The impact of climate change on rice production in Thailand

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In this study, we estimate climate change impacts on rice production in Thailand during 2001-2014, covering two main rice growing seasons: rain-fed and irrigated rice growing seasons. We employ a synergy of remote sensing, econometric analysis, and climate change prediction to evaluate the impact of climate change on rice production in Thailand, aiming to obtain more accurate and timely results. Thailand has four rice ecosystems: lowland rain-fed, lowland irrigated, flood-prone, and upland rice ecosystems. However, the first three ecologies are major rice ecologies of the country, whereas the upland rice ecology accounts for only one percent of the total rice production of the country.

Initially, we apply a satellite product named MODIS/Terra Surface Reflectance 8-day L3 Global 500m SIN Grid V005 (MOD09A1). Basically, we follow the thresholds developed by Xiao et al. (2005; 2006) which are incorporated with the three rice physical growth phases (International Rice Research Institute, 2016) and the paddy rice field's characterisation (Le Toan et al., 1997). However, in this study, we need to modify the threshold to detect the main rice ecosystems in Thailand. More precisely, the algorithm developed by Xiao et al. (2005; 2006) is generally used for lowland rice field detection, excluding flood-prone and upland rice. In this regard, modified rice field detection algorithm can detect the location of different rice ecosystems at 500-meter resolution across the country, consisting of lowland rain-fed, lowland irrigated, and flood-prone rice ecosystems. We also map rice field locations to illustrate the mixture of different rice ecosystems.

We determine the current climate change impacts using econometric analysis to evaluate factors that might affect rice production for both rain-fed and irrigated rice in each rice growth development stage and rice growing cycle. In doing so, we include both weather and non-weather variables in the analysis. Specifically, in addition to weather factors, production factors and relevant government policies/measures are included in the econometric model. To this end, we estimate the variation of spatial precipitation and temperatures in rice production locations derived from Tropical 307 Rainfall Measuring Mission (TRMM) and MODIS Land Surface Temperature instead of climate statistics from weather stations, providing a more accurate estimation of the effects of climate variation over rice fields. These climate variables then link with the rice pixels. In principle, this approach enables us to capture directly the climate variation effect covering large rice production areas on a very localised scale, removing all non-rice pixels. Additionally, we not only prepare weather variables for whole rice growing cycle but also disaggregate the variables into each rice growth phase to monitor the climate variation effect for whole rice growing cycle and in each rice growth development phase. Moreover, we examine the impact of climate change on rice production loss areas for the two rice seasons.

The findings of regression analysis clearly distinguish the main sources of water of both rice growing cycles. More specifically, rain-fed rice yield relies solely on the amount of precipitation, whereas irrigation water is crucial for irrigated rice production. Both minimum and maximum temperatures have less effect on the two rice seasons. Interestingly, the rice pledging scheme, can induce rice farmers to grow irrigated rice for double or multiple cycles. In addition, an expansion of rice field can help to increase the yield of both rice growing seasons, while fertiliser application benefits only rain-fed rice. Moreover, the study results indicate that weather fluctuation has more adverse effects on rain-fed rice than on irrigated rice, causing significantly rice production areas loss for rain-fed rice.

We estimate the future climate change impact on rice production in Thailand, covering the two main rice seasons. We employ six climate models to obtain a wide range of projection results of the climate change impact on rice production. We use the rice location at 500-meter resolution across the country obtained from the rice field detection algorithm. Moreover, we collect climate data from the Regional Climate Consortium for Asia and the Pacific (RCCAP), specifically, precipitation, and both minimum and maximum temperatures. We then link these climate factors with the rice pixels. This approach enables us to specify the weather variation effect directly on the rice fields, removing all non-rice growing areas from our analysis. In this regard, we propose a new method to project irrigation water since the water is essential for the dry season crop or irrigated rice. Therefore, it is beneficial to monitor the available irrigation water for rice growing areas in the future.

The results of applying six climate models indicate a rising trend of precipitation and irrigation water over the 21st century for the two crop cycles. Furthermore, the projected minimum temperature tends to decrease continuously for the two rice seasons in the 21st century. On the other hand, the projected maximum temperature is likely to increase over the same period. Rain-fed rice yield tends to decrease whereas irrigated rice yield is likely to increase in the 21st century.

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