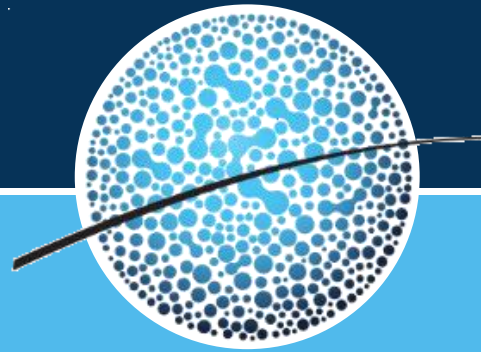


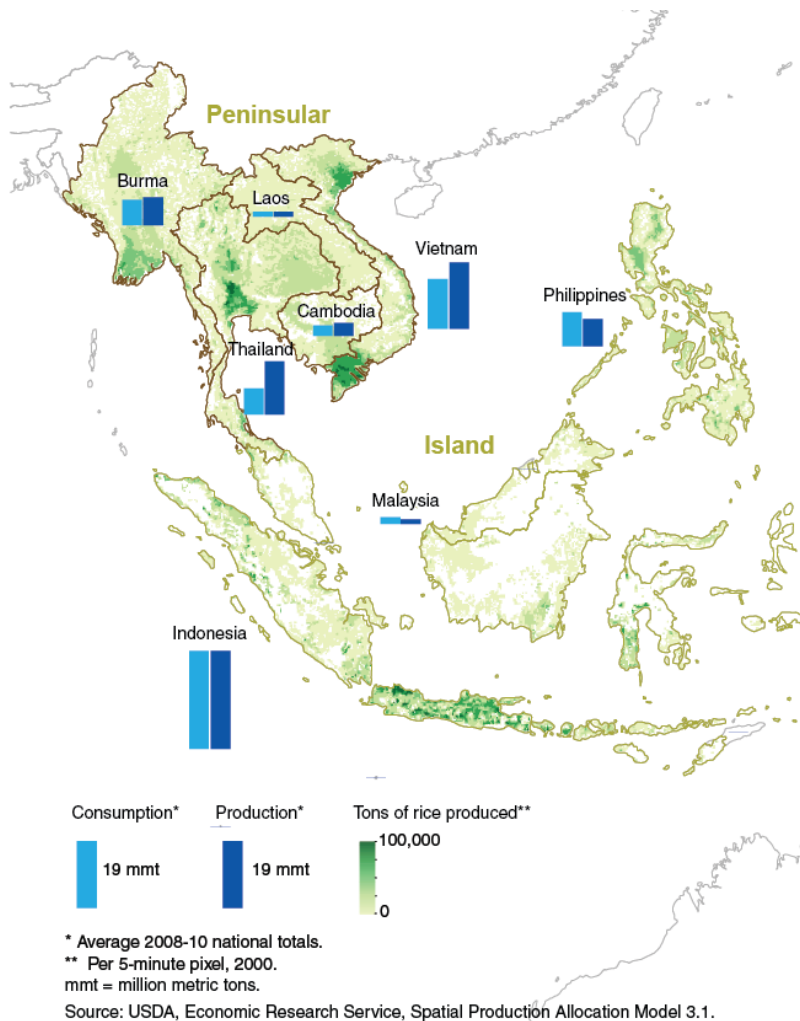
# Food Security Enhancement in Southeast Asia under Climate Change through Multi-Scale Crop Modeling

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APEC Climate Center, Korea



# Introduction

# Southeast Asia



## ● Southeast Asia

- One of the regions deemed particularly vulnerable to climate change
- Already being affected by climate change

## ● Rice is one of the most important staple food crop in Southeast Asia

- Approx. 557 million people (IRRI, 2006; Manzanilla et al., 2011)
- The adverse impacts of climate change on rice production systems have been increasing.

## ● The possible impacts of climate change on rice production in Asian countries have been assessed through a number of modeling studies.



# Multi-scale Modeling Approach

- **Global- or regional scale crop models**

- M-GAEZ (Global Agro-Ecological Zones) model, GLAM (General Large-Area Model)
- Typically do **not provide detailed management information** that can be assessed for **potential adaptation strategies** to reduce the adverse impacts of climate change

- **Field-scale crop models**

- CERES-Rice, ORYZA2000
- Large regions: by aggregating simulation results for each grid cell
- **Not all inputs** (detailed planting and harvest dates, cultivars, fertilizer management techniques, and soil properties) **are available** to run the model

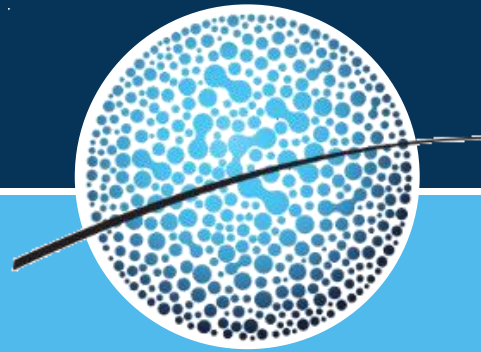
- **Diversity of needs in various stakeholders**

- **Farmers** may be **more interested in agricultural management practices** at the field level
- **Governmental departments** are more likely to be interested in **national policy or planning**



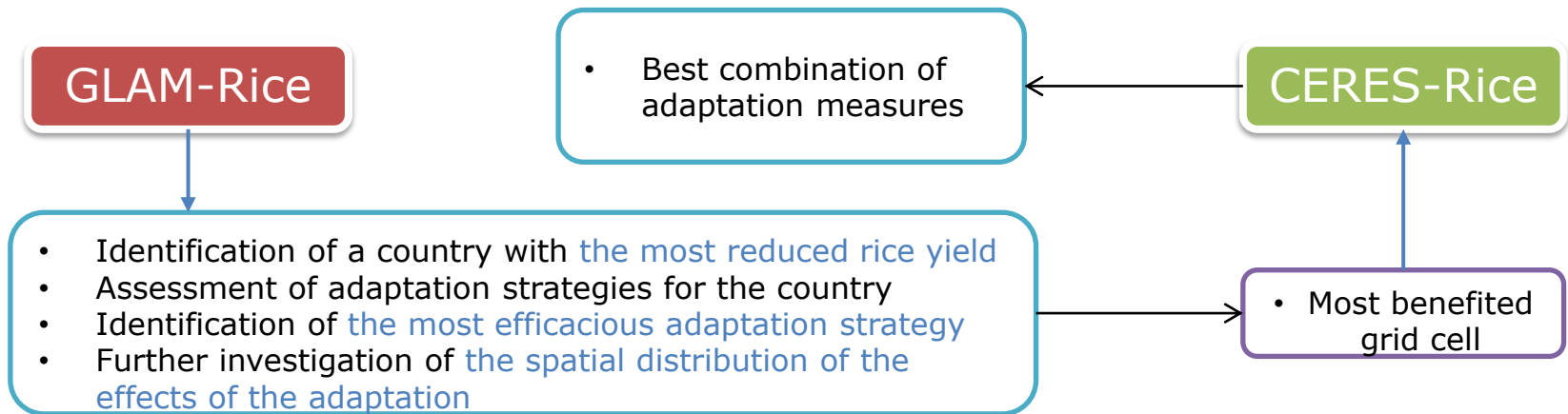
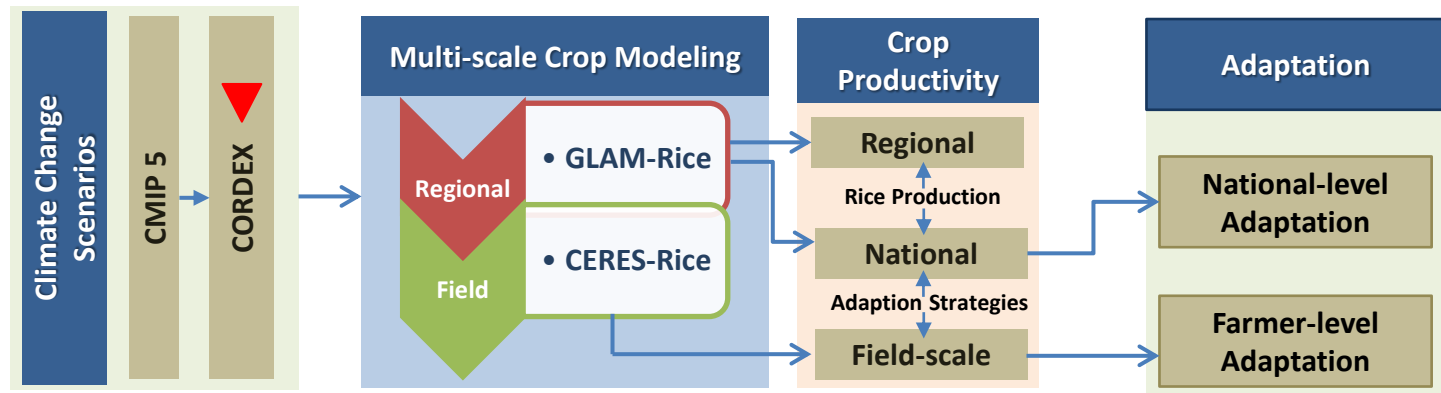
# Objectives

- **We proposed a multi-scale crop modeling approach**
  - By combining the advantages from each scale model to develop effective adaptation strategies to climate change
- **Using the proposed multi-scale crop modeling approach**
  - To assess the impacts of climate change on rice yields in Southeast Asia
  - To make recommendations for national- and farmer-level adaptation strategies appropriate to different stakeholders, such as farmers and governments

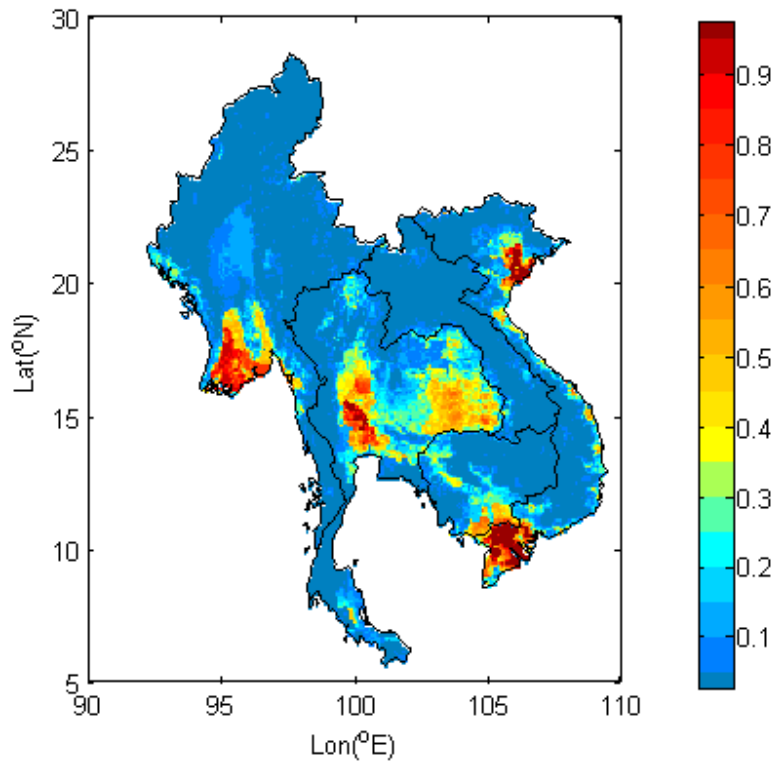


# Materials and Methods

# General Research Strategy: Multi-stage Research Approach



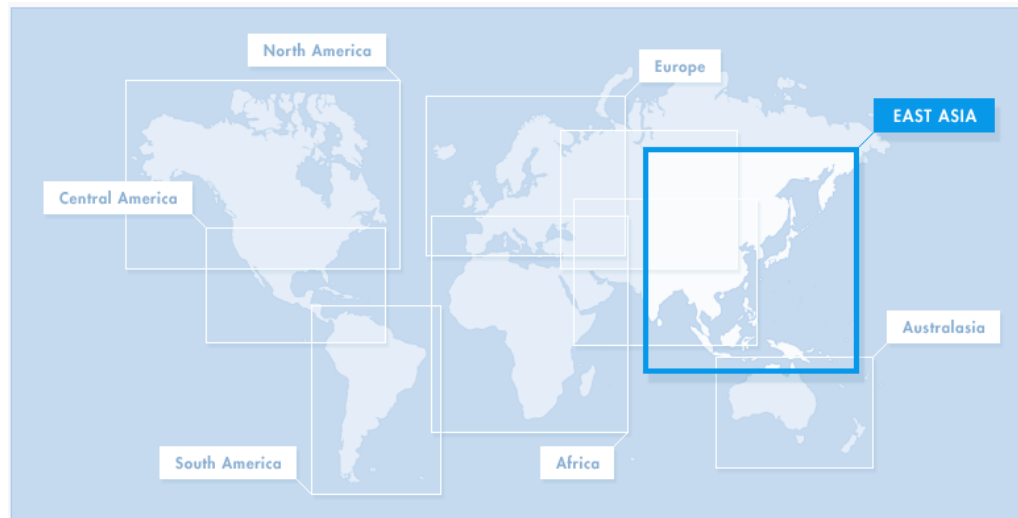
# Site Description



The average fractional proportion of a 5-min by 5-min (approximately 10km by 10km) latitude/longitude grid where rice crop was harvested from 1997 to 2003 (Source: Monfreda et al., 2008)

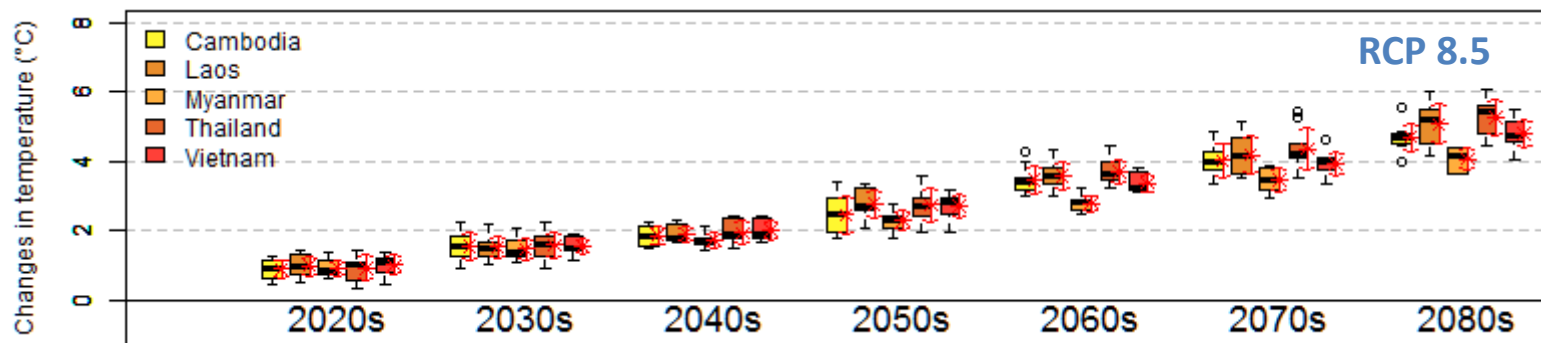
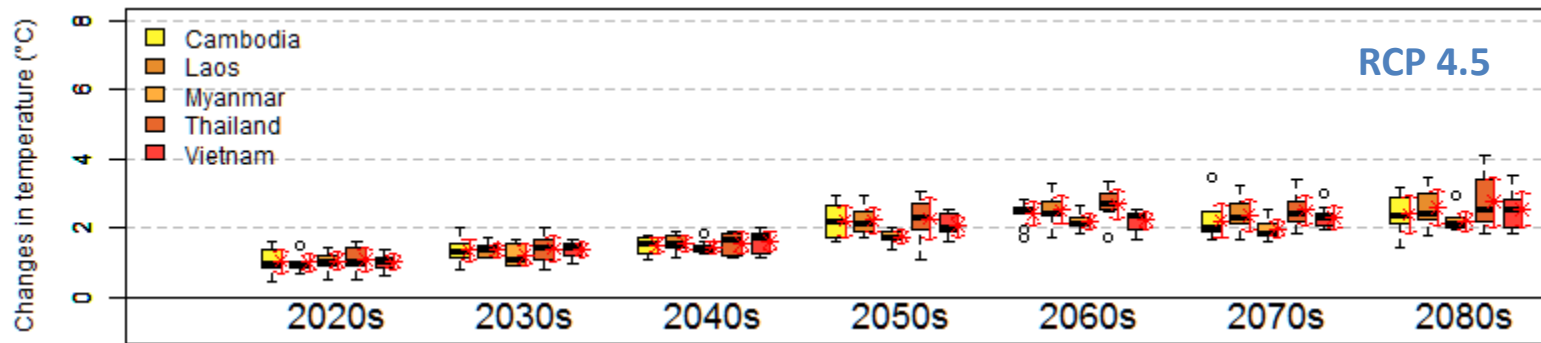
- **Cambodia, Laos, Myanmar, Thailand, and Vietnam**
- **Located between 90–110°E and 5–30°N**
- **Agriculture is one of the most important sectors in these economies**
  - Accounting for 31% of the GDP in Cambodia, 39% in Laos, 48% in Myanmar, 10% in Thailand, and 20% in Vietnam (WBD, 2005)
  - All five economies were listed among the world's 20 greatest rice producing countries in 2013
  - Vietnam, Thailand, and Myanmar ranked consecutively as the 5th to 7th (FAO, n.d.)
  - Rice is cultivated on over 50% of the agricultural land in each country in the region, except for Myanmar (where rice is cultivated on approximately 45% of agricultural land)

# Data Collection-Climate change scenario data



- CORDEX-East Asia (<https://cordex-ea.climate.go.kr/main/aboutCordexPage.do>)
  - **C**oordinated **R**egional climate **D**ownscaling **E**Xperiment
  - East-Asian branch of the CORDEX initiative)
- 3RCMs: YSU-RSM (up to 2050), RegCM4 (up to 2050), and HadGEM3-RA (up to 2100)
- Two emission scenarios: RCP 4.5 and RCP 8.5
- $0.44^\circ \times 0.44^\circ$
- Baseline period (1991-2000)

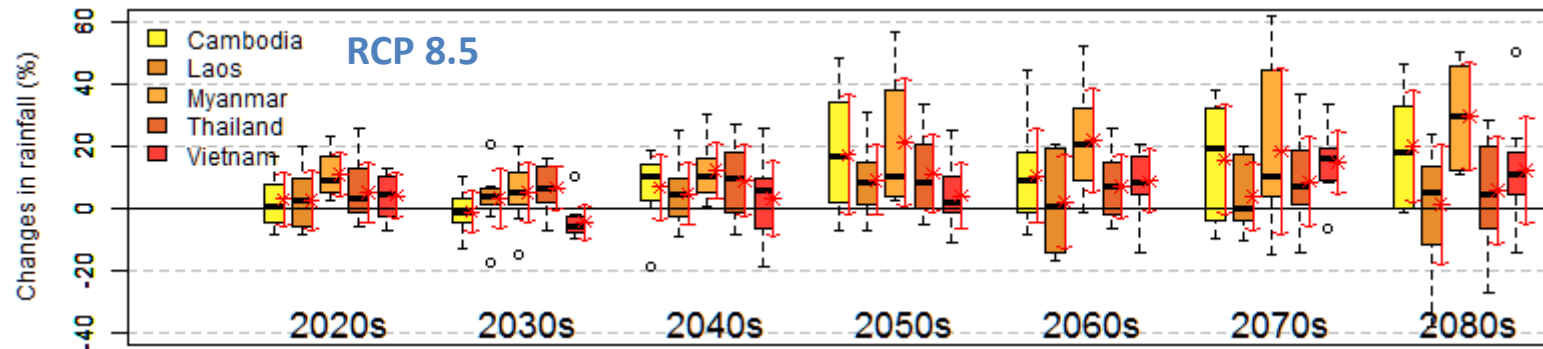
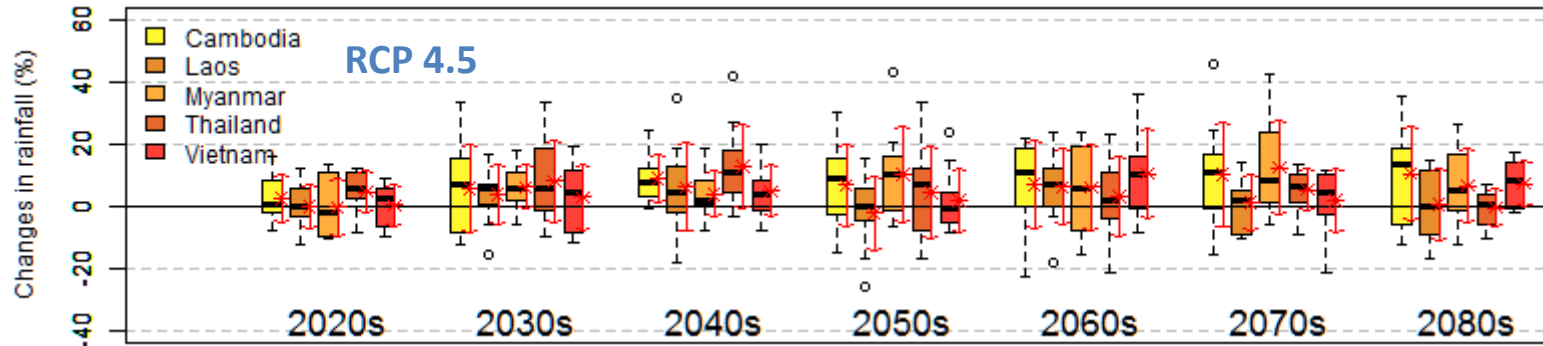
# Changes in Temperature Relative to the Baseline Period (1991-2000) for the Five Countries



A clear warming trend in temperature

Higher warming trend under RCP 8.5

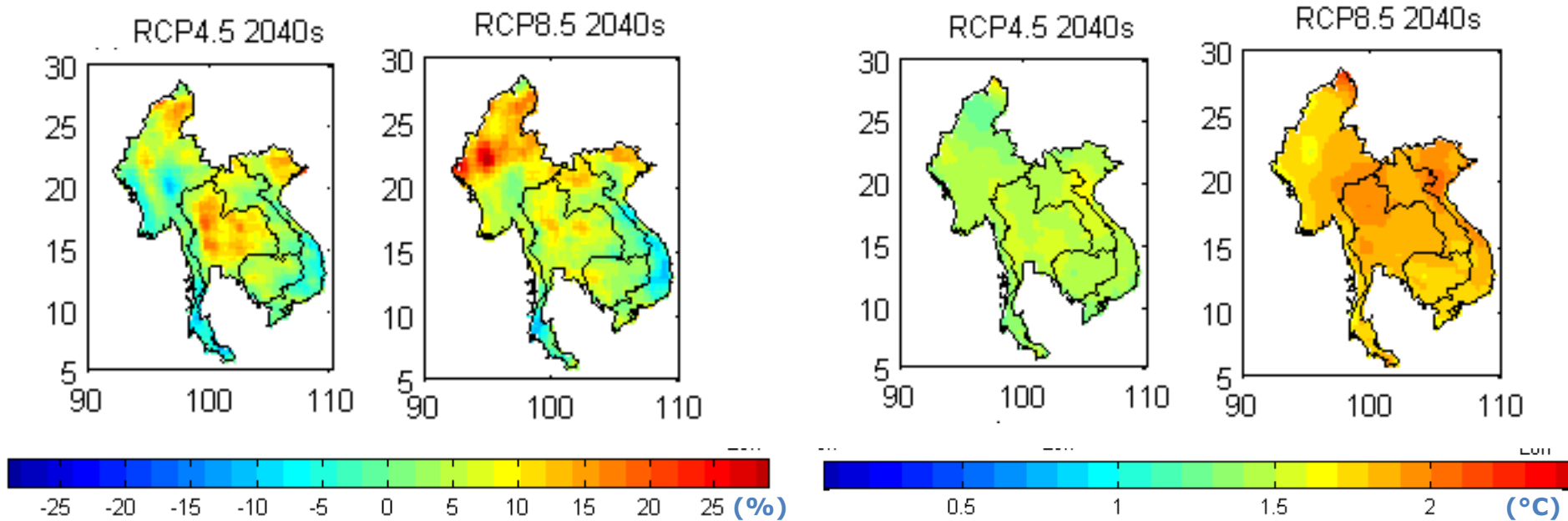
# Changes in Precipitation Relative to the Baseline Period (1991-2000) for the Five Countries



No clear trend in the change in precipitation

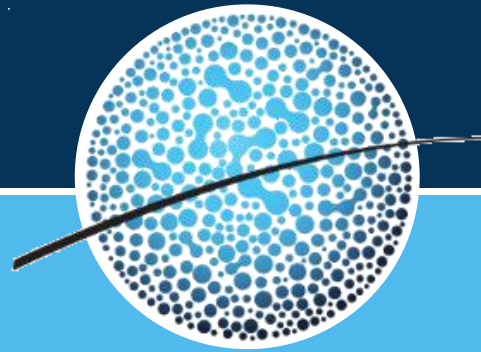
Higher variability in precipitation under RCP 8.5

# Changes in Total Growing Season Rainfall(%) and Mean Growing Season Temperature (°C)

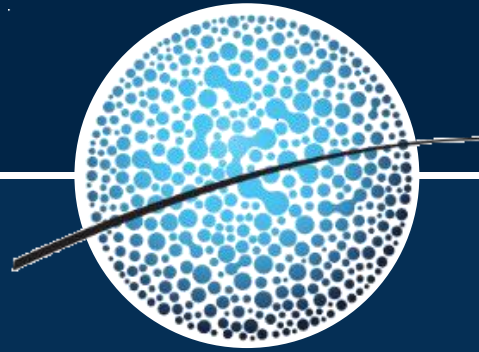


- The RCP8.5 scenario predicted a slightly greater increase in rainfall (5-15%) than that for the RCP4.5 scenario (0-5%)
- The largest increase in rainfall is found in the north of Vietnam, Thailand and northwest of Myanmar

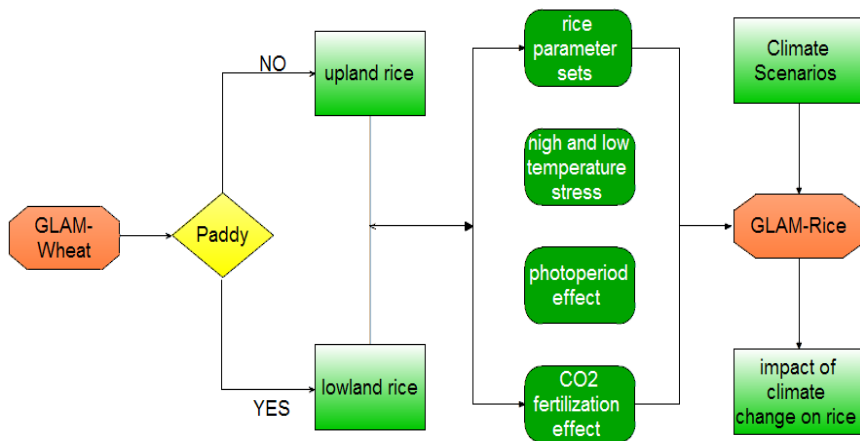
- The largest temperature increase is in Thailand and Vietnam
- The lowest rise in temperature is in the northwest of Myanmar for the RCP8.5 scenario



# Results and Discussion

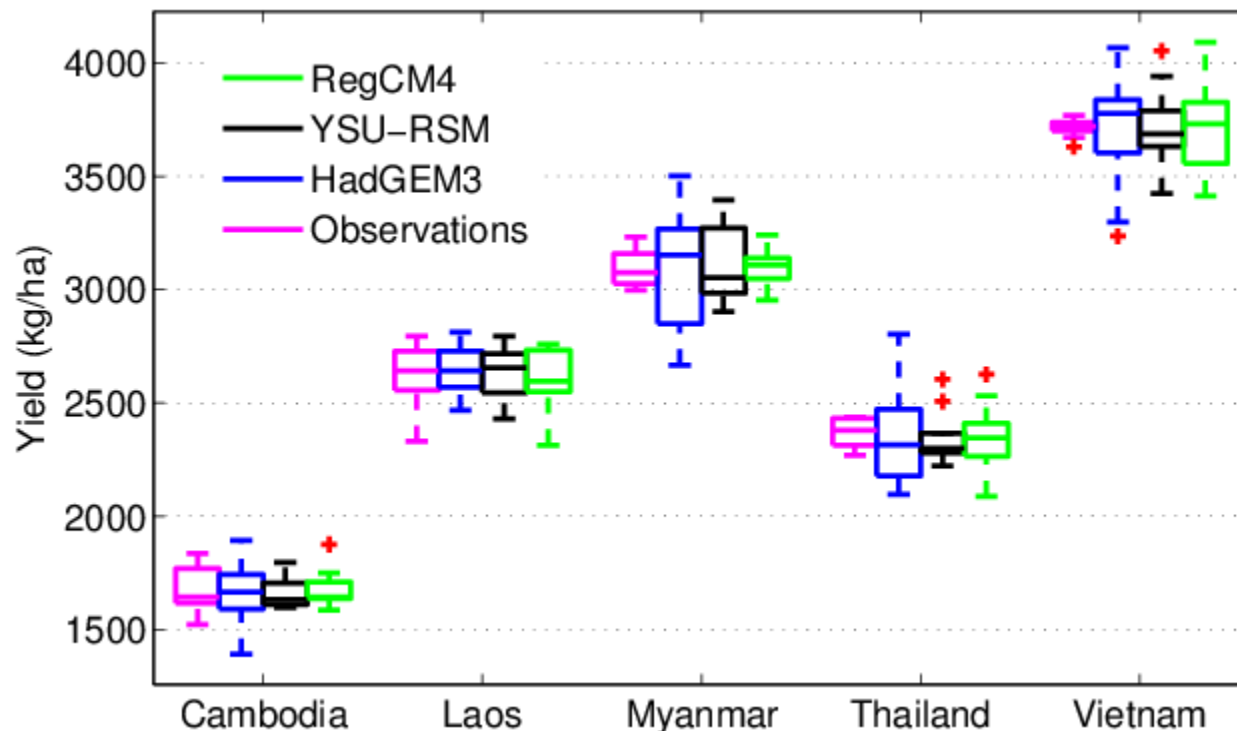


# National-level Adaptations



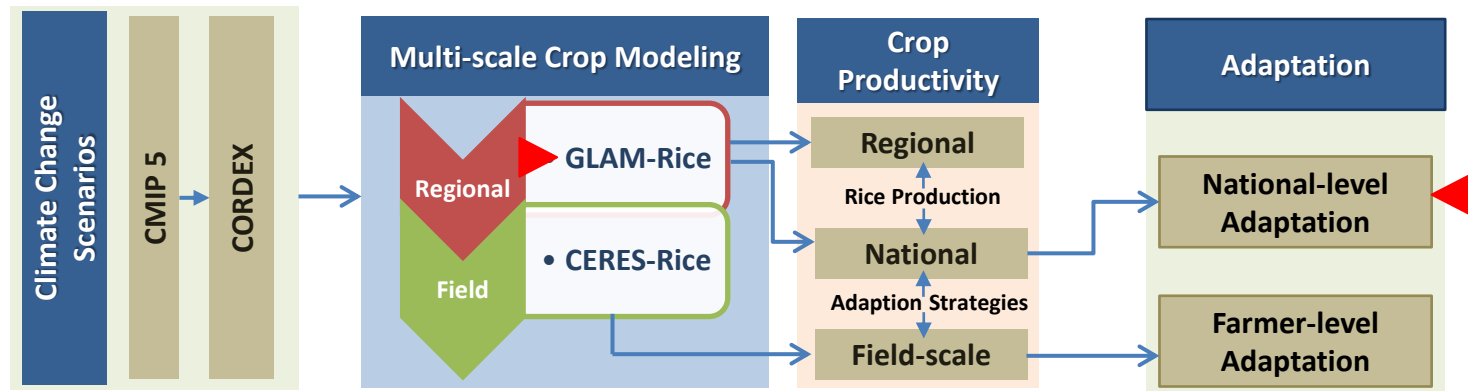
- Planting and harvesting dates
  - Global crop calendar maps with a 0.5° resolution (Sacks et al., 2010)
- Rice cultivated areas
  - The map of Harvested Area and Yields of 175 crops (Monfreda et al., 2008)
- Dominant agricultural soil texture types
  - The FAO digital soil map of the world (Batjes, 1997)
- Previous rice yield information
  - The UN Food and Agriculture Organisation (FAO)

# Validation of GLAM-Rice at the National-Level

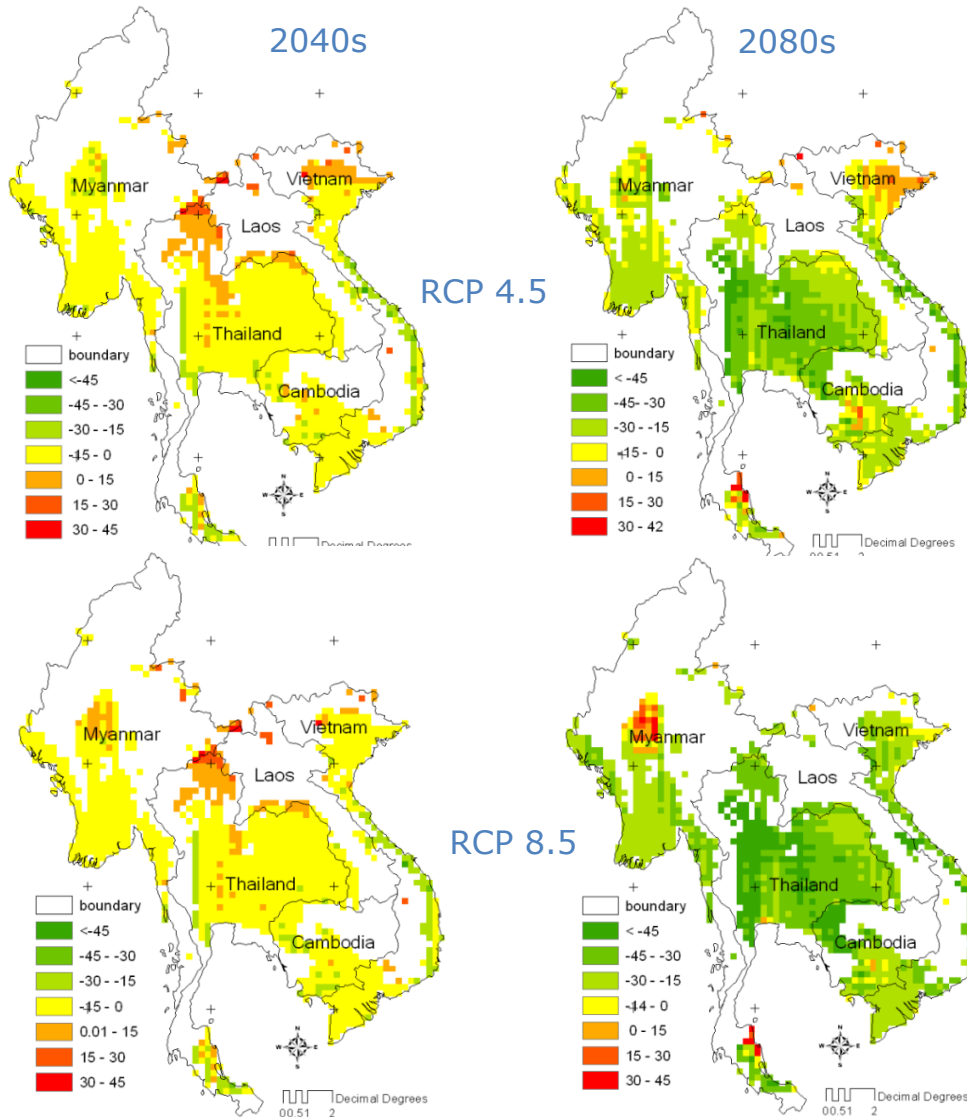


Comparison of the simulated and observed average country-level rice yields for the baseline period (1991–2000)

# Multi-stage Research Approach



# Rice Yields Changes Relative to the Baseline Period



Rice yields for the 2040s under the RCP 4.5 and RCP 8.5 climate change scenarios are expected to slightly increase in the north of Thailand and Vietnam

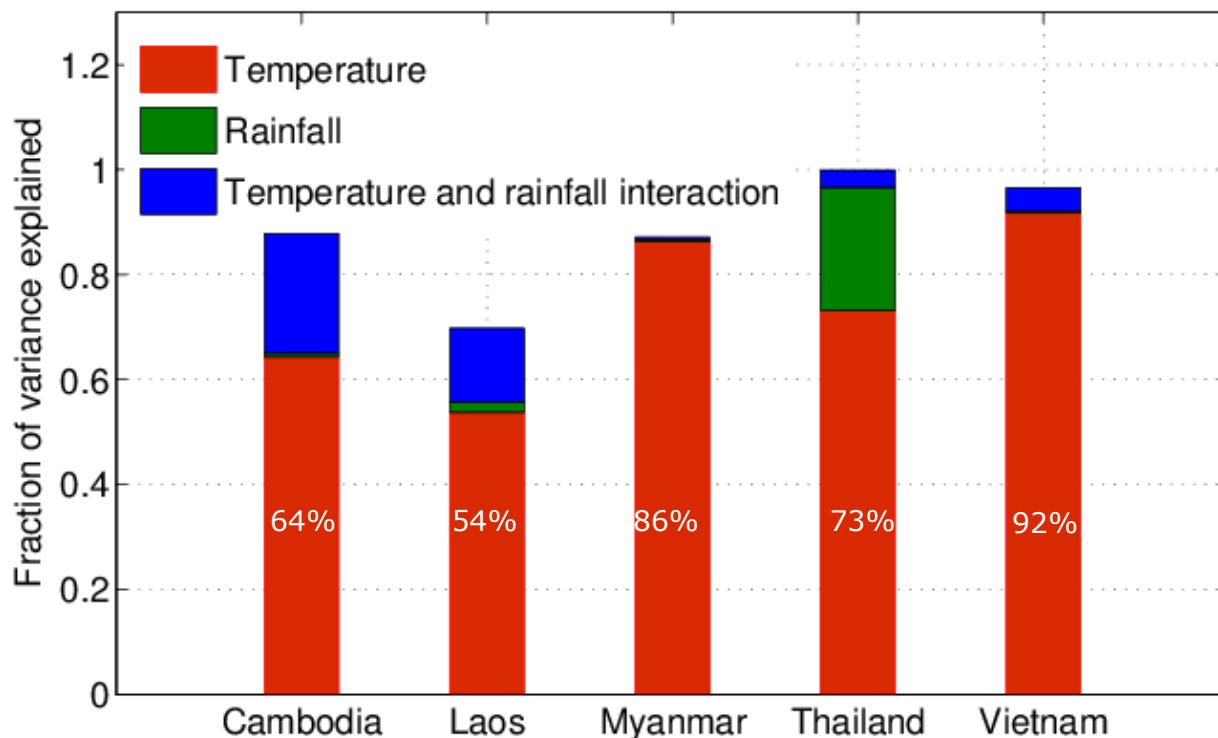
For the 2080s, rice yields will decrease further, with reductions in the range of 15–45%

The decrease in yields will even exceed 45% in most of Thailand and Cambodia under the RCP 8.5 scenario.

Little difference of decreases in rice yields under the RCP 4.5 and RCP 8.5 scenarios was projected in 2040s

Higher decreases in rice yields under the RCP 8.5 scenario were projected in 2080s than that under the RCP 4.5 scenario

# How Climate Variables Affect Future Rice Yield



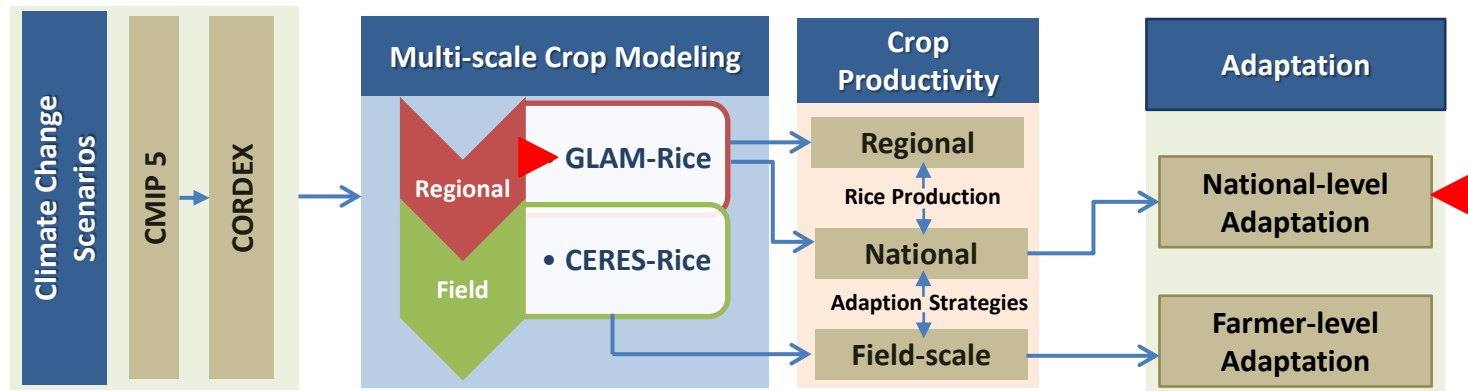
In **Myanmar, Vietnam and Thailand**, the reductions in rice yield can largely be explained by **the increase in seasonal mean temperature**.

Shifting sowing date,  
Heat tolerance varieties

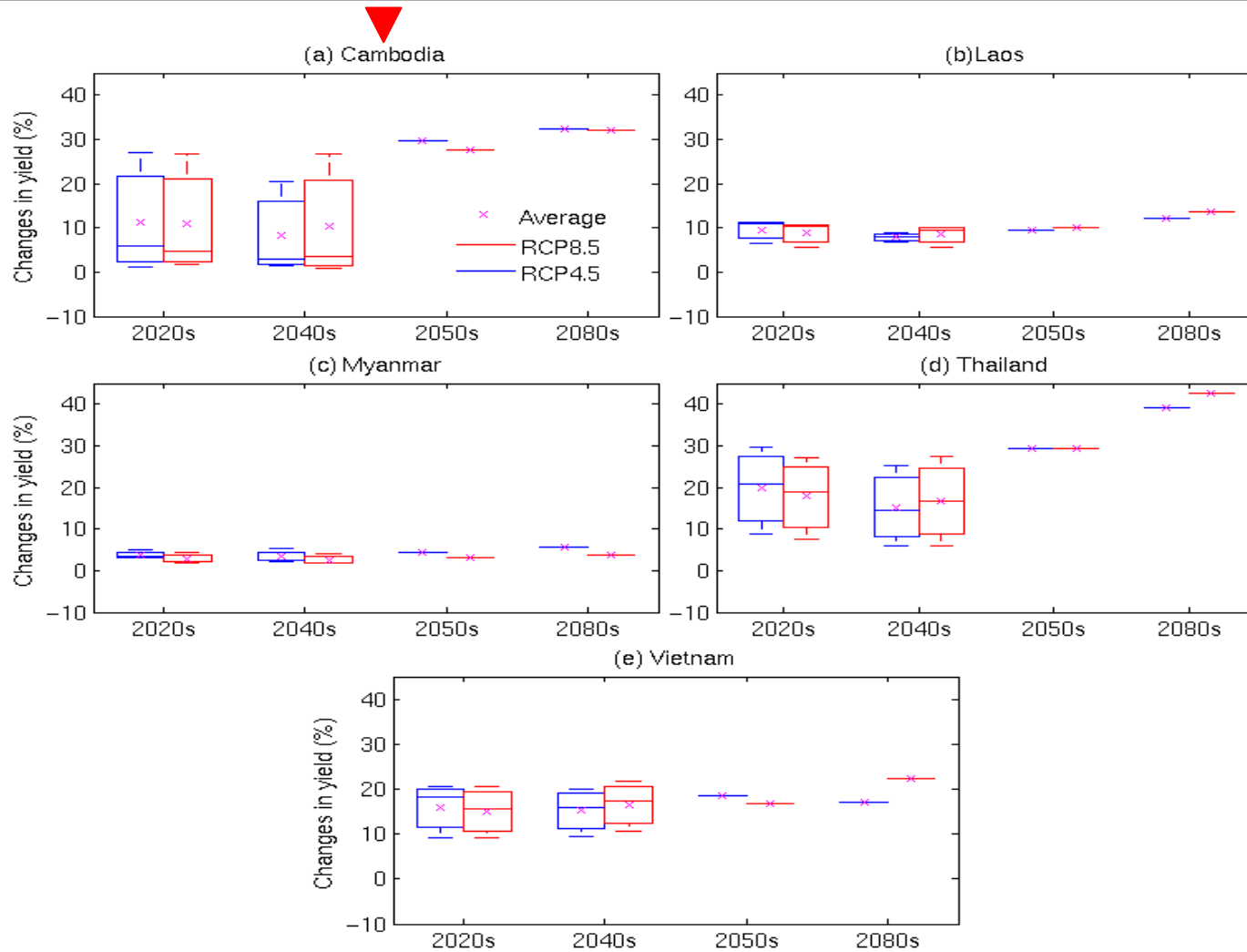
In **Cambodia and Laos**, the decrease in rice yields was mainly due to the effect of **rising mean temperature** and the **interaction of rainfall and temperature**.

Water storage facilities,  
Water saving management

# Multi-stage Research Approach



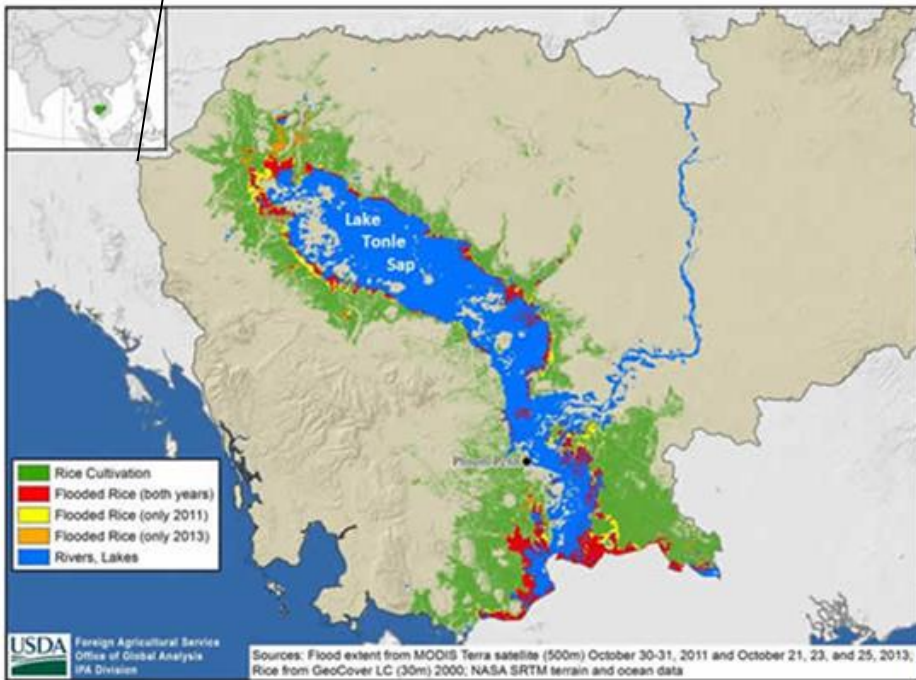
# Adaptation: Irrigation



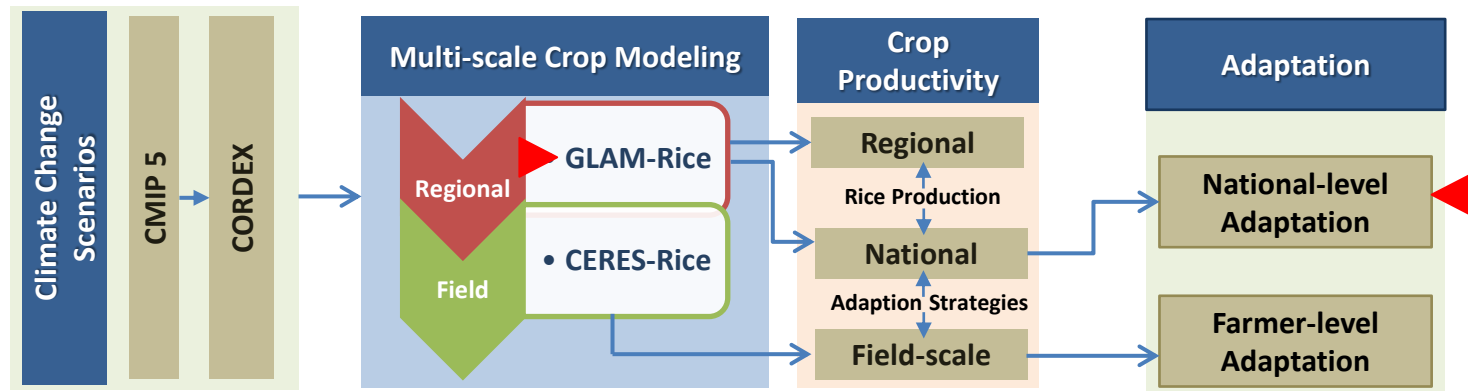
# Cambodia



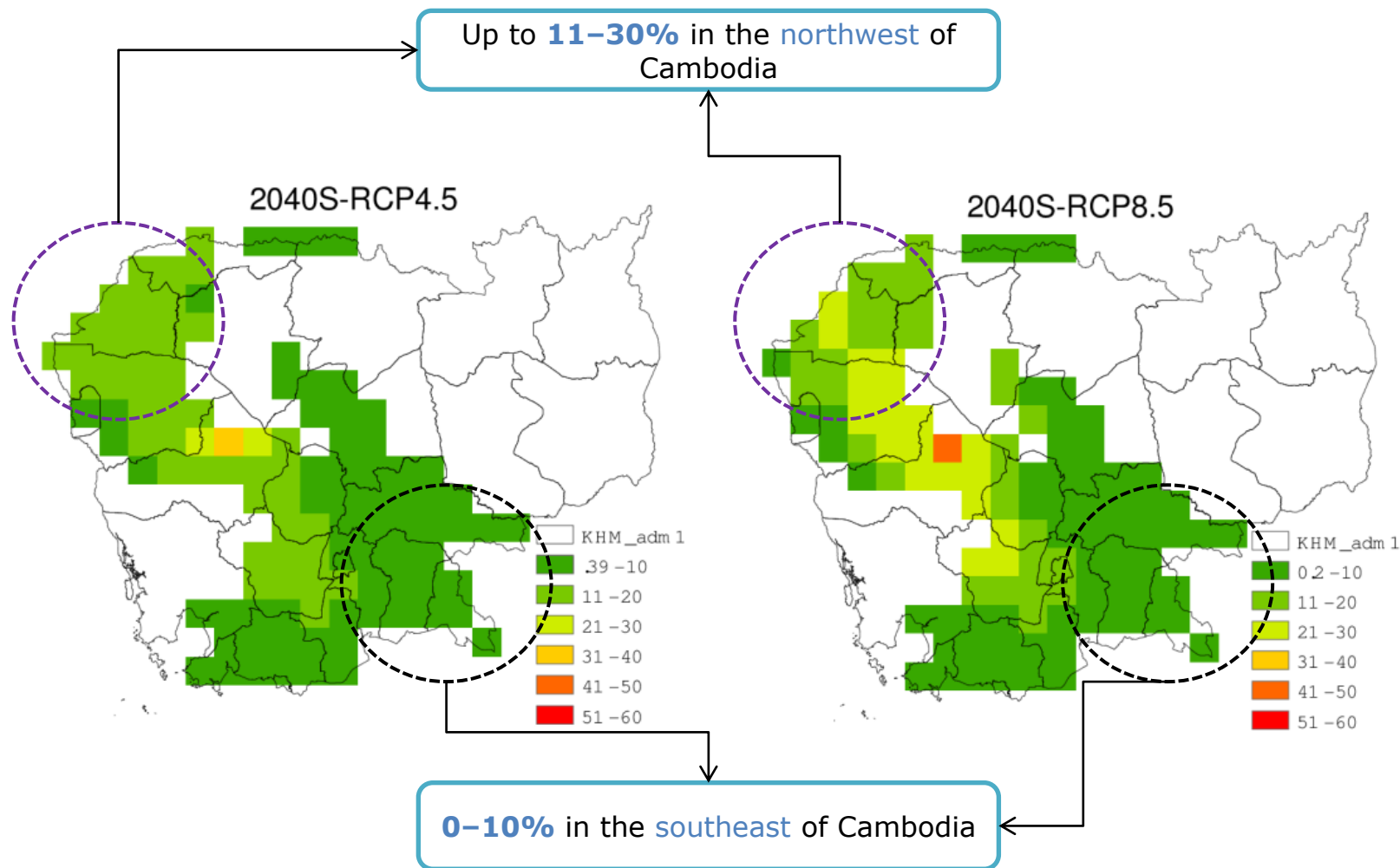
- Located in the southern portion of the Indochina Peninsula
- Shares borders with Vietnam, Laos, and Thailand
- Area: approx. 181,000 km<sup>2</sup>
- Population (2010): 14.3 million
- GDP (2010): \$11.2 billion
  - GDP per capita: \$790
- Average GDP growth: approx. 10% between 1993 and 2011
- Wet season (May to Oct.) and Dry season (Nov. to Mar.)



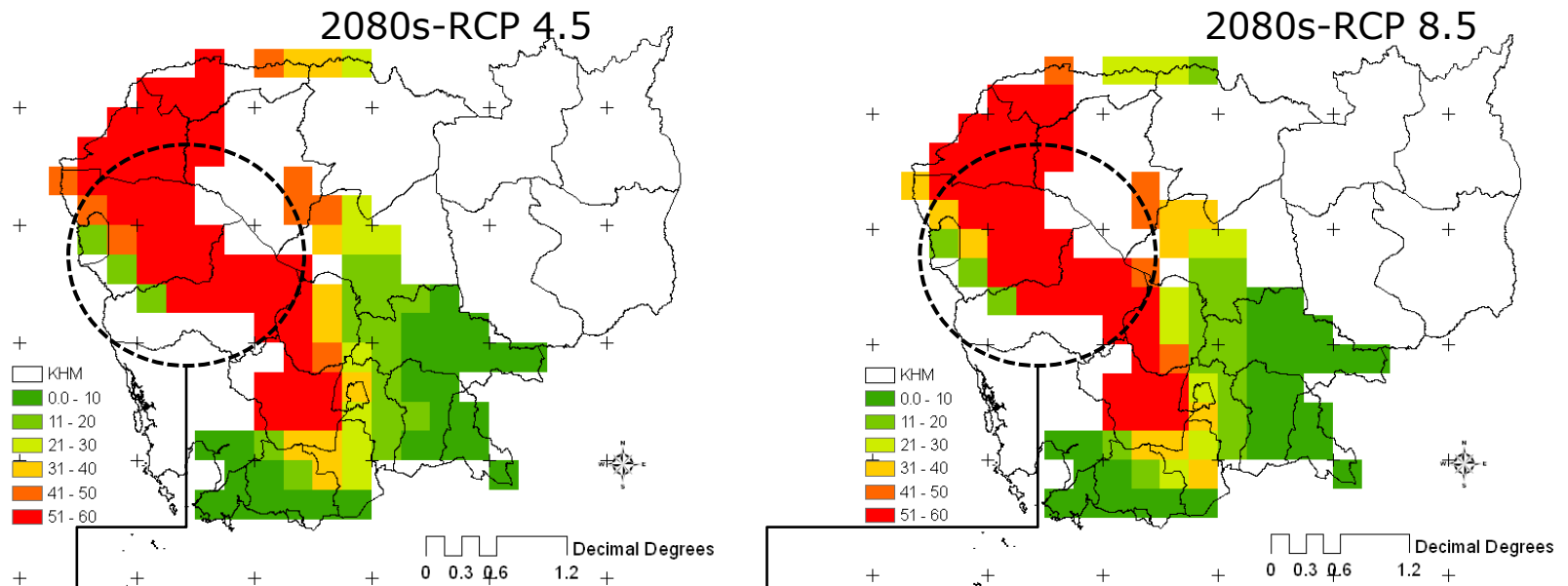
# Multi-stage Research Approach



# Yield Changes in Response to the Use of Irrigation

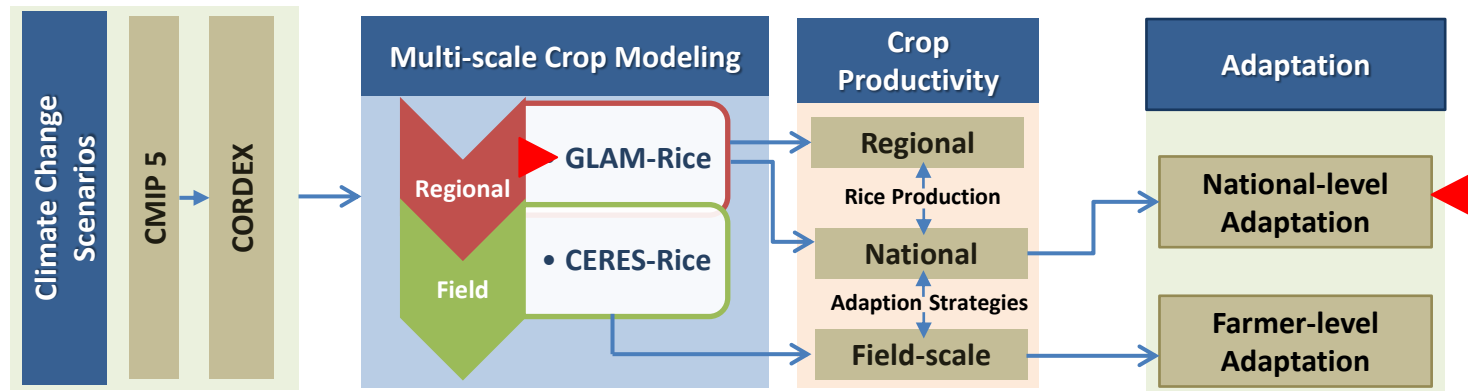


# Yield Changes in Response to the Use of Irrigation

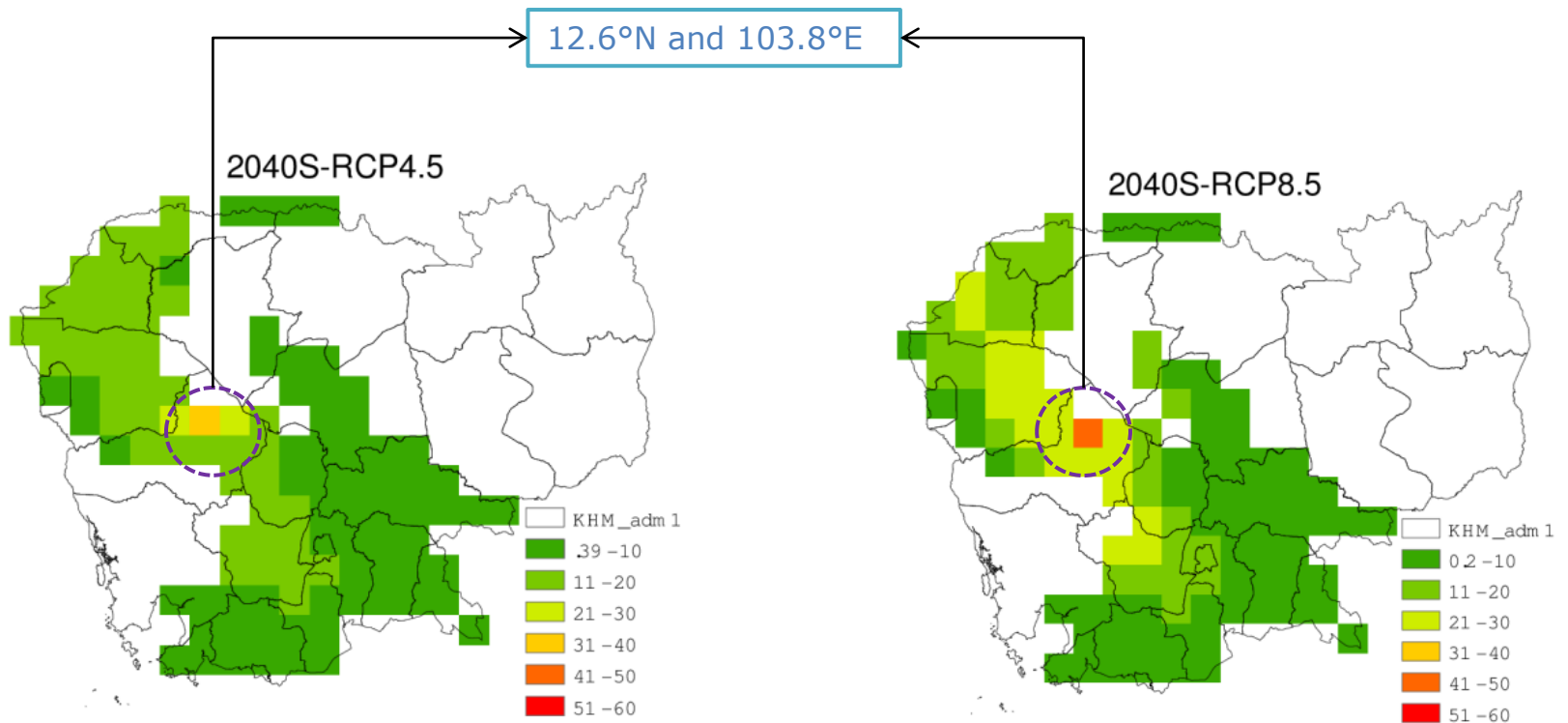


- There is a **large increase** in rice yields following irrigation for both the RCP 4.5 and RCP 8.5 scenarios for the 2080s, especially in **the northwest region of Cambodia** (Puthisat and Batdambang provinces)
- The increase in yields after irrigation would be **greater than 50%**

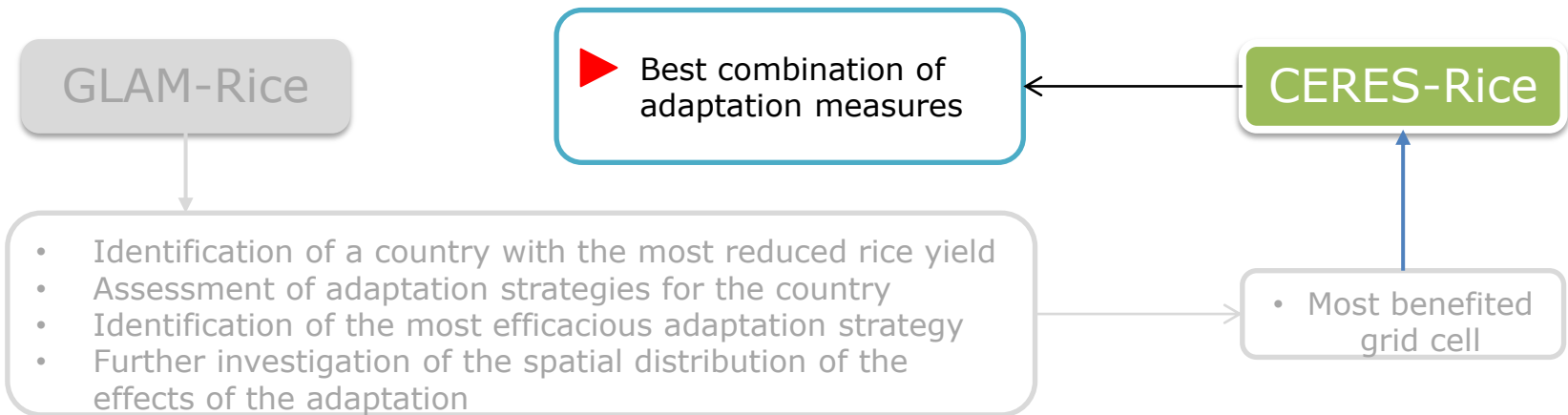
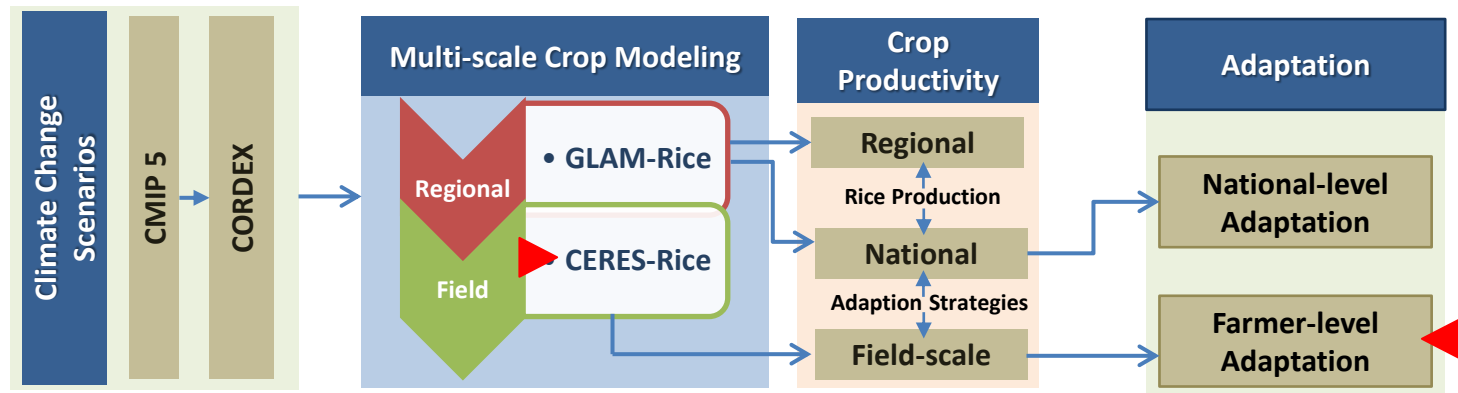
# Multi-stage Research Approach



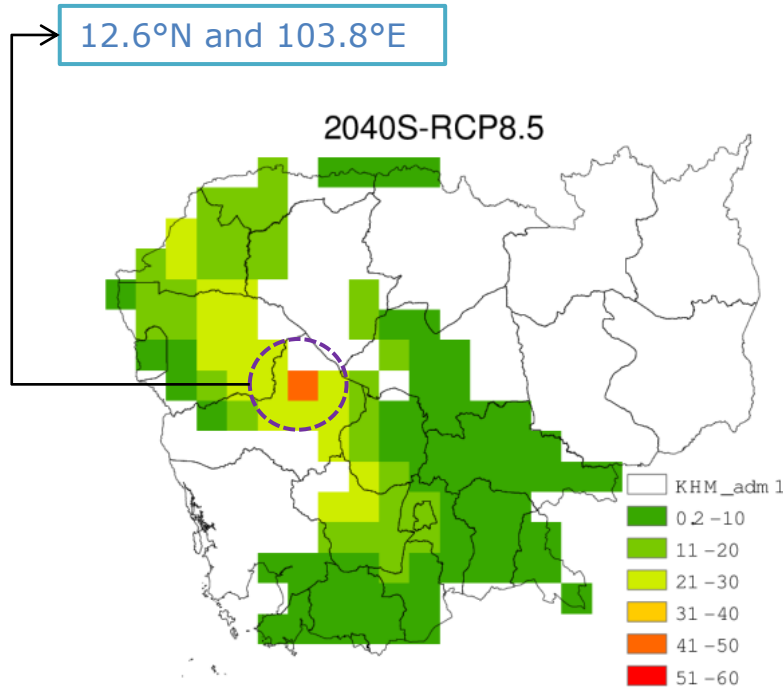
# Various Combinations of Adaptations



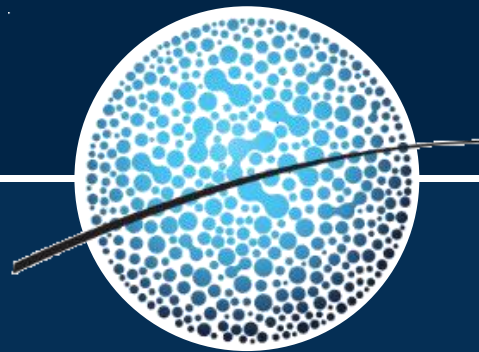
# Multi-stage Research Approach



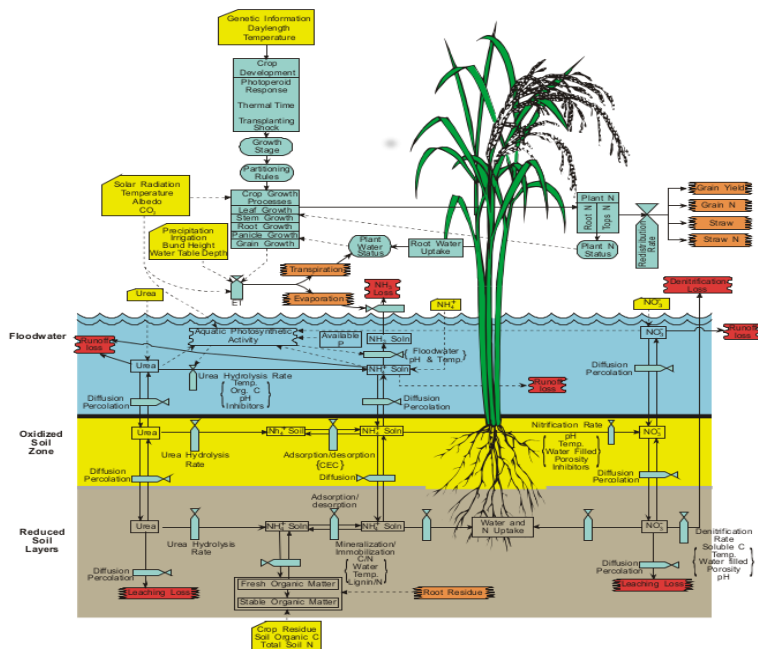
# Various Combinations of Adaptations



- Case1: 50 kg-N/ha and no water stress (denoted as NOAD)
- Case2: 50 kg-N/ha, no water stress and planting adjustment (denoted as N50+PDA)
- Case3: 100 kg-N/ha and no water stress (denoted as N100)
- Case4: 100 kg-N/ha, no water stress, and planting adjustment (denoted as N100+PDA)



# Farmer-level Adaptations

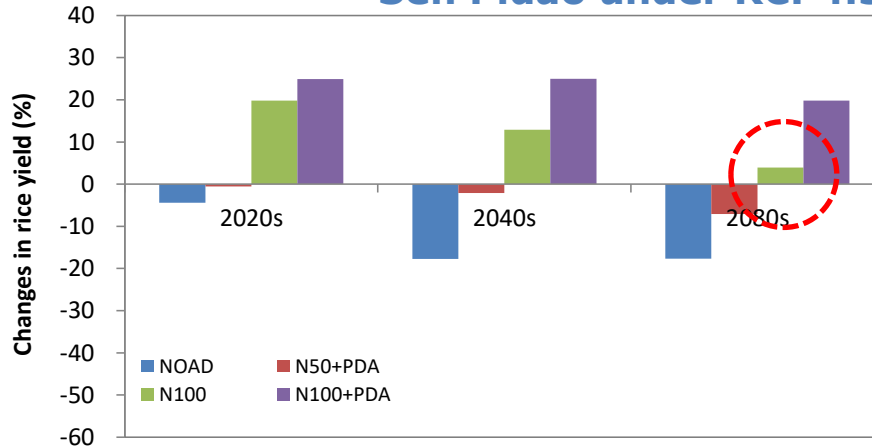


Schematic diagram of the CERES-Rice model (Singh et al. 2002)

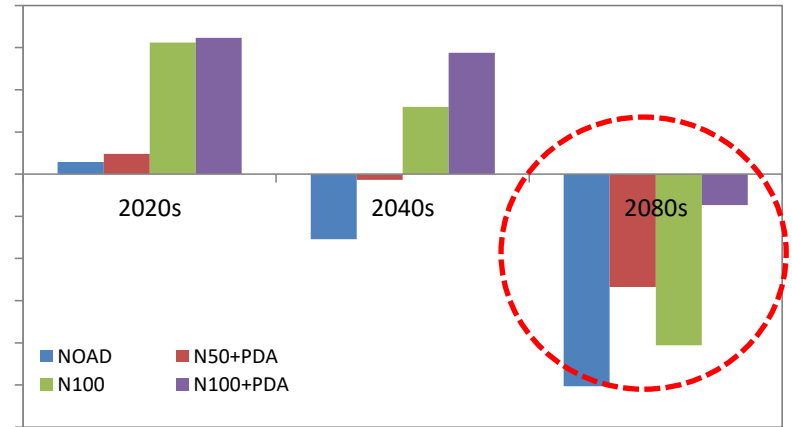
- Field experiments
  - The Cambodian Agricultural Research and Development Institute ([CARDI](#))
  - The years 2010, 2011 and 2013
  - Two aromatic milled rice cultivars: [Sen Pidao](#) and [Phka Rumduol](#)
- Weather station
  - Daily maximum, minimum, and mean temperatures, daily precipitation, and daily solar radiation
- Soil and phenological characteristics

# Best Combination of Adaptation Strategies

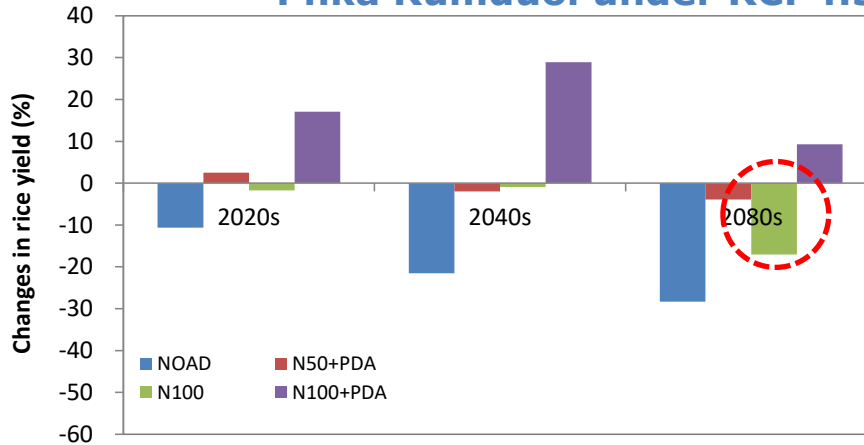
## Sen Pidao under RCP4.5



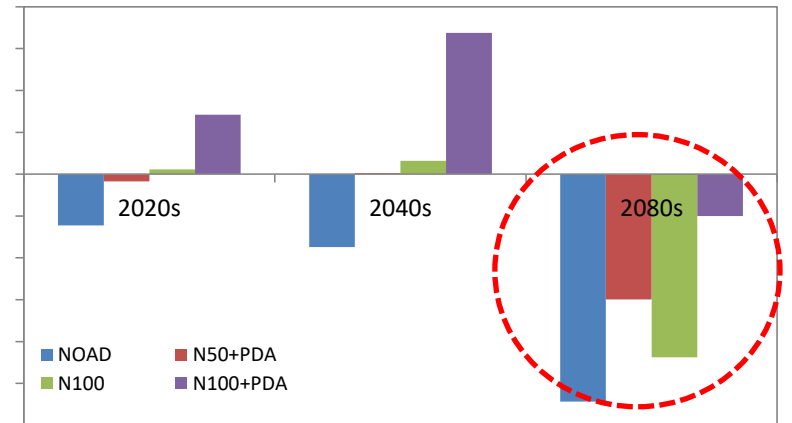
## Sen Pidao under RCP8.5



## Phka Rumduol under RCP4.5



## Phka Rumduol under RCP8.5





# Thank you

- Li, S., Q. Wang, and J.A. Chun\*. 2017. Impact Assessment of Climate Change on Rice Productivity in the Indochinese Peninsula using a Regional-scale Crop Model, *International Journal of Climatology*, doi:10.1002/joc.5072
- Chun, J.A.\*, S. Li, Q. Wang, W.-S. Lee, E.-J. Lee, N. Horstmann, H. Park, T. Veasna, L. Vanndy, K. Pros, and S. Vang. 2016. Assessing Rice Productivity and Adaptation Strategies for Southeast Asia under Climate Change through Multi-Scale Crop Modeling, *Agricultural Systems* 143, 14-21.
- Questions: [jachun@apcc21.org](mailto:jachun@apcc21.org)