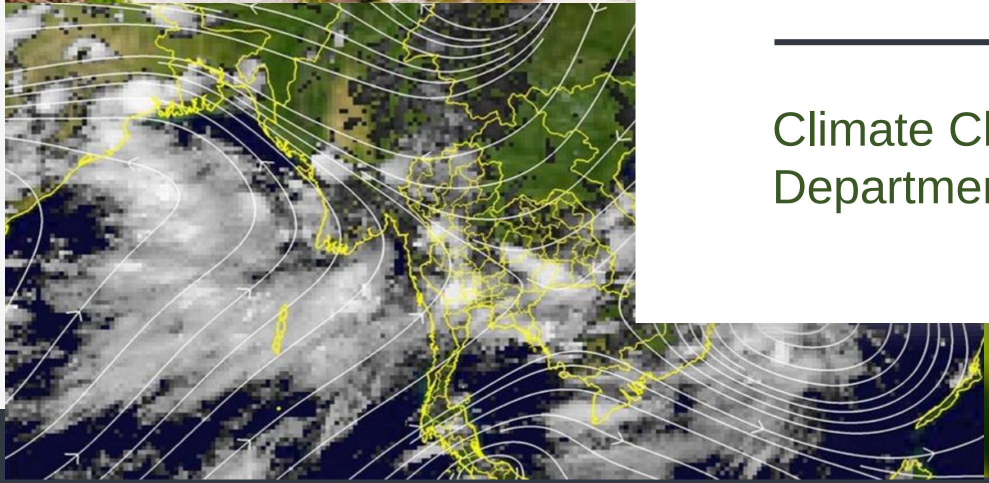

Enhancing climate-resilient Thailand’s rice production

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WEBINAR LAND USE, GREENHOUSE GASES AND CLIMATE CHANGE

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Impacts of El Niño-Southern Oscillation (ENSO) on Rice Production in Thailand during 1961-2016

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ABSTRACT

The impacts of ENSO and its associated climate variability on Thailand's rice production, area harvested and yield during 1961-2016 were examined. Analysis showed that year-to-year weather-related variations in Thailand's rice production, area harvested and yield which accounted for about one third of total interannual variance tended to vary in response to the phase reversals of ENSO events, with large decreases occurred during El Niño events. Rice production, area harvested and yield also exhibited lower (higher) than normal during the years when Thailand experienced deficit (excess) rainfall and lower (greater) number of rainy days. These results in combination with the previous studies suggest that ENSO exerts its influence on rice production and yield in Thailand via inducing anomalies in rainfall and temperature. Another noteworthy finding was the asymmetrical ENSO-Thailand's rice production relationship. Significant decline was observed only during El Niño events, highlighting a much greater influence of El Niño events on Thailand's rice production, area harvested and yield than La Niña events. This observation provides additional evidence extending the previously reported asymmetry in the ENSO-rainfall relationship in Thailand to rice production and yield as well. Hence, the asymmetrical ENSO-rice relationship should be taken into account when developing linearly predictive model.

1. INTRODUCTION

Agricultural production depends strongly on climate. It is known that agriculture is adversely affected by climate variability and weather extreme events especially those associated with ENSO (Tao et al., 2004; Iizumi et al., 2014; Ray et al., 2015; Nobre et al., 2017). ENSO is the dominant mode of coupled ocean-atmosphere variability in tropical oceans on interannual timescales, strongly influencing the global climate system (Brönnimann, 2007; Sarachik and Cane, 2010; Trenberth, 2013; Zhang et al., 2016) and substantially exerting impacts on society, economy and agriculture (Marlier et al., 2012; Cashin et al., 2017; Gutierrez, 2017). Large amplitude and anomalous fluctuations of ENSO-generated climate variability and weather extreme events can lead to crop failure, food insecurity, famine and loss of property and life (Marlier et al., 2012; Trenberth, 2013; Iizumi et al., 2014; Al-Amin and Alam, 2016).

Numerous studies have demonstrated the relationships between ENSO and its associated climate variability and agricultural production in different regions around the world (Cantelaube et al., 2004; Tao et al., 2004; Xiangzheng et al., 2010; Bhuvaneswari et al., 2013; Iizumi et al., 2014; Ray et al., 2015). In Southeast Asia (SEA), for example, ENSO-related climate variability exerts strong influences on agricultural production and food security (Naylor et al., 2007; Roberts et al., 2009; Angulo et al., 2012; Chung et al., 2015; Reda et al., 2015; Al-Amin and Alam, 2016; Pheakdey et al., 2017). Production of rice and corn in Indonesia is especially vulnerable to climate variability associated with ENSO events (Naylor et al., 2007). Roberts et al. (2009) found that Philippine rice production in both irrigated and rainfed systems is affected by an El Niño event. In addition, recent studies have shown that El-Niño generated climate variability exerts many negative impacts on the agriculture sector in Malaysia, Thailand and Cambodia (Reda et al., 2015; Al-Amin and Alam, 2016; Pheakdey et al., 2017).

In the face of on-going anthropogenic climate change, scientific knowledge of the impacts of large-scale climate variability on crop production is essential for identifying the effective adaptation options to improve current food production and to

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Enhancing climate-resilient Thailand's rice production

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Abstract

Rice has long been a major crop in Thailand and is highly climate dependent. Evidence shows that Thai rice sector is vulnerable to climate variability and change. Climate variations and disasters driven by the El Niño phenomenon exert substantial impacts on short-term Thailand's rice production. In addition, future climate changes over Thailand are expected to have significant effects on rice growth period, water availability, and photosynthesis process, leading to alter its production. Among the more vulnerable areas include the Northeast, North and Central where most Thailand's rice is produced. Increasing temperature and changing rainfall will persist to be key vulnerability drivers that will shape rice productivity. With the increasing likelihood of extreme weather events particularly heatwaves, floods and droughts will be more vulnerable to rice destruction and damage. A variety of adaptation strategies and practices already employed in Thai rice sector is valuable in reducing the adverse effects of current climate anomalies but may be insufficient to fully offset the worsening impacts of future climate change. To enhance current adaptation activities and processes for Thai rice sector, climate-smart approach that integrates economic and social strategies with other measures should be more focused.

Keywords: Rice, Thailand, Climate Change, Climate-Smart Approach

1. Introduction

Rice has long been a major food crop in Thailand, economically significant for rural employment, domestic consumption and major agricultural export product. Thailand is a globally important producer and exporter of rice. In the 2020/2021 growing season, Thai-grown rice was 3.7% of the global total (Sowcharoensuk, 2022). Rice exports generated 3.48 billion US dollars in 2021, making Thailand the 2nd largest exporter of rice in the world (OEC, 2023). Rice cultivation accounts for 46.1% of all Thai farmland and 4.9 million farming households (60.5% of those in the agriculture sector) rely on its cultivation (Sowcharoensuk, 2022). Thus, the rice sector has significant importance to the socio-economic life of Thai's farming community. Thailand's rice production for the main growing season between May and December covers an area of about 10 million hectares annually (Dharma, 2021; Buddhaboon et al., 2022). The Northeast, North and Central are the most important rice-growing region accounting for more than 90% of the country's total rice growing area (Kaeomuangmoon et al., 2019; Dharma, 2021; Buddhaboon et al., 2022). About three quarters of rice planted in Thailand are rainfed which relies solely on rainfall during the wet season (Kaeomuangmoon et al., 2019; Dharma, 2021; Buddhaboon et al., 2022). Only a single crop per year can be produced in the rainfed regions. Irrigation is mostly located in the Central region where rice can be grown two to three times per year. Only 10% of rice cultivation in the Northeast is irrigated.

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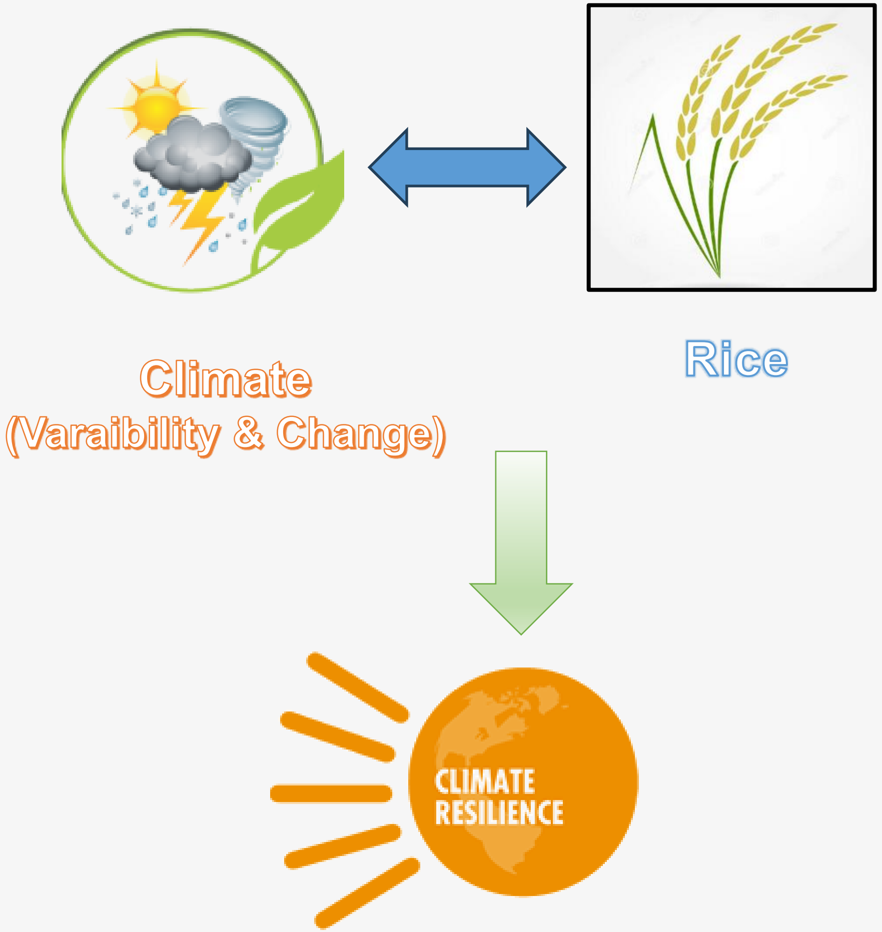
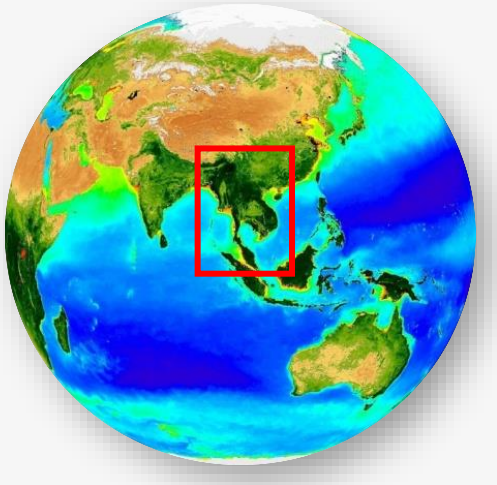
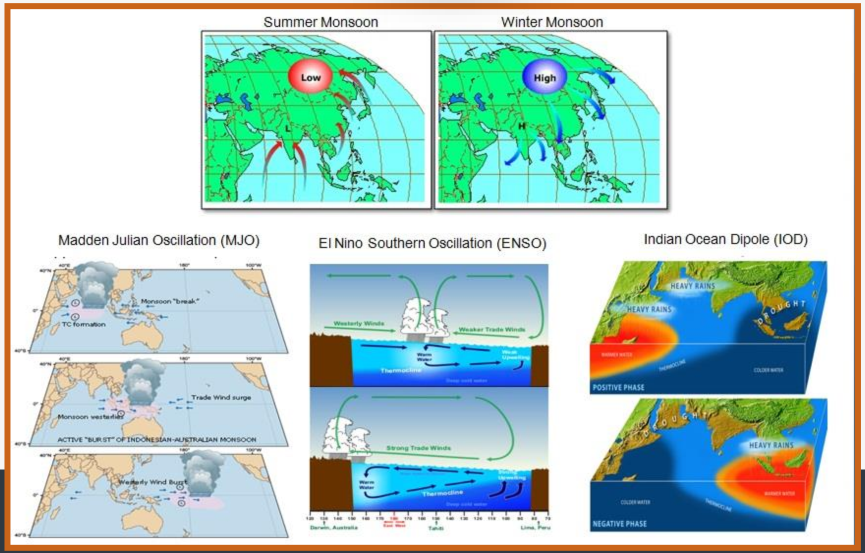


Influence of climate variability and change

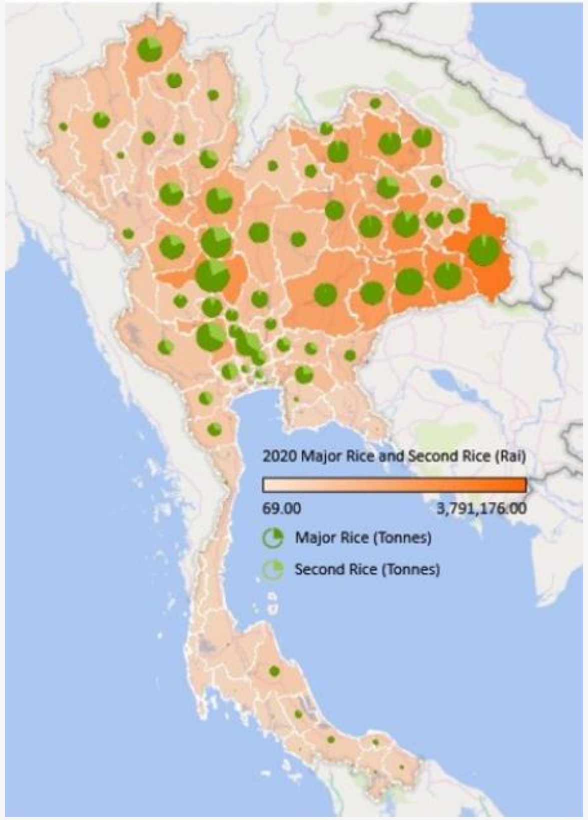




- Strong climate signals induced by complex air-land-sea interaction.
- Existence of multiple climate-related disasters.
- Agriculture remaining a major economic, depending heavily on climate.
- Thailand is one of the most vulnerable countries to climate change impacts.
- Heavy dependency on climate-sensitive sectors, long coastlines and aging society are contributing factors.

Rice production in Thailand

Areas of Rice Production in Thailand (for All Types)



- Rice is socioeconomic significance and a major food crop in Thailand.
- Rice cultivation accounts for 46.1% of agricultural farmland with 4.9 million households rely on its cultivation.
- Three quarters of paddy fields are rainfed.
- Important rice-growing regions are the Northeast, North, and Central Thailand, accounting for ~90% of the total areas.

Source: Office Agricultural Economics, (OAE)

Rice production in Thailand

- Fluctuations of climate variables can substantially influence and regulate rice growth and yield.
- Adverse effects of human-induced climate change on Thai rice sector have also been documented by a number of studies.
- **Building climate-resilient Thai rice sector is a scientifically great challenge.**

Objectives

- To analyze the effects of climate variability & change on rice growth and production in Thailand.
- Review the projected impacts of climate change on rice production from previous studies.
- To elaborate strategies and directions to enhance the current and future adaptation of Thai rice sector to be more climate resilient.

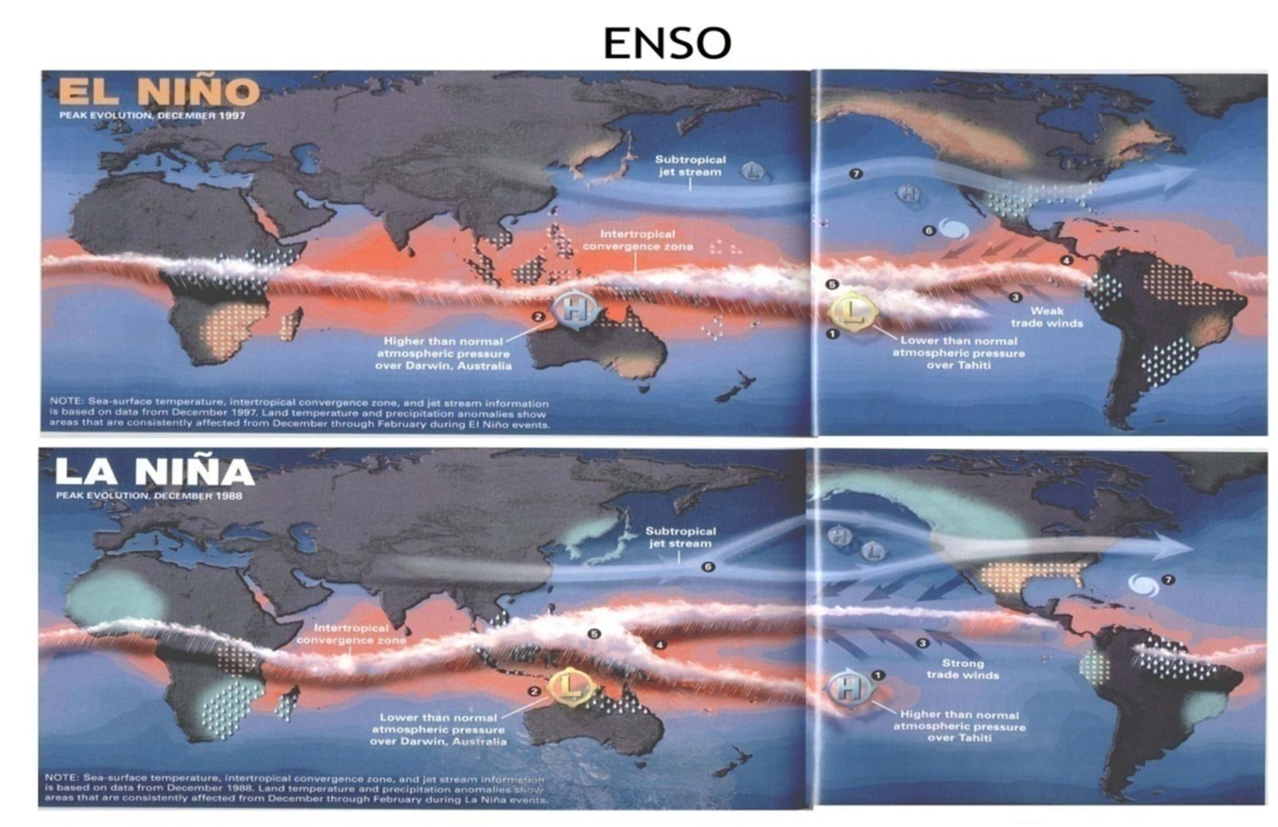
Methods

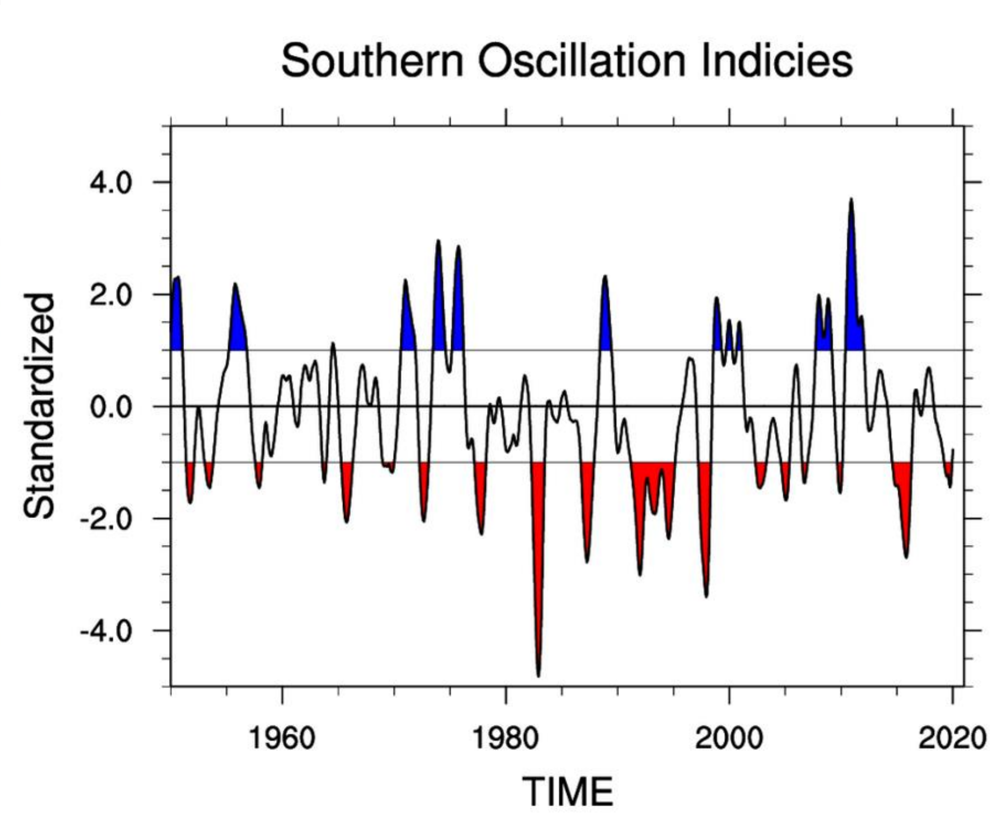
Data

- Climate projection (such as mean temperature, rainfall, relative humidity and extreme temperature and rainfall indices) over Thailand from World Bank (https://climateknowledgeportal.worldbank.org/country/thailand/climate-data-projections.).
- Annual rice production for whole Thailand during 1961-2021 from FAO (https://www.fao.org/faostat/en/#home).
- Provincial-level rice data during 2011-2021 from Office of the Agricultural Economics (https://www.oae.go.th/).
- Southern Oscillation Index (SOI) from UCAR (https://climatedataguide.ucar.edu/climate-data/southern-oscillation-indices-signal-noise-and-tahitidarwin-slp-soi).

Methods

El Niño-Southern Oscillation (ENSO)

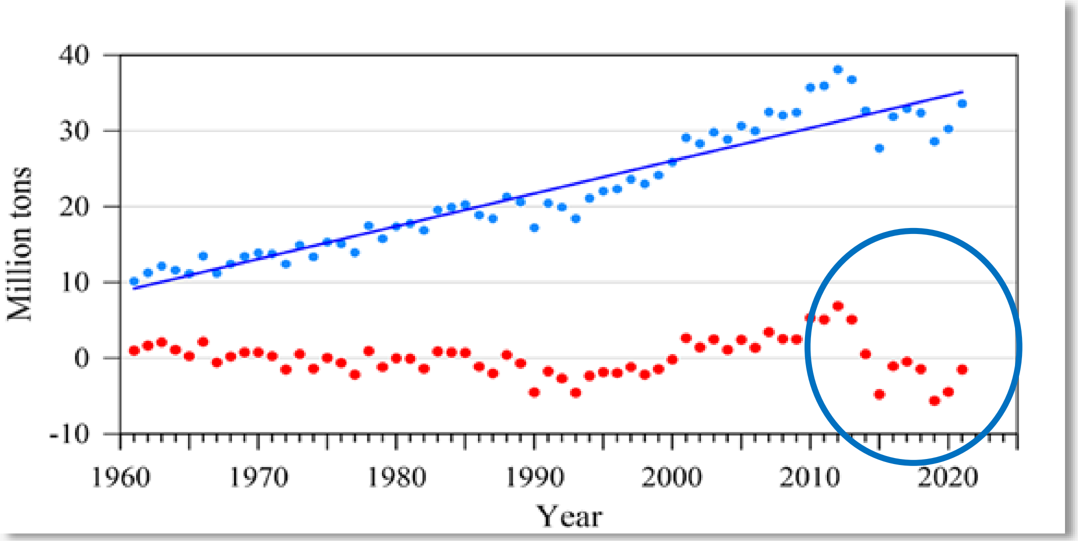




Note: 1/ Index > +1.0, representing the LA Niña phase of ENSO
Index < -1.0, representing the El Niño) phase of ENSO

Results

Past trends and variability in Thailand's rice production

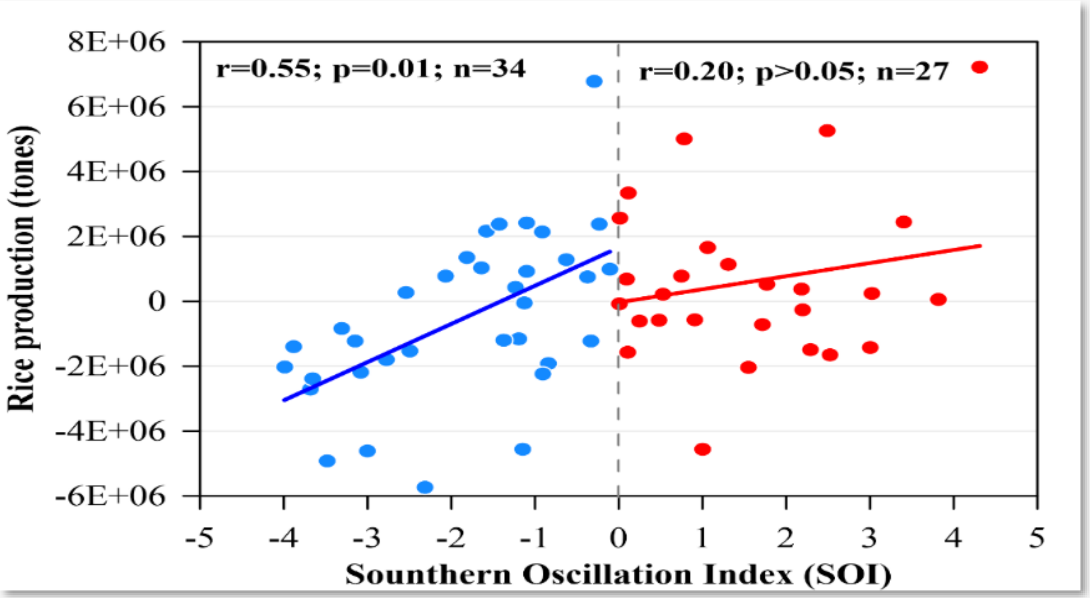


Annual time series of Thailand's rice production as a whole during 1961-2021: general trends (solid line) and anomalies after a linear trend removed (red dots).

- Over the past six decades, Thailand's rice production increased more than three times as a result of non-climate-related trend.
- Year-to-year anomalies of Thailand's rice production tended to vary in response to the phase reversals of ENSO events.
- Negative anomalies of rice production have been observed since 2012, corresponding to the period when Thailand has experienced a series of prolonged and severe droughts.

Results

Past trends and variability in Thailand's rice production

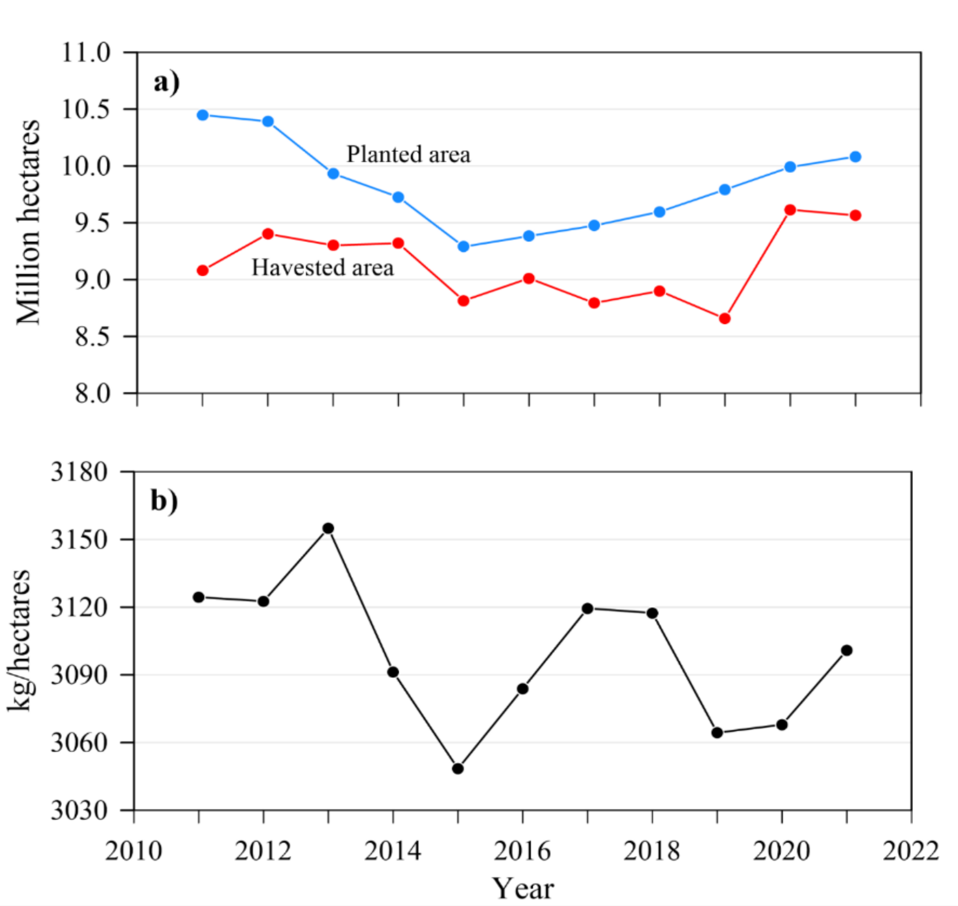


Correlations between annual values of SOI and anomalies of Thailand's rice production for the period 1961-2021. The correlations were determined separately for SOI-positive and SOI-negative values.

- ENSO events correlated asymmetrically with year-to-year variations of Thailand's rice production.
- Asymmetrical relationship highlighted the strength of El Niño years exerting a much greater influence on Thailand's rice production than the magnitude of La Niña years.
- During the 5 strongest historic El Niño events, rice production declined on an average by 10.9% from the long-term means.
- The El Niño event exerts its impact on Thailand's rice production through inducing deficit rainfall and higher temperature, which are conditions for severe droughts.

Results

Past trends and variability in Thailand's rice production

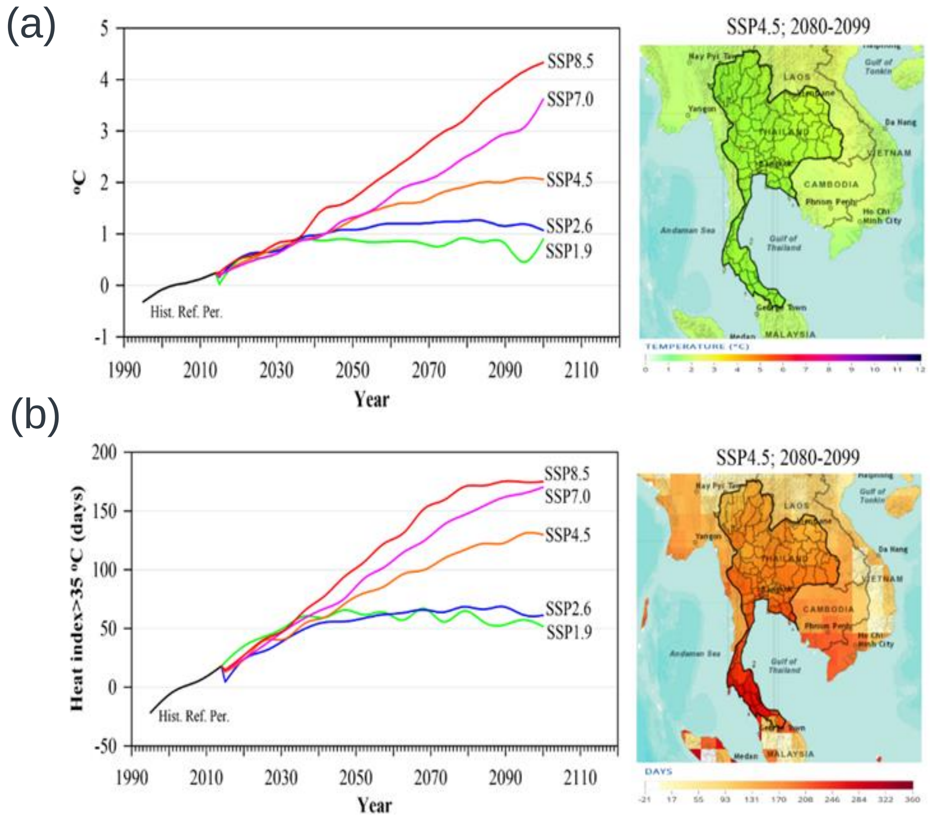


- Climate-induced disasters have been a major contributor to damage of rice.
- Cultivated area of rice in 2011 was damaged and lost more than 10% as a result of the 2011 devasting flood in the north and central Thailand.
- Rice yield during 2011-2021 was also tendency to decline with the minima occurred in 2015 when Thailand experienced prolonged and severe droughts.

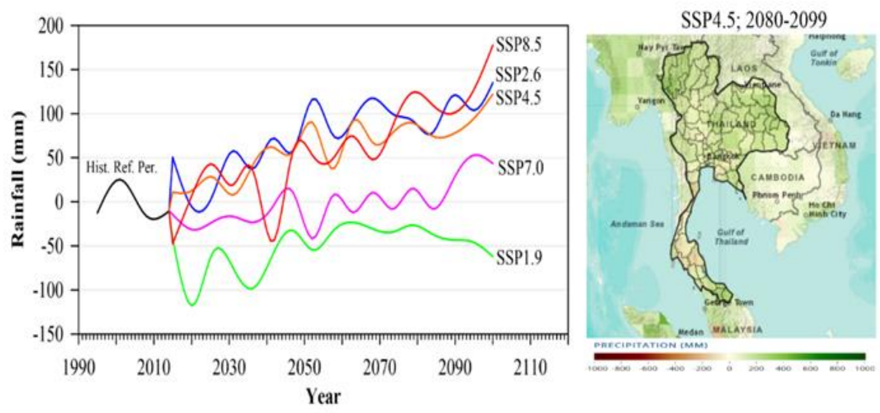
Planted and harvested areas and yield for the main cultivation season during 2011-2021.

Results

Thailand's future climate projection and its possible effects on rice crop calendar



Multi-model ensemble means of (a) annual mean temperature and (b) annual number of days with heat index >35 ºC Thailand projected under Shared Socioeconomic Pathways (SSPs) scenarios.



Multi-model ensemble means of annual rainfall total over Thailand projected under SSPs scenarios.

- By the 2090s, Thailand's annual mean temperature/rainfall are projected to increase under high emission scenarios.
- Annual number of days with heat index>35 ºC will significantly increase.
- Climate change is also bringing multiple different changes in Thailand which will all intensify with further warming.

Results **Thailand's future climate projection** and its possible effects on rice crop calendar

SSP2.6 2040-2059

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Relative humidity (%)	-2.1	-2.7	-1.8	-2.0	-5.4	-2.8	-1.4	-1.2	-0.2	-1.7	-1.3	-0.6
Tropical night (days)	0	0.3	2.8	4.7	6.1	5.4	5.1	4.0	2.1	0.8	0.2	0
Hot days (days)	1.0	2.5	4.3	3.1	4.4	3.2	2.0	1.4	1.3	1.2	0.8	0.5
Mean Temp. (°C)	1.4	1.3	1.5	1.4	1.1	0.8	0.9	1.0	0.9	1.0	1.1	1.4
Wet season					Planting/Growing						Harvesting	
Dry season	Growing		Harvesting								Planting/	
Rainfall (mm)	0.4	0.1	-0.1	3.2	1.1	3.5	3.9	13.5	17.1	20.7	-0.4	1.9
Consecutive dry day (days)	-0.1	0.2	0.2	0.2	0.4	0.3	0	0	-0.3	-0.2	0.2	-0.2
Consecutive wet day (days)	0.1	0	0	0	-0.3	-0.6	0	0.2	0.3	1.2	-0.2	0.2

Changes in climate variables during 2040-2059 projected under SSP2.6 in relation to rice crop calendar. The projected climate variables are relative to the 1995-2014 reference period.

SSP8.5 2040-2059

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Relative humidity (%)	-2.3	-1.6	-1.7	-2.6	-7.3	-3.8	-1.6	-0.9	-0.3	-2.2	-1.8	-1.8
Tropical night (days)	0.1	0.6	4.4	9.0	11.7	11.4	11.3	10.6	7.3	3.3	1.1	0.2
Hot days (days)	1.9	4.7	5.0	4.5	7.0	5.5	3.6	2.8	2.9	2.7	1.4	1.0
Mean Temp. (°C)	1.9	1.9	1.9	2.1	2.1	1.5	1.4	1.6	1.5	1.7	1.7	1.7
Wet season					Planting/Growing						Harvesting	
Dry season	Growing		Harvesting								Planting/	
Rainfall (mm)	1.9	0.4	-3.9	-3.4	-12.7	-8.1	-0.9	0.4	9.6	26.9	3.9	2.8
Consecutive dry day (days)	-0.1	0	0.6	1.5	1.6	0.8	0.3	0.1	-0.3	-0.6	0.1	-0.3
Consecutive wet day (days)	0.2	0	-0.4	-0.4	-1.4	-1.5	-1.2	-0.6	-0.1	1.5	0	0.1

Changes in climate variables during 2040-2059 projected under SSP8.5 in relation to rice crop calendar. The projected climate variables are relative to the 1995-2014 reference period.

- Changes in both magnitude and patterns of the climate variables (temp. & rainfall) are expected to have effects on rice growth period, water availability, and photosynthesis process, leading to alter its production and yield.

- Increases in mean temperature, hot days and tropical nights during planting and growing period are projected to occur in the mid-century especially under high emission scenario.

Results Future projected rice in Thailand

Domain	Major results
1. Whole Thailand - Rainfed rice - Irrigated rice	- Yield will increase 8.8% in 2090-99 from 2493.8 kg/ha (1980-1989) to 2712.5 kg/ha - Yield will decrease 29.8% in 2090-99 from 4906.3 kg/ha (1980-1989) to 4162.5 kg/ha
2. Whole Thailand	Yield will decrease in range of 40% to 45% in 2080
3. Rainfed rice in Northeast Thailand	Average yield for three provinces will decrease 25.7% in 2080-2089 from 2556.0 kg/ha (1997–2006) to 900.0 kg/ha
4. Whole Thailand - Rainfed rice - Irrigated rice	- Yield will increase in range of 3-31% (81.3-675.0 kg/ha) in 2090-2099 relative to 2010-2019 - Yield will decrease in range of 2-30% (-118.8 to -1125.0 kg/ha) in 2090-2099 relative to 2010-2019
5. Northeast Thailand - Rainfed rice - Irrigated rice	- Yield will increase in range of 0-38% (0-775.0 kg/ha) in 2090-2099 relative to 2010-2019 - Yield will decrease in range of 1-24% (-43.8 to -806.3 kg/ha) in 2090-2099 relative to 2010-2019
6. Pichit province - Rainfed rice - Irrigated rice	- Yield will decrease in range of 2.1-14.4% (-127 to -855 kg/ha) in 2070-2100 relative to 1981-2014 - Yield will change in range of -16.4 to 12.6% (1036 to 793 kg/ha) in 2070-2100 relative to 1981-2014

- Based on the compiled results, the overall picture of climate change impacts on Thai rice sector appears to be more negative than positive.

- Top rice producing provinces such as Khon Kaen, Roi-Et and Ubon Ratchathani are likely to experience an averaged decrease in yield of 25.7% by 2080-2089 if there are no adaptation measures being applied.

Results

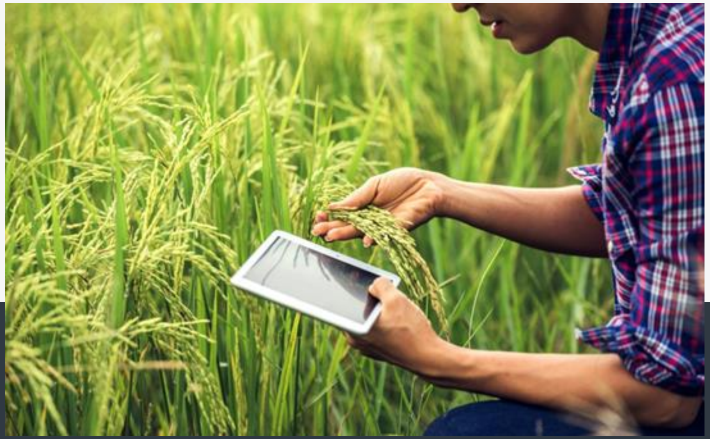
Enhancing climate-resilient Thailand's rice production

Adaptation strategies as important response measures to reduce impacts on rice production.

i) strengthening farmers for self-reliance to have higher income and well-being.

ii) increasing the efficiency of rice production management.

iii) promoting the potential of research and technology development.



Bring precision agriculture, collective farming and digital technology developments to support rice policies and cope with the effects of climate change.

Results

Enhancing climate-resilient Thailand’s rice production

- Rice farmers’ current adaptation practices seem to be inadequate to worsening climate change impacts.
- Promote current adaptation activities and processes for the Thai rice sector through a holistic approach that combines socio-economic strategies with other measures.

Conclusions

- Climate variations and disasters driven by ENSO exert substantial impacts on short-term Thailand’s rice production.
- Future changes in climate condition are expected to have effects on rice growth period, water availability, and photosynthesis process, leading to alter its production and yield.
- Increasing temperature and changing rainfall will persist to be key vulnerability drivers that will shape rice productivity.
- A variety of adaptation strategies/practices already employed in Thai rice sector may be insufficient to fully offset the worsening impacts of future climate change.

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Thank you

for your attention