Challenges and Opportunities of Agricultural Land in Taiwan under two Selected Shared Socioeconomic Pathways (SSPs)

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Motivation & Introduction

We often used to consider the impact of the climate change by making use of the directly assessment of climate fields such as temperature or precipitation; however, we may overlook the synergy effect resulting from the interactions among the cultivated plant species, environmental factors, and (crop-) managements such as shifting/adjusting the transplanting date, crop species changes, or land fallowing. Here, we demonstrated the challenges and opportunities of agricultural land in Taiwan under two selected SSPs SSP1.26 & SSP5.85 using the advanced Earth model (TaiESM1, Lee et al. 2021) projected temperature changes and future land use/land change maps originated from LUH2 (Hurtt et al. 2020; Chen et al. in preparation).

Methodology

Datasets

Temperature Data

Historical records: CWB (1969-1994) Baseline
Future Projection: TaiESM1. After CWB sites bias correction, statistical down-scaling
Resolution: 5km × 5km (81 × 60 pixels spacing)

LUH2

Land Use/Land Cover Data: SSP1.26 & SSP 5.85
Resolution: 500m × 500m (900 × 747 pixels spacing)

TARI

Agri. Land Cover: select rice, maize, potato

Data pre-processing

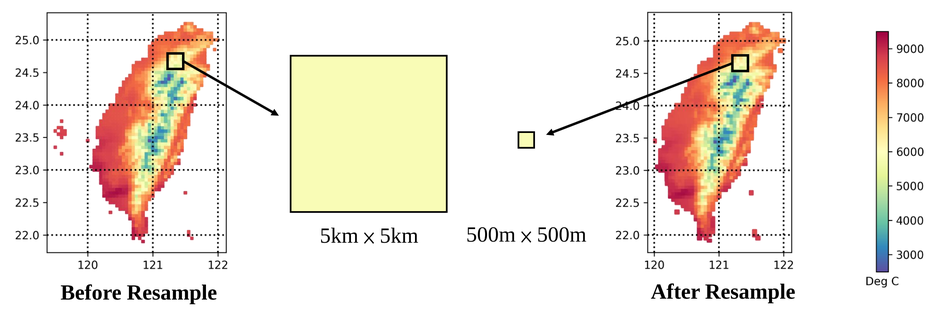
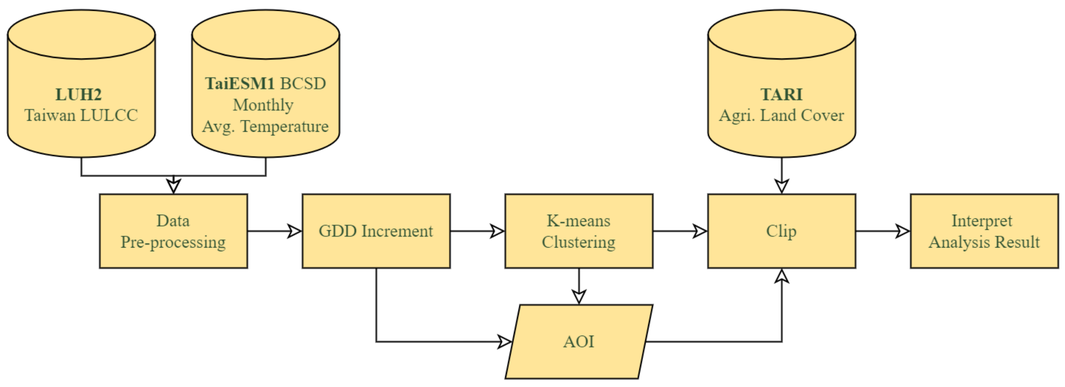


Figure 1. In order to merge land use/land cover data and temperature data, using Nearest Neighbor Search resamples temperature data (5km × 5km) based on LUH2 land use/land cover data (500m × 500m)

To learn further about the changes of temperature under different spatiotemporal situation, take 2020~2030/2050~2060/2080~2090 annual average cumulative temperature as the early/mid/late 21st century cumulative temperature
※Baseline cumulative temperature: 1979~1994 annual average cumulative temperature

Workflow

Coding Env.: 300T + Google Colaboratory



Growing Degree-Day (GDD)

GDD Increment

$$GDD\ Increment = \frac{(T_{max}+T_{min})}{2} - T_{base}$$

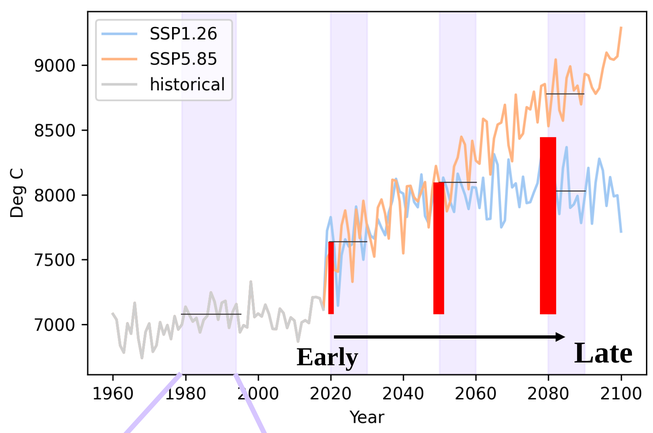


Figure 2. TaiESM1 temperature prediction under SSP1.26 & SSP5.85

Under different SSPs and temporal change , the spatial distribution of the higher and lower GDD increment is different, but some regularities can still be seen. In order to more clearly point out the area and tendency of the GDD increment, it is decided to use K-means clustering to analyze.

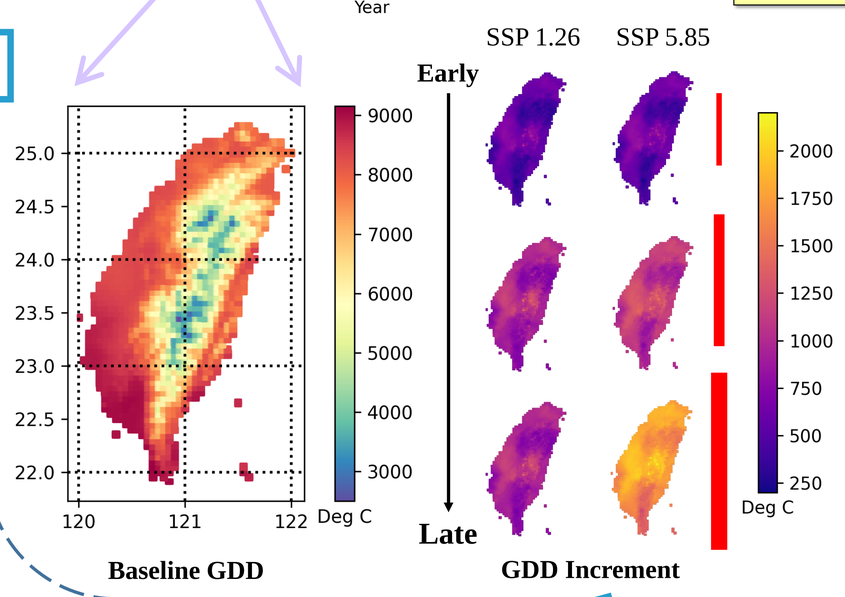


Figure 3. GDD increment under SSP1.26 & SSP5.85 in the early/mid/late 21st century. Take the SSP1.26 & SSP5.85 in early/mid/late 21st century cumulative temperature subtract baseline cumulative temperature.

K-means clustering

Reference

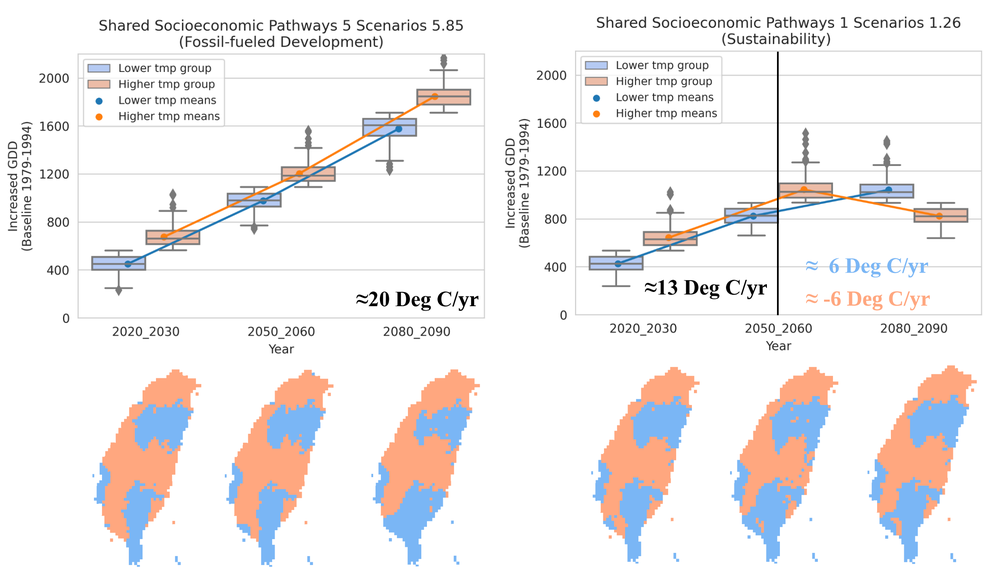
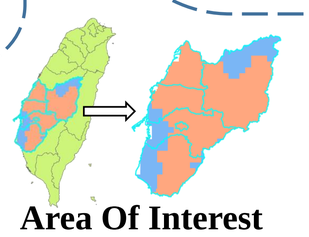


Figure 4. GDD increment changes under SSP5.85 & SSP1.26 in the early/mid/late 21st century

Result



Area Of Interest (AOI)

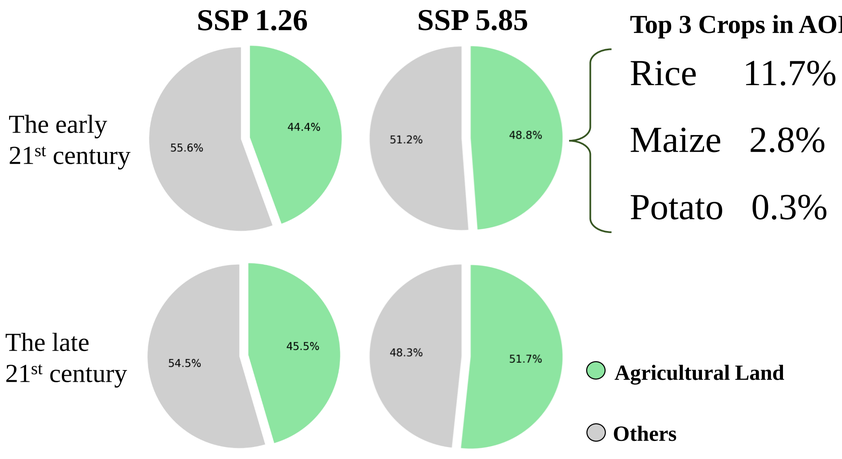


Figure 5. The proportion of Agricultural lands in AOI in the early & late 21st century under SSP 1.26 & SSP 5.85

	GDD (Deg C)	GDD Increment (Deg C)	
		SSP1.26	SSP5.85
Rice	2750	682 (24.8%)	722 (26.3%)
Maize	2093	485 (23.2%)	538 (25.7%)
Potato	1755	650 (37%)	688 (39.2%)

	GDD (Deg C)	GDD Increment (Deg C)	
		SSP1.26	SSP5.85
Rice	2750	1084 (39.7%)	**1883 (68.5%)**
Maize	2093	884 (42.2%)	**1695 (81%)**
Potato	1755	**1050 (59.9%)**	**1846 (105.2%)**

Discussion & Summary

1. The AOI allows for more flexibility in adjusting land managements due to sufficient GDD increments.

For example:

- Extend the fallow period helps to restore soil fertility.
- Increase tourism-related usage.
- Adjust the crop period to use agricultural land more efficiently.

2. The rotation time of potatoes is expected to decrease and the total yield to increase in the future due to the projected climate change (GDD increment). However, this may lead to water resources related adaptations such as availability/allocation.

Acknowledgement & Reference

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Chen et al. (in preparation). Down-scaling the global land cover and use data-set (LUH2) for Taiwan: Challenges and opportunities.
Hurtt et al. (2020). Harmonization of global land use change and management for the period 850--2100 (LUH2) for CMIP6.
Lee et al. (2020). Taiwan Earth System Model Version 1: Description and Evaluation of Mean State. doi: 10.5194/gmd-2019-377.

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Code

GDD (Increment) Web Page