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Effects of Climate and Land Use Change on Food Security: a Case Study of Phra Nakhon Si Ayutthaya Province, Thailand

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Abstract

Addressing climate change for food security poses a great challenge to social welfare in developing countries where agricultural sector plays a significant role in driving economic growth and sustaining livelihoods. Natural climate variability and anthropogenic emissions introduce the considerable effects on agriculture yields and productivity, including nexus of food-water-energy. This paper aims at exploring land suitability for rice farmland in Phra NaKhon Si Ayuttaya province. Projection of temperature and precipitation over a province in 2050 in according to representative concentration pathway (RCP) 4.5 and 8.5 scenarios show a few increase in mean monthly temperature, monthly maximum temperature and minimum temperature about 0.5 to 1 degree celcius. Annual precipitation tends to be reduced for RCP 8.5 in comparison to RCP 4.5. Land suitability for growing rice is simulated by using EcoCrop model which requires input parameters from temperature and precipitation projection in 2050. Results reveal a decreasing in land suitability for rice both under RCP 4.5 and 8.5 scenarios. Agricultural land use tends to be transformed into residential and industrial land by 2050, resulting in the reduction in agricultural land and rice production. Successful adaptation to climate change in the agricultural sector needs to be encouraged by government to build robust cooperative efforts from all stakeholders.

Keywords: Climate change; rice; Phra Nakhon Si Ayuttaya, food security; adaptation

Introduction

Addressing climate change for food security poses a great challenge to social welfare in developing countries. Climate change, population growth and land use transition are among drivers contributing to food insecurity, water scarcity and ecosystem degradation. Extreme weather such as flood, drought and storm driven by climate change are expected to gradually increase and will deliver huge effects on food production and water availability. Meanwhile, climate variability can capable of

influencing year to year crop production, even in high yielding and high-technology agricultural areas (Kang et al., 2009). It is expected that about 70 percent of water withdrawal from irrigation system will be used in crop production. There are reports suggesting that weather change could reduce grain yields of rice and wheat in Indo-Gangetic Plains (IGP) (Aggarwal et al., 2004). Beside the direct impact of climate change on crop yields, there are some evidences related to indirect impacts caused by climate change in changing soil moisture and spatial distribution of pest (Mendelsohn, 2014)

Nowadays, climate change and global food crisis receive considerable attention, especially in Africa and Asia. Adaptation study conducted by Calzadilla et al. (2014) suggested that Africa would require yield improvement of more than 20 percent over baseline investment in agricultural research and development and an attempt to irrigation development will no longer be sufficient for agriculture. Research conducted by Naresh Kumar et al. (2013) shown a decrease in irrigated rice yields in India by about 4, 7, and 10 % during the 2020s (2010–2039), 2050s (2040–2069), and 2080s (2070–2099), respectively.

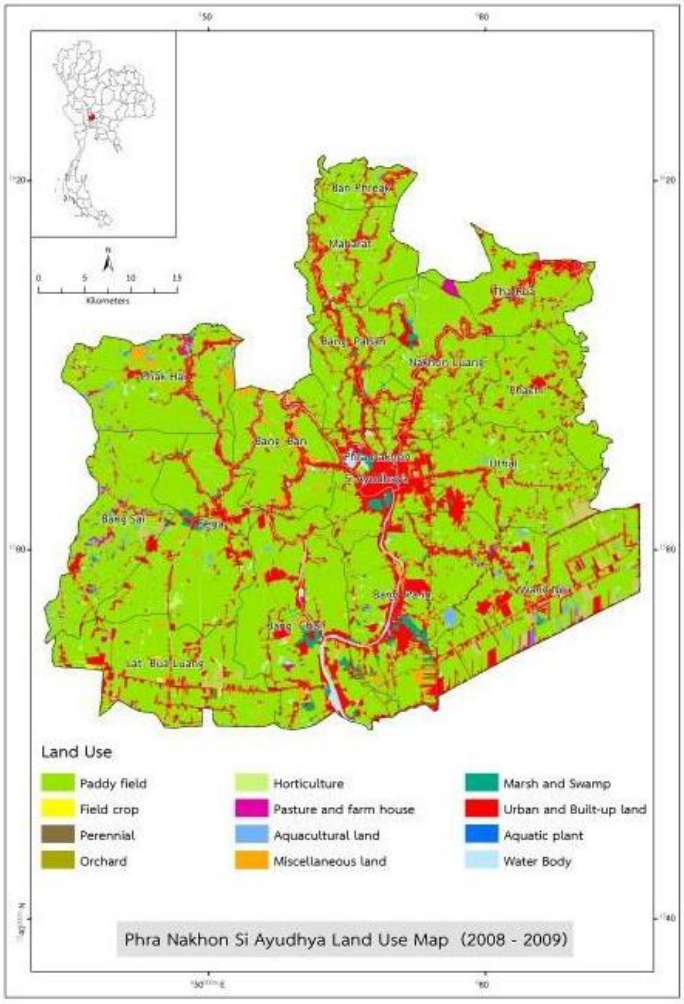
Phra Nakhon Si Ayuttaya is one of the central provinces of Thailand where it is famous for history, culture, rice farmland, industry and tourism. Most of agricultural land in the past is typically devoted to rice cultivation. However, area of rice cultivation tends to be decreased by 14.77 % from 2008 to 2013. In the last two decades, the province has also been suffered from water related disaster more frequent than the past. A great flood of 2011 in Thailand witnessed its worst flooding in Thailand and caused significant loss and damage to agricultural are in Phra Nakhon Si Ayuttaya province, including rice cultivated area.

Method

Mean monthly average temperature, mean monthly maximum temperature, mean monthly minimum temperature and annual precipitation in 2050 are extracted by using WorldClim database (www.worldclim.org). HadGEM2-ES climate model is used for generating climate database for representative concentration pathway (RCP) 4.5 and 8.5. In order to analyze land suitability for rice under eleven climate factors; *Tkill* (temperature at which the crop will die in celsius), *Tmin* (minimum temperature at which the crop will grow in celsius), *Topmin* (minimum optimum temperature at which the crop grows in celsius), *Topmax* (maximum optimum temperature at which the crop grows in celsius), *Tmax* (maximum temperature at which the crop will grow in celsius), *Rmin* (minimum amount of rain water required for the crop to grow in mm), *Ropmin* (minimum optimum amount of rain water required for the crop to grow in mm), *Ropmax* (maximum optimum amount of water for the crop to grow in mm), *Rmax* (maximum amount of rain water below which the crop grows in mm), *Gmin* (minimum length of the growing season in days),

and *Gmax* (maximum length of the growing season in days) are created by Ecocrop model. Land suitability for rice is illustrated by six suitability classes.

From the past land use change, area of rice farmland in Phra Nakhon Si Ayuttaya has been decreased by 14.77 percent between 2008-2013 as shown in Figure 1. Rapid urban land expansion is a main reason behind transforming from agriculture to urban land. In response to urban sprawl, adaptation practices are analyzed by comprehensively reviewing previous literatures and related government policy related to agricultural sector. It is expected that agricultural land use will be transformed to residential and industrial area in 2050 which entails a significant change in surface runoff and population. A proposed plan for adaptation to climate and land use change in agriculture, focusing on rice farmland, is developed in accordance with food security and farmer well-being perspectives.



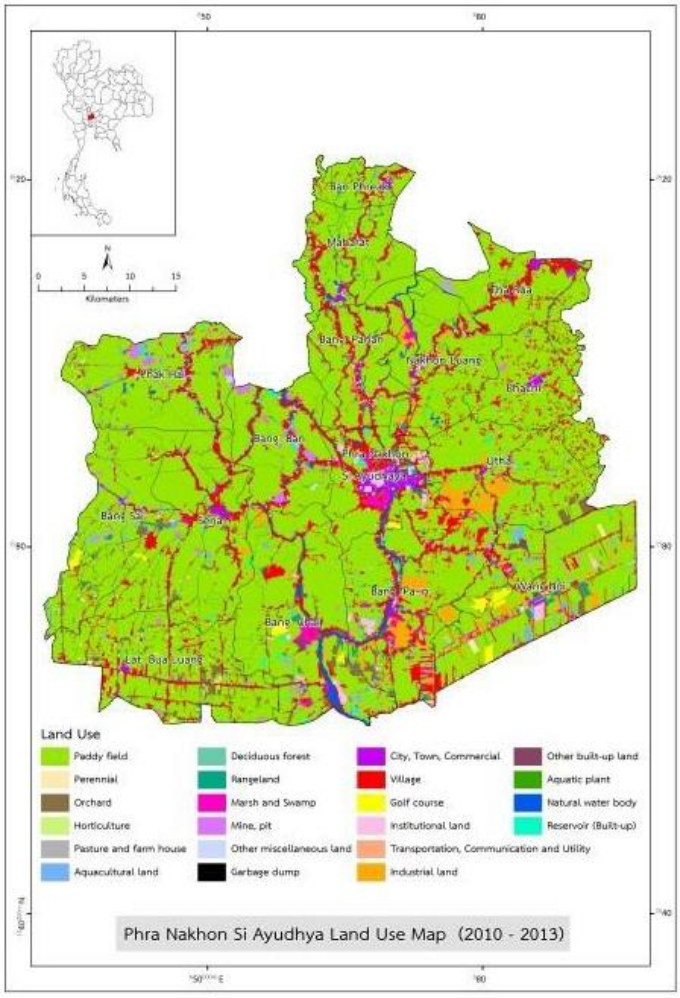


Figure 1 Land use change between 2008-2013 in Phra Nakhon Si Ayuttaya province

Results and discussions

Mean monthly average temperature is within the range of 30 °C to 31 °C by 2050 for RCP 4.5 and tends to increase about 0.5 °C under RCP 8.5. The increase in mean monthly average temperature for RCP 8.5 is equally distributed in every district in a province as shown in Figure 2

The highest mean monthly minimum temperature occurred in Bang Sai, Bang Pa-in and Wang Noi districts for RCP 4.5 and RCP 8.5. Changing in mean monthly minimum temperature is expected to be increased by 0.5-1.0 °C as shown in Figure 4. Mean monthly maximum temperature varies from 35 °C to 35.5 °C for RCP 4.5 and tends to be increased by the range of 35.5 °C to 36.5 °C for RCP 8.5. The highest temperature

found in Ban Phreak and Maharat districts for RCP 8.5 as shown in Figure 3. According to annual precipitation in Figure 5, amount varies from 1,200 mm to 1,391 mm and 1,120 to 1,288 for RCP 4.5 and RCP 8.5 respectively. Wang Noi and some area of Uthai districts appear to be highest temperature for RCP 8.5.

Mean monthly average temperature

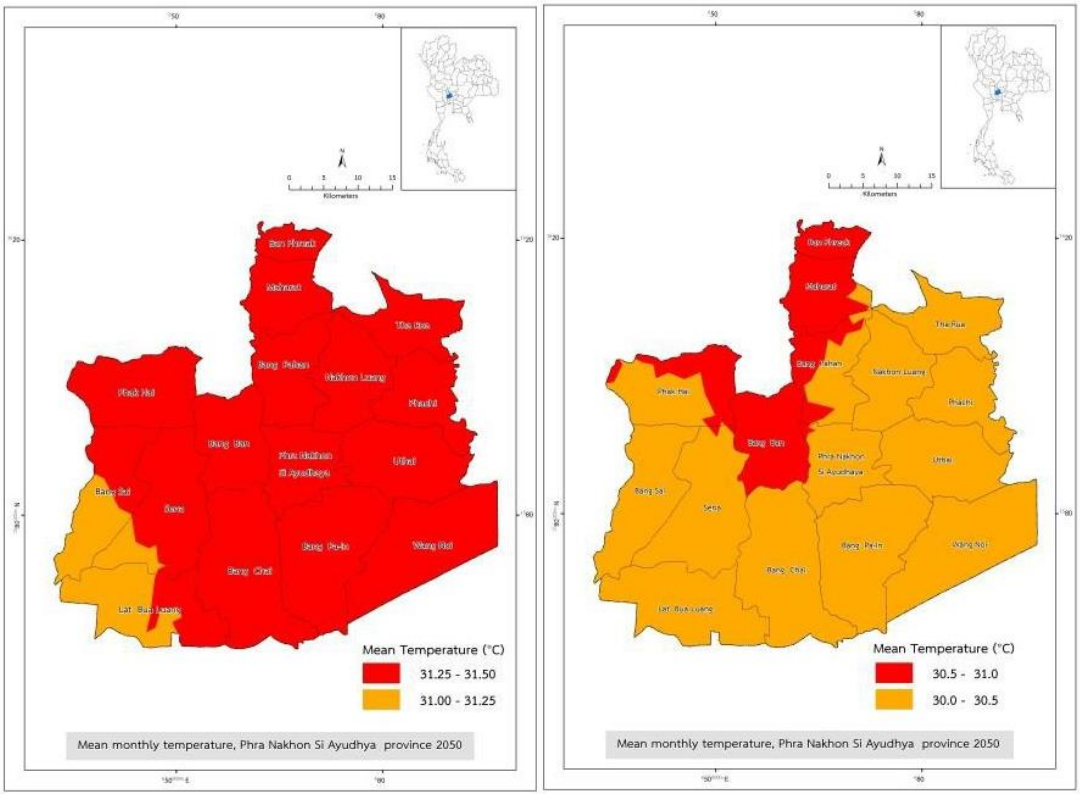


Figure 2 Mean monthly average temperature for RCP 4.5 and 8.5 in 2050

Mean monthly maximum temperature

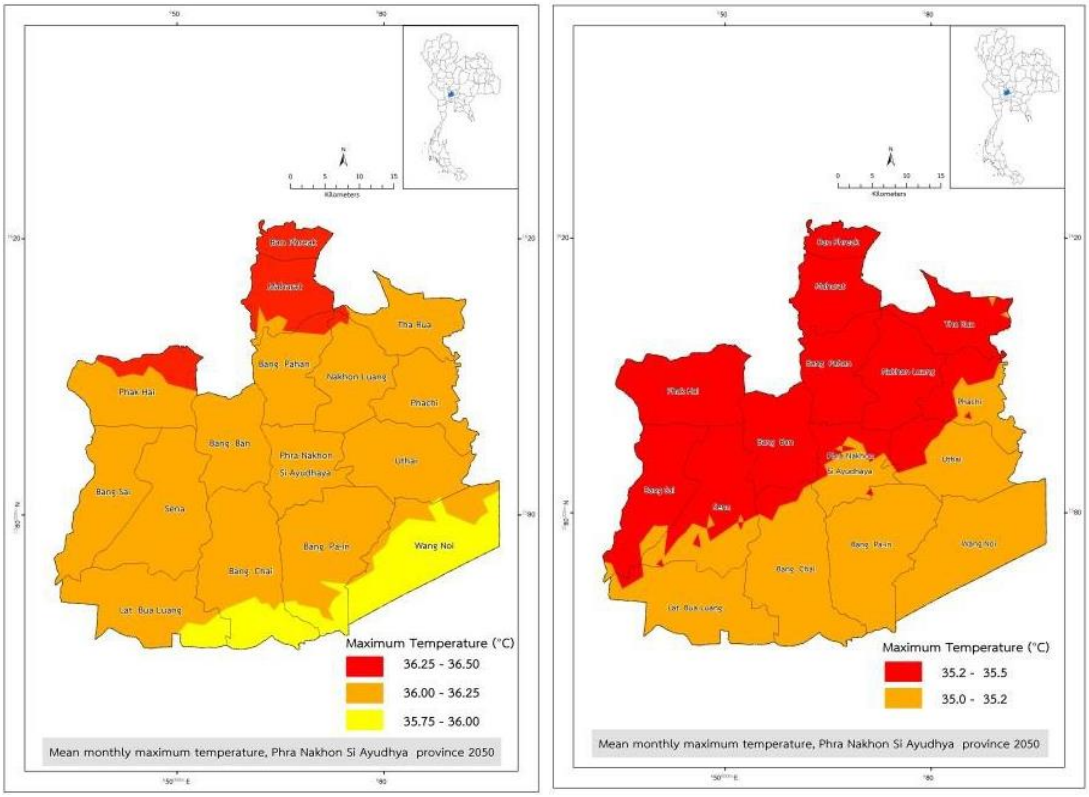


Figure 3 Mean monthly maximum temperature for RCP 4.5 and 8.5 in 2050

Mean monthly minimum temperature

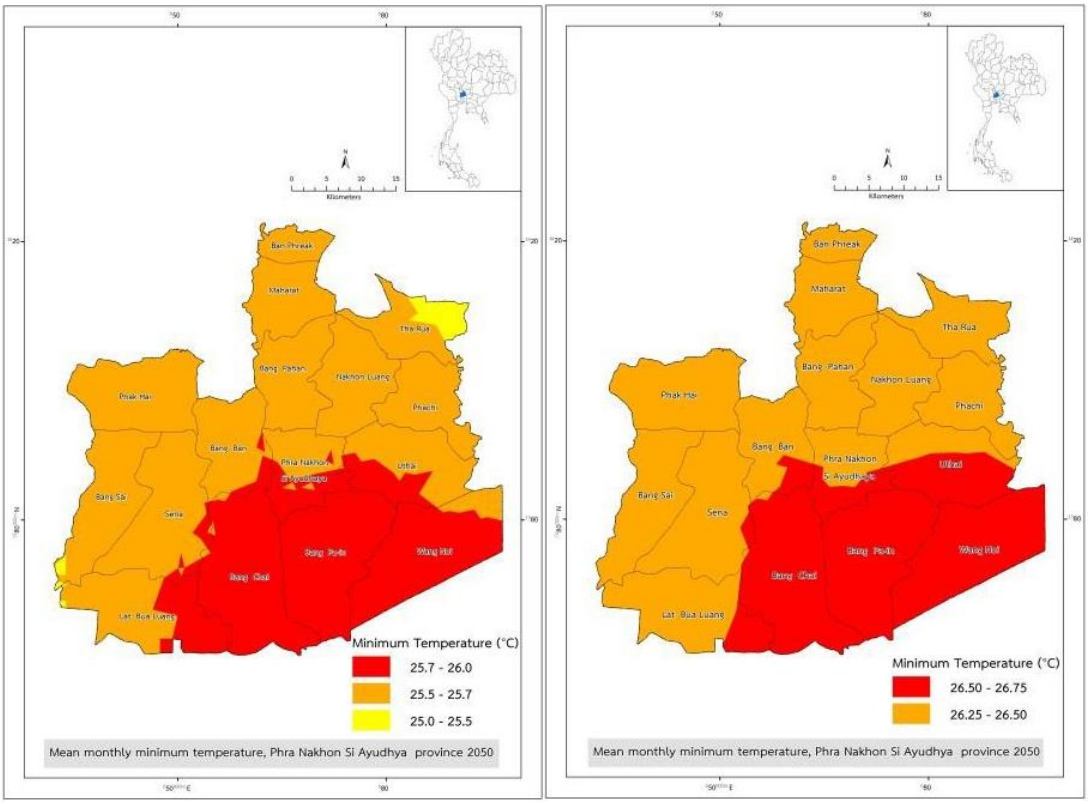


Figure 4 Mean monthly minimum temperature for RCP 4.5 and 8.5 in 2050

Annual precipitation

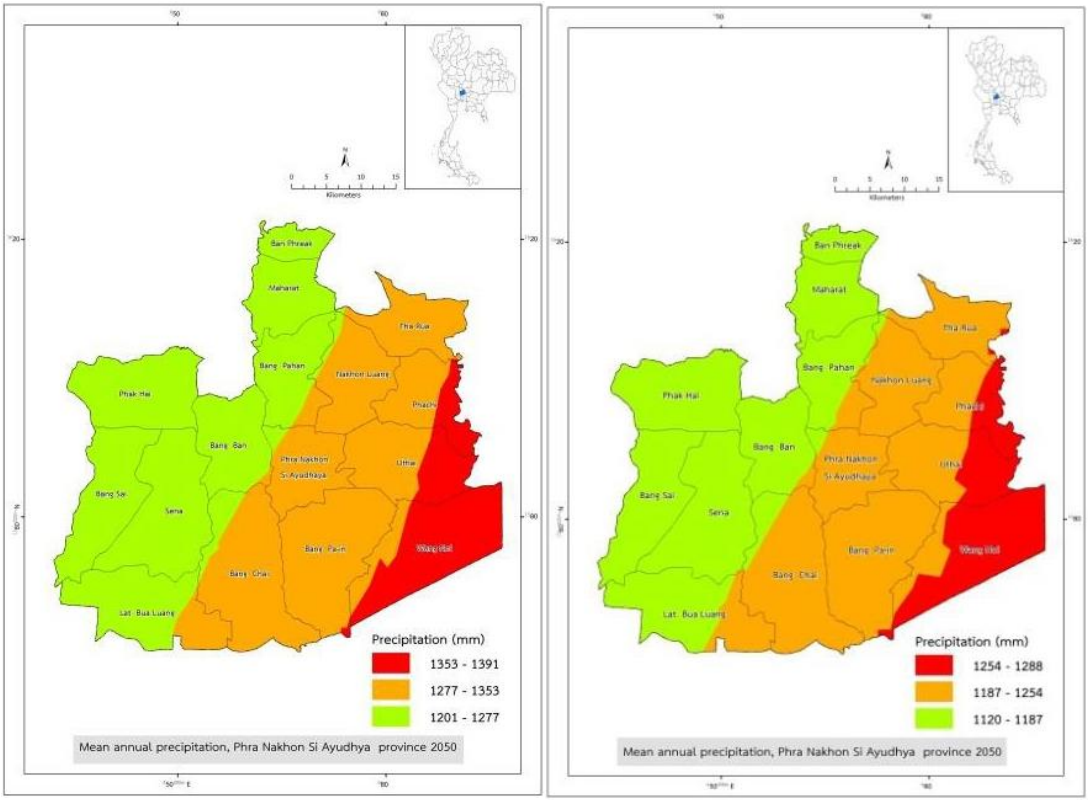


Figure 5 Annual precipitation for RCP 4.5 and 8.5 in 2050

Land suitability for rice

In 27.7 percent of the total land area by 2050 for RCP 4.5 is classified as marginal suitable for rice cultivation, while 71.2 percent and 1.1 percent of total area is classified into very marginal suitable and not suit respectively. In comparison with RCP 8.5 scenario, there is a significant change in suitability level by which 54.1 and 45.9 percent of land area are classified as very marginal suitable and not suitable respectively as shown in Figure 6. It should be noted that land suitability for rice tend to be decreased under highest Greenhous Gas emission (RCP 8.5) than those in stabilizing scenarios (RCP 4.5). Agricultural land is being transformed into residential and industrial use which makes a situation of food production even more difficult to secure food security in 2050.

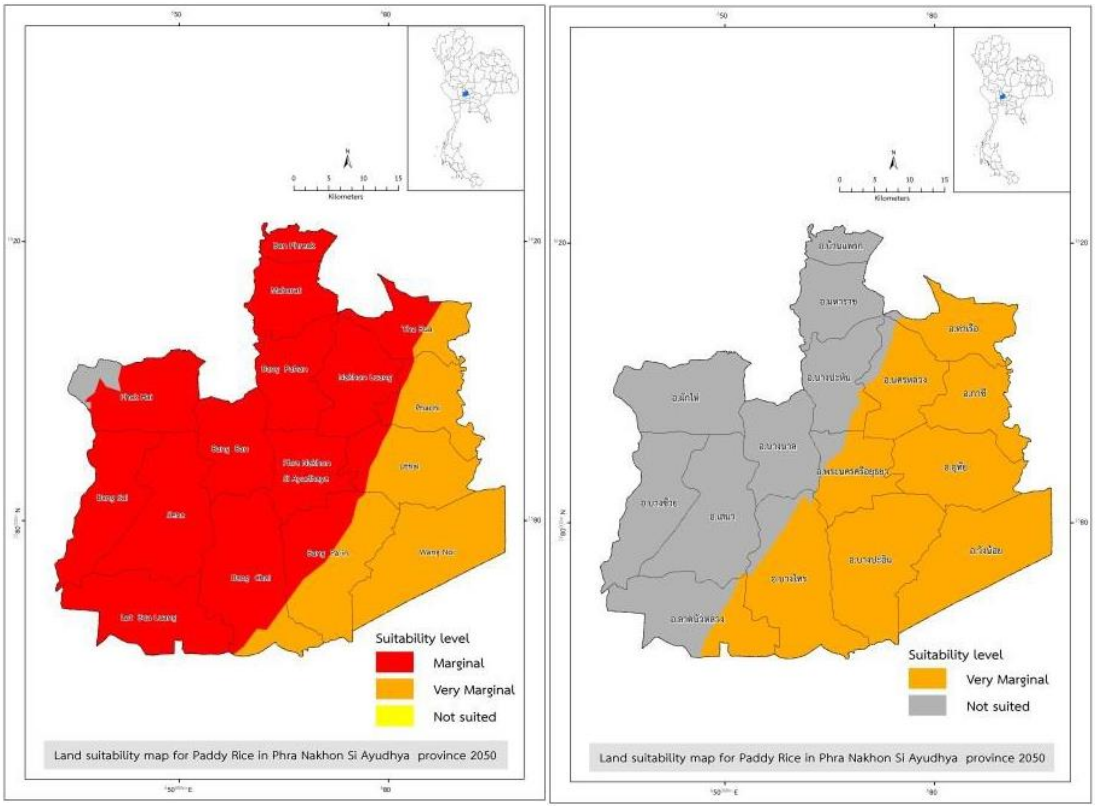


Figure 6. Land suitability for rice by 2050 for RCP 4.5 and 8.5 scenarios

It is very important to consider administrative level's adaptation plan in response to different climate change scenarios e.g. RCP 4.5 and 8.5 due to inherent uncertainty of Greenhouse Gas emission in a future .There are not only climate itself tends to be changing but also includes the frequency of extreme weather events such as flood drought and storm. Implementation of adaptation strategies such as flood retention infrastructure, urban wetland and/or pond and water conservation would be able to secure sufficient water for domestic supply and rice farmland, making it resilient to water related disaster. Other strategies e.g. crop diversification, submergence and drought tolerant rice are should be promoted by government and be implemented by smallholder farm. Land use planning that includes control and optimize land transformation is one of the effective adaptation strategies to slow down urban expansion and impervious surface. To ensure an effective of adaptation practices at farm level, capacity building for smallholder rice farming is necessary to make them understand and improve their farming practices. Knowledge of climate change and effective adaptation strategies, including water management at smallholder level will encourage them understanding climate change process and its impact, including resilient to climate change in order to ensure yields and well-being under uncertainty.

Conclusion

An increasing trend in mean monthly average temperature, maximum temperature and minimum temperature, including the decrease in annual precipitation are expected in Phra Nakhon Si Ayuttaya Province by 2050. The highest annual precipitation occurs in Wang Noi and Uthai districts where agricultural land is a major use of land. Change in mean monthly maximum and minimum temperature for RCP 8.5 is projected to be increased by 0.5-1.0 °C. In consideration of land suitability for rice in 2050 when considering different climate scenarios, there are disappeared of marginal suitable level and significantly increase in very marginal and not suit suitable levels. Shrinking agriculture land will make food security situation worse. Government and all related stakeholders in agricultural sector should take adaptation into their regional and/or provincial plan and policy both short term and long term. Many adaptation strategies such as climate tolerant rice, land use planning and controlling, hard infrastructure construction, and capacity building will play an important role in ensuring rice yields and food security in response to threat from climate change.

Acknowledgement

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