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Investigating future yield and adaptation measures in rice production under climate change scenarios in Quang Nam province, Vietnam

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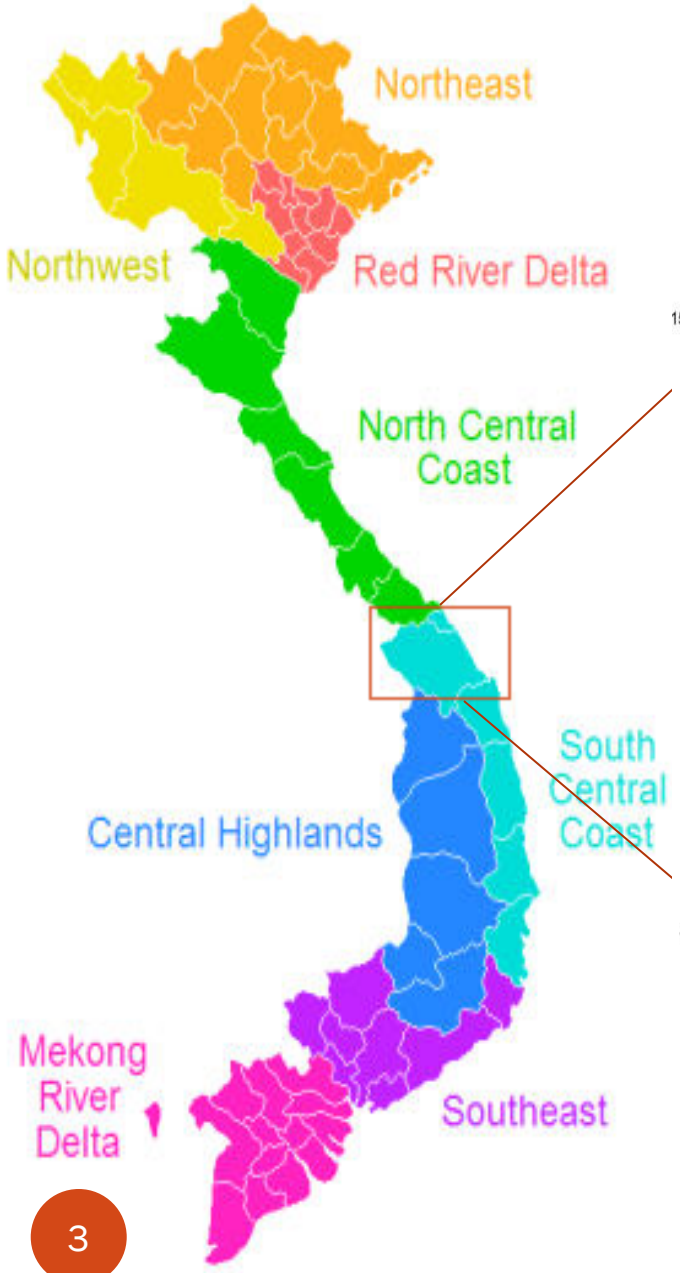
Objective of the Study

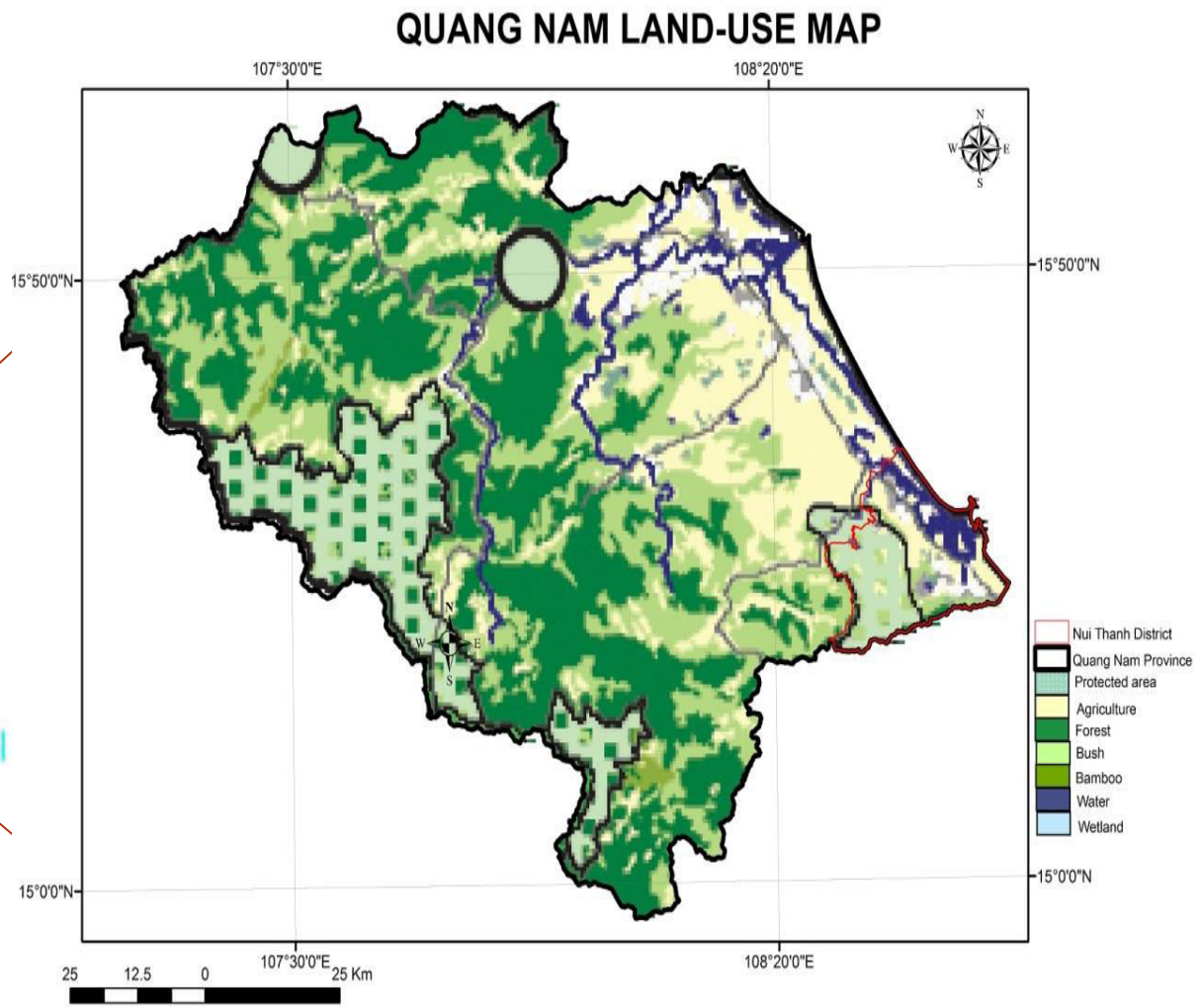
General objective:

to forecast future rainfall, temperature and rice yield, and analyze adaptation measures to improve rice production under different climate change scenarios in Nui Thanh district, Quang Nam province, Vietnam.

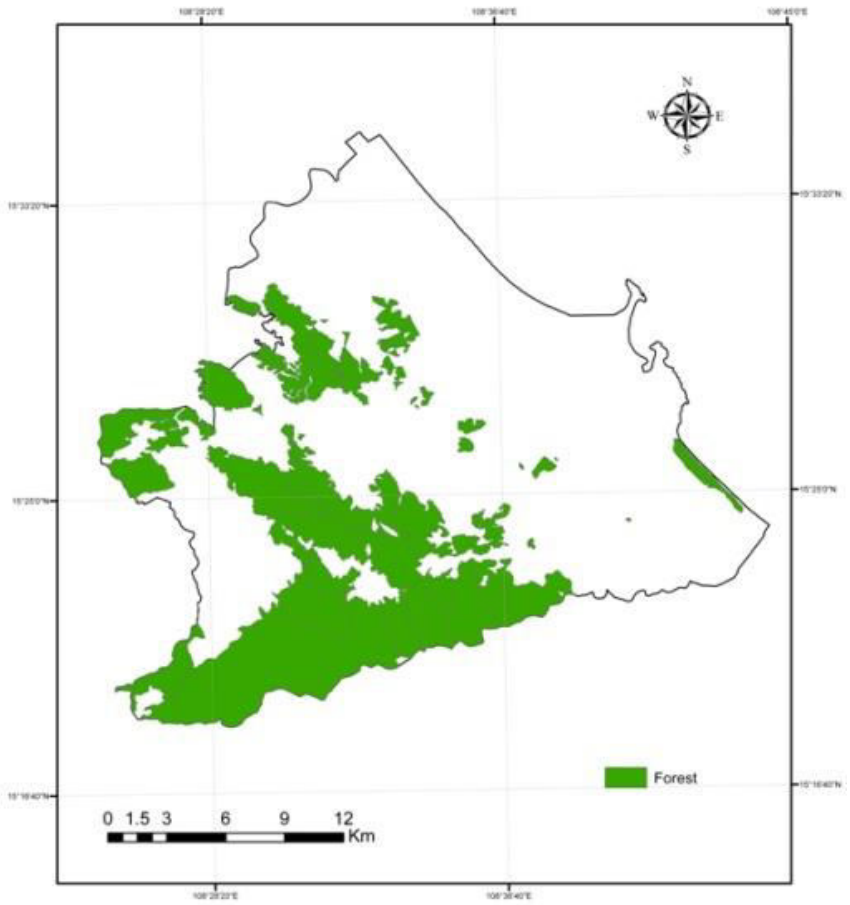
Specific objectives:

- To forecast amount of rainfall, temperature on the future in the study area under climate change condition
- To predict yield crop in future by using result of climate change scenarios
- To evaluate adaptation measures to improve rice production under climate change, based on water management

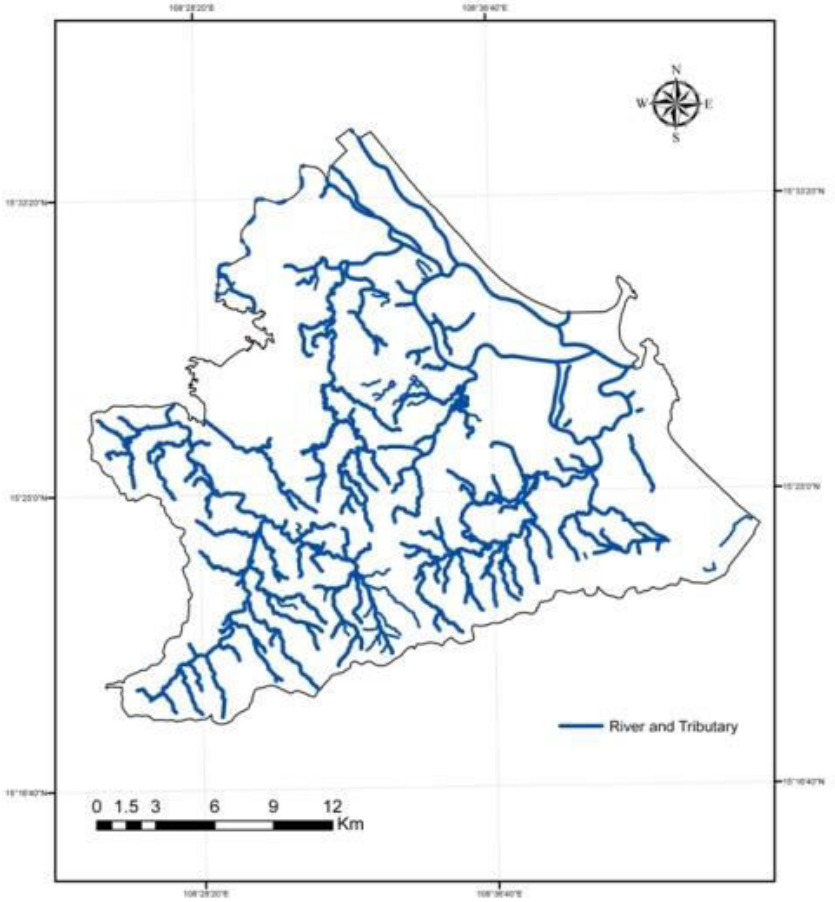

Northeast
Northwest
Red River Delta
North Central Coast
South Central Coast
Central Highlands
Mekong River Delta
Southeast


QUANG NAM LAND-USE MAP
107°30'0"E
108°20'0"E
15°50'0"N
15°0'0"N
N
W
E
S
25
12.5
0
25 Km
Nui Thanh District
Quang Nam Province
Protected area
Agriculture
Forest
Bush
Bamboo
Water
Wetland

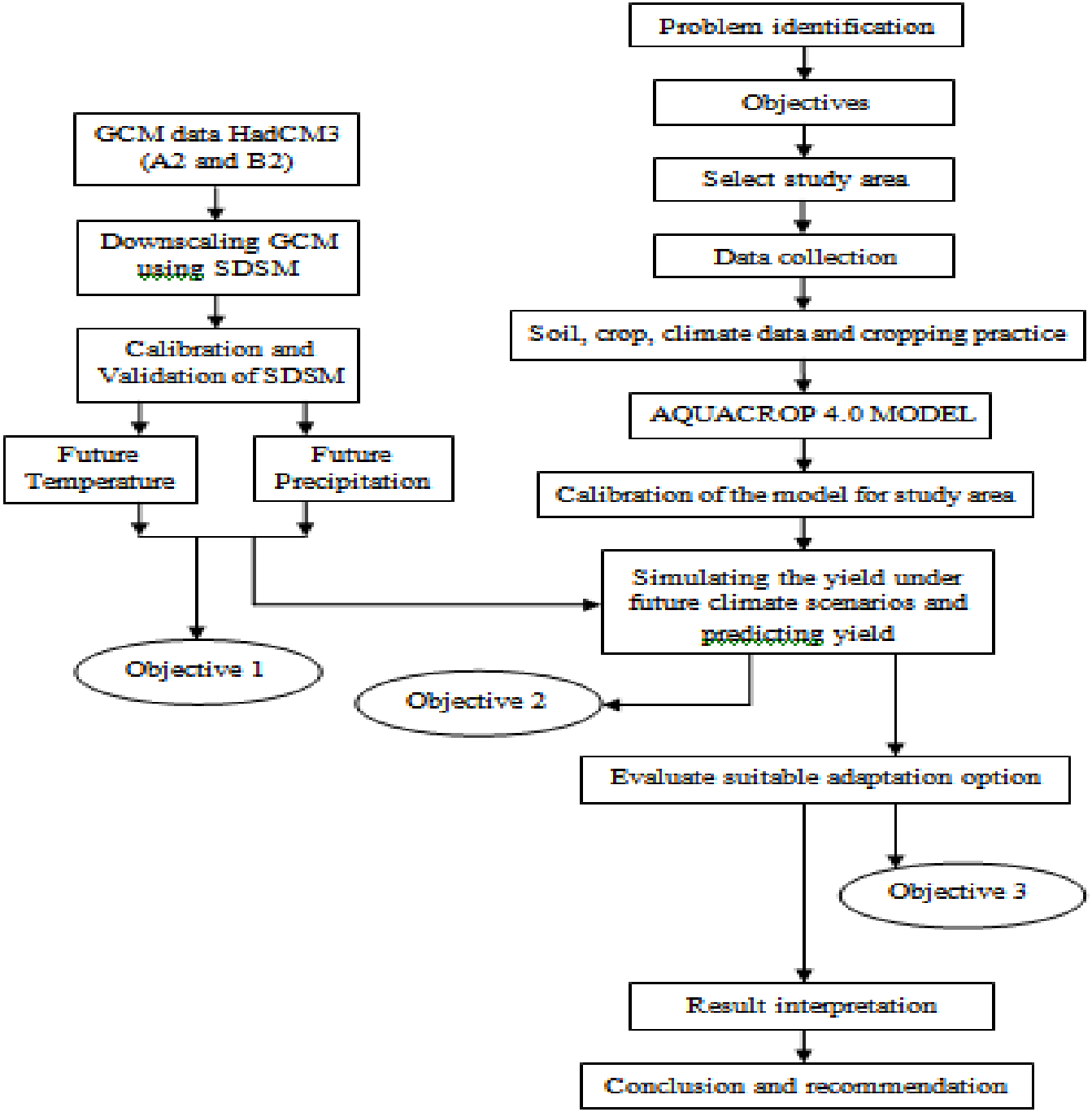
NUI THANH FOREST MAP



NUI THANH HYDROLOGY MAP



Methodology



The input and output data of Aquacrop model

Data	Input	Output
Climatic	- Daily rainfall, daily maximum/ minimum temperature, daily air relative humidity, daily sunshine duration, daily wind speed at 2 m high (m/s) (2001-2010) - Average monthly means of minimum temperature (^{0}C), maximum temperature, air relative humidity, sunshine duration, wind speed at 2 m high (2001-2010) - Potential evapotranspiration (ETo) measured or calculated with Penman-Monteith - Daily future climate scenarios - Average monthly rainfall, minimum temperature (^{0}C), maximum temperature (^{0}C) of the future climate (Periods: 2014-2040, 2041-2070, 2071-2090)	- To choose the suitable parameter for model - Crop water requirement - Irrigation requirement - The yield of baseline
Crop	- Sowing date, density of plants, flowering date, area, maturity date, grain yield	- Actual crop evapotranspiration
Soil	- Initial soil moisture condition - Maximum root infiltration rate - Maximum rooting depth - Soil properties (soil texture, field capacity, permanent wilting point, saturated hydraulic conductivity, bulk density, electrical conductivity, pH)	- Daily soil moisture deficit
Irrigation	- Irrigation scheduling criteria - Amount of water management for development stages of the rice plant	- Irrigation scheduling - Estimated yield reduction due to crop stress

Projection of future temperature

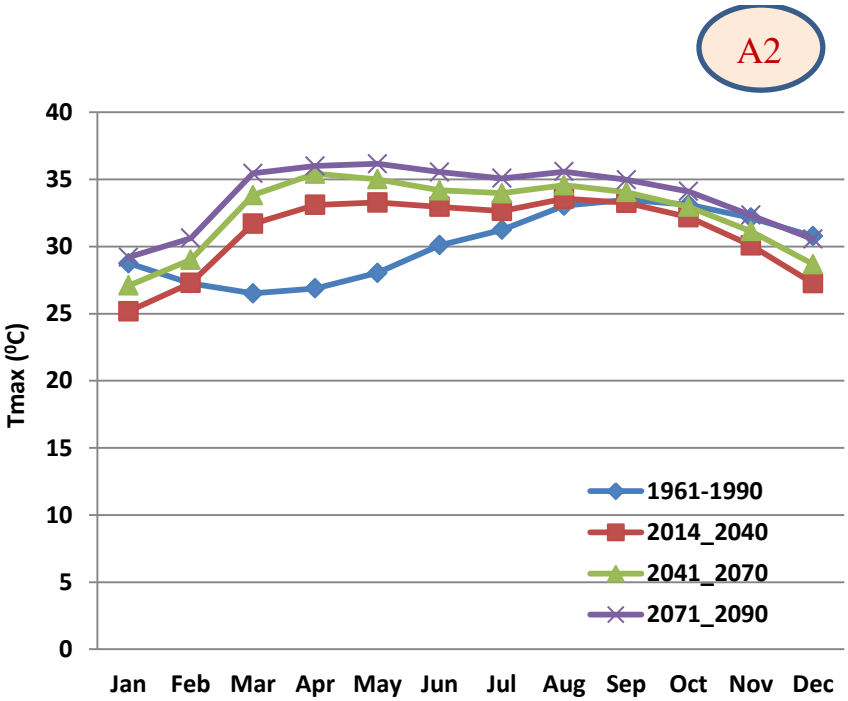
Future changes in maximum temperature

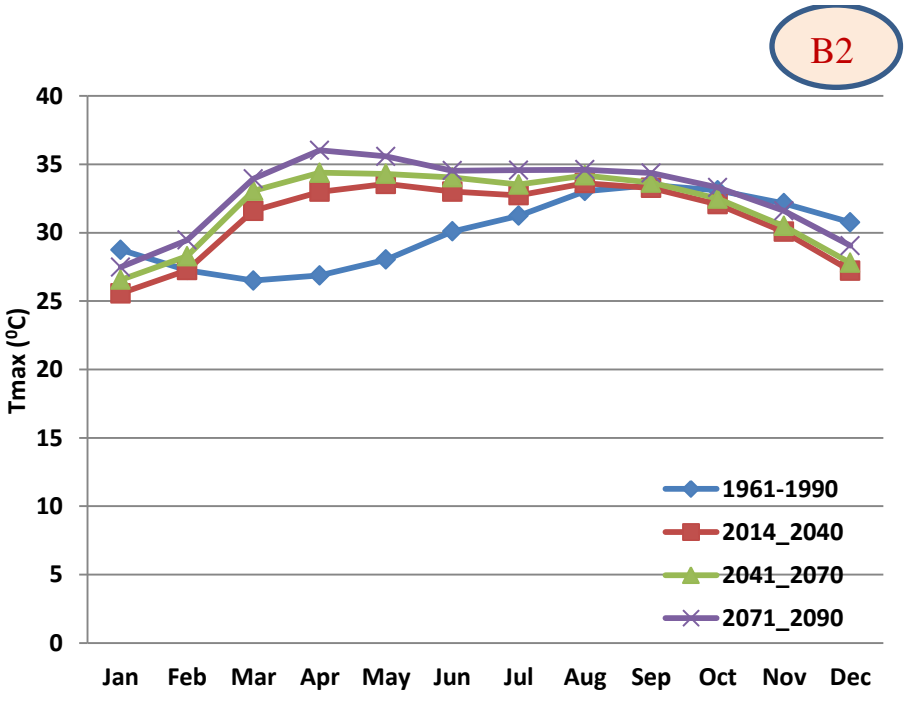
Time Period	Maximum Temperature (Tmax) (°C)				
	Baseline	Scenario A2		Scenario B2	
		Tmax	Change	Tmax	Change
2014-2040	30.11	31.04	0.93	31.09	0.98
2041-2070		32.49	2.38	31.90	1.79
2071-2090		33.80	3.69	32.89	2.78

Future changes in minimum temperature

Time Period	Minimum Temperature (Tmin) (°C)				
	Baseline	Scenario A2		Scenario B2	
		Tmin	Change	Tmin	Change
2014-2040	21.60	21.95	0.35	21.99	0.39
2041-2070		22.70	1.10	22.41	0.81
2071-2090		23.32	1.72	22.89	1.29

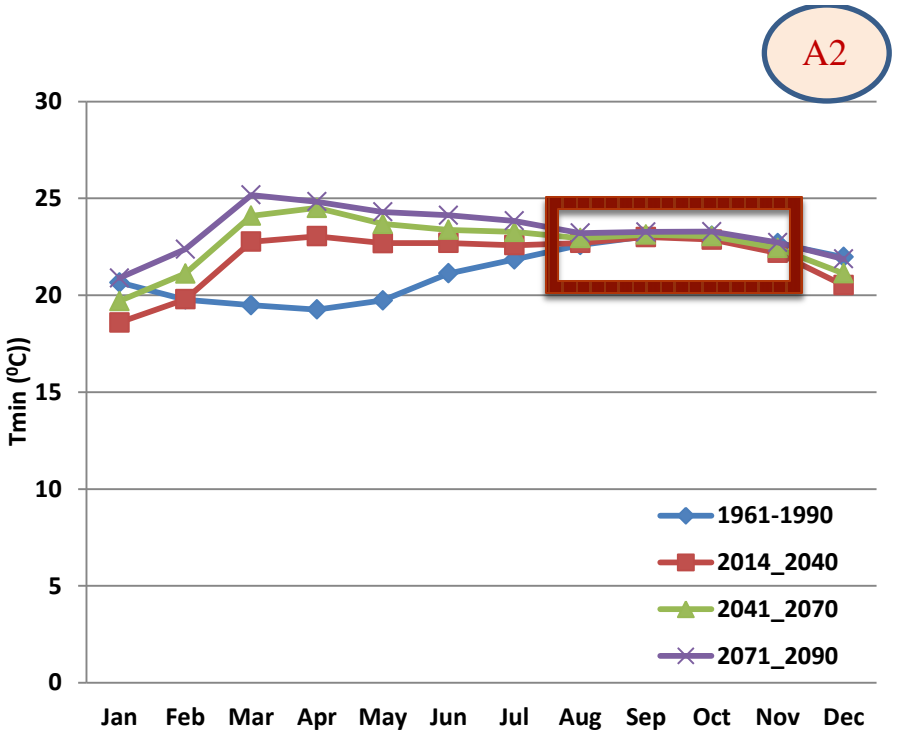
Projection of future temperature

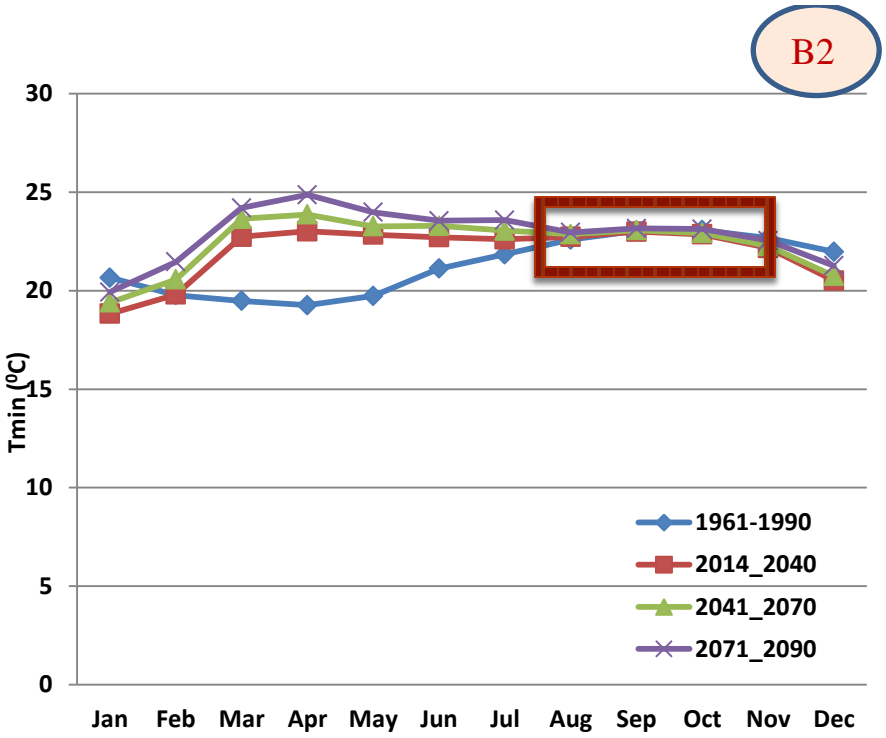




Monthly average maximum temperature for 30 years interval for A2 and B2 scenarios

Projection of future temperature





Monthly average minimum temperature for 30 years interval for A2 and B2 scenarios

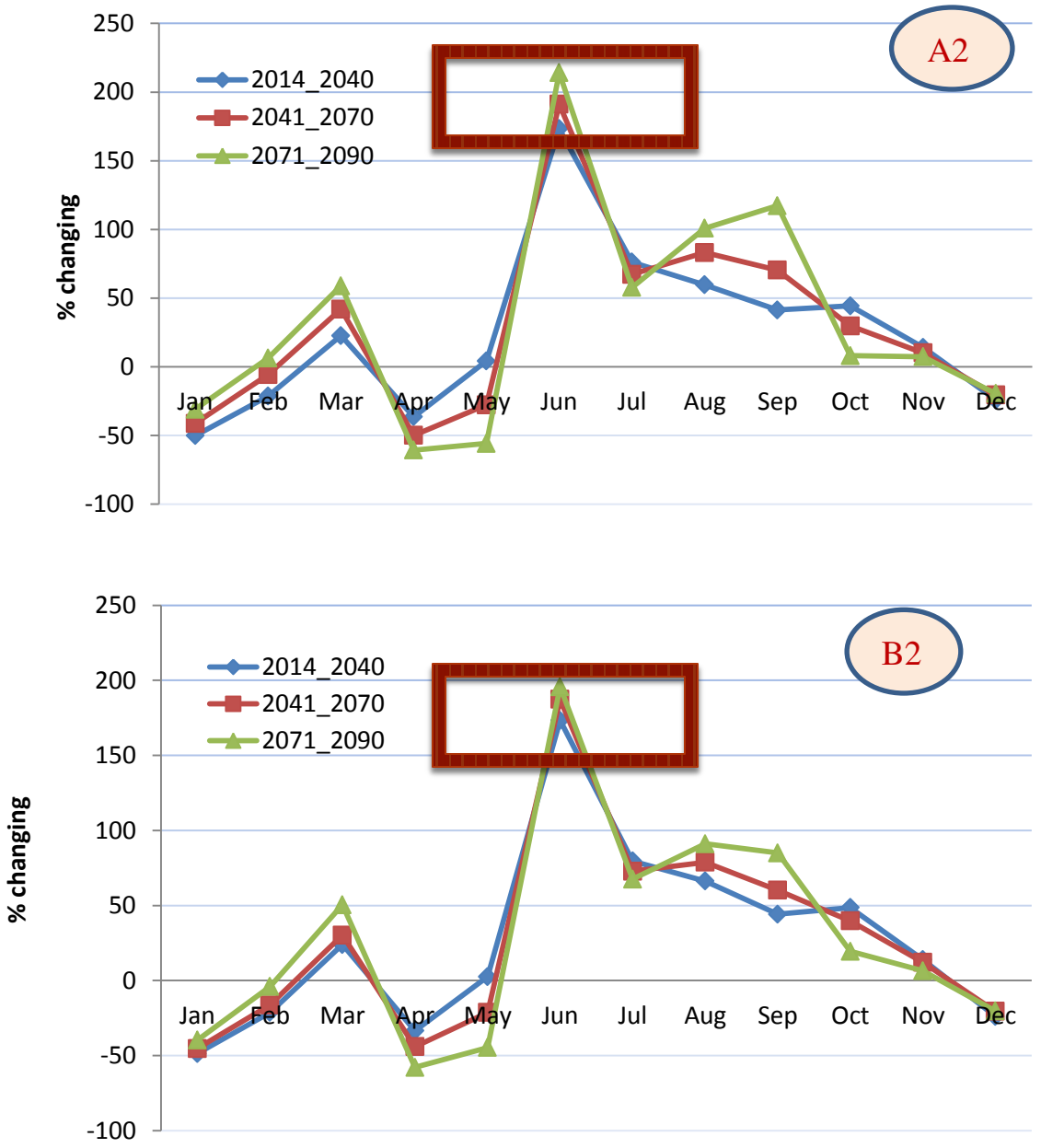
Projection of future precipitation

Percentage changes in precipitation with A2 and B2 scenarios compared to baseline

Time Period	**Precipitation (Precp) (mm)**				
	Baseline	Scenario A2		Scenario B2	
		Precp	Change (%)	Precp	Change (%)
2014-2040	2655.44	2673.05	0.66	2703.92	1.83
2041-2070		2801.63	5.51	2747.65	3.47
2071-2090		2914.41	9.75	2804.70	5.62

Projection of future precipitation

Changing in precipitation for A2 and B2 scenarios compared to the baseline period



Impact of future climate change scenarios on rice

Simulate rice yield and biomass of observe for A2 and B2 emission scenarios using Aquacrop model for winter crop

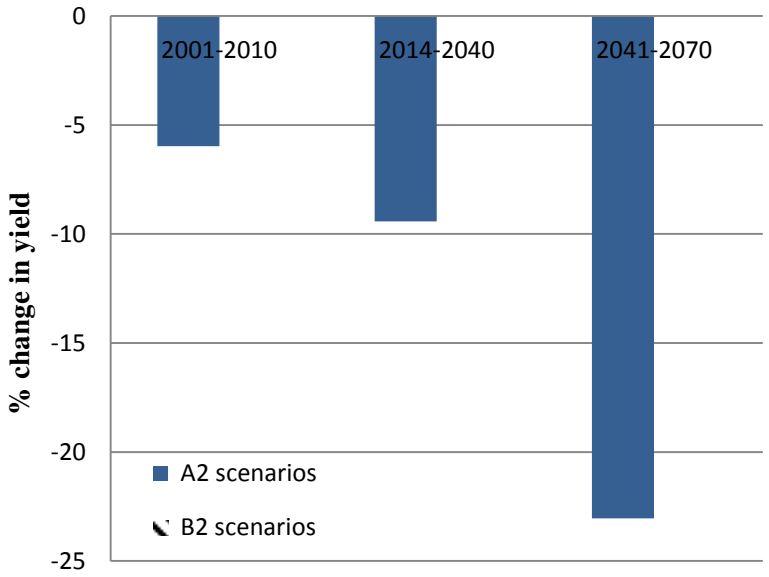
Time period		Yield (t/ha)	Change (%)	Biomass (t/ha)
Baseline	2001-2010	5.21		14.89
A2	2014-2040	4.90	-5.97	14.00
	2041-2070	4.72	-9.42	13.49
	2071-2090	4.01	-23.05	11.46
B2	2014-2040	5.14	-1.29	14.70
	2041-2070	4.83	-7.31	13.80
	2071-2090	4.64	-10.96	13.26

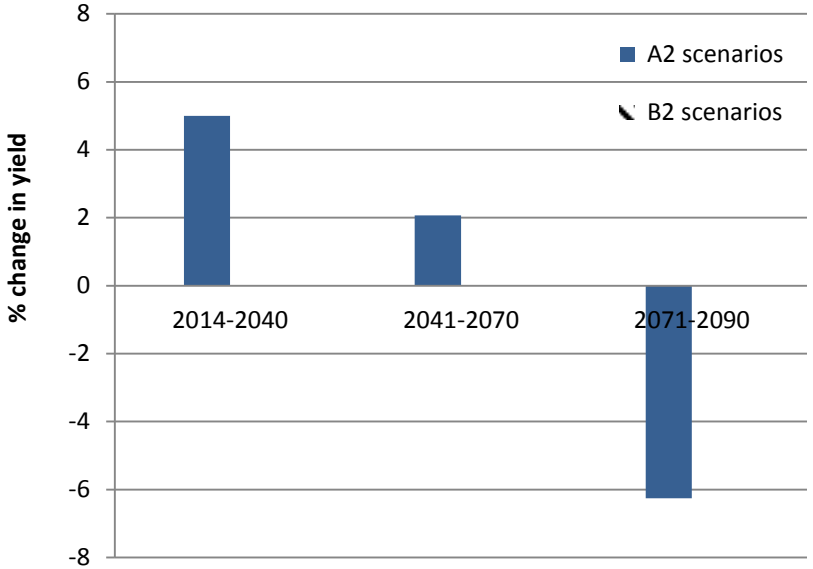
Impact of future climate change scenarios on rice

Simulate rice yield and biomass of observe for A2 and B2 emission scenarios using Aquacrop model for summer crop

Period		Yield (t/ha)	Change (%)	Biomass (t/ha)
Baseline	2001-2010	5.42		15.38
A2	2014-2040	5.69	5.00	16.26
	2041-2070	5.53	2.07	15.80
	2071-2090	5.08	-6.26	14.51
B2	2014-2040	5.78	6.66	16.51
	2041-2070	5.57	2.79	15.91
	2071-2090	5.32	-1.83	15.20

Percentage change in rice yields with A2 and B2 scenarios for periods 2014-2040, 2041-2040 and 2071-2090 relative to 1961-1990

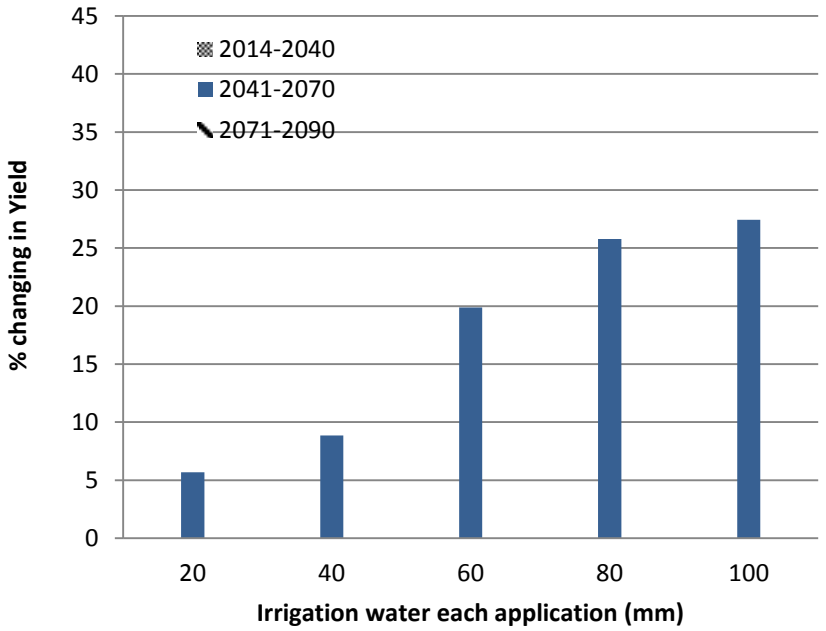


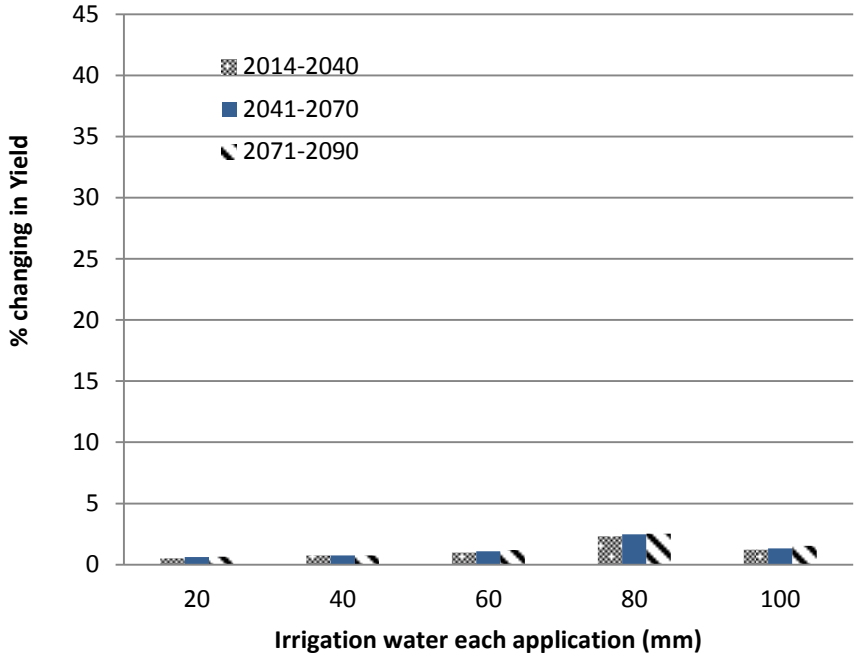


Winter crop

Summer crop

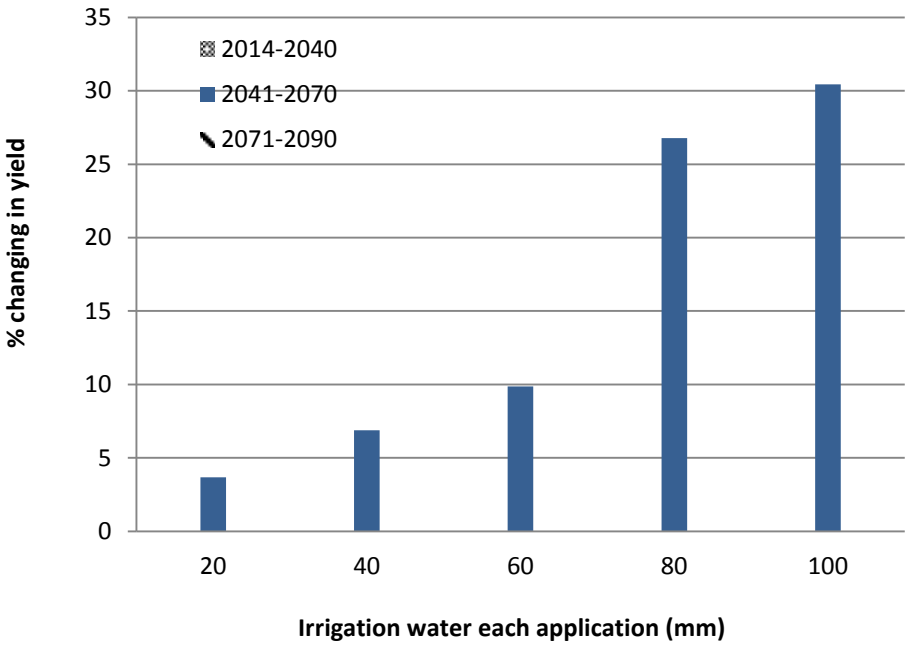
Impacts of supplementary irrigation on rice yield for A2 scenario

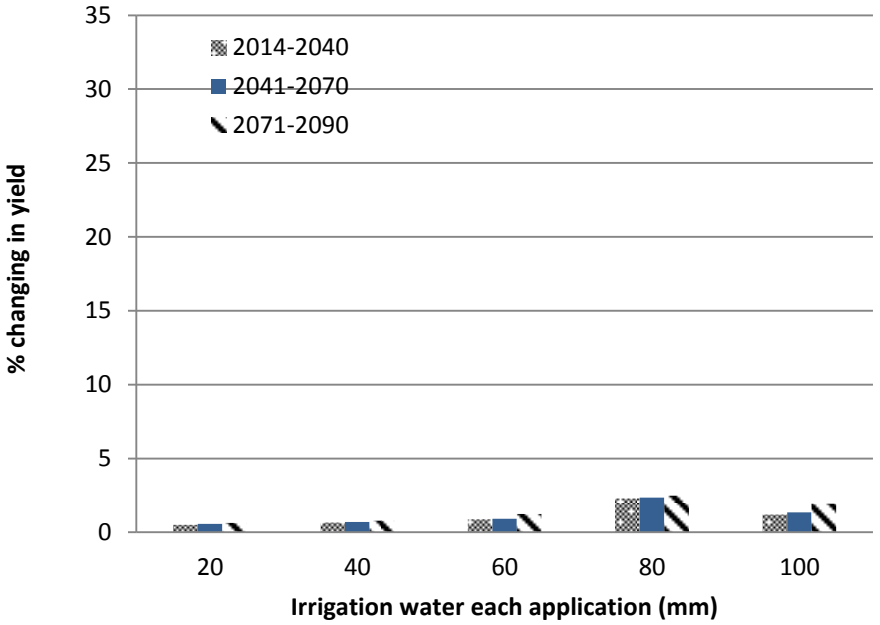




Impact of supplemental irrigation on rice for A2 scenario
(a) winter crop and (b) summer crop

Impacts of supplementary irrigation on rice yield for B2 scenario



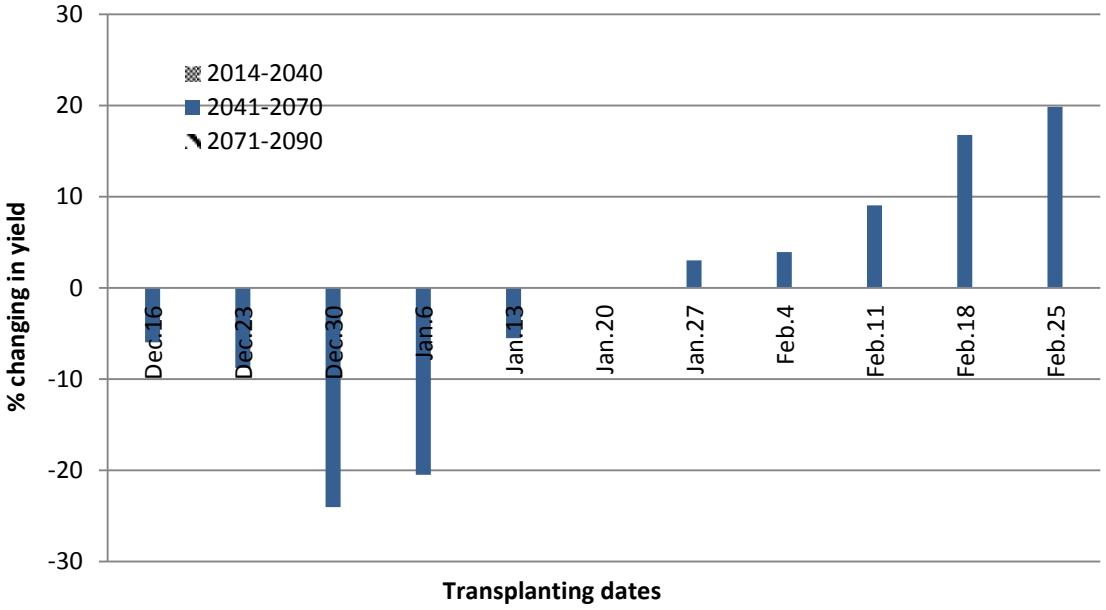


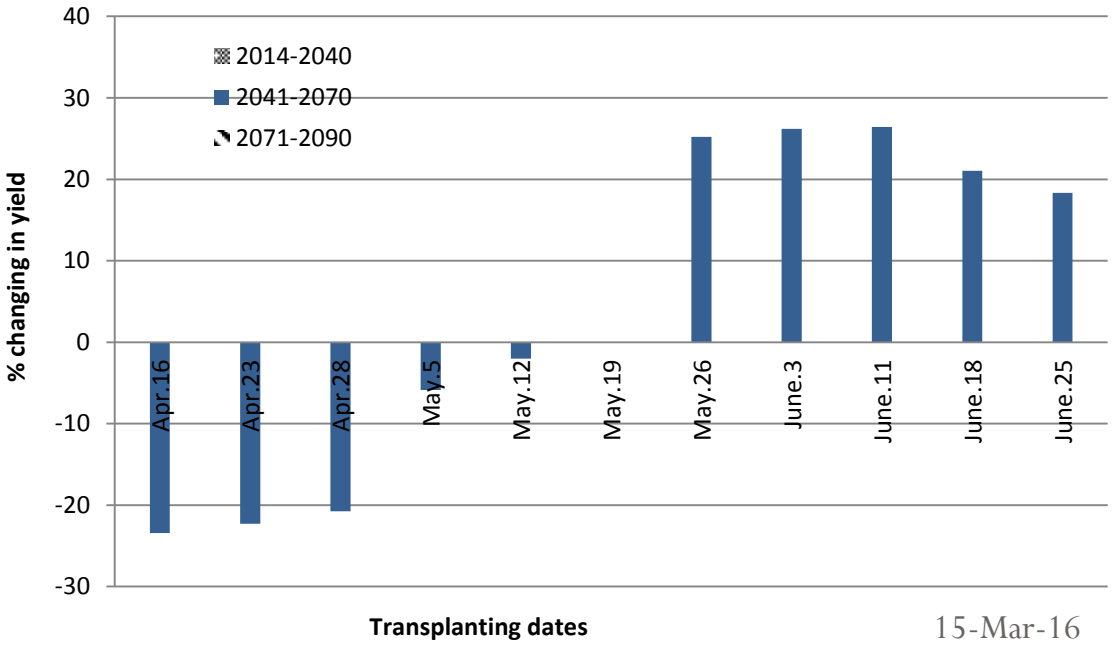
Impact of supplemental irrigation on rice for B2 scenario
(a) winter crop and (b) summer crop

Impact of changing transplanting date on rice yield A2 scenario

Jan 20th and March 19th are current transplanting date

(a) Winter crop
(b) Summer crop

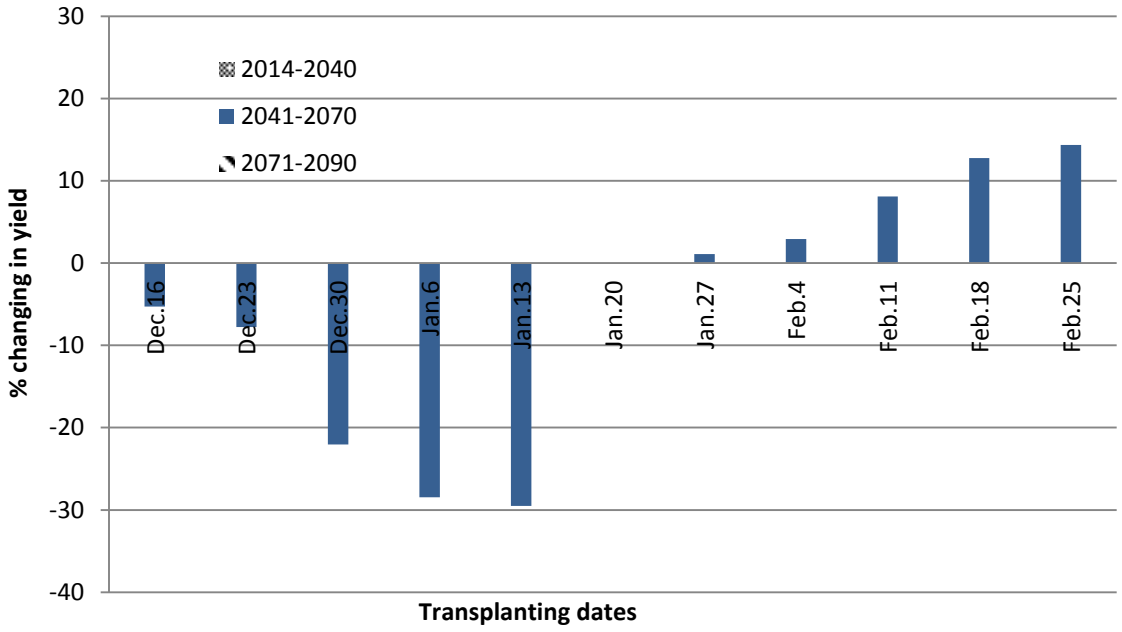


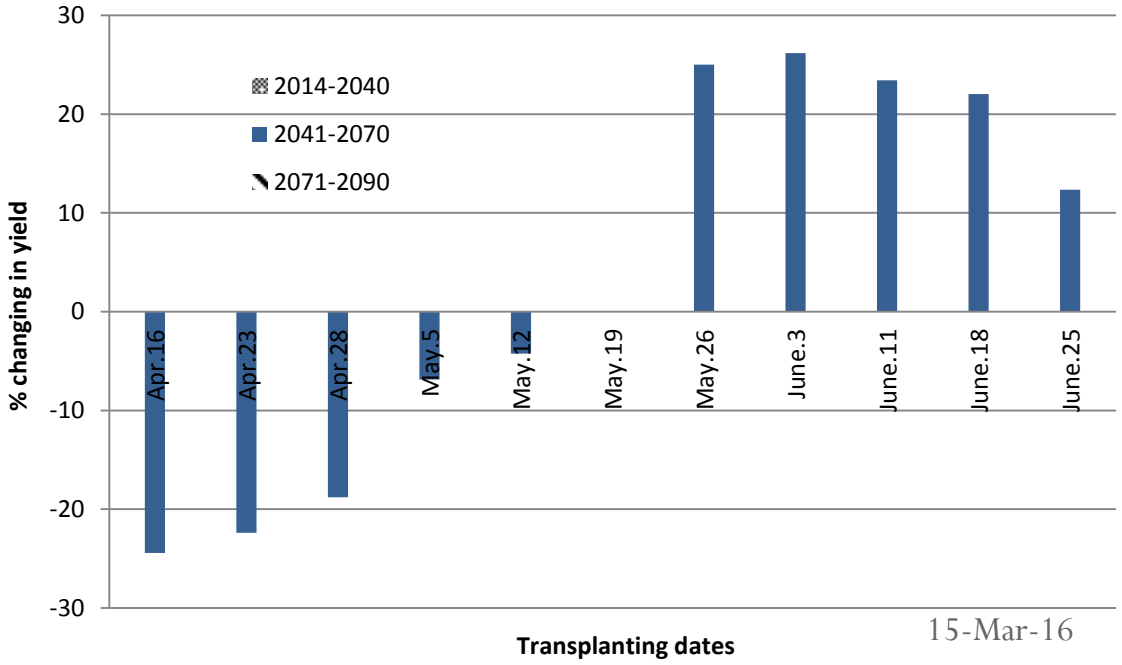


Impact of changing transplanting date on rice yield B2 scenario

Jan 20th and March 19th are current transplanting date

(a) Winter crop
(b) Summer crop





Conclusions

1. Downscaling with SDSM model has well estimated, then the simulated weather data downscaled by SDSM from the GCM HadCM3 had a good agreement with observed data.

2. Aquacrop model and the ETo calculator (Evapotranspiration from reference surface) performed satisfactorily in the study.

3. The annual precipitation may increase from 0.66% to 9.75% for A2 scenario and from 1.83% to 5.62% for B2 scenario. The precipitation will be decrease during rainy season and increase from mid of dry season.

4. Evapotranspiration from a reference surface will increase during time of March to July, decrease on January, November and December for both A2 and B2 scenarios.

Conclusions

5. Project future temperature

The minimum temperature (21.6^0C)

- Increase about 0.35^0C, 1.10^0C and 1.72^0C in periods 2014-2040, 2041-2070 and 2071-2090 respectively with A2 scenario;
- Increase about 0.39^0C, 0.81^0C and 1.29^0C in periods 2014-2040, 2041-2070 and 1971-2090 respectively for B2 scenario.

The maximum temperature (30.11^0C)

- Increase about 0.93^0C (in period 2014-2040), 2.38^0C (in period 2041-2070) and 3.69^0C (in period 2071-2090) for A2 scenario;
- Increase about 0.98^0C (in period 2014-2040), 1.79^0C (in period 2041-2070) and 2.78^0C (in period 2071-2090) for B2 scenario.

Conclusions

6. Simulate the yield using Aquacrop

- For winter crop: The yield significantly decreases during period 2071-2090 with both A2 and B2 scenarios. The yield simulated by Aquacrop express a decline about 5.97% to 23.05% and 1.29% to 10.96% percent compared to the yield of the baseline period for A2 and B2 scenarios respectively.

- For summer crop: The yield increase about 5% and 6.67% for period 2014-2040, 2% and 2.78 % for 2041-2070 with A2 and B2 scenarios respectively. The yield will reduce 1.83% and 6.26% for 2071-2090 with A2 and B2 scenarios respectively.

Conclusions

7. Impacts of supplementary irrigation on rice yield

For winter crop, optimum of supplementary irrigation is at 400mm which would increase the yield about 24.13% to 42.1% with A2 scenario and about 20.13% to 32.81% with B2 scenario. The application for irrigation water in summer crop does not increase the yields significantly, the optimum amount of supplementary irrigation is about 320mm and this would increase the yield by 2.32% to 2.52% with A2 scenario and 2.28% to 2.48% with B2 scenario.

8. Impact of changing sowing date on rice yield

Changing the transplanting dates can increase the yield to higher extent under climate change scenarios. The yield obtains higher if transplanting during 10^{th}-30^{th} February for winter crop, and from 26^{th} May to 18^{th} June for summer crop.

Recommendation

1. **Recommendations for farmers**

- Altering the sowing dates of the rice can help in reducing the negative impacts of climate change and gain higher yield. Transplanting during about 10^{th}-30^{th} February for winter crop, and about 26^{th} May to 18th June for summer crop would increase the average rice yields.

- Supplementary irrigation about 400mm for winter crop for all future periods and 320mm for summer crop for period 1971-1990 to increase the average rice yields.

Recommendation

2. Recommendation for Vietnam Council of Agricultural Research

- The result of the research has revealed that temperature is going to increase and the trend of rainfall is changing (increase rainfall in dry season, decrease rainfall in rainy season). Therefore, Vietnam Council of Agricultural Research needs to determine how to adaptation and take steps in developing such as various varieties, improving water irrigated system.

- Vietnam Council of Agricultural Research should organize some training programs and workshops related to the adaptation to climate change.

Recommendation

3. Recommendation for Researchers

- The future research should be analyzed the effect of different varieties to the yield of rice and assessment of their resilience to future climate change.

- The future research with various GCM with same and other downscaling methods should be performed.

THANK YOU FOR YOUR ATTENTION!