Best Management Strategies for Sustainable Rice Production with Minimum Water Requirement

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Society's Grand Challenges

- **Feed the Future – Food Insecurity**

- **Securing Water for Food**
  - Water reuse and efficiency
  - Water capture and storage
  - Salinity

- **Saving Lives at Birth**
  - Science and technology advances that prevent, detect or treat maternal and newborn problems at the time of birth
  - New approaches to delivering high-quality care at the time of birth
  - Empowering and engaging pregnant women and their families

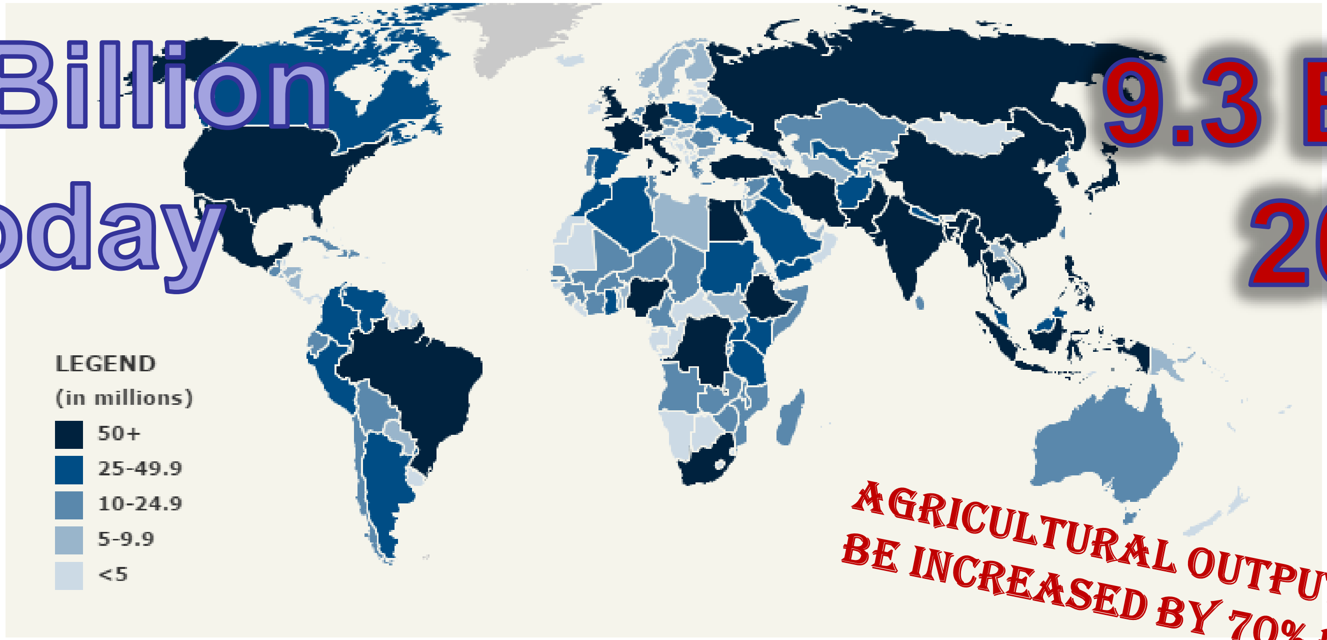
- **All Children Reading**
  - Improving the design, production, distribution and use of high-quality, appropriate teaching and learning materials
  - Improving the quality and increasing the accessibility of education data and information to support decision-making, incentives, transparency, and accountability

- **Making All Voices Count**

Source: USAID

Increasing Need of Food

7.3 Billion Today



9.3 Billion 2050

AGRICULTURAL OUTPUT WILL NEED TO BE INCREASED BY 70% BY 2050

- Most of the population increase in developing countries
- Already **842 Million** people suffering from hunger

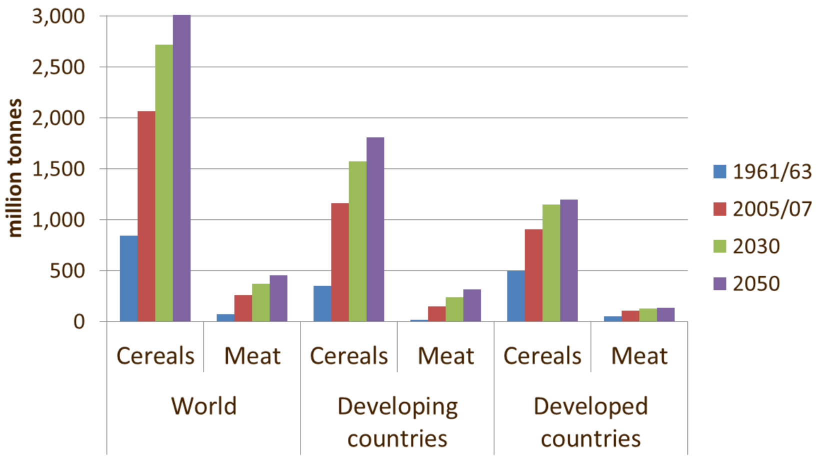


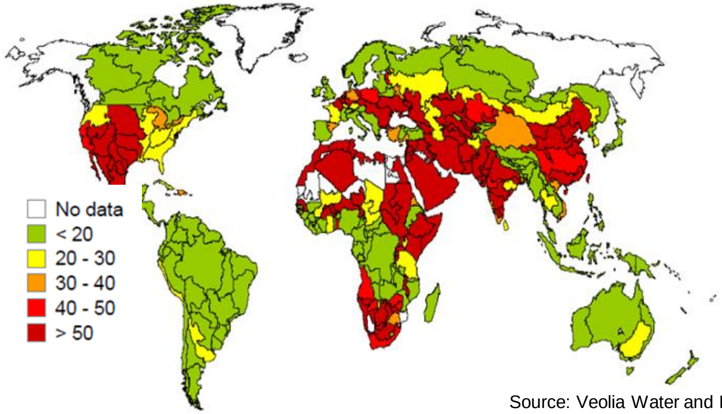
Photo Source: http://www.prb.org/publications/datasheets/2013/2013-world-population-data-sheet/world-map.aspx#map/world/population/2013

Agriculture Adds to Growing Water Challenges

Agriculture uses:

Source: Farming First 2012

Water stress
Total renewable water withdrawn, BAU, 2050 (%)



Source: Veolia Water and IFPRI 2011

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Rice Cultivation- water demanding crop

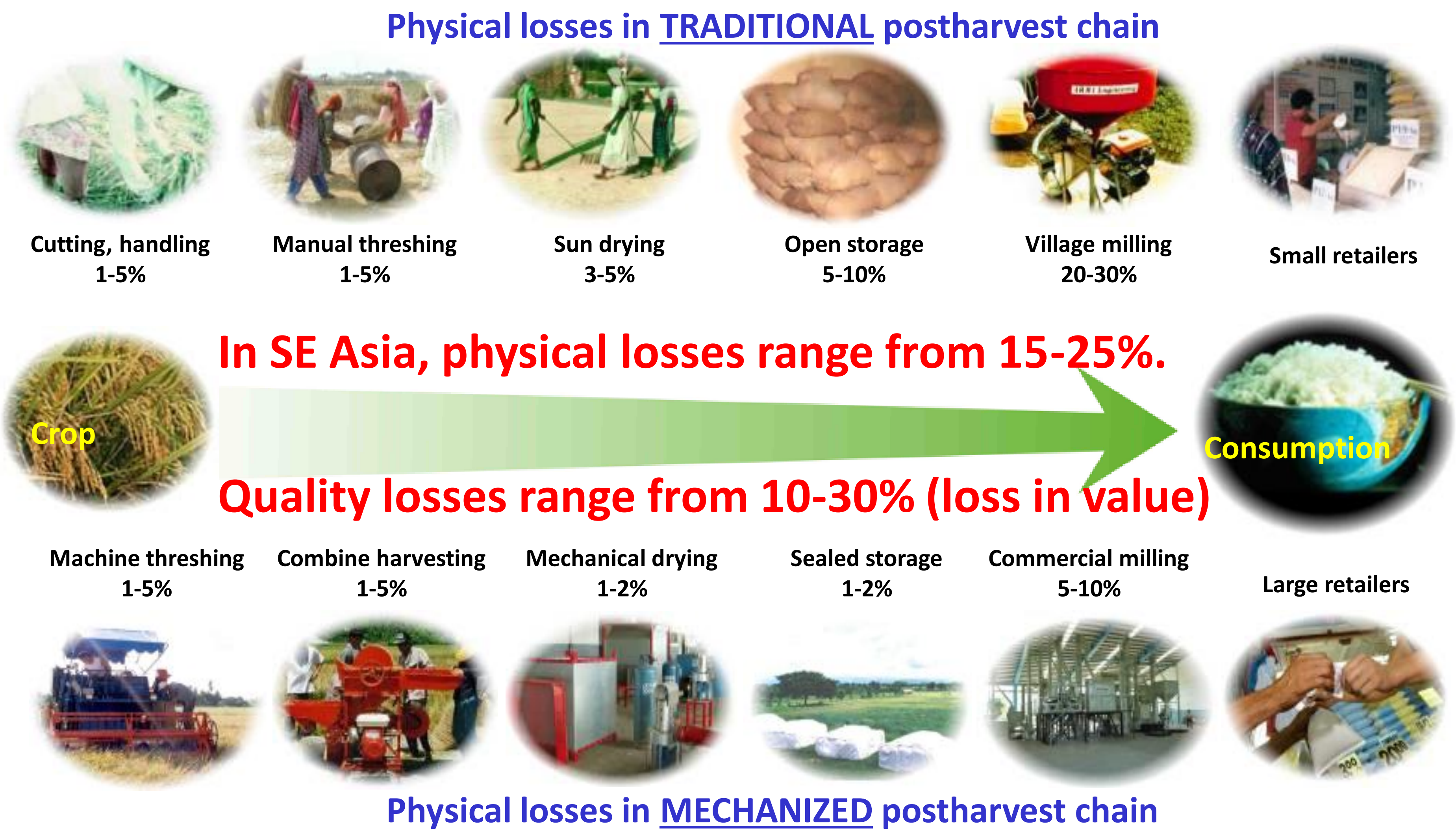
- Rice is a staple food for nearly half of the world's population- primary food for 3.5 billion people. Rice is a high water demanding crop.

- In Asia, 137 million hectares of farmland are used for rice cultivation, which is about 89% of land utilized for agricultural production.

- For Bihar, one of the poorest states in India, rice is the most important crop grown in approximately 5.4 Mha - 60% of the total agricultural land.
- Population of the state of Bihar, India is 115 Million -third largest state of India by population. (USA=326 Million, Brazil=210 Million, Israel = 8.8 Million). More than 80% of the total population in Bihar depend on agriculture - average farm family income is less than $1.25 a day.

- In Bihar 33% of total rice cultivated lands are controlled by irrigation, while the remaining land is totally dependent upon rainfall.

Postharvest Losses in Rice (IRRI)



Objectives

- To investigate the impact of water stress condition on rice yield at various growth stages for the Rajendra Mahsuri rice variety, and to recommend best management strategies for the highest rice production.

- Predict changes in rice yield and phenological growth due to the effects of projected climate change by 2060, with the help of the crop growth model -DSSAT.

- Analyze projected change in water demand for (a) rice production by 2060, as well as (b) 60% increase in rice yield to meet the demand of growing population by 2060.

Study Area Description

- Research is being conducted in collaboration between Borlaug Institute for South Asia (BISA), Bihar, India and University of Illinois at Urbana Champaign, USA.

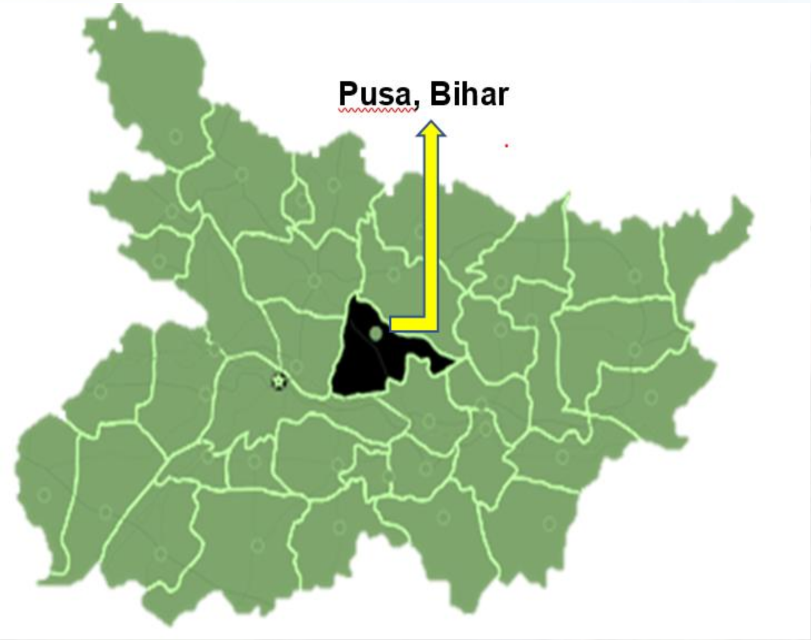
- **Experimental site:** Research Field of the "Borlaug Institute of South Asia", Pusa, Bihar, India.

  Latitude- 25°98' N

  Longitude- 85°67' E

- **Climate:** Hot and humid summers *(T max = 38 °C)* and cold winters *(T min= 0 °C)* with an average annual rainfall of 1297 mm.

- **Soil:** Alluvial sandy loam, which has 0.42% of organic matter content

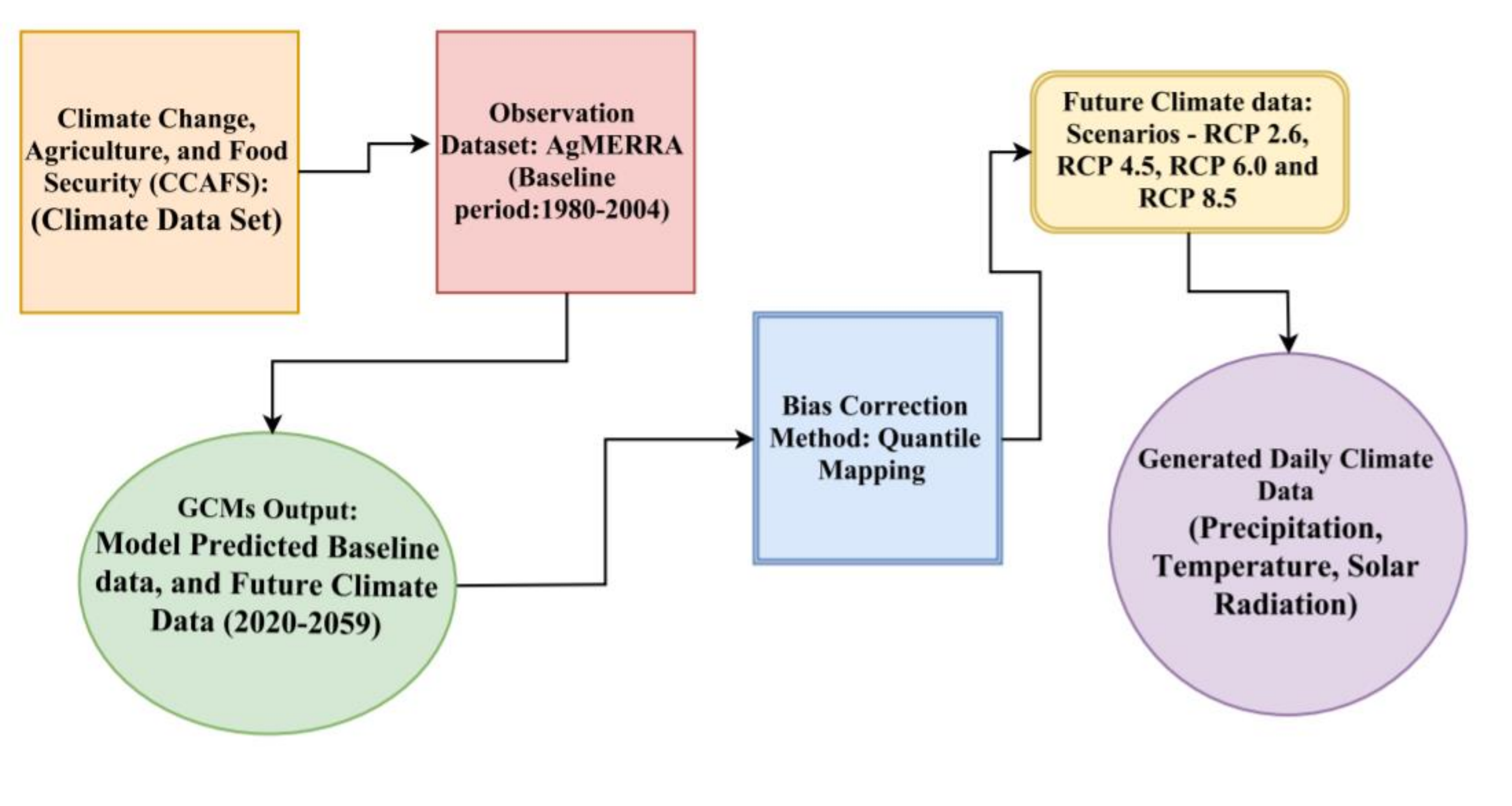


Geographical size of Bihar: 94.2 thousand square km

Population: 10.38 crores as per census 2011

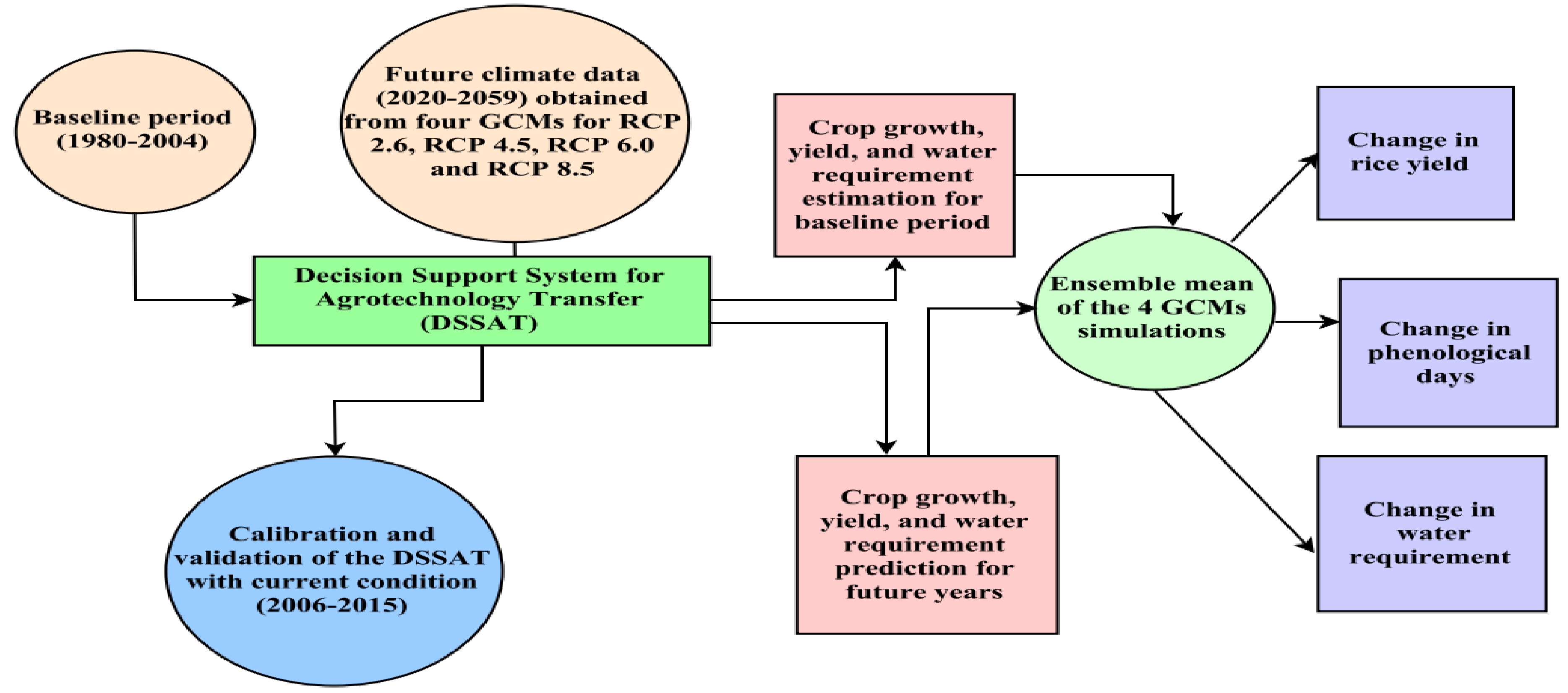
Climate change study

- **Steps in collection and correction of climate data**

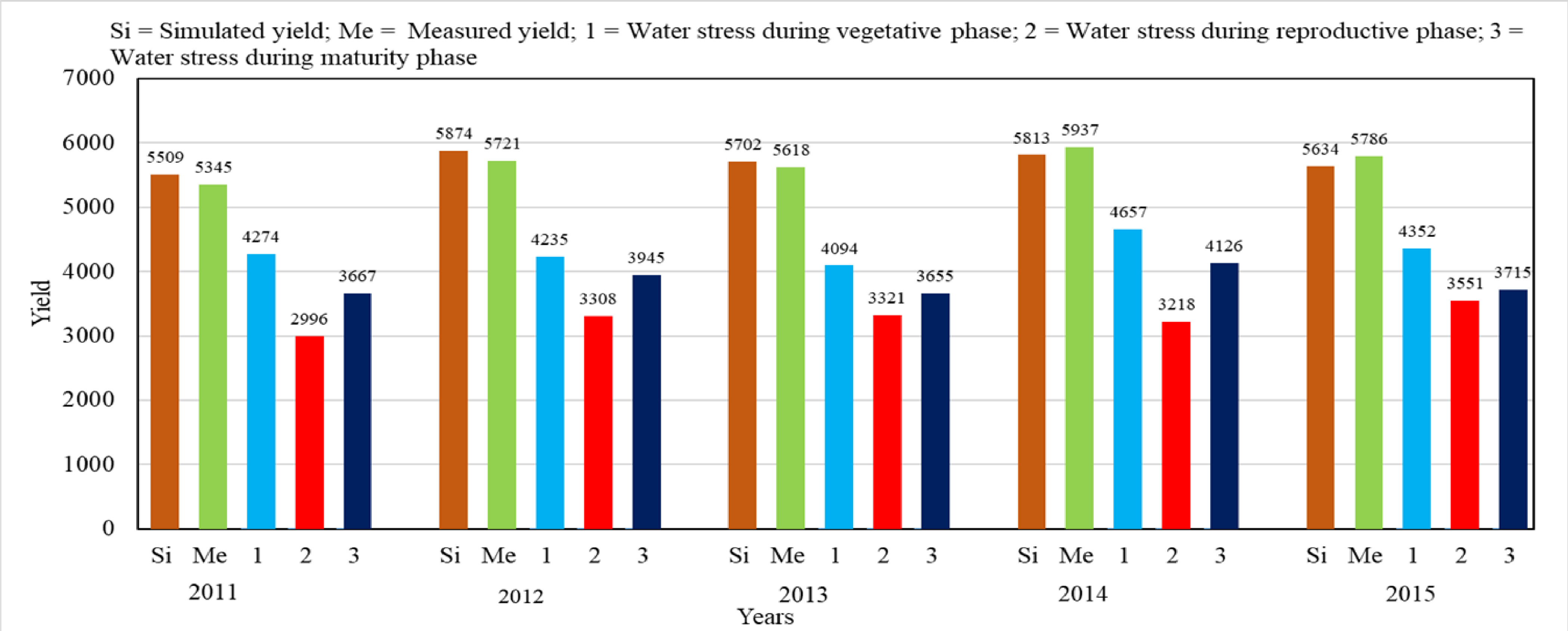


- **GCMs:**
  - **4 General circulation models GCMs**
    - **a.** bcc_csm1_1
    - b. ipsl_csm5a_mr
    - c. csiro_mk3_6_0
    - d. miroc_miroc5
- **Observation dataset** - "AgMERRA" has resolution of 0.25 degrees approx 25km.
- **Future Prediction:** 2020-2059 (40 years)

Estimation of climate change impact on rice production, phenological days, and water demand

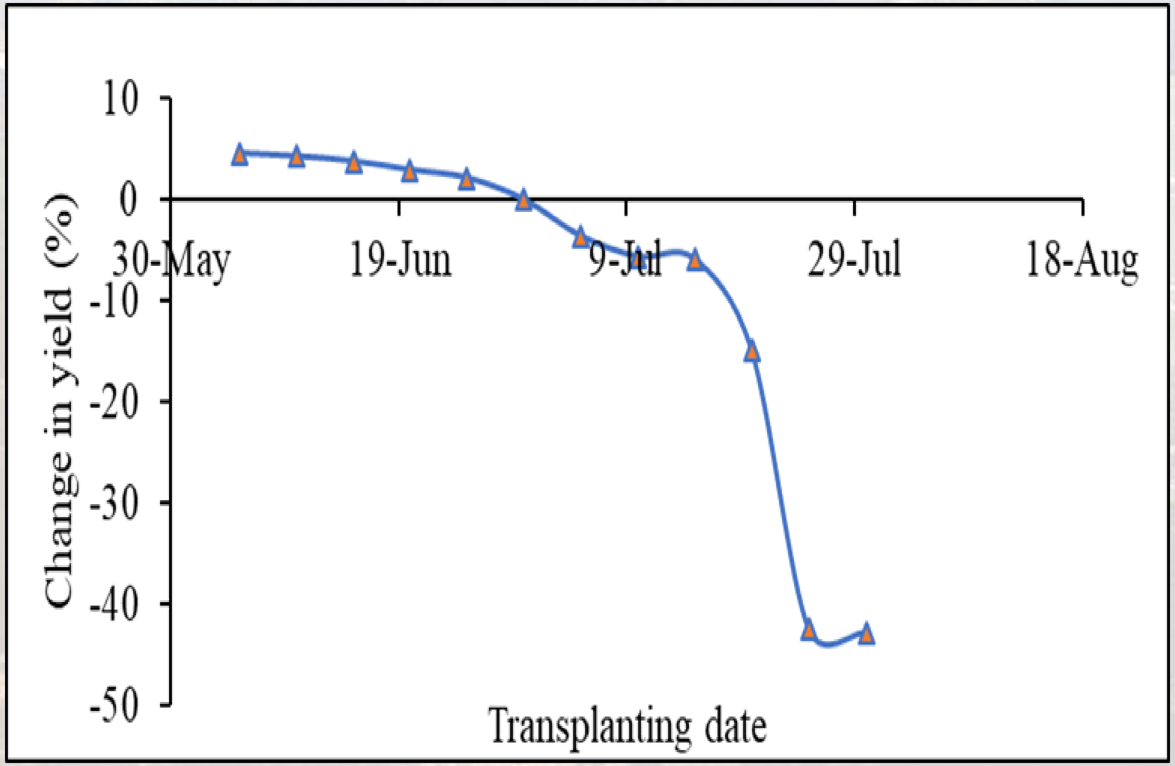


Water stress impact on rice yield at different phenological stages

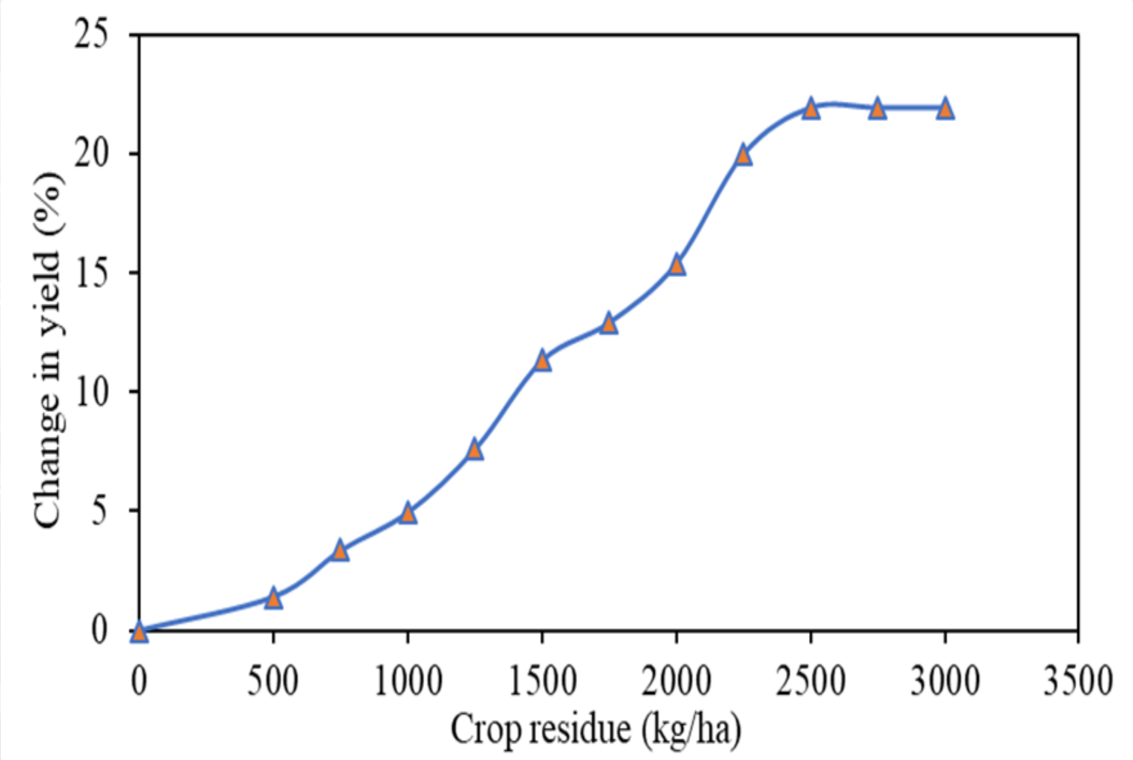


Management strategies for maximum yield of rice

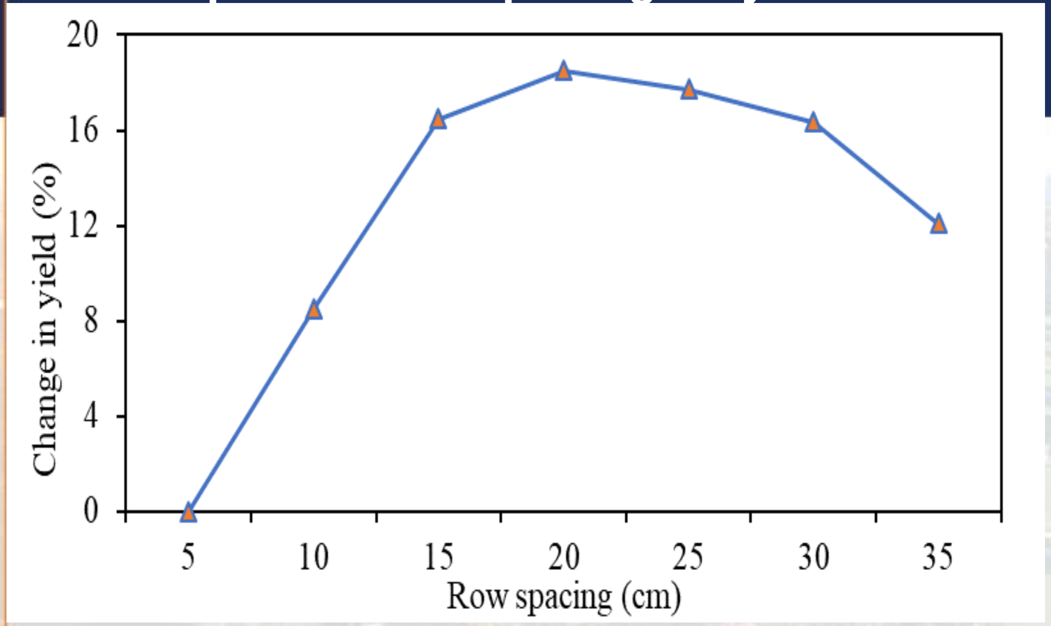
Impact of Transplanting date on yield



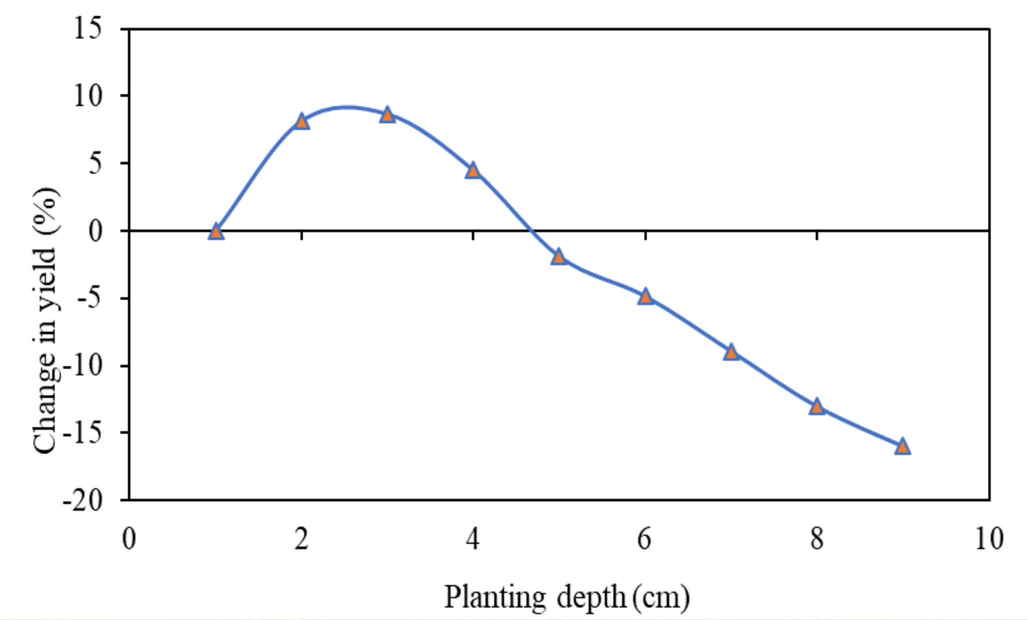
Impact of crop residue on yield

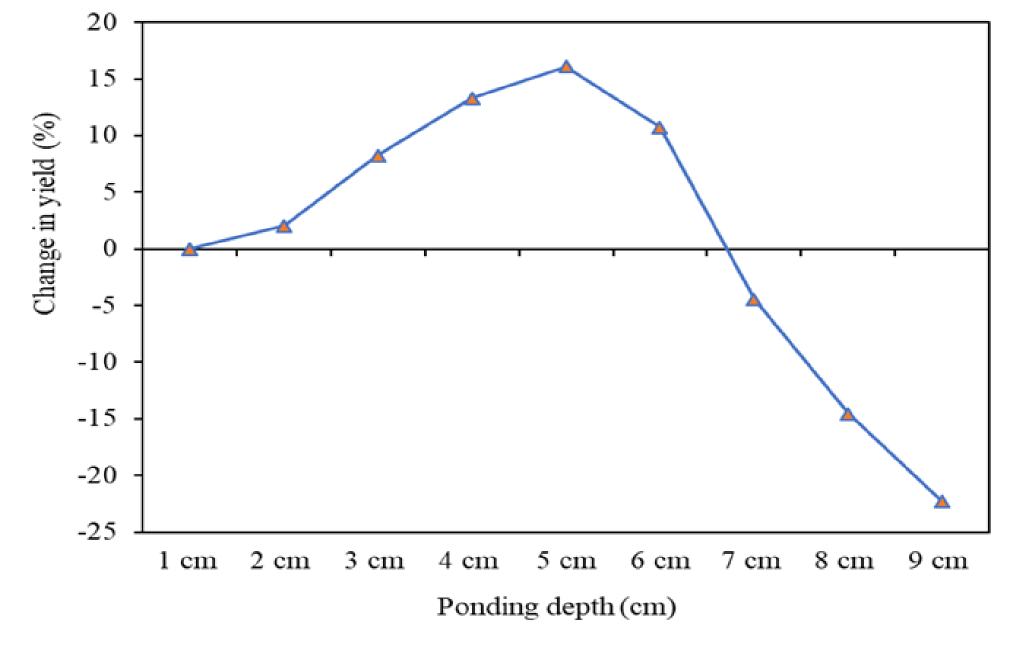


Impact of row spacing on yield



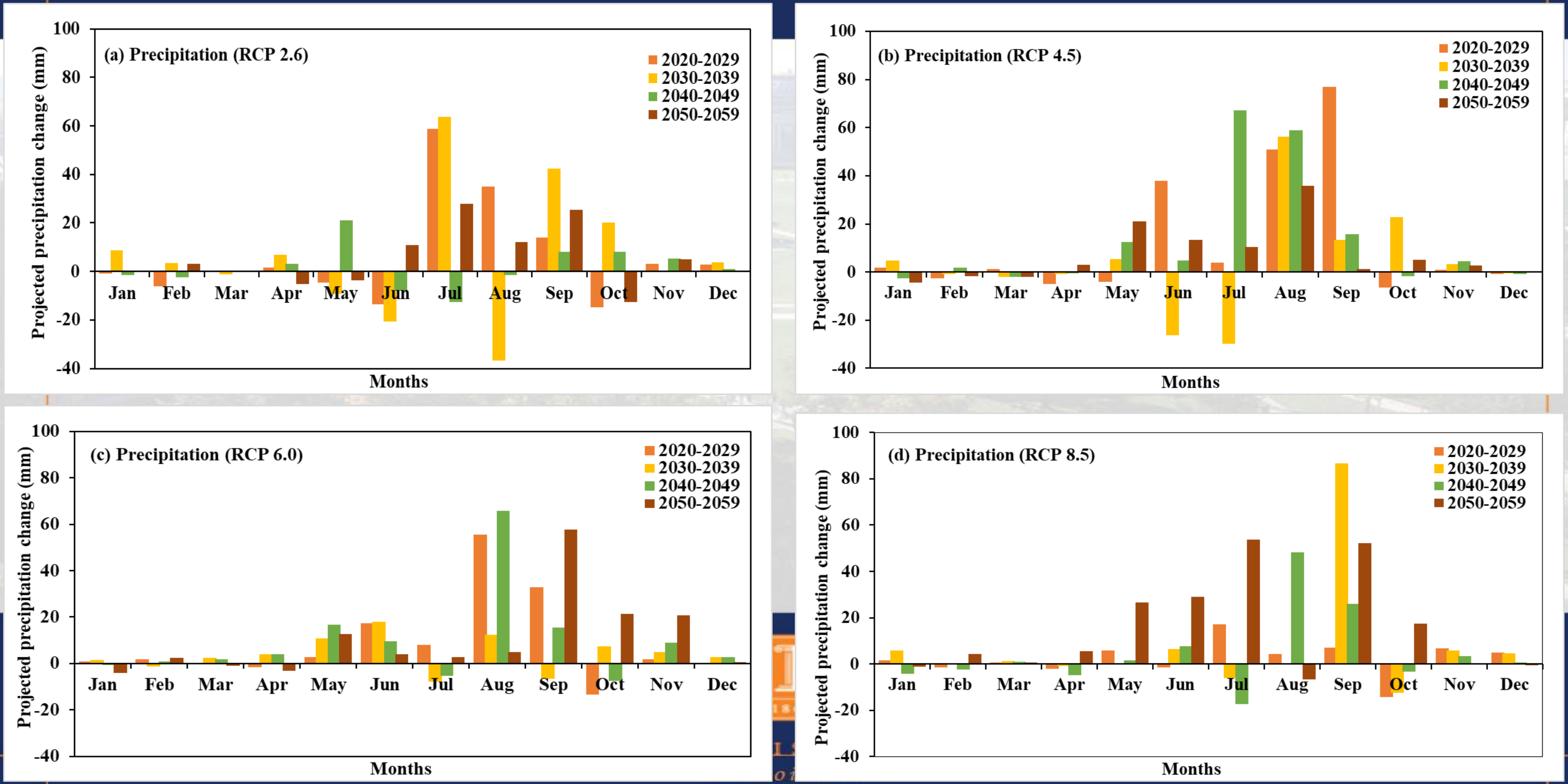
Impact of planting depth on yield



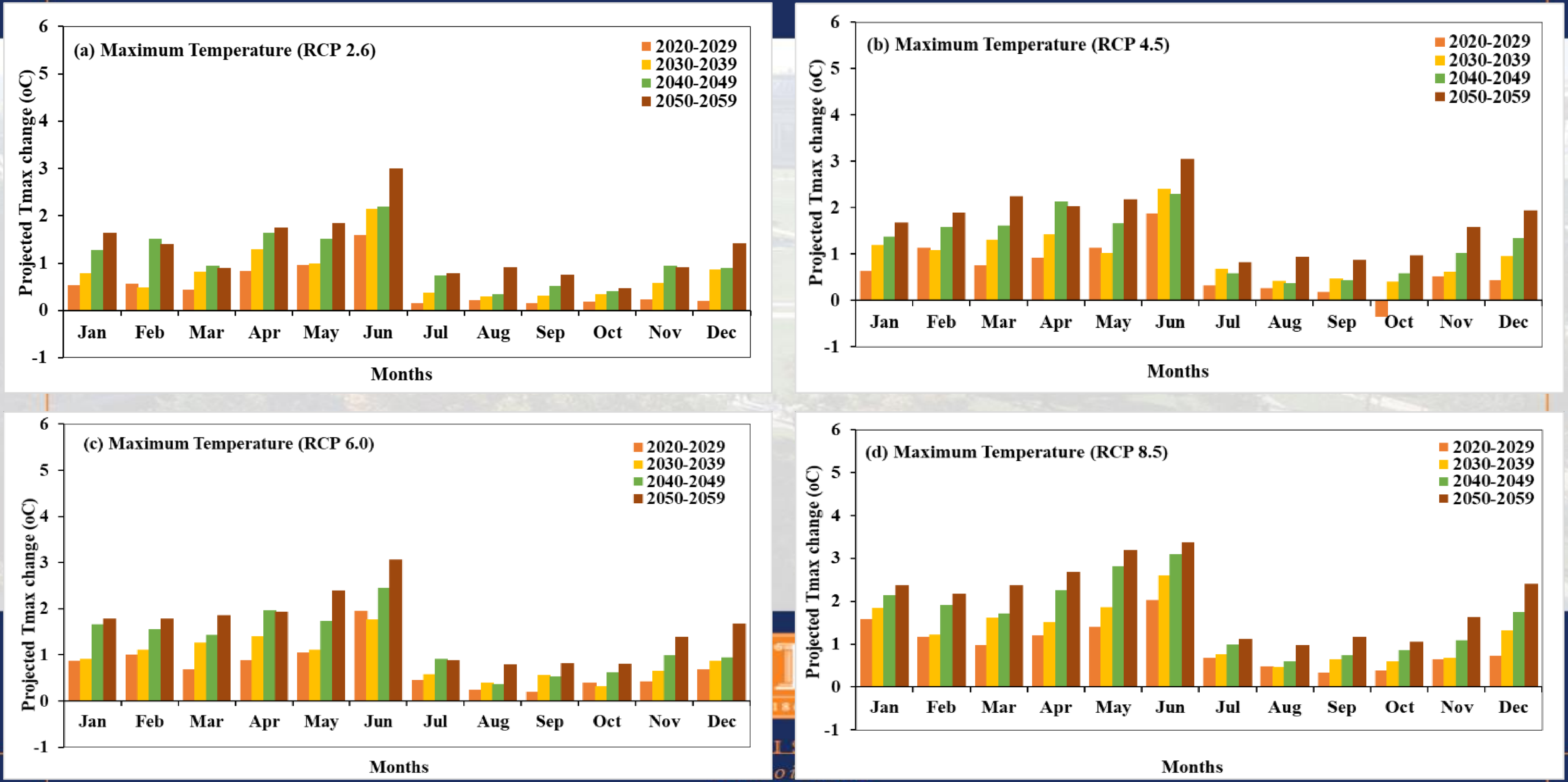


Impact of ponding depth on yield

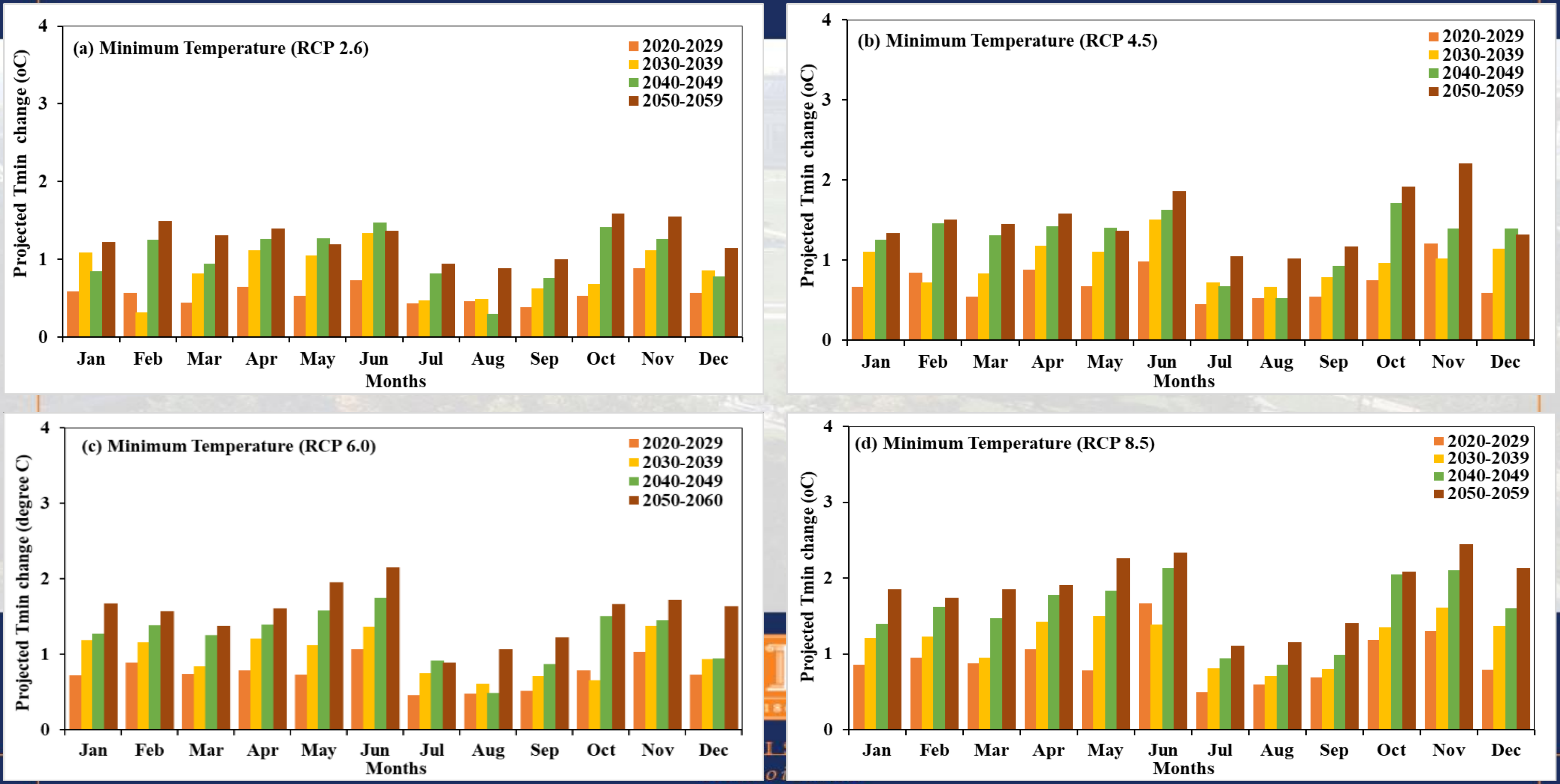
Projected Change in Precipitation



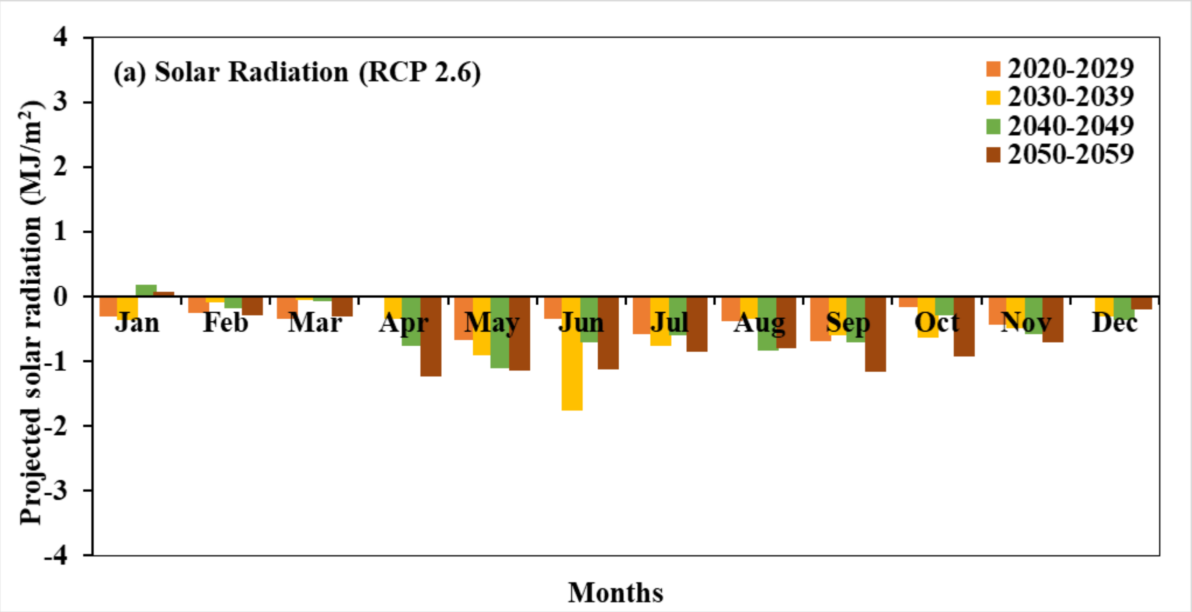
Projected Change in Maximum Temperature

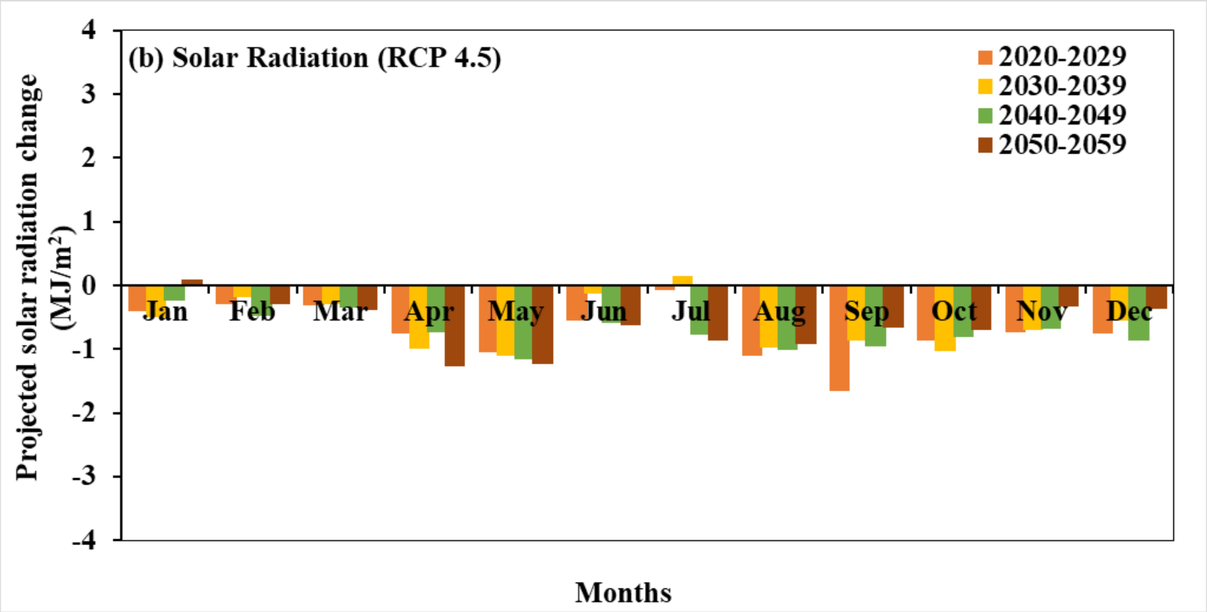


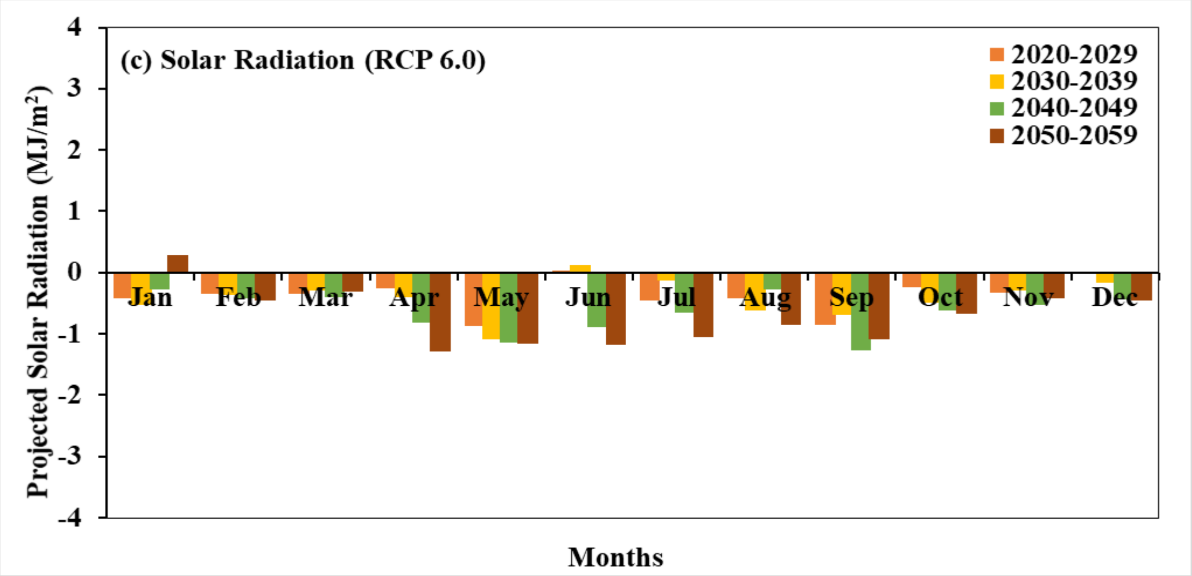
Projected Change in Minimum Temperature

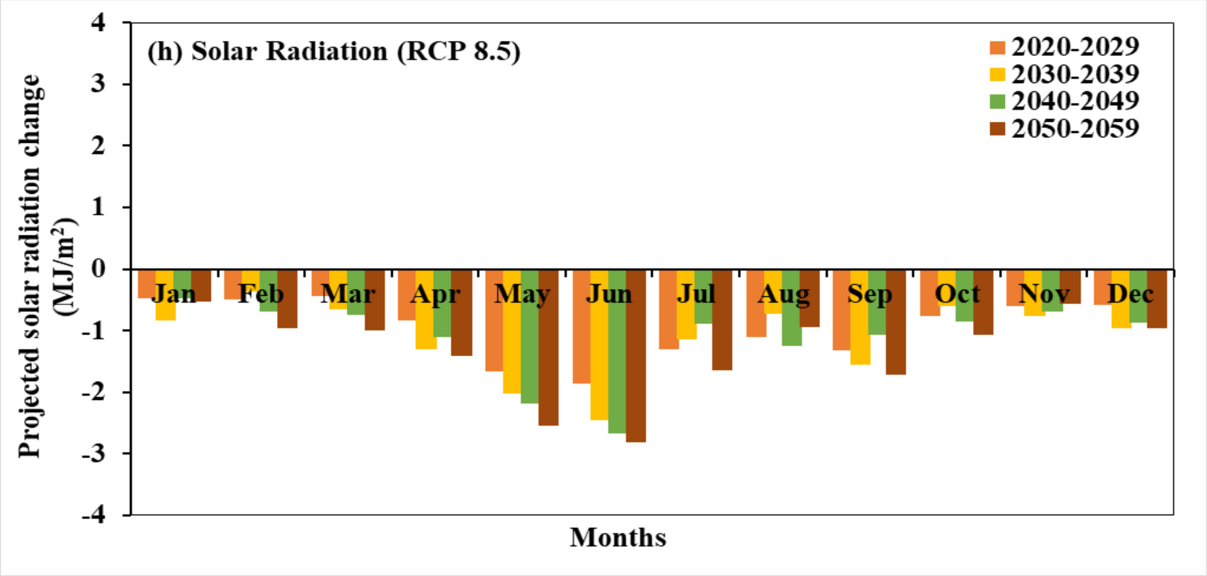


Projected Change in Solar Radiation

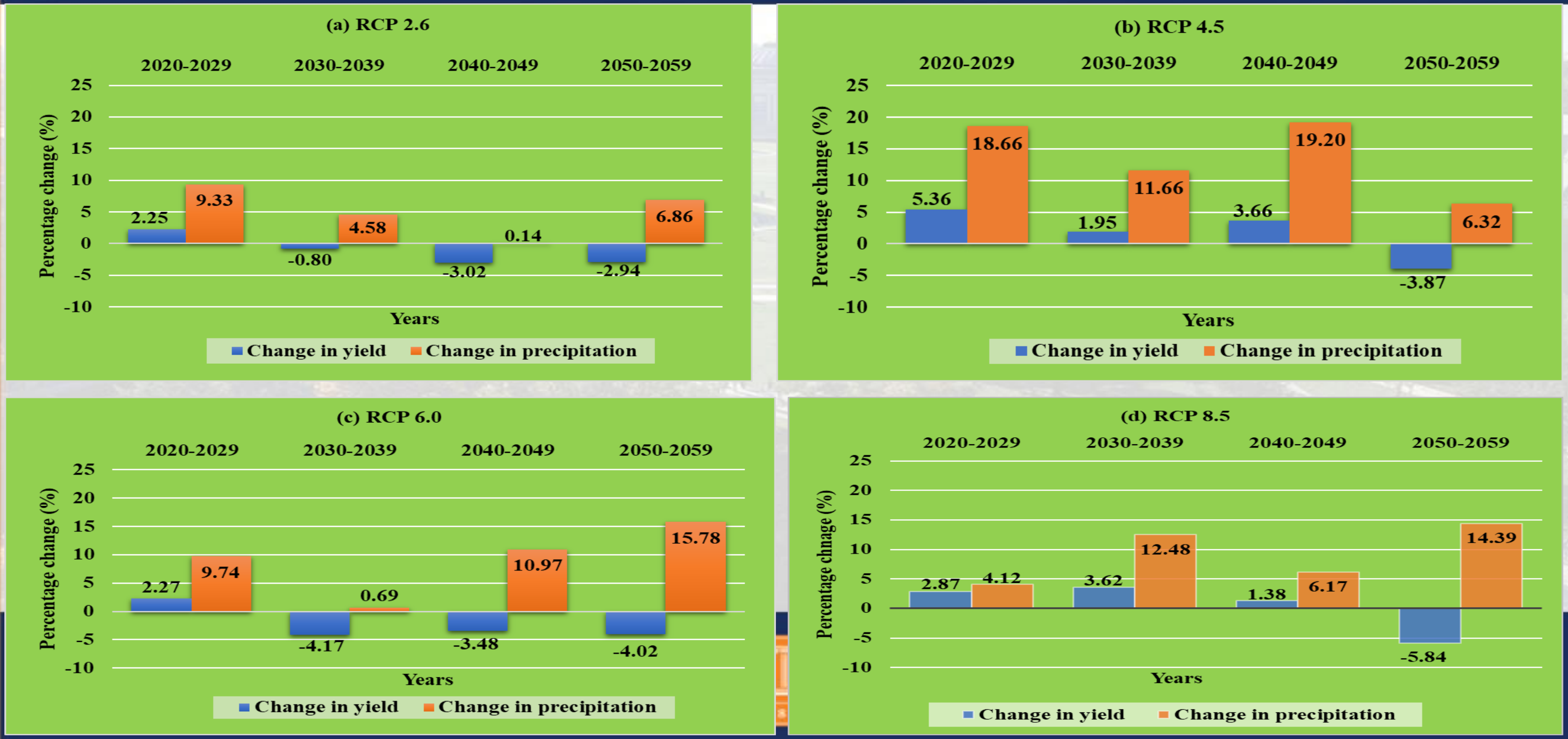




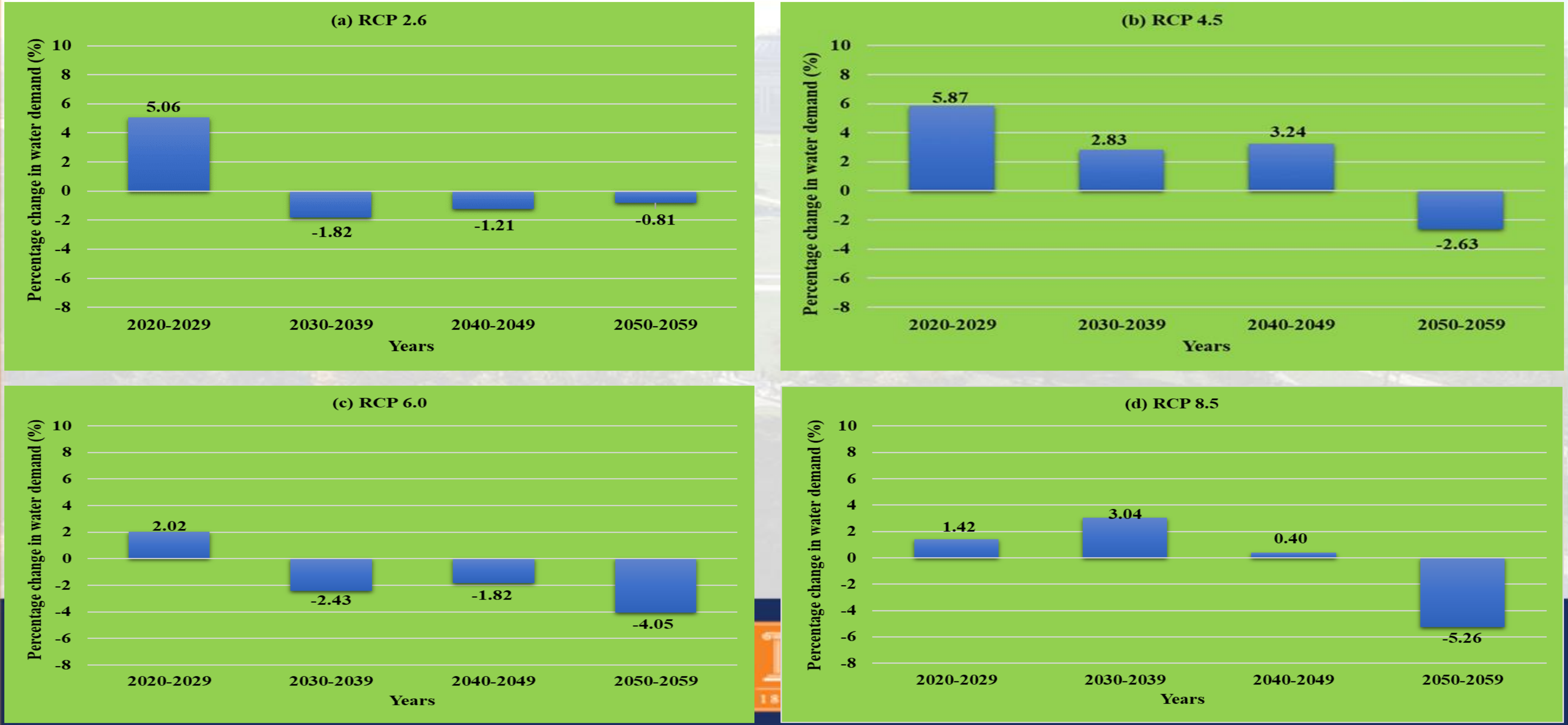




Climate change impact on Rice Productivity (% change over baseline)

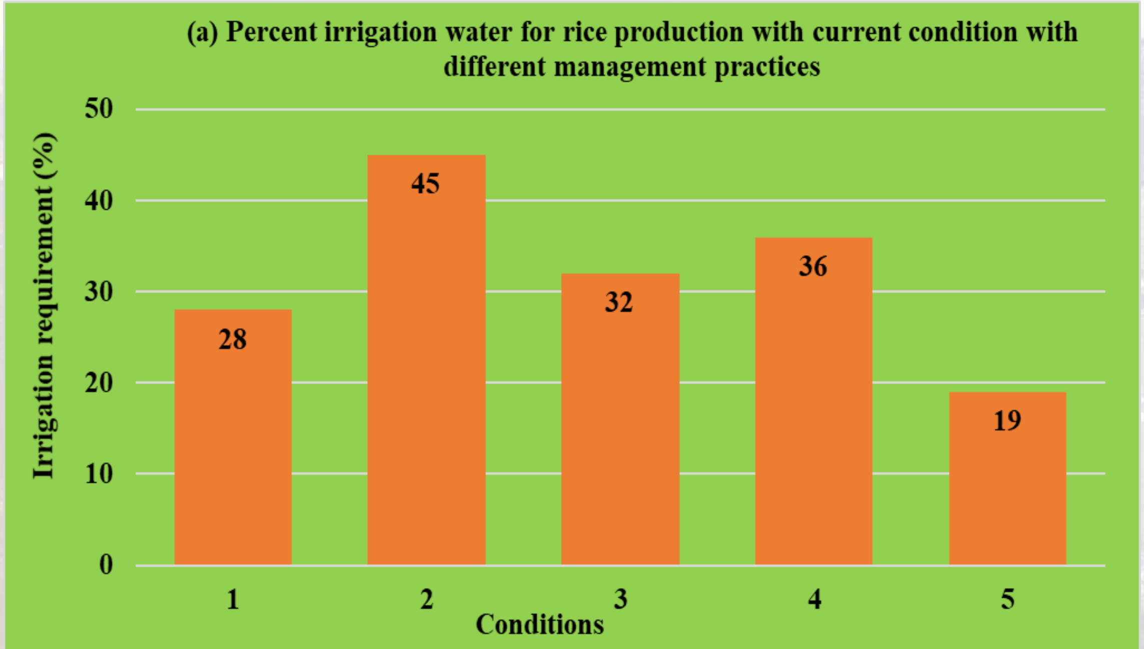


Climate change impact on water demand (% change over baseline)

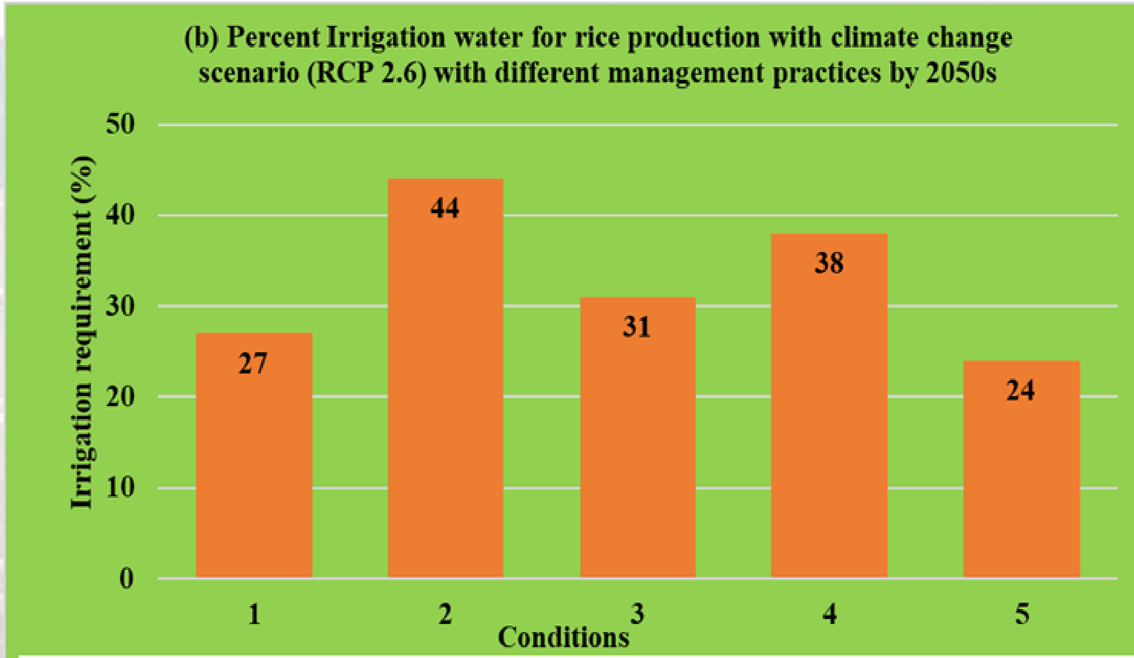


Climate change impact on Phenological Days (change in days from baseline period)

Irrigation requirement for current scenario and RCP 2.6 with different management practices

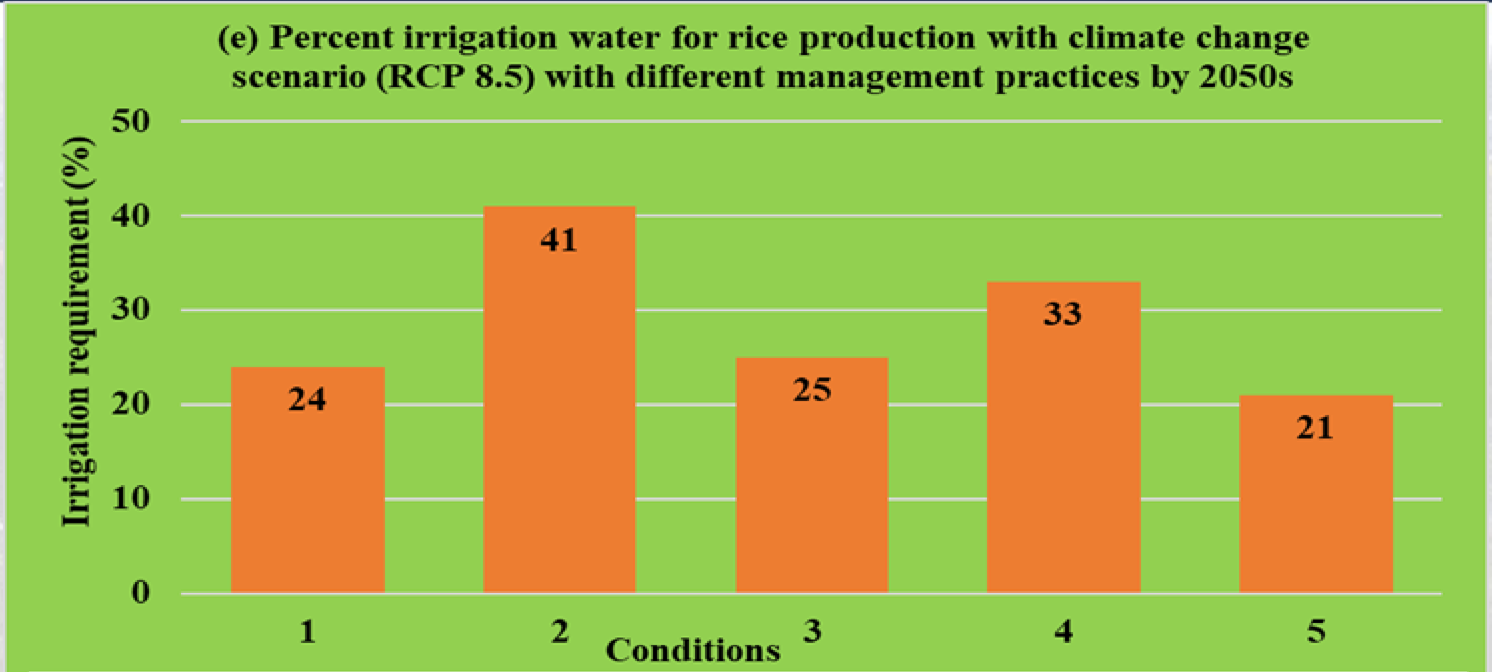


1. Current condition/Existing management.
2. For increase in yield by 60% with current management practice.
3. For increase in yield by 60% with conservation agriculture (Direct-seeded rice with residue (2500 kg/ha)).
4. For increase in yield by 30% (and reducing post-harvest loss by 30%) with current condition.
5. For increase in yield by 30% (with reducing post-harvest loss by 30% and applying conservation agriculture) with current condition.



1. For obtained yield with RCP 2.6 by 2050s.
2. For increase in yield by 60% with RCP 2.6 by 2050s.
3. For increase in yield by 60% with conservation agriculture (Direct-seeded rice with residue (2500 kg/ha)).
4. For increase in yield by 30% (and reducing post-harvest loss by 30%) with RCP 2.6.
5. For increase in yield by 30% (with reducing post-harvest loss by 30% and applying conservation agriculture) with RCP 2.6.

Irrigation requirement for climate change scenario (RCP 8.5) with different management practices by 2050s



1. For obtained yield with RCP 8.5 by 2050s.
2. For increase in yield by 60% with RCP 8.5 by 2050s.
3. For increase in yield by 60% with conservation agriculture (Direct-seeded rice with residue (2500 kg/ha)).
4. For increase in yield by 30% (and reducing post-harvest loss by 30%) with RCP 8.5.
5. For increase in yield by 30% (with reducing post-harvest loss by 30% and applying conservation agriculture) with RCP 8.5.

Summary

- Water stress during vegetative and maturity phase will decrease the yield by 24% and 33% respectively. However, the maximum decrease in yield by 43% will occur, while water stress during reproductive phase.

- Change in water demand was observed to vary with fluctuation in yield. The change in water demand was affected by increased CO_2 concentration (which reduces the water requirement for same level of yield).

- The gradual decrease in phenological days reflected that rice growth was affected by increase in temperature and decrease in solar radiation.

- The irrigation requirement is 28 % for rice production with current condition (5580 kg/ha) where puddling transplanted rice is used for cultivation. The yield obtained with climate change scenarios, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, were 5306 kg/ha, 5255 kg/ha, 5247 kg/ha and 5148 kg/ha, respectively, for 2050s, and requires 27%, 26%, 23% and 24% irrigation water, respectively.

Summary

- **Increase in yield by 60% by 2050s with current agronomic conditions, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5 needs 45%, 44%, 43%, 39% and 41% irrigation water, respectively. These results show that on an average, irrigation water demand would be increased by 17% for a 60% increase in yield.**

- **If conservation agriculture is utilized, irrigation requirement for the 60% increase in yield would be 32%, 31%, 28%, 26% and 25% with current condition, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, respectively. These results show that an increase of 60% yield can be achieved with conservation agriculture (direct seeding and residue incorporation) with only a 1 to 4% increase in irrigation requirement, given other conditions remain the same. This is a significant water saving.**

- **To increase the yield by 30% with transplanting method of rice cultivation (and reducing the post-harvest losses by 30%) will need irrigation water of 36%, 38%, 35%, 30% and 33% with current condition, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, respectively. These results show that for a 30% yield increase, an increase in irrigation requirement of about 9% will be required.**

- **Increase in yield by 30% (and reducing post-harvest losses by 30%) and applying conservation agriculture (direct seeding and residue incorporation) will need 19%, 24%, 22%, 17% and 21% irrigation water with current condition, RCP 2.6, RCP 4.5, RCP 6.0 and RCP 8.5, respectively.**

Toda raba - Thank you very much