https://doi.org/10.48047/AFJBS.6.15.2024.7903-7906

AFJBS

African Journal of Biological Sciences

Journal homepage: http://www.afjbs.com

Research Paper Open Access

Application of Geographic Information System for Food Security Assessment under Climate Change in Rayong Province, Thailand

[1]**Sathaporn Monprapussorn**

Department of Geography, Faculty of Social Sciences, Srinakharinwirot University, Bangkok, Thailand
[1]sathaporn@g.swu.ac.th

Volume 6, Issue 15, Sep 2024

Received: 15 July 2024

Accepted: 25 Aug 2024

Published: 05 Sep 2024

doi: 10.48047/AFJBS.6.15.2024.7903-7906

Abstract— *Currently, climate change poses one of the most significant global challenges we face. The rise in average global temperature and the occurrence of extreme weather events have the potential to result in natural disasters such as sea level rise, floods, droughts, and storms, which can negatively impact society. In developing countries, the agricultural sector plays a vital role in driving economic growth and sustaining social well-being. A decrease in crop productivity serves as strong evidence of impact of climate change on food insecurity. Uncertainty of climate conditions are also increasingly influential in determining crop yields. This paper aims to project climate data for the year 2040 and 2060 by using the shared socio-economic pathway (SSP) 585 to evaluate land suitability for rice, rubber, and cassava in Rayong province. The projected climate data illustrates a trend toward rising temperatures and small changes in rainfall. Ecocrop model is used to predict the level of suitability for rice, rubber, and cassava which requires the projected climate data as input parameter. Results reveal the increase in area of suitability in 2060 in comparison with those of 2040 for rice and rubber, especially in the eastern part of Rayong. While suitability level of cassava is changed from excellence to very suitable in western districts of the province. These findings can be utilized in long-term policy and planning efforts to optimize the productivity of agricultural land in the province.*

Index Terms—Climate change, crop suitability, Geogaphic information system, Rayong

I. INTRODUCTION

Climate change affects the food production system in many ways, ranging from reduced crop productivity and the death of livestock to its indirect effects, such as fluctuations in food prices and market supply [1]. Weather and climate variability is one of the pressures aside from government policies, current economic markets, and the availability of farm supplies that regularly influence local agricultural production [3]. Agriculture is arguably the economy's most vulnerable sector to climate change [6]. The agricultural sector plays an important role in driving economic growth and sustaining social well-being in developing country. In Asia, rice is the main staple food and the main source of employment and GDP [10]. Nowadays, climate change and global food crisis receive considerable attention, especially in Africa region. A study conducted by [4] suggests 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 only will no longer be sufficient for agriculture. Focusing on measures and initiatives promoted by the central government and addressing efforts to establish a multi-sectoral coordination unit, specific adaptation plans and measures for the different sectors, including agriculture would be a wise strategy to climate change in Spain [2]. Crop yields may respond in a changing mean temperature, precipitation, and extreme events, notably of droughts and floods. For example, corn and soybean yields have found to be a nonlinear and inverted relationship with weather variables [7]. The evaluation of climate change impact on irrigated agriculture in the Guadiana river basin in the south of Portugal reveal an increase in crop irrigation requirement due to the decrease in rain-fed crop yield in 2011-2040 [8]. Rising temperatures in developed countries would cause significant losses in agricultural gross value added per worker ranging from 10% to 30% by the end of the century [5]. Another study proposed that yield of double cropping rice will be highest increased for SSP1-RCP 2.6 scenario of climate change due to the increase in temperature [9]. This paper aims to study climate change projection in 2040 and 2060 under SSP 585 scenario which represents the upper boundary of the range of scenarios by assuming a high level of greenhouse gas emissions. An impact of projected climate on land suitability for three cash crops (rice, rubber and cassava) in Rayong province between 2040 and 2060 has also been compared.

II. MATERIAL AND METHOD

Study area

Rayong province is located in eastern part of Thailand and lies in low coastal plain. Major economic activities in the provinces include agriculture, fishery, chemical and automobile industries. Agricultural land is the largest in province (67%), while urban takes up 16% of the province land. Figure 1 depicts land use in Rayong province for 2020.

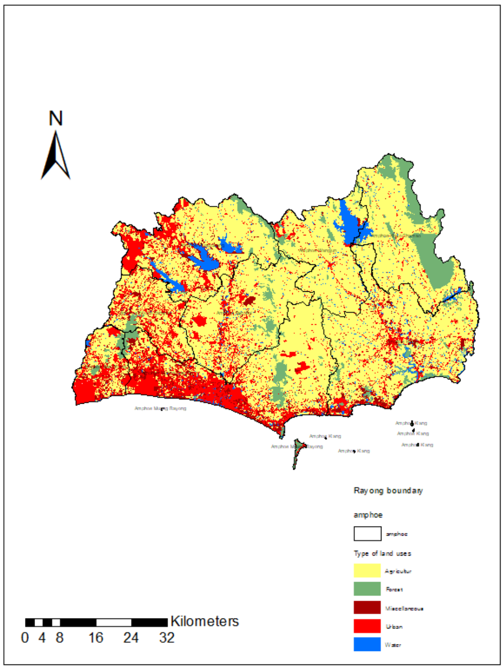


Figure 1. Land use in Rayong province

A. Climate projection

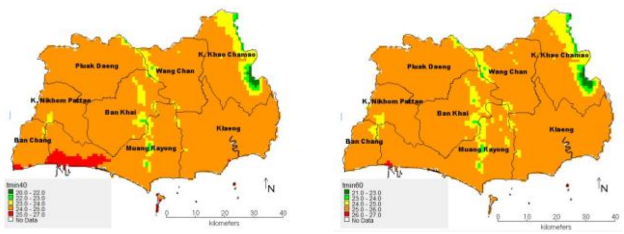
Minimum, maximum, mean temperature and precipitation projections for 2040 and 2060 are projected using the EC-Earth3-Veg climate model under the Shared Socioeconomic Pathway 585 (SSP585), which show the highest greenhouse gas emission scenario, representing the upper boundary of the range of scenarios. A comparison between a projected climate conditions in 2040 and 2060 has been made to observe a relative of change. The Ecocrop model within DIVA-GIS software is used to evaluate crop suitability for rice, rubber, and cassava. Suitability levels were categorized into six classes: not suited, very marginal, marginal, suitable, very suitable, and excellent. The Ecocrop model combines temperature and precipitation thresholds to determine land suitability for crop cultivation, which are linked to the WorldClim climate database.

B. Crop suitability assessment

Ten climate parameters extracted from climate projections in 2040 and 2060 are used to determine suitability levels: 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). Suitability maps for rice, rubber and cassava were created based on the projected climate data for 2040 and 2060.

III. RESULTS

A. Mean monthly minimum temperature

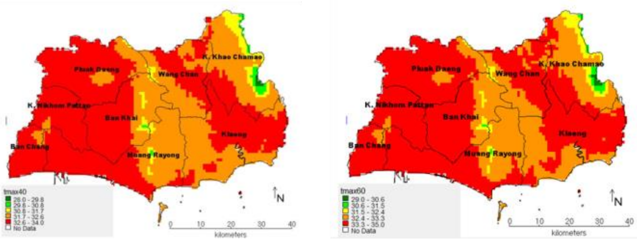


(a) (b)

Figure 2 Mean monthly minimum temperature; 2040 (a) and 2060 (b)

Mean monthly minimum temperature are projected to range from 20 °C to 27 °C in 2040 and 21 °C to 27 °C in 2060. Almost all area shows a range of minimum temperatures from 24 °C to 26 °C. However, temperature in central and northeastern districts is less than those of other areas.

B. Mean monthly maximum temperature

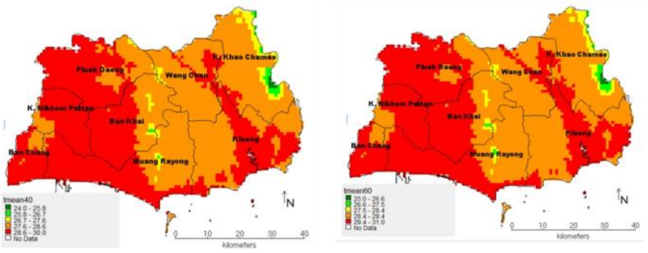


(a) (b)

Figure 3. Mean monthly maximum temperature; 2040 (a) and 2060 (b)

Mean monthly maximum temperatures are predicted to be between 28 ºC and 34 ºC in 2040 and 29 ºC and 35 ºC in 2060. Mean maximum temperature in 2060 is slightly greater than those of 2040 about 1 ºC. In some area of western districts of Rayong province experience higher temperature than those of eastern districts.

C. *Mean monthly average temperature*

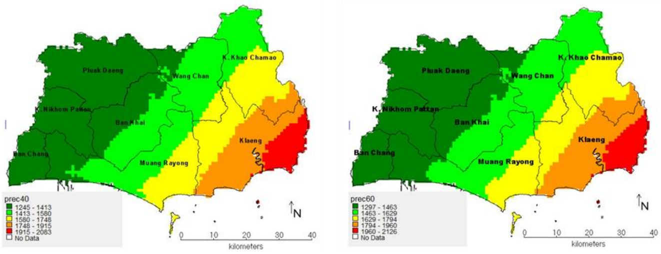


(a) (b)

Figure 4. Mean monthly average temperature; 2040 (a) and 2060 (b)

Mean monthly average temperature in 2060 is projected to be slightly higher than those of 2040, especially in western districts of the province. In the eastern part of Khao Chamao district, mean monthly temperature tends to has less temperature than other areas.

D. *Mean annual precipitation*

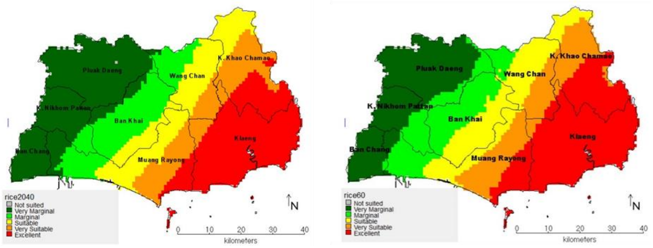


(a) (b)

Figure 5. Mean annual precipitation; 2040 (a) and 2060 (b)

Mean annual precipitation in 2060 is expected to range from 1,297 to 2,126 mm, a few increase from 2040 (1,245 to 2,083 mm). Generally, precipitation tend to increase northward and also west to east.

E. *Land suitability for rice*

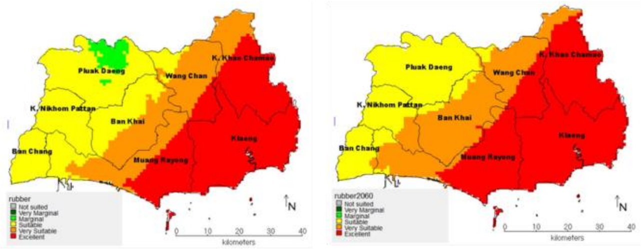


(a) (b)

Figure 6. Suitability level for rice cultivation in Rayong; 2040 (a) and 2060 (b)

In both 2040 and 2060, eastern districts of Rayong province exhibit excellent or very suitable conditions for rice cultivation, while central and western districts will be moderately suitable and marginally suitable, respectively. This indicates the increase in suitable areas for rice production in 2060 comparing to those of 2040.

F. *Land suitability for rubber*

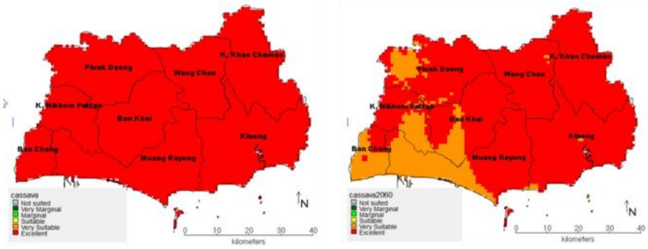


(a) (b)

Figure 7. Suitability level for rubber cultivation in Rayong; 2040 (a) and 2060 (b)

Figure 7. depicts the suitability area for rubber by 2040 and 2060. Almost all districts in eastern and central area have excellence and very suitable level for rubber cultivation while western districts depict moderately suitable level for rubber.

G. *Land suitability for cassava*



(a) (b)

Figure 8. Suitability level for cassava cultivation in Rayong; 2040 (a) and 2060 (b)

Figure 8. illustrates land suitability level for cassava by 2040 and 2060. In 2040, All districts in Rayong province are excellent suitability level. In 2060, level of suitability in some areas in western district have been changed from “excellence” to “very suitable” level. As a result, Rayong province could be appropriate to grow cassava.

Result of crops suitability analysis after projecting climate parameter in Rayong province shows high suitability level for rubber and cassava cultivation. While some areas in western districts are classed as marginal and very marginal suitability level for rice. To ensure the resilience of agricultural sectors in Rayong province in the face of climate change, it is crucial to implement several adaptation strategies such as water management improvement through implementing water conservation measures and drought-tolerant crop varieties in response to water shortages. Crop diversification is one of adaptation measures by introducing diverse crop species at smallholder farms which could enhances crop resilience to climate variability. Land use optimization can also control and optimize land activities which minimize negative impacts on agricultural productivity. Educating key stakeholders i.e. head of community and representative from government agencies on climate change issue and sustainable farming practices in an era of climate change could empower them to learn, understand and adapt to changing conditions. Afterwards, sharing knowledge about climate change awareness and effective management strategies among smallholder farmers is essential for long-term agricultural resilience. By implementing these adaptation strategies, Rayong province can build a resilience of agricultural yields and sustain its agricultural sector in the face of future climate challenges.

IV. CONCLUSIONS

By 2060, SSP 585 scenario predicts a few increases in both temperature and precipitation amount in Rayong province comparing with those of 2040. Higher temperatures could benefit rice cultivation, but adequate water supply is also one of the crucial aspects for agriculture land. Rice suitability areas are expected to increase (suitable to excellence level) in 2060, except some areas of central district which marginal suitability is dominated. Almost province lands are classed as very suitable to excellence suitability level for rubber and cassava cultivation. Research results can inform long term climate change adaptation preparedness and plans in agricultural sectors for central, regional and provincial administrations. Both short term and long term policies should address issue of water management and land use planning in response to climate change to enhance agricultural resilience in a future.

V. ACKNOWLEDGEMENT

This work was supported by funding from the Faculty of Social Sciences, Srinakharinwirot University, THAILAND

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