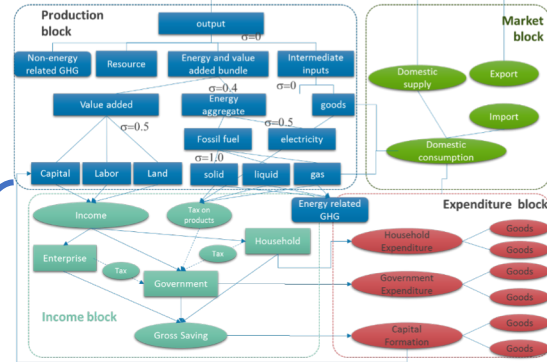
# Coupling H08 and AIM/CGE

43 sectors, 17 regions, annual  
Energy-economic variables

Sector aggregation  
Spatial downscale  
Temporal downscale  
Variable conversion

Socio economic constraint

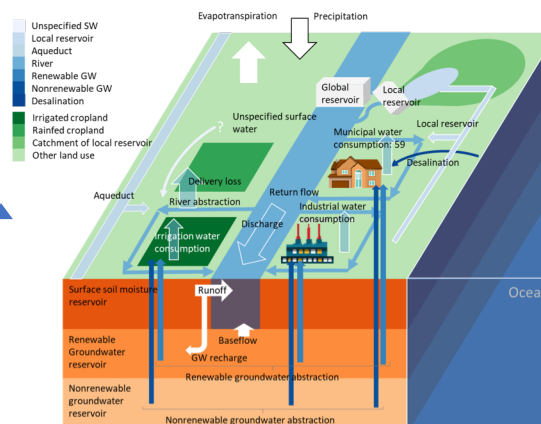
## AIM/CGE



Physical constraint

Sector disaggregation  
Spatial upscale  
Temporal upscale  
Variable conversion

## H08

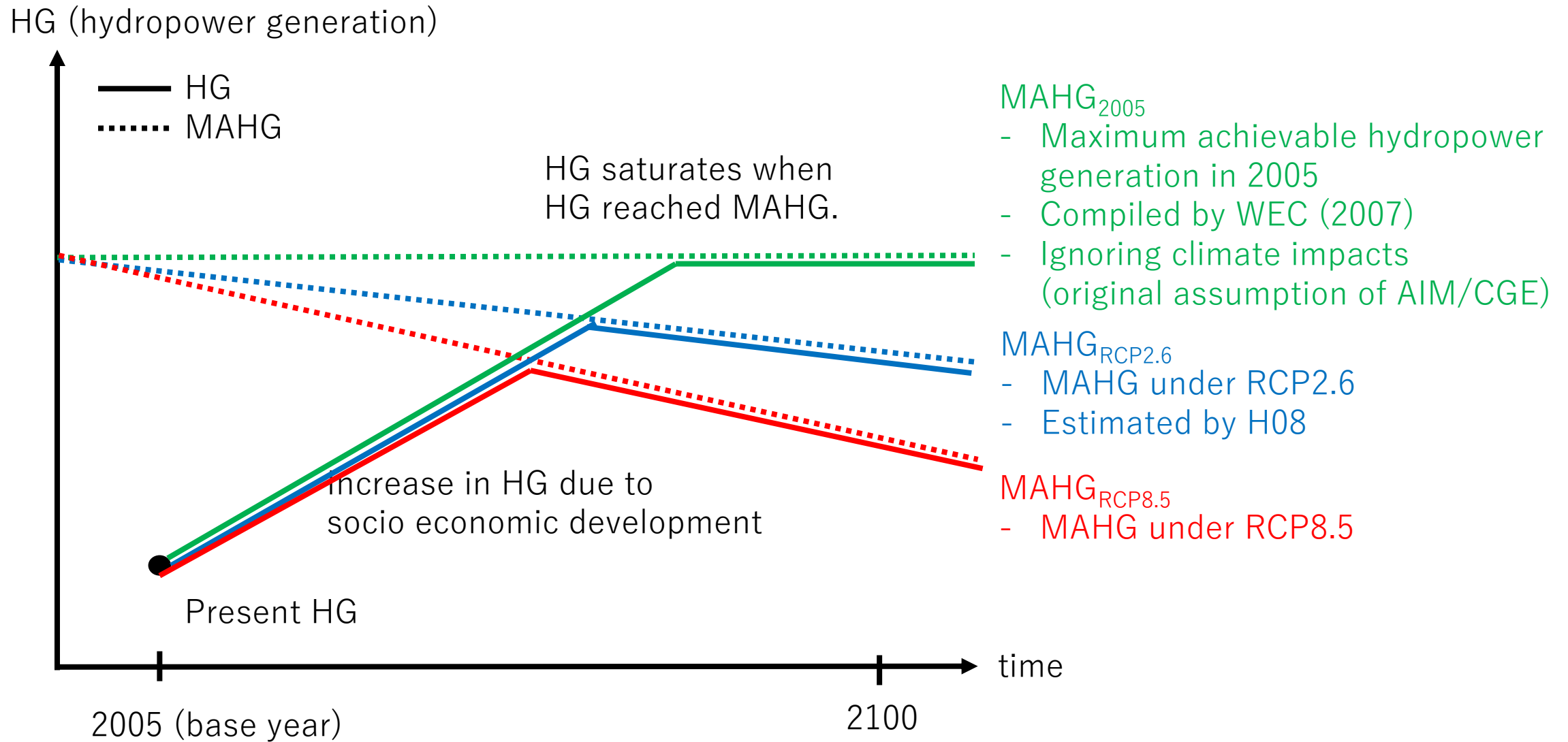


4 sectors,  $0.5^\circ \times 0.5^\circ$ , daily  
Hydrological variables

# Hydropower: Introduction

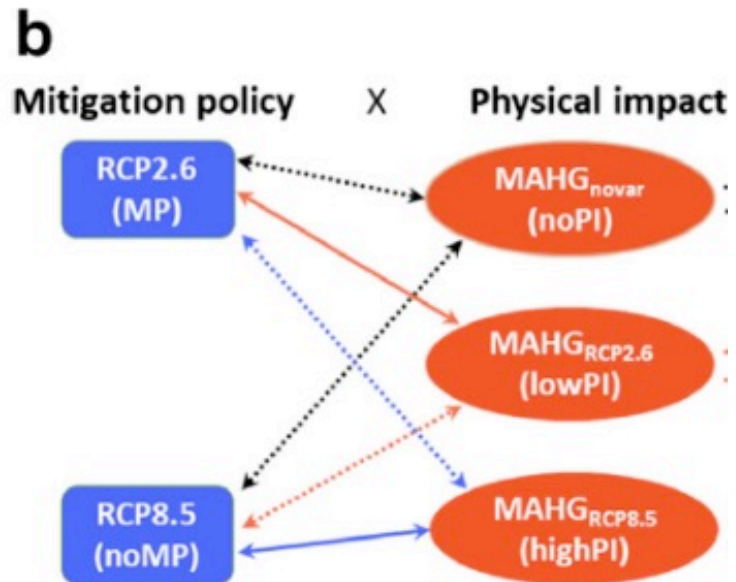
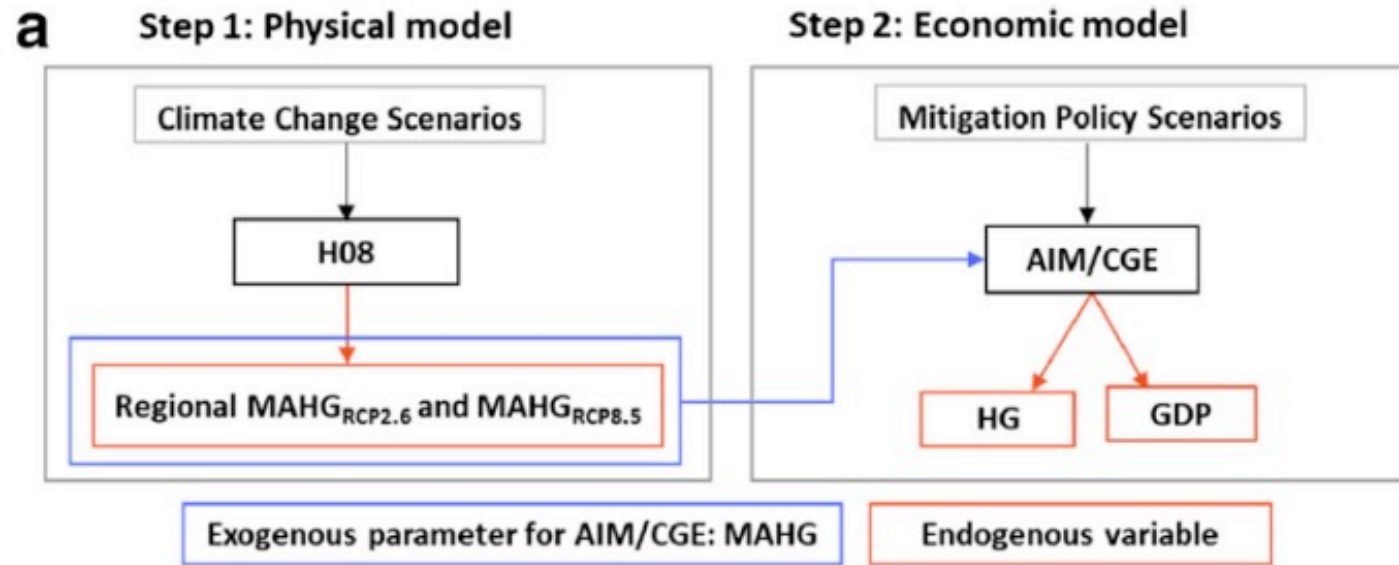
- Hydropower
  - 16%+ of total electricity generation in the world
  - promoted as a measure of mitigation policy
  - affected by climatic change
- Earlier works
  - Climatic change impacts on hydropower potential using global hydrological models (e.g. Lehner et al. 2005; Zhou et al. 2015; Van Vliet et al. 2016)
  - Numerous studies on mitigation policy and renewable energy using integrated assessment models.  
Most studies assumed hydropower potential constant during the 21<sup>st</sup> century.
- Objective
  - What will be the economical impact of climatic change on hydropower potential?

# Concept



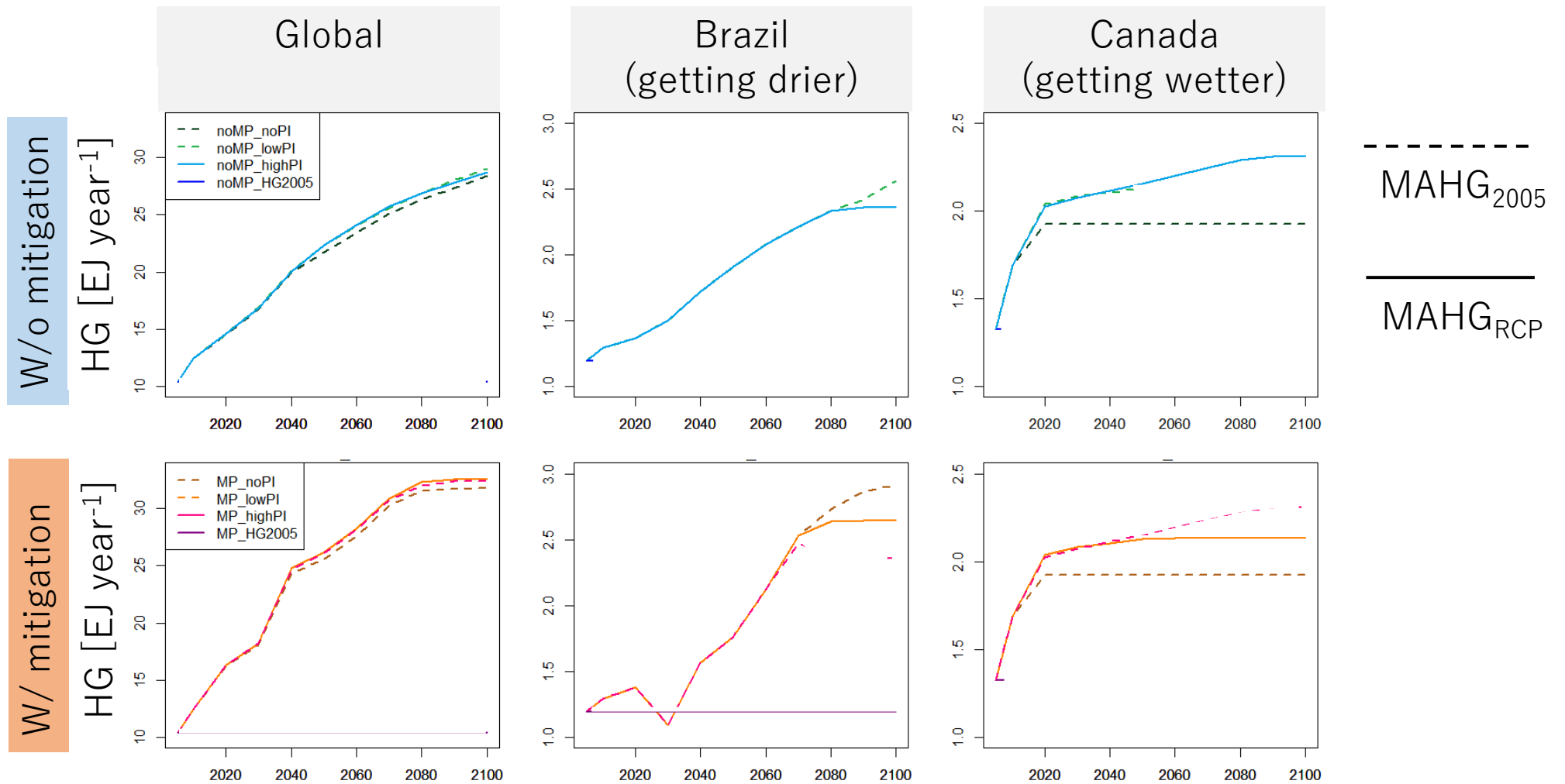


# Method



# Results

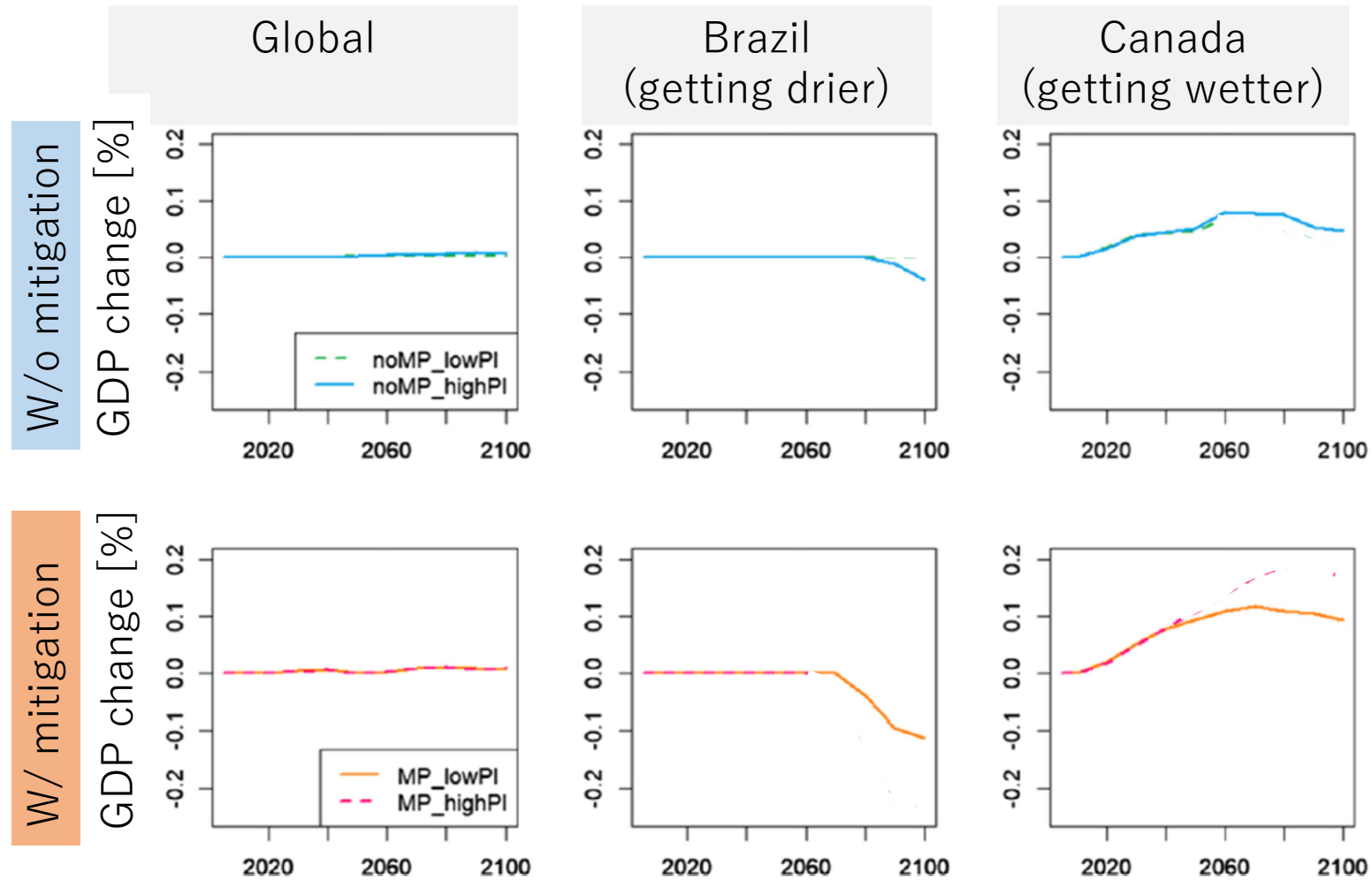
What will be the climatic change impacts on hydropower generation?



Climatic change influences regional hydropower generation. Impacts are dependent on mitigation policy. Considerable increase in hydropower generation is expected by AIM/CGE.

# Results

What will be the economic consequences?

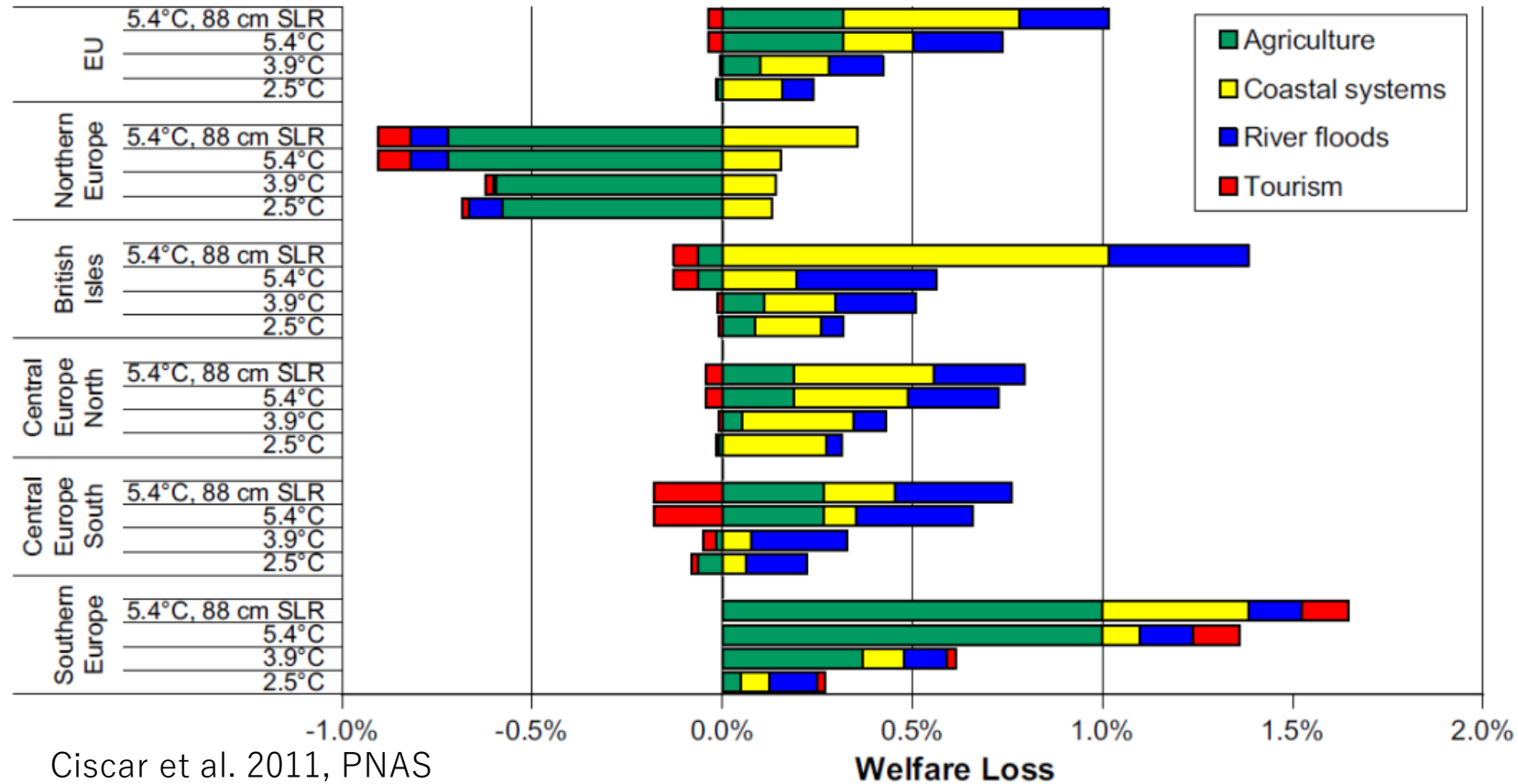


Regional GDP impacts will be  $\pm 0.1\%$ .  
Total global impacts will be small.

# Discussion

Is  $\pm 0.1\%$  of regional GDP change small (and negligible)?

## Welfare ( $\sim$ GDP) loss due to climate change in Europe

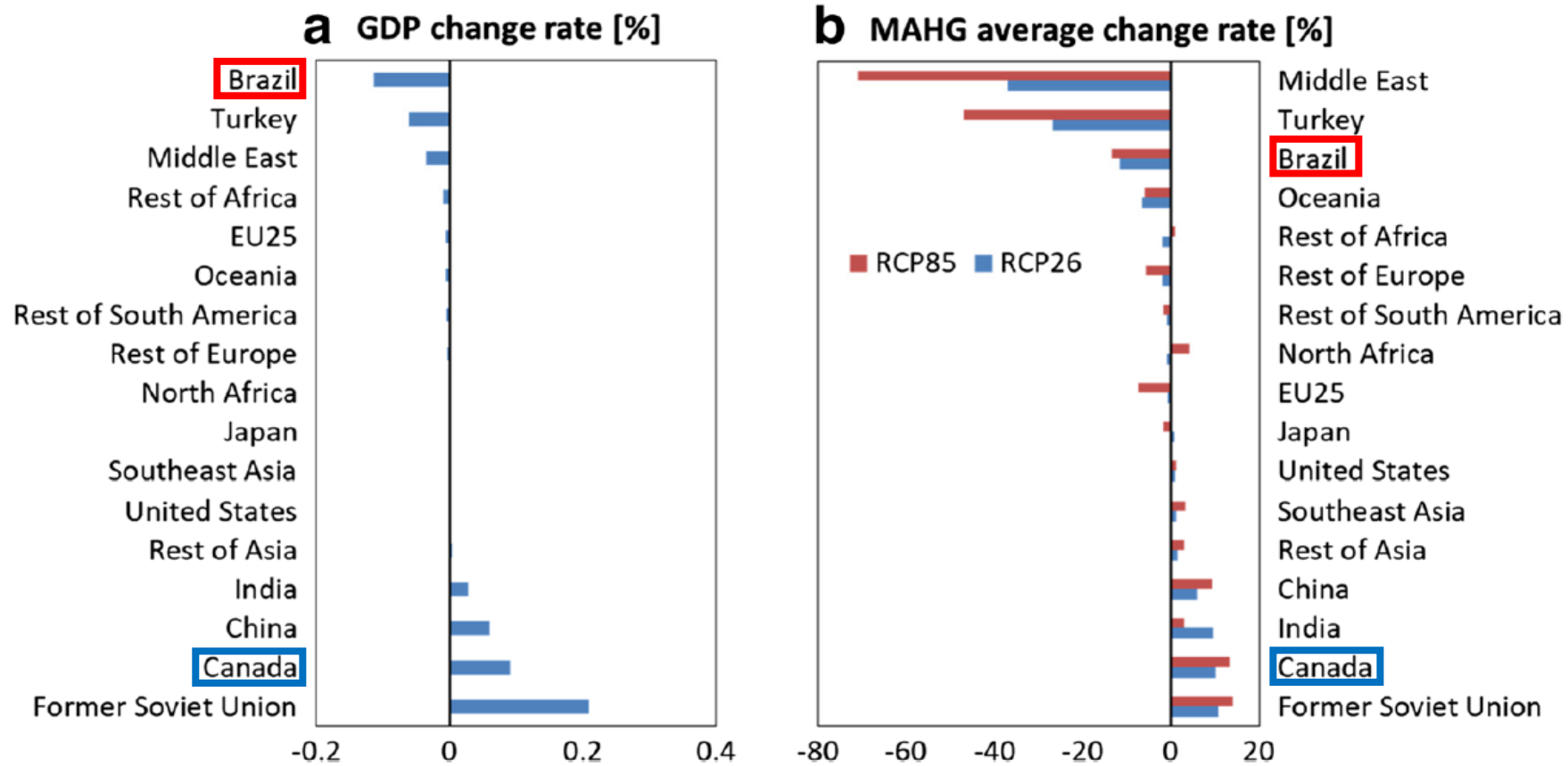


Ciscar et al. 2011, PNAS

No. This is typical magnitude for climatic change impacts on single sector.

# Discussion

Why global impact is so small?

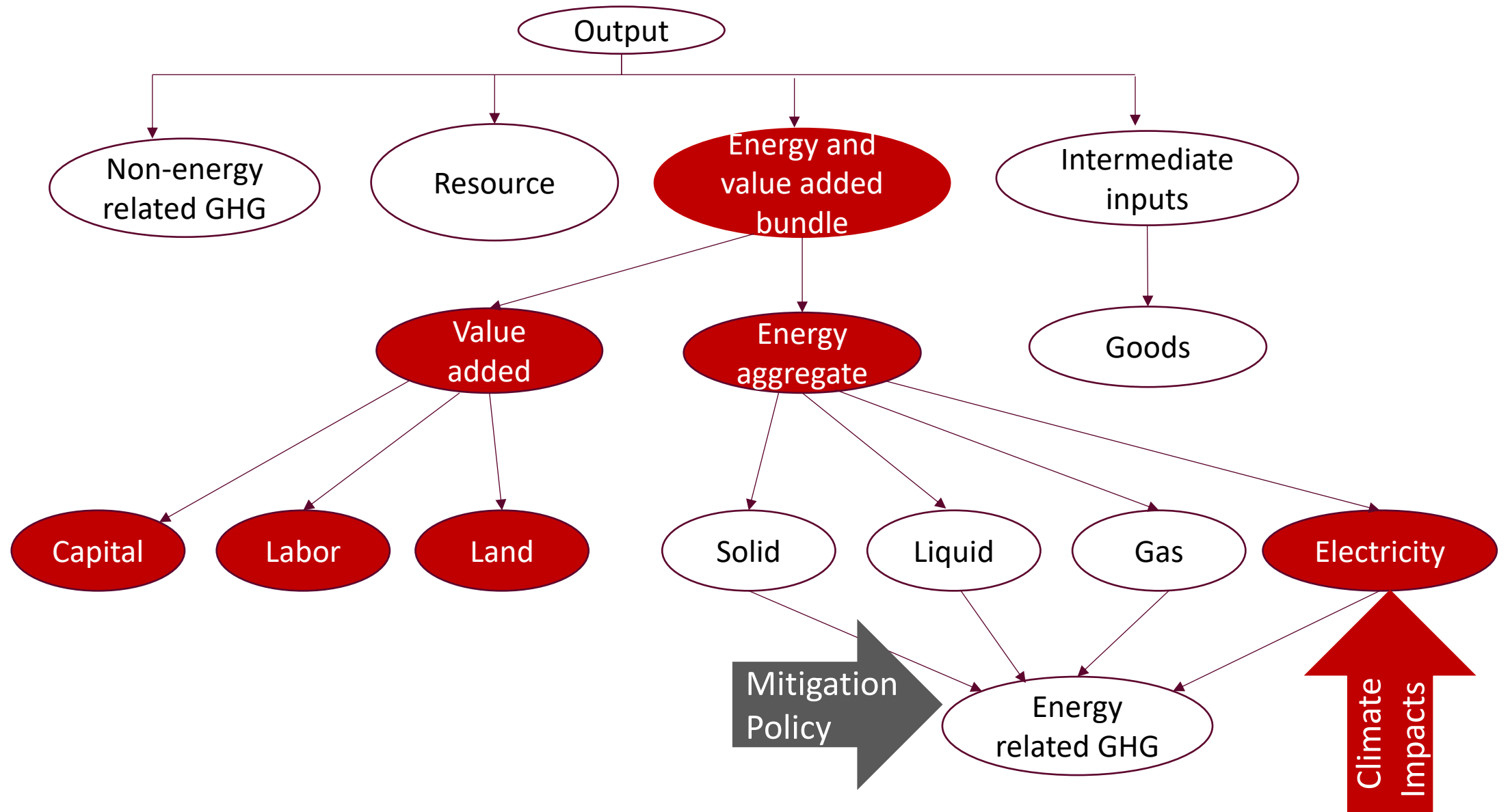


Positive and negative effects cancel out among regions.  
Positive/negative consequences are expected in several regions.

# Conclusions

- Water-energy nexus studies
  - Global hydrological model is a powerful tool for water energy nexus studies.
  - Coupling with energy-economic model further strengthens the capability.
- Climate change on hydropower
  - Problem is both physically and economically driven.
  - Two roles of mitigation policy: reduce climate impacts & promote hydropower
  - Challenges remain (e.g. maximum achievable hydropower generation)
- Other water-energy nexus topics
  - Economical consequence of thermoelectric cooling water insufficiency
  - Irrigation for bioenergy crop to achieve 2 degree target

# Input tree of AIM/CGE



# GDP change under no new hydropower development

