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Assessing Rice Yield Changes based on CORDEX-Southeast Asia simulations in Sumatra

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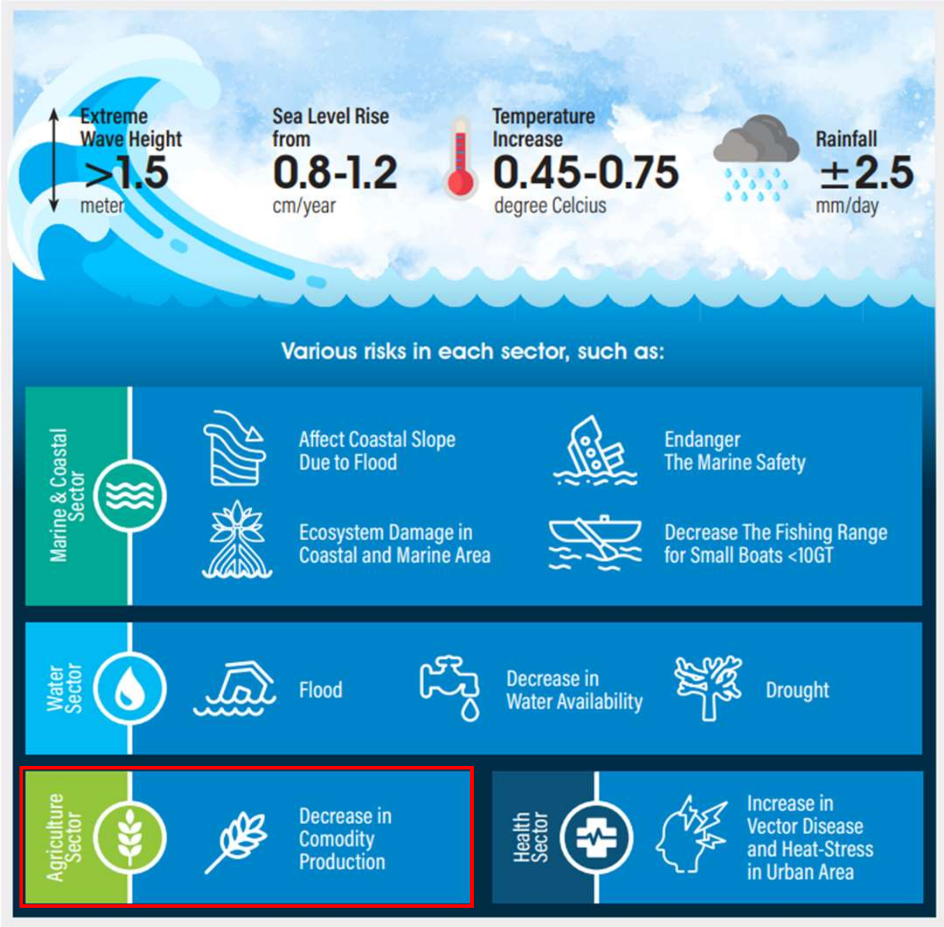
Outline

- Introduction
- Methods
- Results and Discussion
- Conclusion

Introduction

- Climate change presents a serious challenge to the food security system in terms of availability, access, utilization and stability (IPCC)
- Agriculture in Indonesia is mainly cultivate rice as a staple food in Indonesia
- Indonesia population is projected to exceed 300 million in 2045 (Indonesia Statistic Agency, 2018).
- the rapid surge in population will undoubtedly increase the food demand and water consumption generating agriculture to face the challenge of producing more food to meet food demand in the year 2050 (van Dijk et al., 2021; Zhang et al., 2022).
- climate change is expected to exacerbate the water resources availability, posing great challenges to rice production and food security in future climate conditions



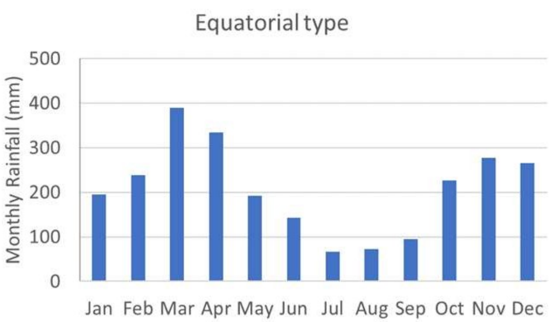
Source: https://lcdi-indonesia.id/wp-content/uploads/2021/11/0_Executive-Summary.pdf

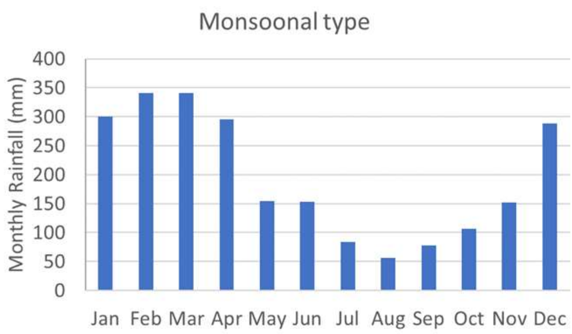
Objectives

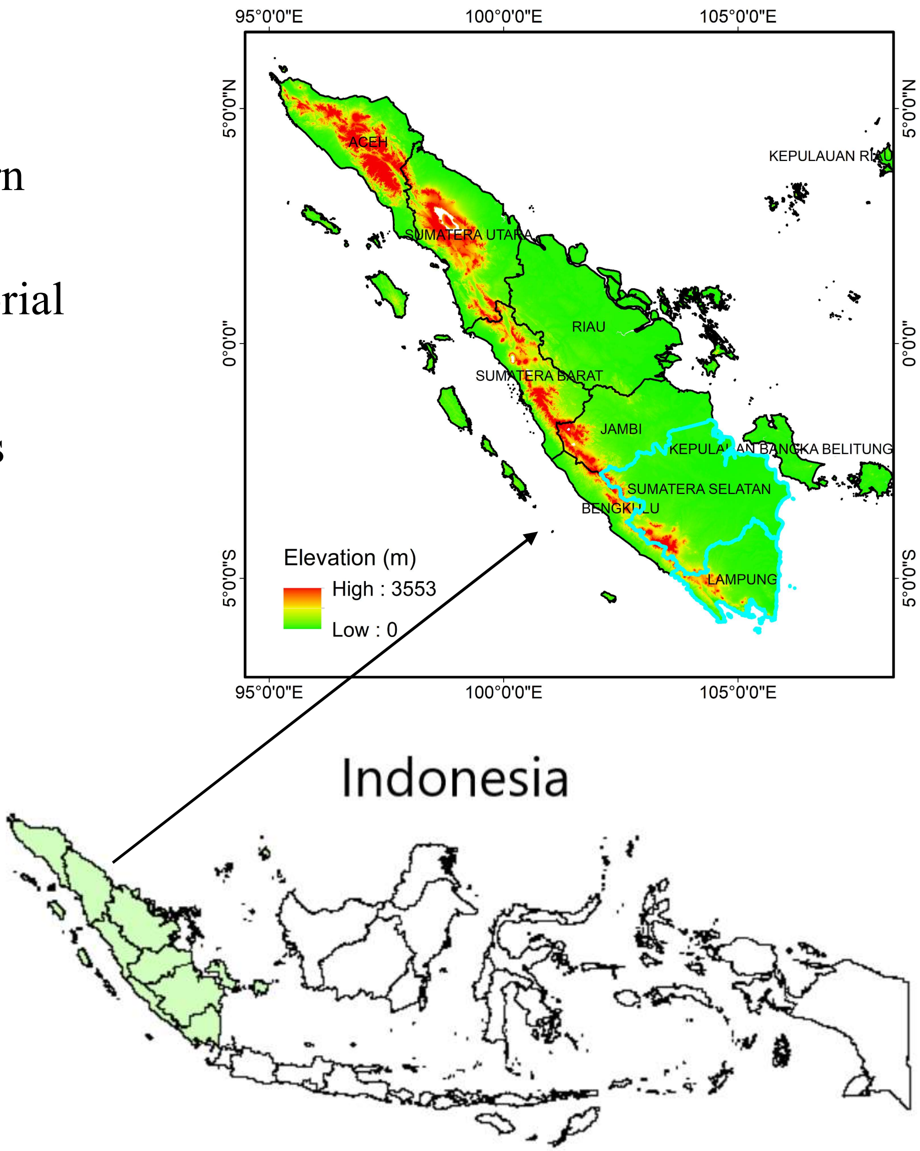
- Assessing the change in rice production is critical to find which area will experience increasing and decreasing rice production in the future and to manage strategies to face the climate change impact
- This study aims to assess the projected change of rice yield in Sumatra by 2045
- To support Indonesia government goal to be world food granary in 2045

Study Area

- Sumatra has Bukit Barisan Mountain which extends from northern Aceh to Southern Lampung
- Sumatra has two types of rainfall patterns: monsoonal and equatorial
- Annual rainfall of about 1500–3500 mm
- Several provinces in Sumatra were rice production center and has about 1.82 million ha of rice field







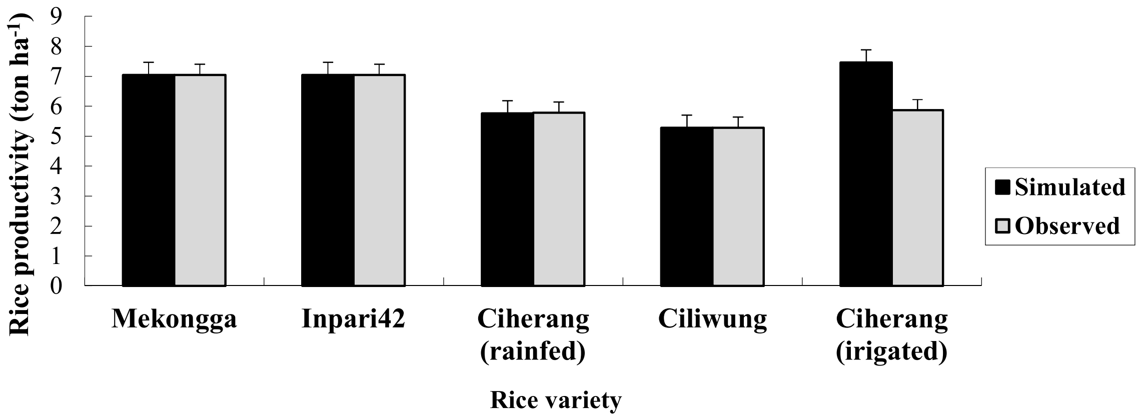
Data

1. Field experiment is conducted in 2 representative rice field areas (irrigated and rainfed) in 2 provinces on May 2021:
   - South Sumatra (4 sites)
   - Lampung (4 sites)
2. To obtain observed data for APSIM parameterization:
   - Soil (soil texture, C, N, pH, bulk density, field capacity, wilting point and saturated water)
   - crop parameter (variety, crop age, crop residue, phenology stage and crop productivity)
   - management practices (planting time, planting space, irrigation and fertilizer)
   - weather data (rainfall, minimum temperature, maximum temperature and solar radiation)
3. Climate Projection data

   3 models from CORDEX-SEA simulations (CNRM-CM5, CSIRO MK3.6 and HadGEM2) with resolution 25 km for baseline (1991-2025), RCP4.5 and RCP8.5 (2026-2045) obtained from BMKG
4. Gridded soil data: Soilgrids

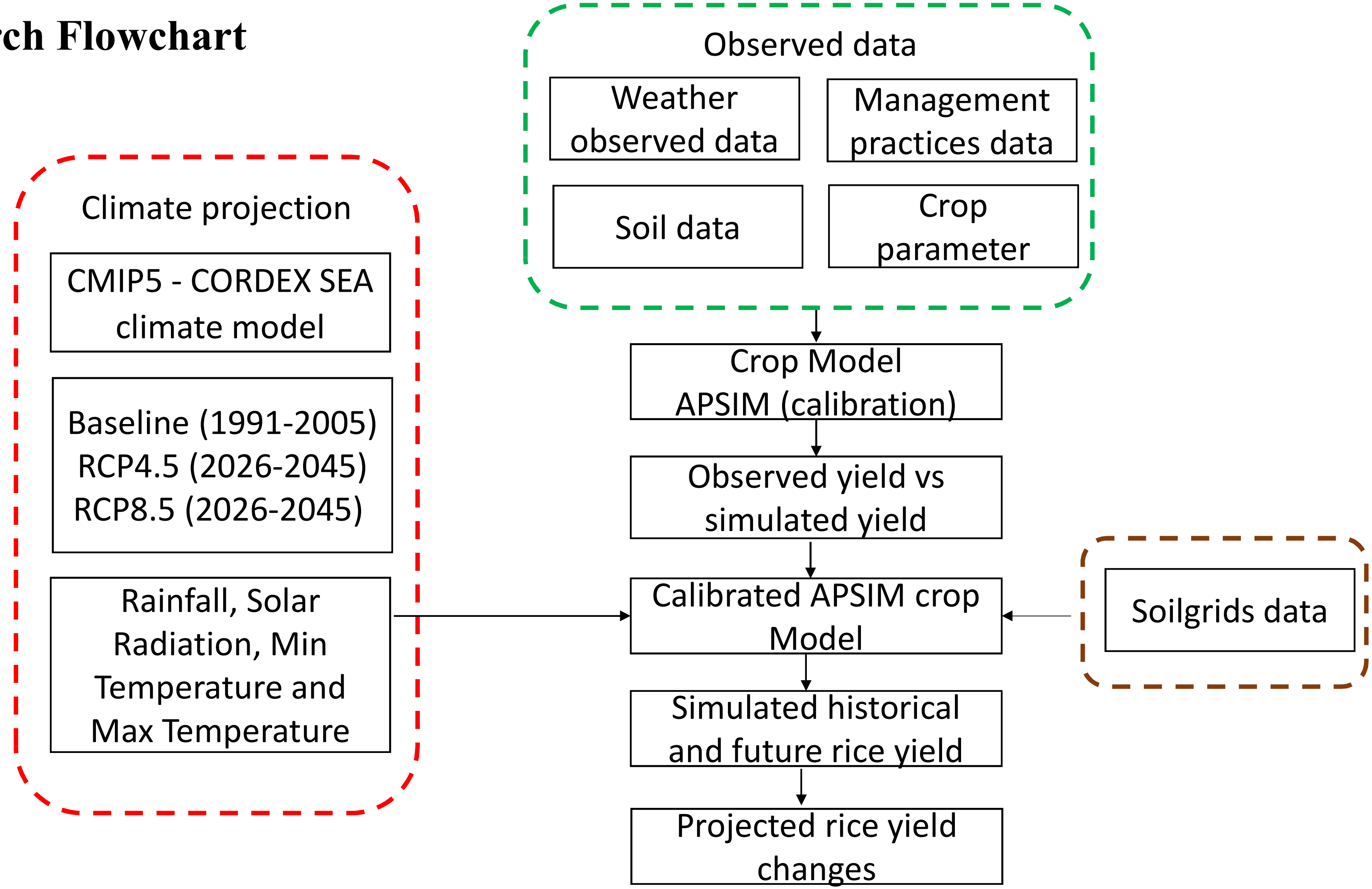
APSIM crop model simulation

1. APSIM calibration is using field experiment data

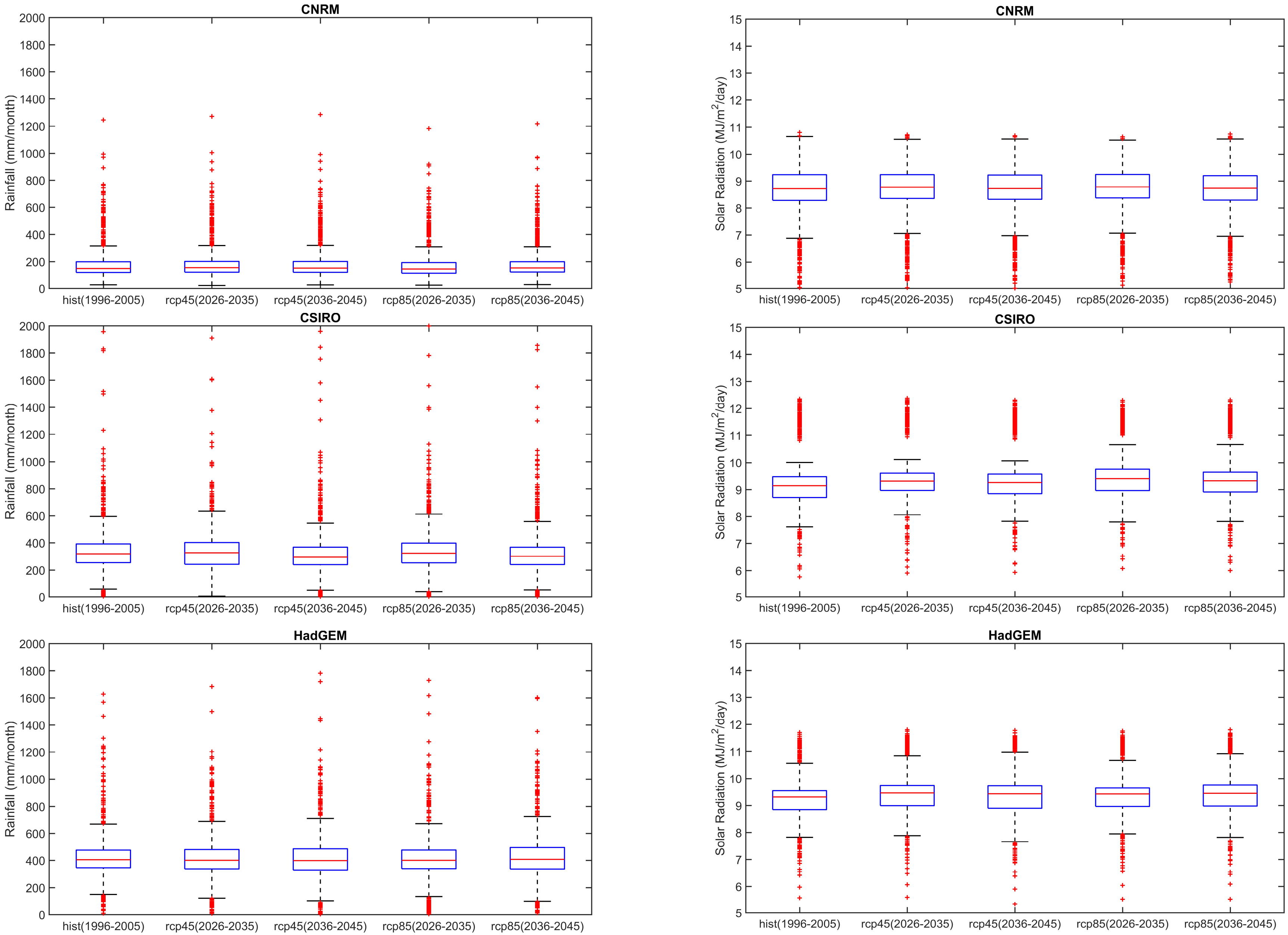


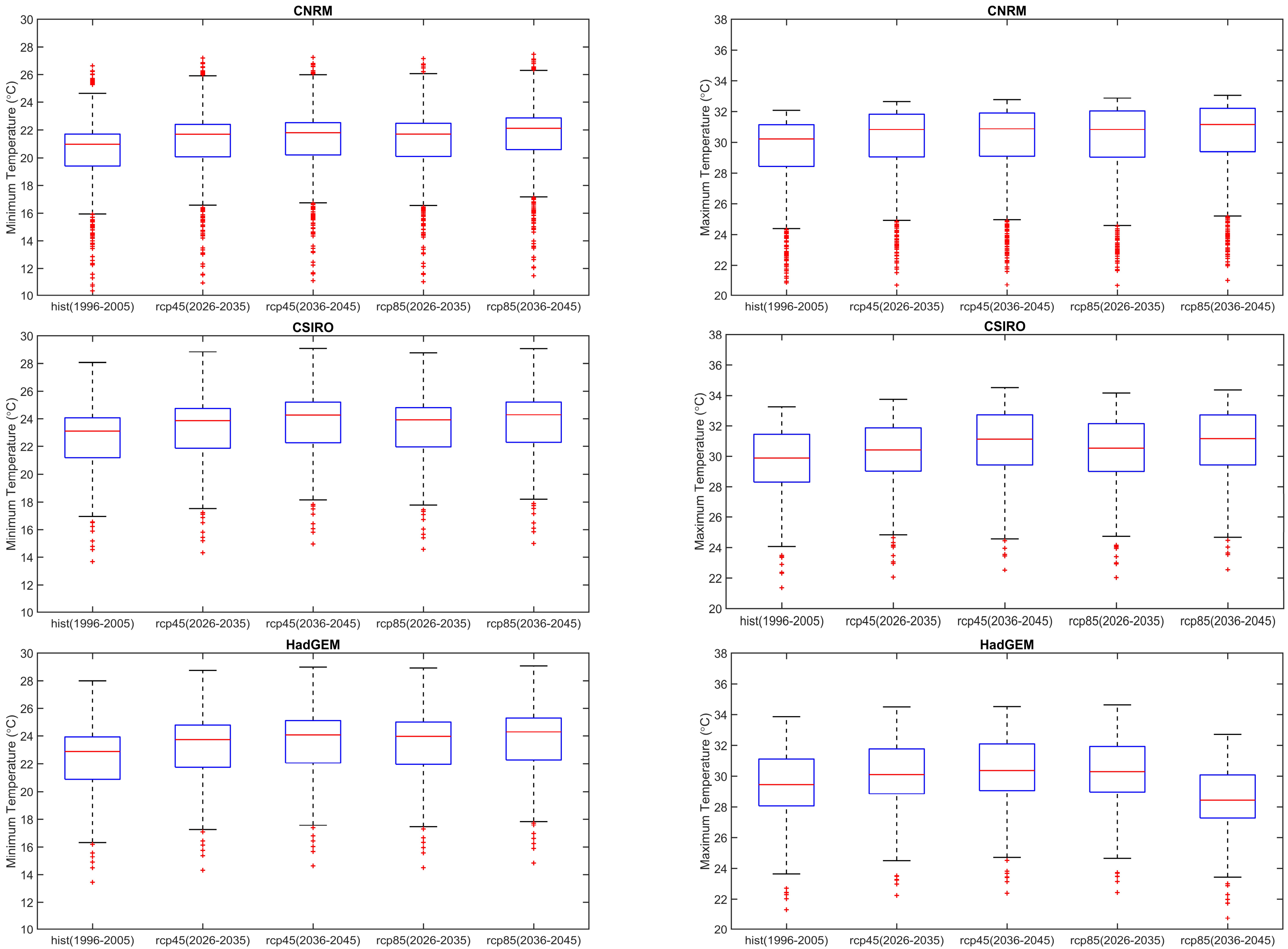
2. APSIM simulate the historical and future rice yield in 2 seasons:
   - Rainy Season (RS): 20 September and 30 October
   - Dry season (DS): 20 April and 10 May
   - Using CORDEX SEA, soilgrids, field experiment data (crop parameter and management)

Research Flowchart

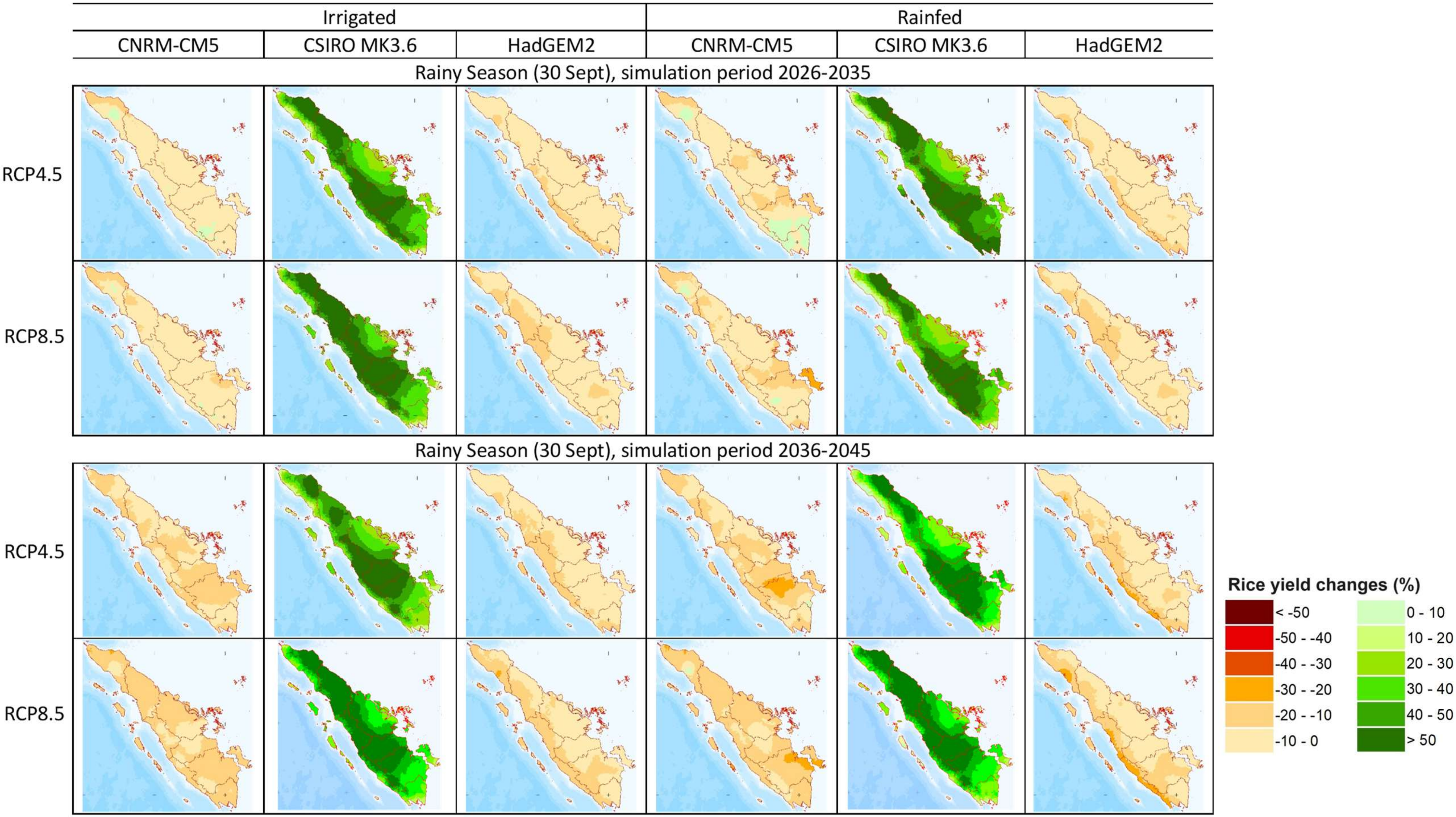


Result and Discussion

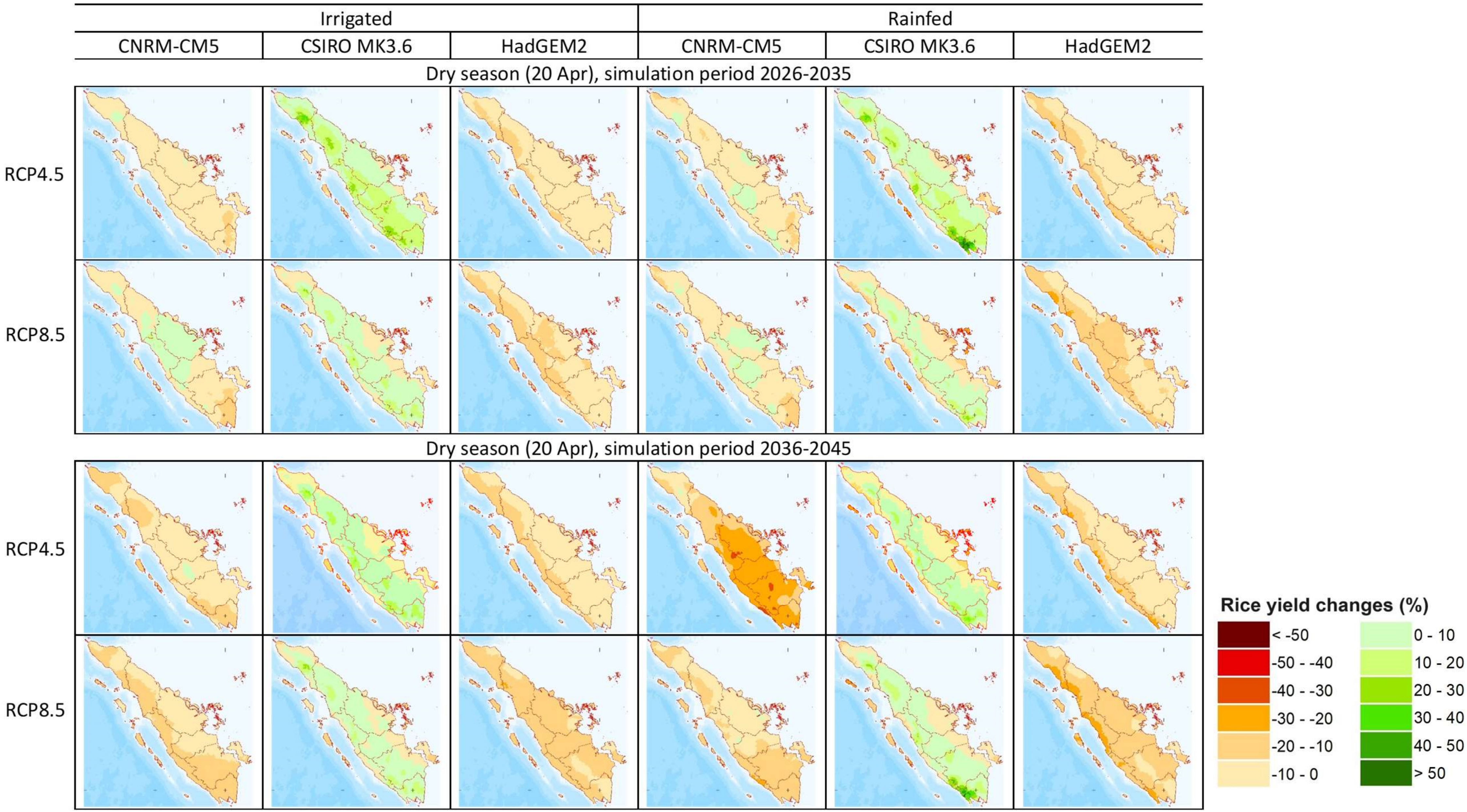




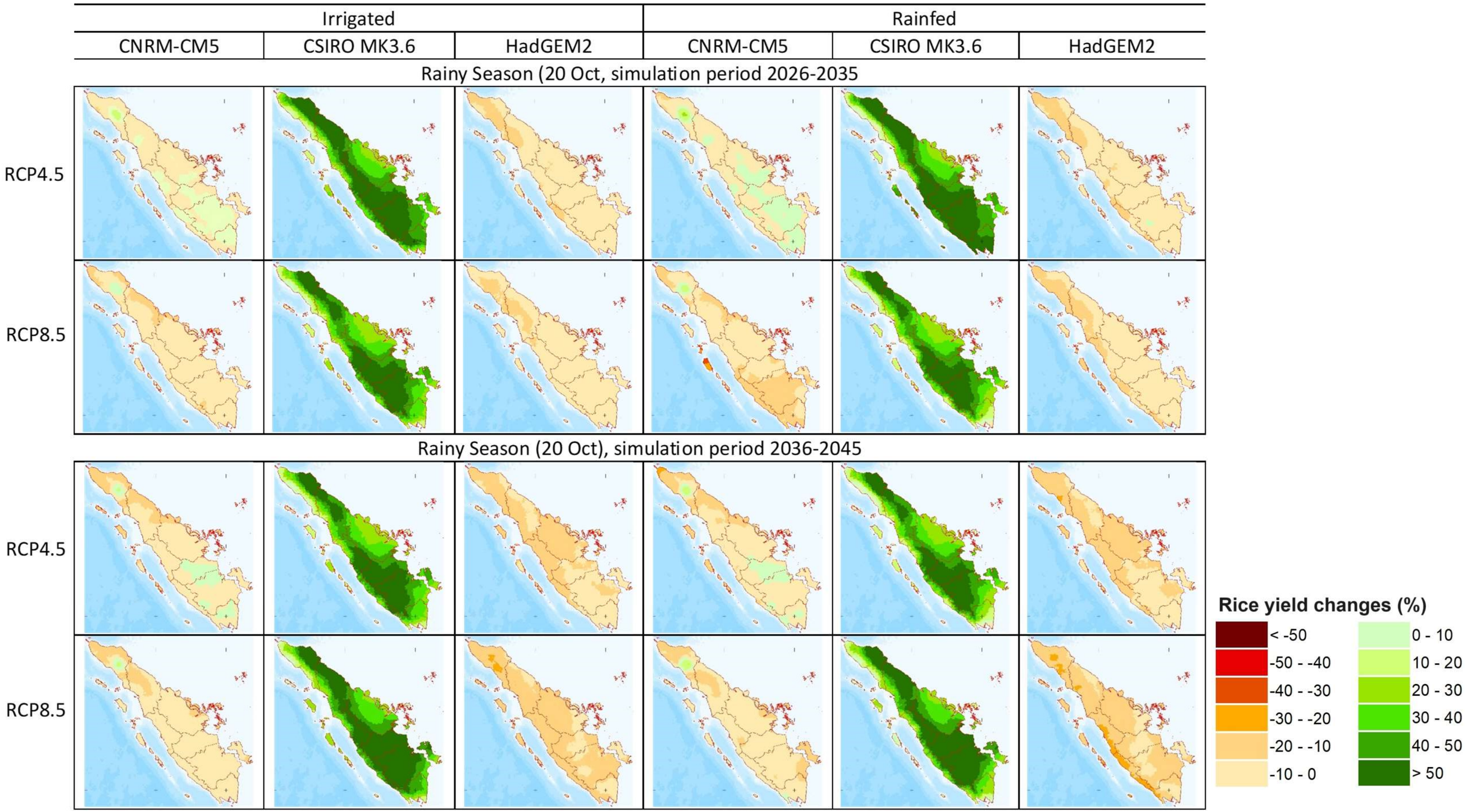
CNRM
Minimum Temperature (°C)
CNRM
Maximum Temperature (°C)
CSIRO
Minimum Temperature (°C)
CSIRO
Maximum Temperature (°C)
HadGEM
Minimum Temperature (°C)
HadGEM
Maximum Temperature (°C)
hist(1996-2005)
rcp45(2026-2035)
rcp45(2036-2045)
rcp85(2026-2035)
rcp85(2036-2045)

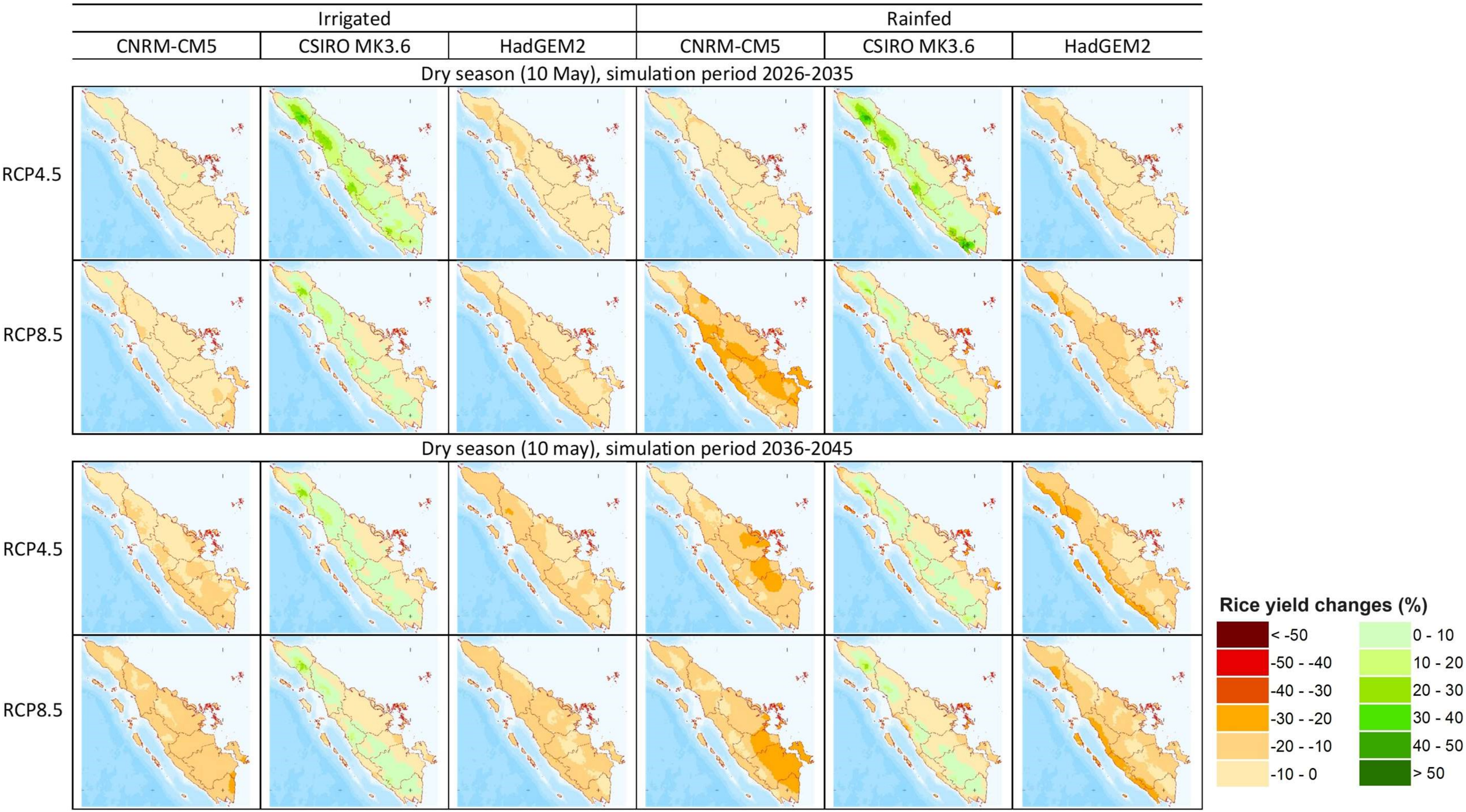


Irrigated
Rainfed
CNRM-CM5
CSIRO MK3.6
HadGEM2
CNRM-CM5
CSIRO MK3.6
HadGEM2
Rainy Season (30 Sept), simulation period 2026-2035
RCP4.5
RCP8.5
Rainy Season (30 Sept), simulation period 2036-2045
RCP4.5
RCP8.5
Rice yield changes (%)
< -50
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
> 50

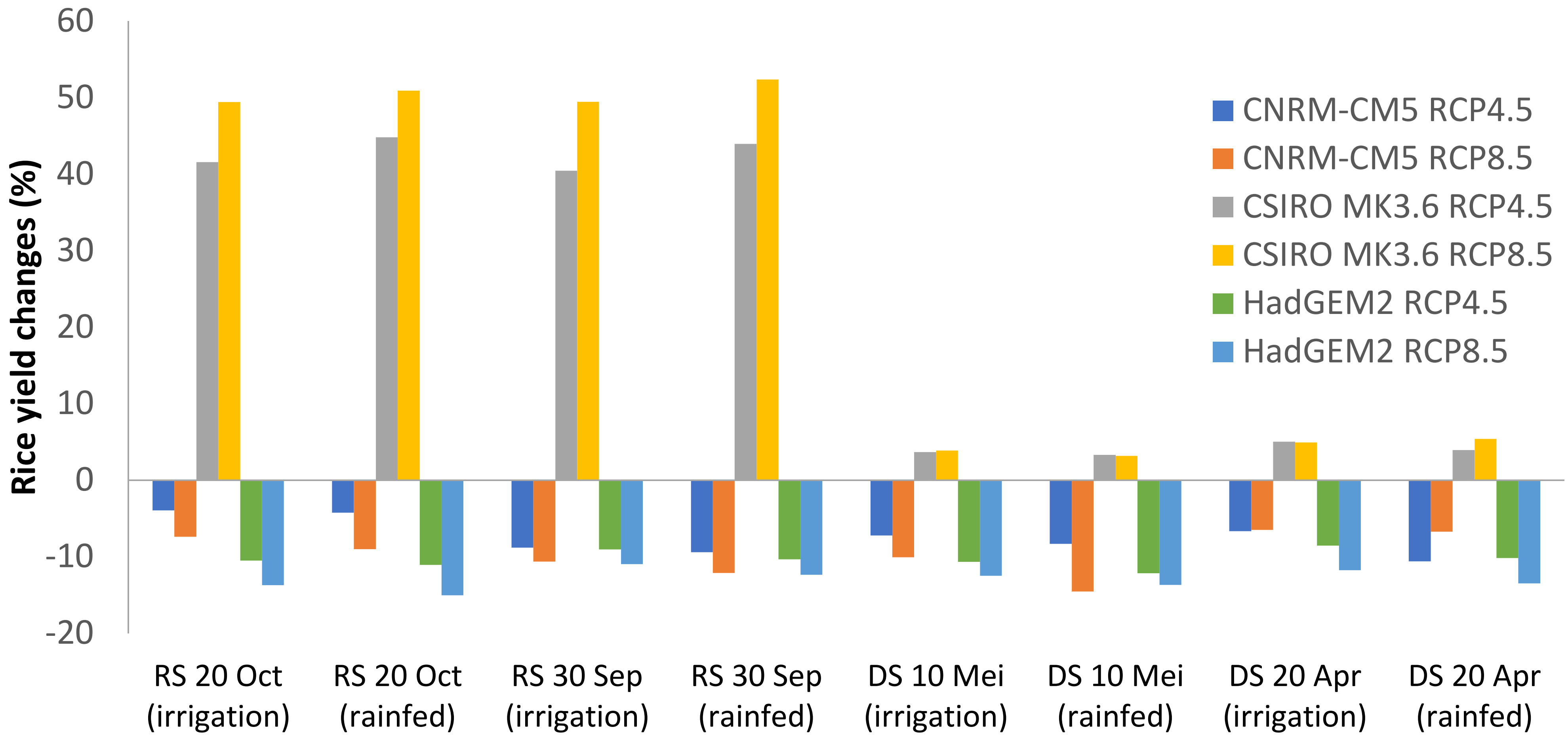


Irrigated
Rainfed
CNRM-CM5
CSIRO MK3.6
HadGEM2
CNRM-CM5
CSIRO MK3.6
HadGEM2
Dry season (20 Apr), simulation period 2026-2035
RCP4.5
RCP8.5
Dry season (20 Apr), simulation period 2036-2045
RCP4.5
RCP8.5
Rice yield changes (%)
< -50
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
> 50


Irrigated
Rainfed
CNRM-CM5
CSIRO MK3.6
HadGEM2
CNRM-CM5
CSIRO MK3.6
HadGEM2
Rainy Season (20 Oct, simulation period 2026-2035
RCP4.5
RCP8.5
Rainy Season (20 Oct), simulation period 2036-2045
RCP4.5
RCP8.5
Rice yield changes (%)
< -50
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
> 50



Irrigated
Rainfed
CNRM-CM5
CSIRO MK3.6
HadGEM2
CNRM-CM5
CSIRO MK3.6
HadGEM2
Dry season (10 May), simulation period 2026-2035
RCP4.5
RCP8.5
Dry season (10 may), simulation period 2036-2045
RCP4.5
RCP8.5
Rice yield changes (%)
< -50
-50 - -40
-40 - -30
-30 - -20
-20 - -10
-10 - 0
0 - 10
10 - 20
20 - 30
30 - 40
40 - 50
> 50



Rice yield changes (%)
60
50
40
30
20
10
0
-10
-20
CNRM-CM5 RCP4.5
CNRM-CM5 RCP8.5
CSIRO MK3.6 RCP4.5
CSIRO MK3.6 RCP8.5
HadGEM2 RCP4.5
HadGEM2 RCP8.5
RS 20 Oct (irrigation)
RS 20 Oct (rainfed)
RS 30 Sep (irrigation)
RS 30 Sep (rainfed)
DS 10 Mei (irrigation)
DS 10 Mei (rainfed)
DS 20 Apr (irrigation)
DS 20 Apr (rainfed)

Conclusion

- CSIRO MK3.6 indicates the increasing of rice yield in both rainy season and dry season, either in irrigated or rainfed areas under RCP4.5 and RCP8.5 emission scenarios
- While CNRM-CM5 and HadGEM2 show decreasing rice yield in the future in both rainy season and dry season, either in irrigated or rainfed areas under RCP4.5 and RCP8.5 emission scenarios
- policymakers can utilize the results of this study to determine water and rice production management practices for planning dan anticipating appropriate adaptation strategies to future climate change.

Terima Kasih