# Development of an impact function of global crop productivity for climate change policy support models

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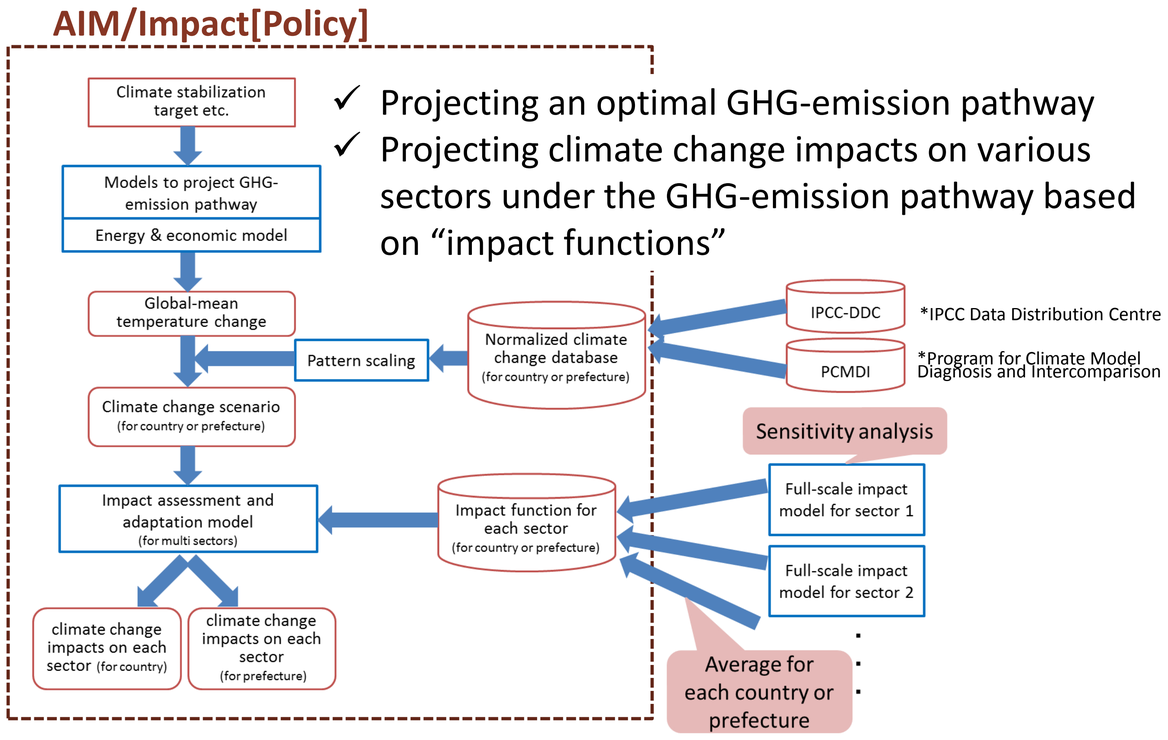
We developed impact functions for maize, wheat, and paddy-rice productivity with two explanatory variables, change in annual mean temperature (ΔT) and change in annual mean precipitation (ΔP), using the M-GAEZ model to utilize it in an integrated analyses tool named AIM/Impact[Policy]. According to the analysis of the impact functions, the level of ΔT and ΔP where a reduction in productivity becomes visible varies with both crops and countries. The impact functions enable us to derive the impacts on crop productivity in each country under various assumptions of ΔT and ΔP immediately, and it is useful to support policy decisions.

## Introduction

- Global warming will affect various sectors such as agriculture, water resources, etc. Decision-making on climate stabilization target and reduction pathway of greenhouse gases (GHG) emission is the international issue to be solved.
- For the purpose of supporting the decision-making based on integrated assessment of impacts on multiple sectors, an integrated analyses tool, AIM/Impact[Policy] (Hijioka et al., 2009) was developed.

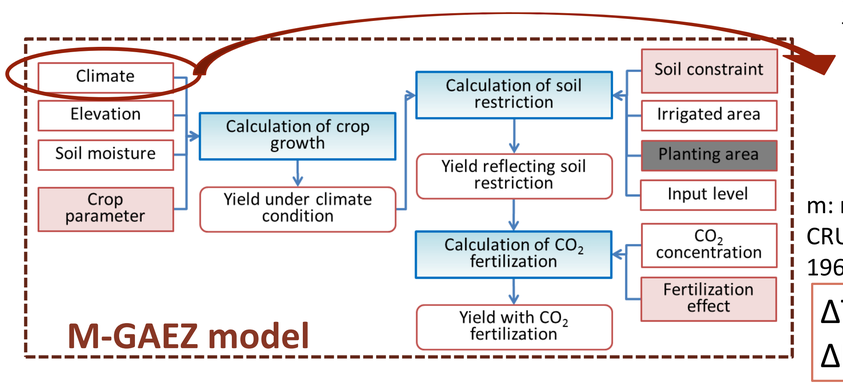



✓ Projecting an optimal GHG-emission pathway
✓ Projecting climate change impacts on various sectors under the GHG-emission pathway based on "impact functions"

- What is an impact function?
  - A look-up table of the country-averaged impacts on a certain sector under many arbitrary conditions of climate change
  - The look-up table is created based on a sensitivity analysis of the impact by running a full-scale impact model with varying key climatic variables.
  - The difference between the impact function and the outputs of original model needs to be grasped.
- The purpose of this study:
  - **To develop impact functions of global crop productivity for maize, wheat, and paddy-rice.**
  - **To examine how well the impact functions emulate the outputs of original full-scale model.**

## Methods —How to develop the impact functions—

- We conducted sensitivity analysis using the M-GAEZ model (Masutomi et al., 2009) with varying annual mean temperature and annual mean precipitation arbitrary.




Temperature (T):

$$T_{\mathrm{m}}^{AIP} = T_{196190,\mathrm{m}}^{CRU} + \Delta T$$

Precipitation (P):

$$P_{\mathrm{m}}^{AIP} = P_{196190,\mathrm{m}}^{CRU} \times \Delta P / 100$$

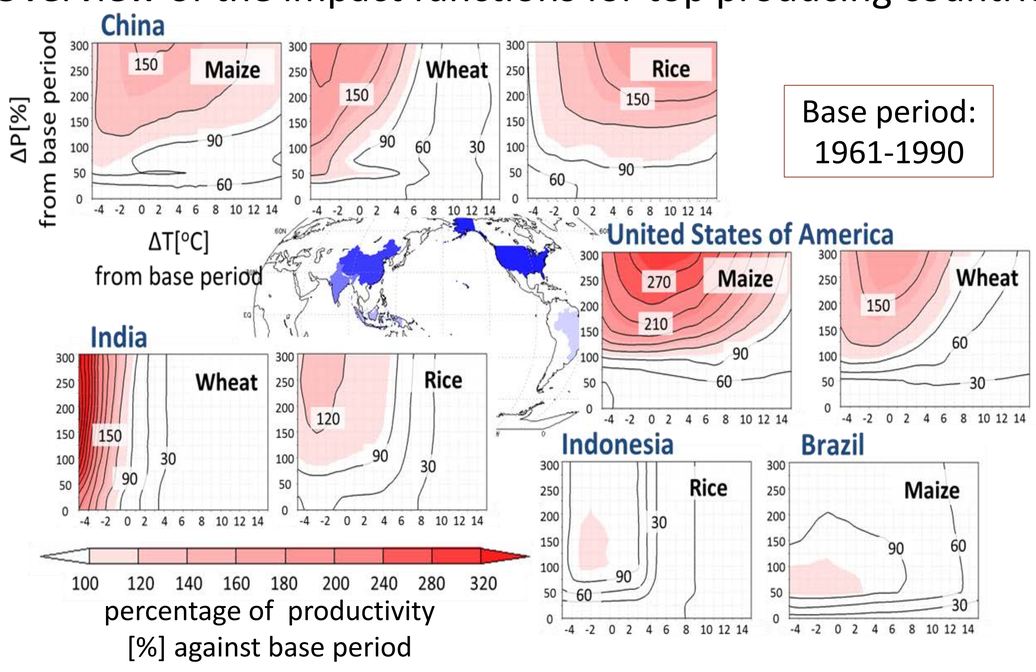
m: month AIP: Input for sensitivity analysis
CRU: Climate Research Unit (CRU)
196190: climatological mean for 1961-1990

ΔT: -5～+15°C (at 1°C interval)
ΔP: 0～300% (at 25% interval)

- Calculations for all varieties and for each planting date from Jan 1 to Dec 31 were done, and the maximum productivity[kg/ha] was selected on each grid-cell.
- In each case of the condition of ΔT and ΔP, we averaged the outputted productivity for each country.
  - To evaluate potential productivity in each country, we did not consider planting areas.

## Results

- Overview of the impact functions for top producing countries




- The sensitivity of crop productivity to the temperature and the precipitation differs by crops and countries.
- The level of ΔT and ΔP where a reduction in productivity becomes visible varies with both crops and countries.

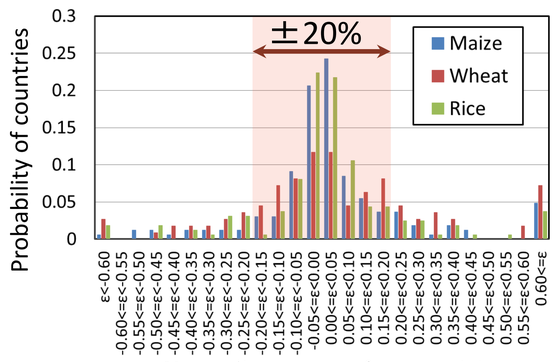
America:
- The productivity of maize and wheat increases with the increase in precipitation, and it decreases with the increase in temperature.

China:
- For maize and wheat, the productivity increases with the increase in precipitation, and it decreases with the increase in temperature.
- For rice, the productivity does not change with the increase in temperature.

India:
- Wheat hardly grows when the annual mean temperature increases by 4°C or more.

Indonesia (rice) & Brazil (maize):
- In most of the cases, the productivity decreases.

- How well do the impact functions emulate the original model?




*During 2061-2090 under RCP8.5 scenario by MIROC5 model

- We compared the following input cases of M-GAEZ model, using a specific climate prediction*:
  - A) Annual average & country-averaged T and P (corresponds to the impact function)
  - B) Monthly & gridded T and P (corresponds to the original M-GAEZ model)
- The percentage of countries whose error is within ±20% is 77.6%, 62.2%, and 75.8% for maize, wheat, and rice, respectively. As for wheat, 75.7% is within the error of ±30%.

## Conclusions

- We developed impact functions for maize, wheat, and paddy-rice productivity. The impact functions emulate the outputs of original model with an error of about ±20% for maize and rice, and with an error of about ±30% for wheat.
- As shown above, the impact functions enable us to derive the impacts on crop productivity under various assumptions of ΔT and ΔP immediately, and it is useful to support policy decisions.