Impact Assessment of Climate Change on Rice Production in Asia in Comprehensive Consideration of Uncertainties in Future Climate projections

Yuji Masutomi [1],
Kiyoshi Takahashi [2],
Hideo Harasawa [2],
and Yuzuru Matsuoka [3]

1): Center for Environmental Science in Saitama
2): National Institute for Environmental Studies
3): Kyoto University

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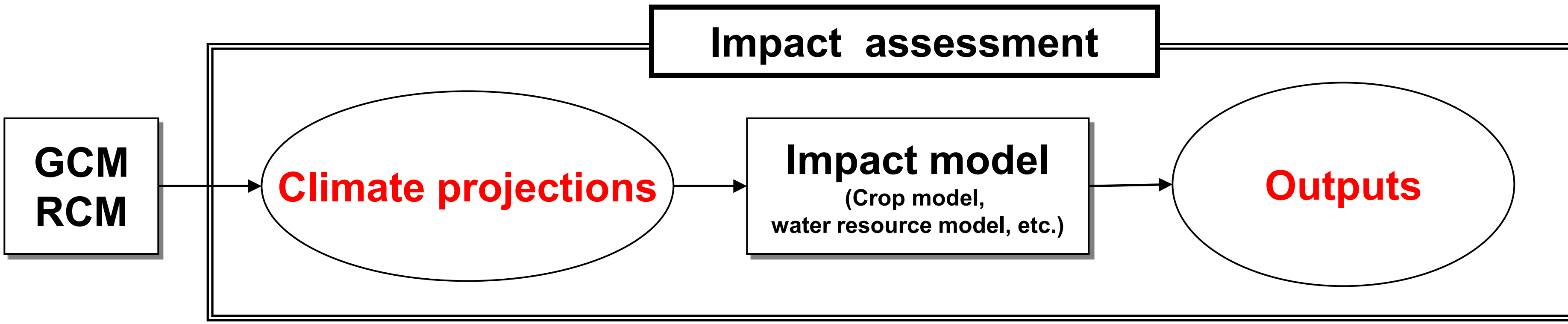
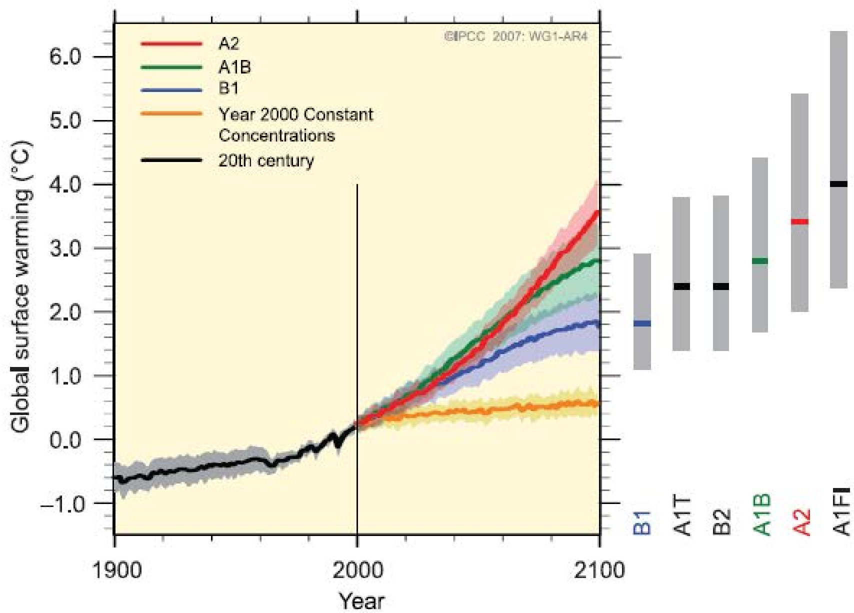
- Part II
  - Adaptation policy assessment

Part I

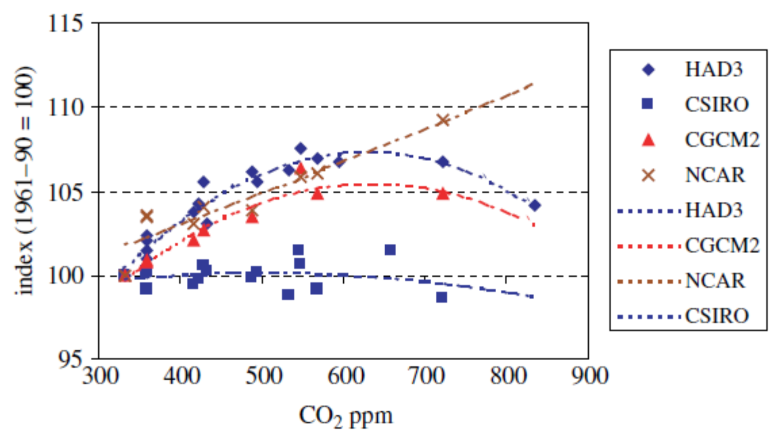
Impact assessment

Introduction I
-Uncertainties in impact assessment-





(IPCC AR4)

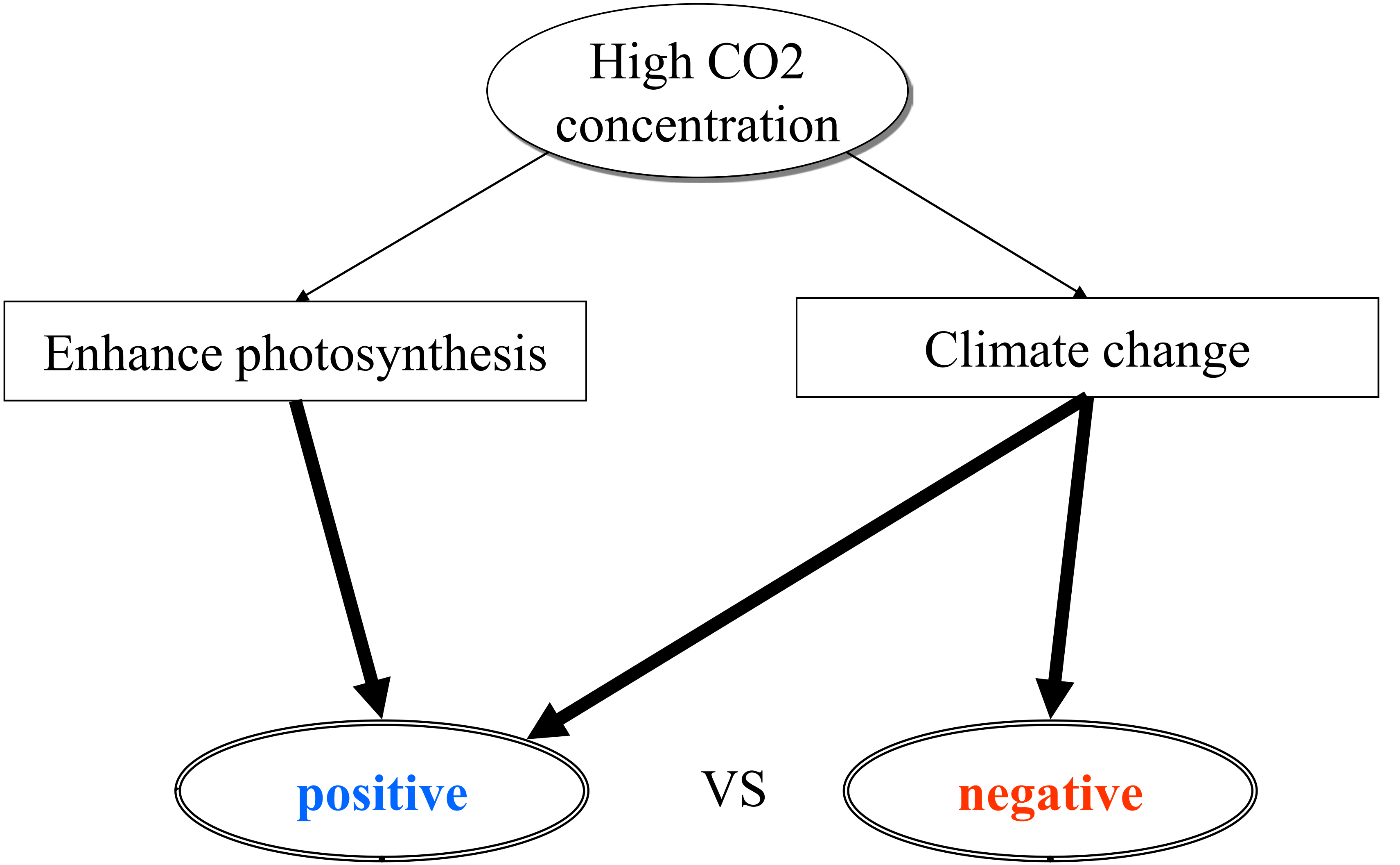


(Ficsher et al., (2005))

1st Key Question

- How much impact does climate change have in comprehensive consideration of uncertainty in future climate projections?

Introduction II
- CO2 fertilization effect -

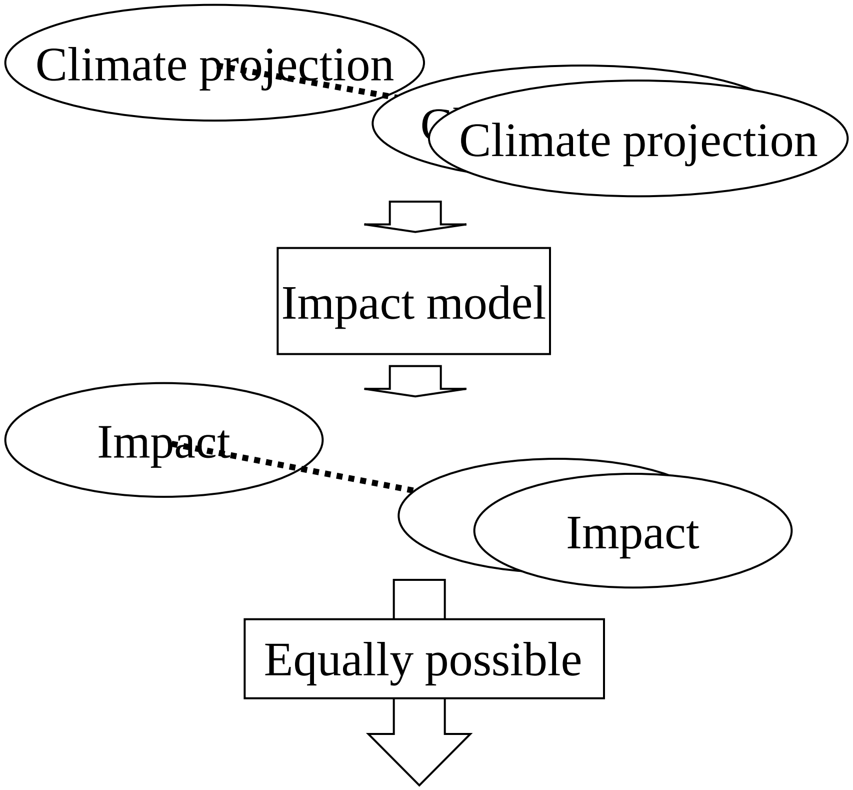


2nd Key Question

- Is net effect of elevated CO_2 concentration positive or negative?
  - In the 2020s, 2050s, and 2080s

Method

- How to take uncertainties into consideration?-



1. Average
2. Standard deviation
3. Probabilities

- Step1
  - Calculation of multi-impacts by using multi-climate projections
- Step2
  - Assuming that each impact is equally possible, we calculate statistical metrics.

Ex. -5%, 5%, -15%,-10%,9%

Ave. = [-5+5+(-15)+(-10)+9]/ 5
= -3.2 [%]

Stdev. = 10 [%]

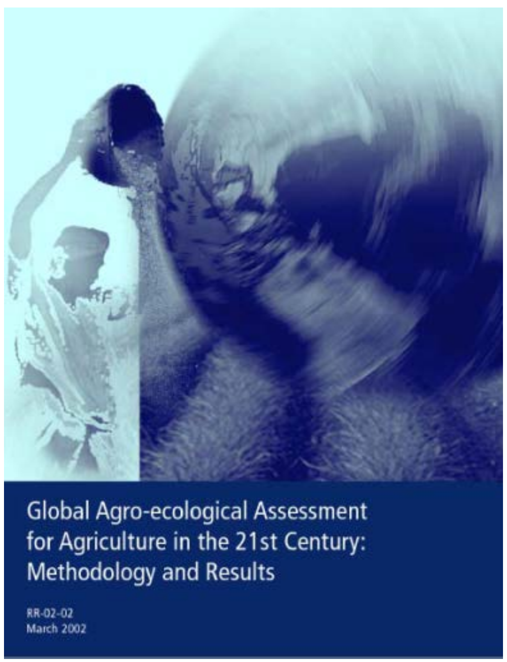
Pr. of yield decrease = 60 [%]

Climate projections (from PCMDI)

Country	Model name	A1B (18 GCMs)	A2 (14 GCMs)	B1 (17 GCMs)
Norway	BCCR-BCM2.0		○	○
Canada	CGCM3.1(T47)	○	○	○
Canada	CGCM3.1(T63)	○		○
France	CNRM-CM3	○	○	○
Germany	ECHAM5/MPI-OM	○	○	○
Germany / Korea	ECHO-G	○	○	○
China	FGOALS-g1.0	○		○
USA	GFDL-CM2.0	○	○	○
USA	GFDL-CM2.1	○	○	○
USA	GISS-AOM	○		○
USA	GISS-EH	○		
USA	GISS-ER	○	○	○
Russia	INM-CM3.0	○	○	○
France	IPSL-CM4	○	○	○
Japan	MIROC3.2(hires)	○		○
Japan	MIROC3.2(medres)	○	○	○
Japan	MRI-CGCM2.3.2	○	○	○
UK	UKMO-HadCM3	○	○	○
UK	UKMO-HadGEM1	○	○	

Crop model

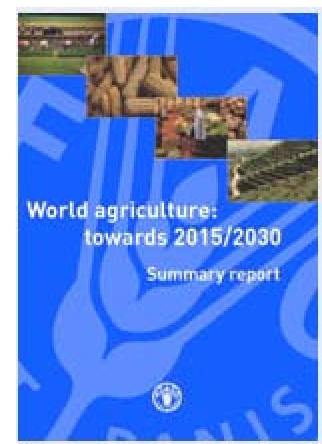
- M-GAEZ model
  - Based on **Global Agro-Ecological Zone model (GAEZ-model)**
    - **GAEZ-model** was Developed by IIASA and FAO (Fischer et al., 2002)
      - was used for the assessment of global food security in IPCC AR4.
      - is one of main tools used by FAO for analyses of land resources



Manual of GAEZ

Reference	2020 Millions at risk AEZ-BLS	2020 Millions at risk DSSAT-BLS	2050 Millions at risk AEZ-BLS	2050 Millions at risk DSSAT-BLS	2080 Millions at risk AEZ-BLS	2080 Millions at risk DSSAT-BLS
A1	663	663	208	208	108	108
A2	782	782	721	721	768	769
B1	749	749	239	240	91	90
B2	630	630	348	348	233	233

Number of hunger (IPCC AR4)



FAO report

M-GAEZ methodology

Actual Yield = **Potential Yield** × **Water stress** × **Agro -climatic stress** × **Soil stress**

Potential Yield : Yield limited by Temperature and Radiation
Photosynthesis (T,R) – Respiration (T)

Water stress : Multiplier determined by soil water stress

Agro -climatic stress : Multiplier related to constraints by insect, pest, weed, etc.

Ex. Yearly warm region has high agro-climatic stress.

Soil stress : Crop can not grow in rock and sandy region

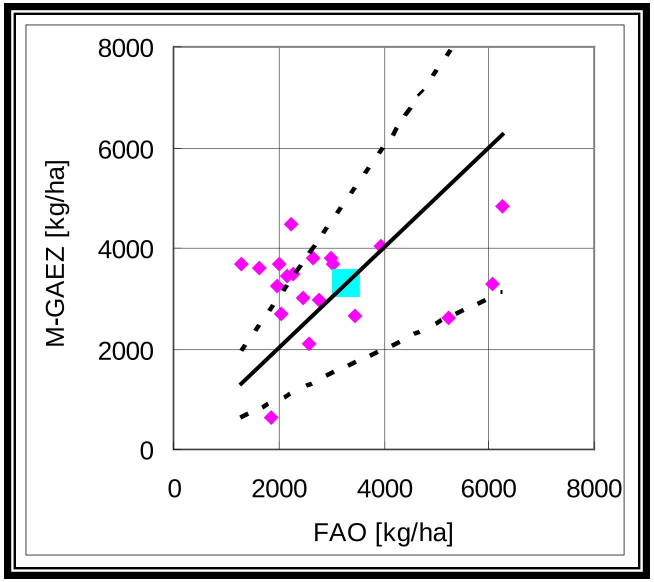
Advantages and Disadvantages of M-GAEZ model

- Advantages
  - Multi-crops: 26 crops (154 sub-species)
  - Soil water balance (FAO56 methodology)
    - crop water demand can be calculated.
  - Constraints by pest, insect, weed are considered
    - But poor!
- Disadvantages
  - Old type process model (or semi-process model)
    - Based on 1970s’ knowledge
  - No soil nutrient dynamics (no fertilizer effect)

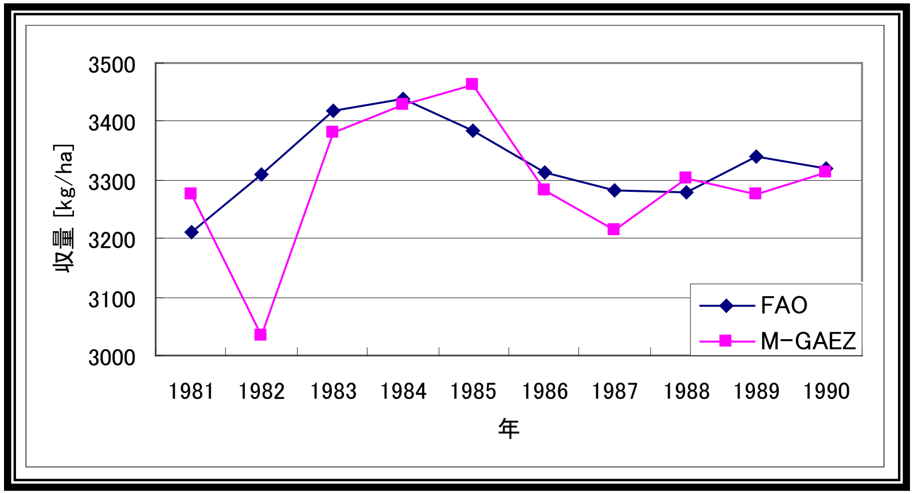
Validation of M-GAEZ

Comparison of yields between simulation and observation

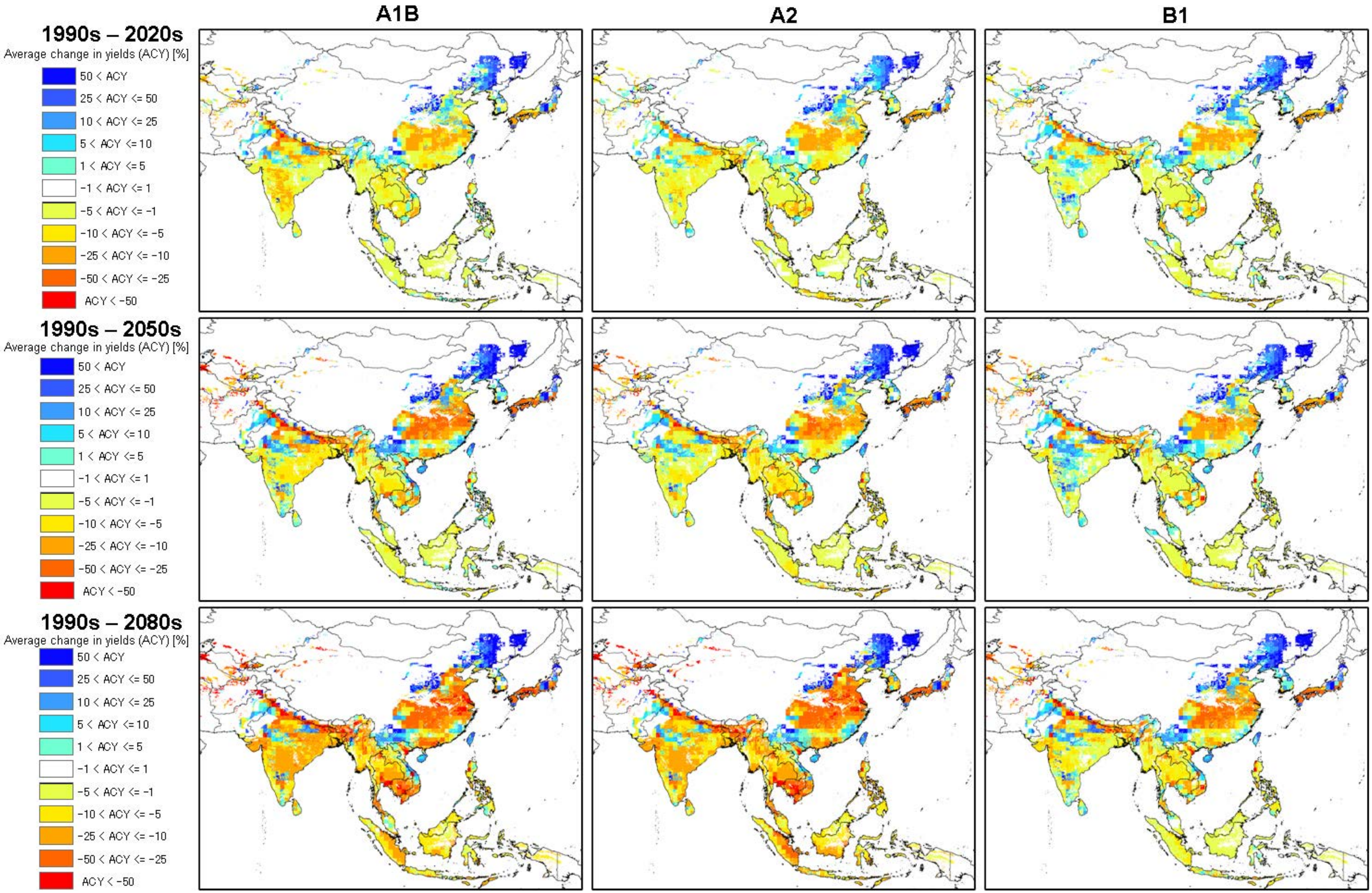
Average yields for 1980s by Asian countries



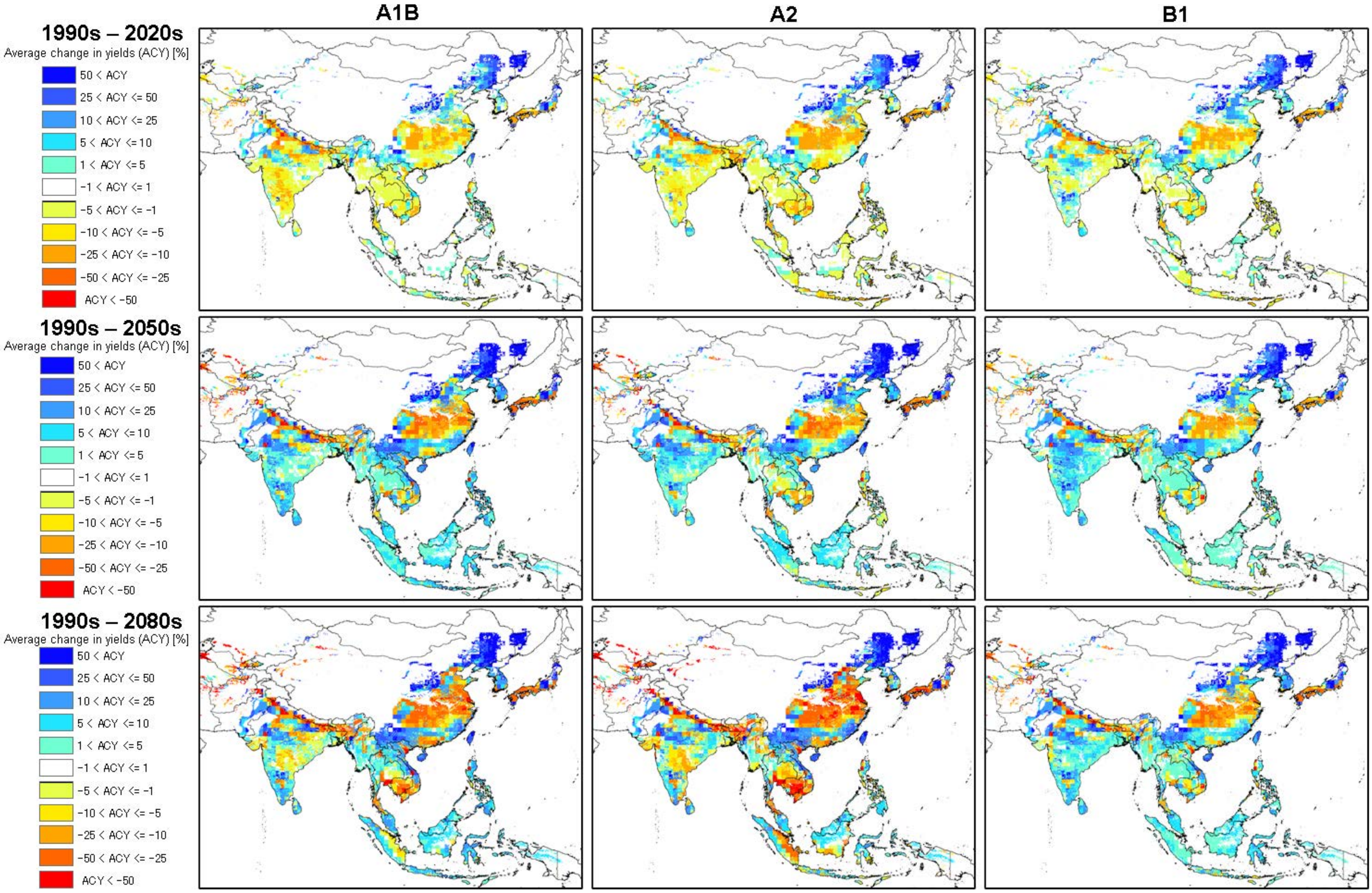
Yearly variability in yields in 1980s in Asia



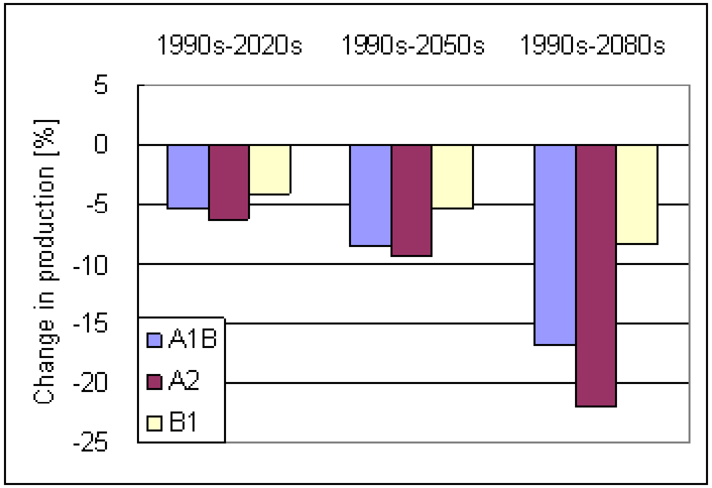
Result I - without CO2 fertilization effect -



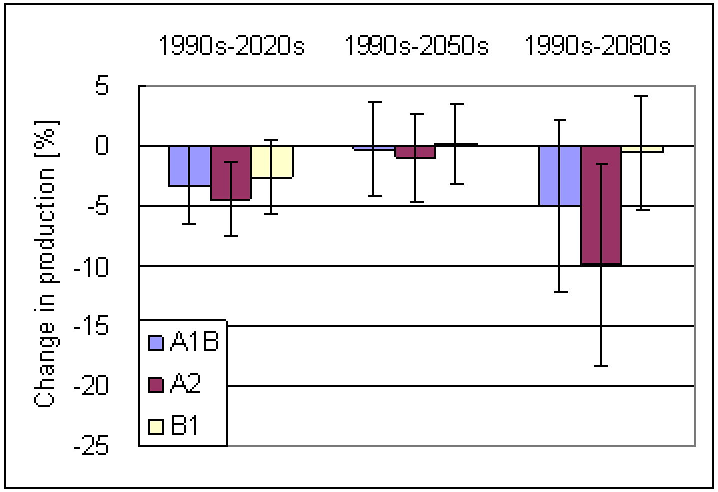
Result II - with CO2 fertilization effect -



Result III



without CO2 fertilization effect



with CO2 fertilization effect

	1990s-2020s			1990s-2050s			1990s-2080s		
	A1B	A2	B1	A1B	A2	B1	A1B	A2	B1
ACP without CO_2 effect	-5.2	-6.3	-4.2	-8.6	-9.4	-5.4	-16.8	-22.0	-8.4
ACP	-3.3	-4.5	-2.5	-0.3	-0.9	0.2	-5.0	-9.9	-0.5
SDCP	3.2	3.2	3.1	3.9	3.7	3.3	7.2	8.4	4.8
Pr(*CP*<0)	83.3	100.0	76.5	44.4	57.1	52.9	72.2	85.7	47.1

- In the 2020s
  - Little difference in average changes in production (*ACP*s) among SRES scenarios
  - The probabilities of production decrease (Pr(*CP*<0)) are high for all SRES scenarios
- In the 2050s
  - Positive and negative effects are in equilibrium
- In the 2080s
  - Large difference in *ACP*s and Pr(*CP*<0))s among SRES scenarios.
    - A2 has largest adverse effect although A2 has the largest CO2 fertilization effect

Summary of the Part I

- **Key questions**
  - How much impact does climate change have in comprehensive consideration of future climate projections?
  - Is net effect of elevated CO_2 concentration positive or negative?
- **Our answer**
  - Net effect of elevated CO_2 concentration in comprehensive consideration of future climate projections is negative in the 2020s and 2080s, and nearly zero in the 2050s.
- **Suggestions**
  - **It is necessary to take immediate adaptive actions in the near future, regardless of socio-economic development.**
    - Because the probabilities of production decrease are high for all SRES scenarios in the 2020s
  - **The reduction of CO_2 emission in the long term has a large potential to mitigate negative changes.**
    - Large difference in change in production among SRES scenarios in the 2080s
    - High CO_2 concentration scenario, A2, has largest adverse effect in the 2080s, while low CO_2 concentration scenario, B1, has smallest adverse effect in the 2080s.

Part II

Adaptation policy assessment

Introduction
- Mitigation and adaptation policy

Characteristics of mitigation and adaptation

	Mitigation of climate change	**Adaptation** to climate change
Benefited systems	All systems	Selected systems
Scale of effect	Global	Local to regional
Life time	Centuries	Years to centuries
Lead time	Decades	Immediate to decades
Effectiveness	Certain	Generally less certain
Ancillary benefits	Sometimes	Mostly
Polluter pays	Typically yes	Not necessarily
Payer benefits	Only little	Almost fully
Monitoring	Relatively easy	More difficult

Fussel and Klein (2006)

Adaptation policies are only actions against the near future impacts

3rd Key Question

- How much can adaptation policies reduce the impacts of climate change in the near future?

or

- Which adaptation policies are effective?

Method

- Quantification of effectiveness of adaptive actions-

- Risk of decrease in yields: R

$$R = \Sigma \text{impact} \times \text{Probability}$$

※only negative impacts are summed

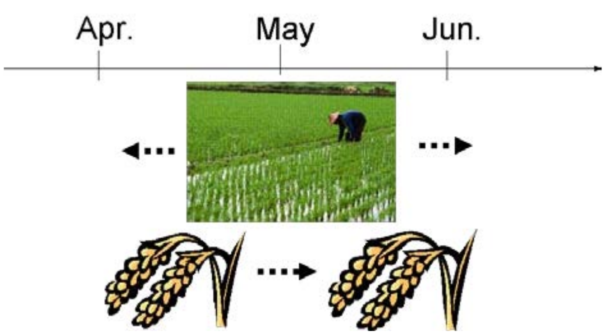
- Effect of adaptive action A: E_A

$$E_A = (R_A/R_0)*100$$

R_A: R with adaptive action A

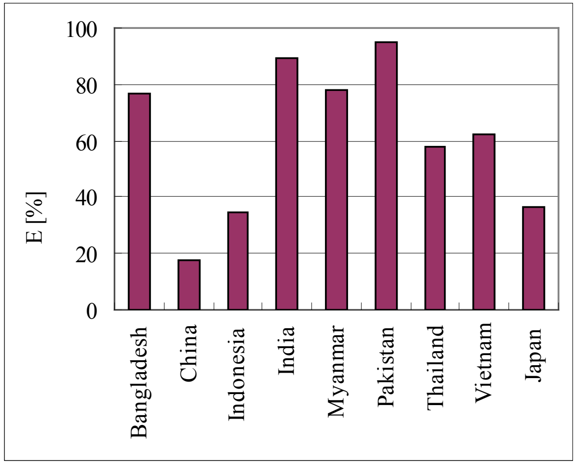
R_0: R with no adaptive action

Adaptive actions

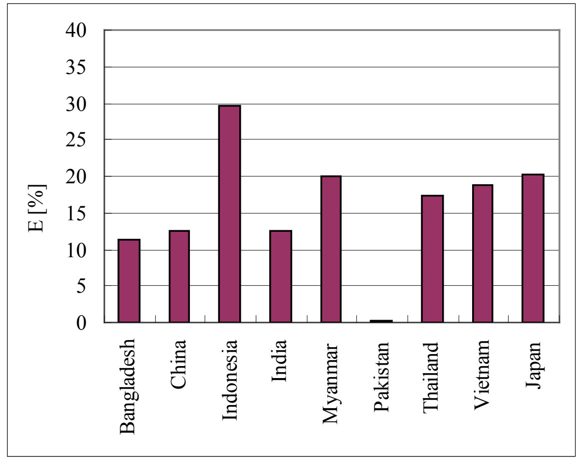


- 1: Changes in crop variety and planting date
  - Changes to suitable crop variety and planting date for future climate condition
  - Autonomous adaptation
- 2: Expanding irrigated area
  - Changes from rain-fed to irrigated area
  - Stable water enough for crop growing are supplied in irrigated area
  - Planed adaptation
- 3: Expanding crop area
  - Changes to rice fields from other land uses.
  - Planed adaptation

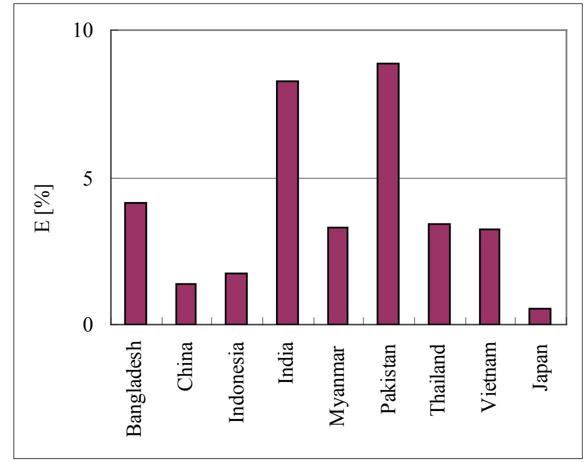
Result I



Changes in varieties and planting date



Rice fields expansion (+1%)



Irrigated area expansion (+1%)

- There is large difference in effects of adaptive actions among countries.
- Changes in varieties and planting date have high effect for most countries.
- Irrigated area expansion has high effect in India and Pakistan

Summary in Part II

- **Key questions**
  - How much do adaptation policies reduce the impacts of climate change in the near future?
  - Which adaptation policies are effective?

- **Our answer**
  - There is large difference in effects of adaptive actions among countries.
  - Changes in varieties and planting date have high effect for most countries.

- Suggestions
  - Adaptive actions suitable for each countries should be taken

Thank you for your attention!!