A REVIEW ON THE CLIMATE CHANGE PROJECTIONS IN THE MEKONG DELTA, BASED ON DATA ON 1980 - 1990, PROJECTED FOR 2010s – 2050s

Le Anh Tuan – Van Pham Dang Tri – Nguyen Hieu Trung

(2021)

An Additional Reading served for the Training course

Fundamentals of climate change and natural disasters

Code: ER602

Contents

Abstract

The study is to review the historical rainfall and temperature regimes, and to reflect the future changes according to the SEASTART datasets (with two future scenarios *i.e.* A2 and B2). In general, the future mean temperature is projected to be greater than that in the present; in addition, the annual rainfall is projected to be changed as well with greater rainfall concentrating on the raining season while dryer less rainfall concentrating on the dry season. In order to be able to have a proper projection which suits the hydrodynamic modelling purposes, further analysis on adjusting the projected data is required.

Introduction

1. Background and motivation

In order to understand the water resource changes in the Vietnamese Mekong Delta (VMD), apart from projecting the changes on upstream discharge from the upper Mekong, it is also important to understand the changes of the local rainfall and temperature regime.

2. Objectives

The study is to review the historical data (of rainfall and temperature) in the Vietnamese Mekong Delta and to project the future changes in the Mekong Delta, including the Vietnamese and Cambodia parts.

3. Hypothesis

The projected historical data (of rainfall and temperature) can be adjusted according to the measured historical data and the approach used to adjust the historical data can be used to adjust the projected data.

4. Scope of the study

The study historical data was collected for the Vietnamese Mekong Delta only but the projected data was analyzed for the whole Mekong Delta (including the Vietnamese and Cambodia section).

I. Literature review

Over the past ten years, climate change has become one of the most socio-economical and environmental problems in the world. Changes of the world climate are projected to lead to crop failures, life damage and losses and other critical ecosystem vulnerabilities, especially in Asia and Pacific Ocean region. The VMD, the most downstream part of the Mekong River Basin, is the greatest agriculture and aquaculture region of Vietnam. Agriculture and aquaculture sectors are the focal points of rural development policies of the Central Governments of Thailand, Laos, Cambodia and Vietnam over the last 30 years. The Mekong River Delta is a “hot spot” for climate change, which is one of the three most vulnerable deltas on the world (Figure 1). IPPC (2007) has warned that if the sea level rises 1 meter, the Mekong Delta may lose 15,000 – 20,000 km2 of land, and about 3.5 to 5.0 million of people will be affected. However, mentioned damages are relatively simple based on the consideration of the natural Delta’s topography and current population distribution only. Other important factors like precipitation, upstream discharge, storm surges, and tidal regime have not been calculated yet.

Figure 1: Relative vulnerability of coastal deltas as shown by the indicative population potentially displaced by current sea-level trends to 2050 (Extreme = >1 million; High 1 million to 50,000; Medium = 50,000 to 5,000; following Ericson et al., 2006). (*Sources*: Nicholls et al., 2007)

Climate change, an inevitable effect of global warming, has become a global concern due to its potential consequences on various systems and sectors, threatening human wellbeing (IPCC, 2001). Understanding climate change is at the base of proper planning of adaptation measures to cope with future risks. However, global warming is a slow process and requires rather long-term future climate projections in order to clearly detect the change in future climate patterns (IPCC 2007) and its impact on certain sectors within a specific area. Global circulation models (GCMs) have been developed and are commonly used to simulate future climate. However, the majority of simulation results available today from most GCMs is in coarse scale due to technological limitations and is not an effective tool for climate change impact assessment at the local level. Therefore, regional climate projections in high resolution have been developed based on various techniques to address the requirement in climate change impact assessment. Typically, there are three types of techniques for obtaining high resolution regional climate change projections: statistical, dynamical and hybrid (statistical-dynamical). The use of Regional Climate Models (RCMs) falls into the dynamical category (Jones et al. 2004). This paper discusses the approach in dynamic downscaling of GCM data using the regional climate model to develop future climate projections for the Mekong River Delta (MD).

An RCM is a downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global GCM. While GCMs typically run with horizontal scales of a few hundred kilometers, regional models can resolve features down to a much smaller scale of 50km or less. This results in more accurate representation of many surface features, such as complex mountain topographies and coastlines. It also allows small islands and peninsulas to be represented realistically, whereas in a global model their size would associate their climate with that of the surrounding ocean. RCMs are full climate models, and as such, are physical-based. They represent most, if not all, of the processes, interactions and feedbacks among climate system components represented in GCMs. They produce a comprehensive set of output data over the model domain. This study uses a regional climate model, namely PRECIS, for downscaling coarse scale GCM to derive climate change scenarios for the Mekong River Delta (Jones et al. 2004)

PRECIS is a regional climate model that was developed by the Hadley Centre for Climate Prediction and Research and is based on the Hadley Centre's regional climate modeling system. It can be used as a downscaling tool that adds fine scale (high resolution) information to the large-scale projections of a global GCM. It has been ported to run on a PC (under Linux) with a simple user interface, so that experiments can easily be set up over any region. PRECIS was developed in order to help generate high-resolution climate change information for as many regions of the world as possible. These scenarios can be used in impact, vulnerability and adaptation studies (Simson et al. 2006).

Water vapour and carbon dioxide (CO2) are main gases responsible for the greenhouse gas (GHG) effect. The Intergovernmental Panel on Climate Change (IPCC) has considered carbon dioxide emissions and concentrations as a fundamental factor in controlling climate variations over this time scale. Increasing atmospheric greenhouse gas is the key influence to global warming and it is expected that GHG will continue to increase in the future. However, changes in the level of atmospheric GHG depend on the level of human activity, thus would affect GHG emission in the future. The IPCC has projected CO2 emission and concentration scenarios, changing future socio-economic conditions to measure different plausible GHG emission and concentration outcomes (IPCC, 2000) (Figure 2).

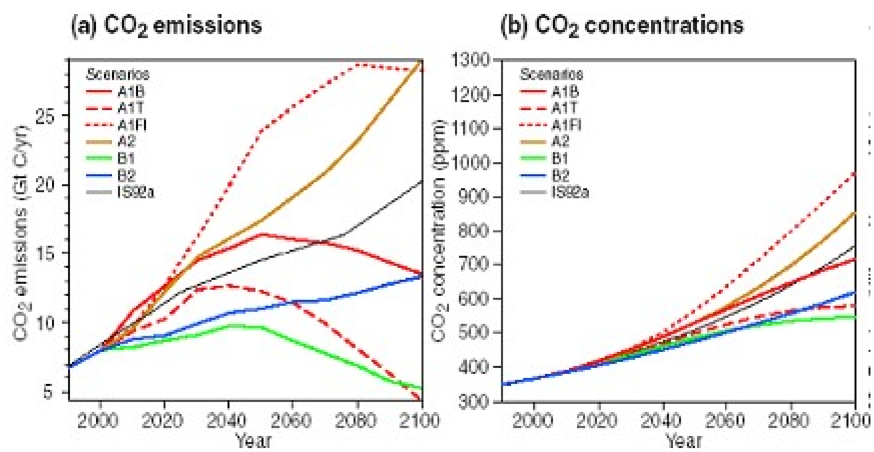

Figure 2: Emissions and concentrations of CO2 for the various reference scenarios by IPCC.

This study conducted dynamic downscaling based on an initial dataset from ECHAM4 GCM from the Max Planck Institute for Meteorology, Germany (http://cera-www.dkrz.de/IPCC_DDC/IS92a/Max-Planck-Institut/echam4opyc3.html) and used PRECIS RCM to simulate future climate scenarios for the Southeast Asia region at a resolution of .22 degree grid (approximately 25x25 km) with daily time step.

II. Material and methods

- Literature review.
- Available historical data (rainfall and temperature) were collected at different stations in the VMD.
- Trend analysis was done in order to realize the pattern of changes for rainfall and temperature regime.

III.Results and discussion

3.1. The Mekong region climate change projection

Based on the results from the Global Circulation Models (GCMs) combined with the downscaling regional climate model PRECIS developed by the Hadley Center for Climate Prediction and Research, it is projected that, coming next 2 - 3 decades in the Mekong Basin, the average max/min temperature will increase from 1 – 3 °C in the hot months (from January to April) (Figure 3 and Figure 4). The dry seasons are predicted to lengthen and intensify and the wet seasons are expected to shorten due to start later 2 weeks. The decease of the water flow from the upstream of the Mekong River in the dry seasons plus the sea level rise phenomena may lead more serious in saline intrusion into the Lower Mekong River Delta in Vietnam. Salinity intrusion in the Mekong Delta region is expected to increase, resulting in changes to cropping patterns and productivity and negative effects on aquatic and terrestrial ecosystems (MRC, 2009). The rainfall will be fewer in the early of rainy seasons (April – May) but it may increase dramatically in the end of rainy seasons (September – October). Under the projected climate in 2030, in north-east Thailand region and the Tonle Sap catchment of Cambodia will meet to suffer high water stress during the dry season (Eastham et. al., 2008).

According Supparkorn (2008), in case of the CO2 amount in atmosphere increasing double from nowadays, the rainfall in the whole Mekong Region will be changed as (Figure 5). It is also projected that the duration of the flood days in the border area of Cambodia – Vietnam, in Long Xuyen Quadrant and the Plain of Reeds may reduce. Otherwise, the flooded area may be extended its inundation boundary towards Ca Mau Peninsula. The storms seem to move down to the southern region in the East Sea. A combination of higher temperatures, lower rainfall, more extensive flooding and a rise in sea level will impact significantly on agricultural activities in general and on rice production in particular, adding more pressure to the livelihoods of people in the delta area (TTK & SEA START RC, 2009).

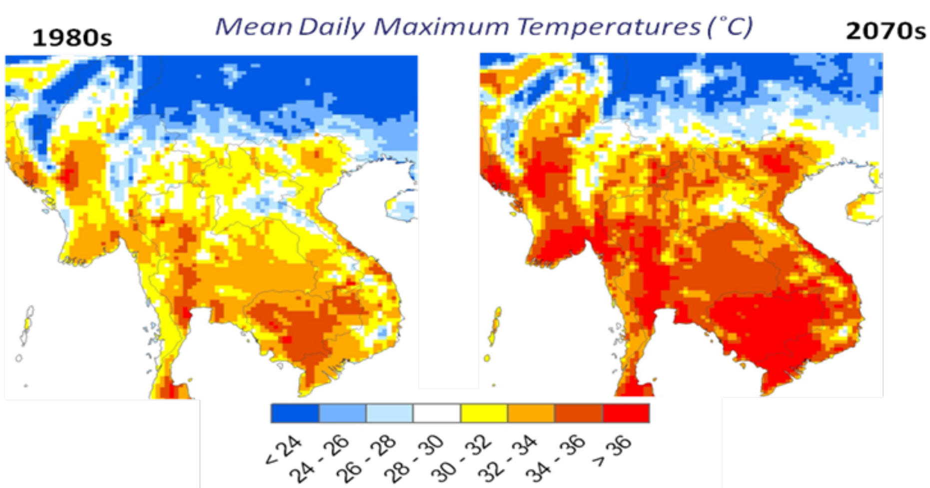

Figure 3: The projected change of mean daily maximum temperature in the Mekong Region since 1980s to 2070s (Source: TTK & SEA START RC, 2009).

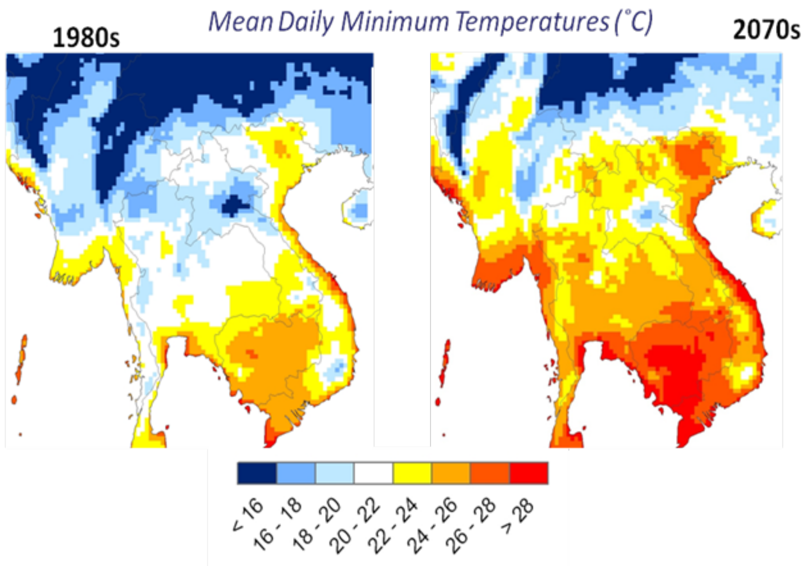

Figure 4: The projected change of mean daily minimum temperature in the Mekong Region since 1980s to 2070s (Source: TTK & SEA START RC, 2009).

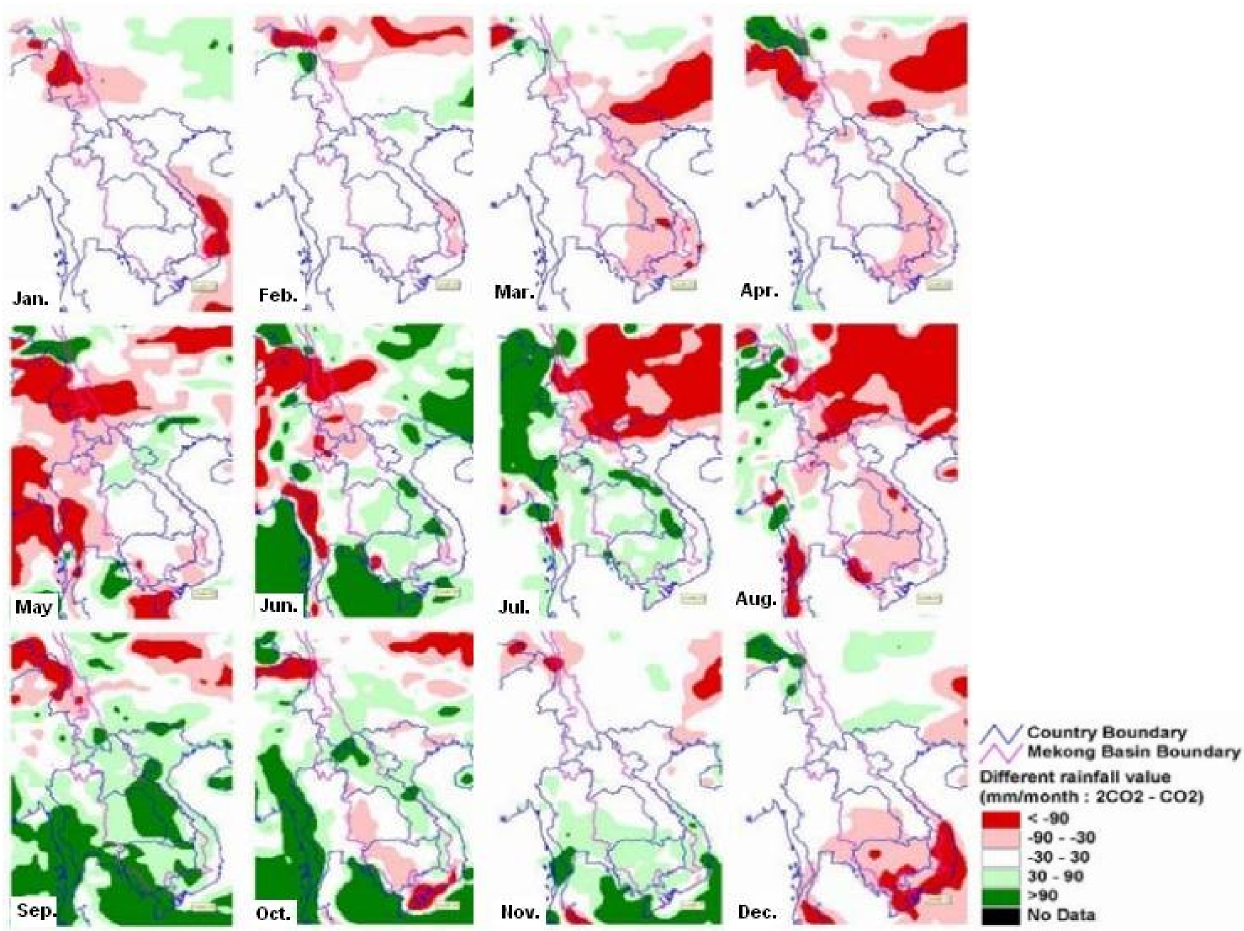

Figure 5: Different in the rainfall, comparison rainfall level between in the region at 1xCO2 at present time and 2xCO2 levels in the future. (Source: Supparkorn, 2008).

3.2. Temperature and precipitation projection for the Mekong River Delta

As explained above, the future climate projection data was simulated by ECHAM4 Global Circulation Model under the IPCC SRES A2 and B2 GHG scenarios and downscaled to high resolution using the PRECIS regional climate model. Simulation results from the PRECIS regional climate model show that the Mekong River delta will likely be a few degrees Celsius warmer in the 2030 - 2040 than in the 1980 - 1990, the baseline period for comparison. Warmer temperatures can be seen in both the average maximum and minimum temperatures. Moreover, the extreme maximum temperature, i.e. the maximum temperature of the hottest day in the year, will also be warmer by a few degrees Celsius. See figure 6, 7, 8 and figure 9.

Changes in warming climate in the Mekong River delta can also be seen from the temporal aspect, in addition to the magnitude of change. From the simulation, results show that it will not only be warmer, but the hot period is also expected to be longer. Figure 5 shows that the hot period, defined in this paper as the number of days annually where the maximum temperature is over 35ºC, will extend to about 2 months longer in the 2030s compared to that of the 1980s. It is similar in the case to consider the number of over35ºC-hot days for both GHS emission scenarios A2 and B2 (Figure 10 to Figure 13).

The average annual precipitation is likely to decrease by 10 – 20% in the future throughout the delta area generally (Figure 14 and Figure 15). As a comparison of change in annual precipitation in the Mekong River delta between the 1980s and 2030s, it is found that the annual precipitation is reduced for the whole delta (Figure 16). The modeled projection has shown that the monthly rainfall distribution is changed; in the early of rainfall season the monthly rainfall will be reduced but in the end of rainfall season the monthly rainfall trend will be increased (Figure 17). Otherwise, the starting periods of rainfall season in 2030s seem later than in 1980s for An Giang, Can tho and Soc Trang provinces (Figure 18).

In general, all the climate change projection is likely to threat the rice production in the VMD.

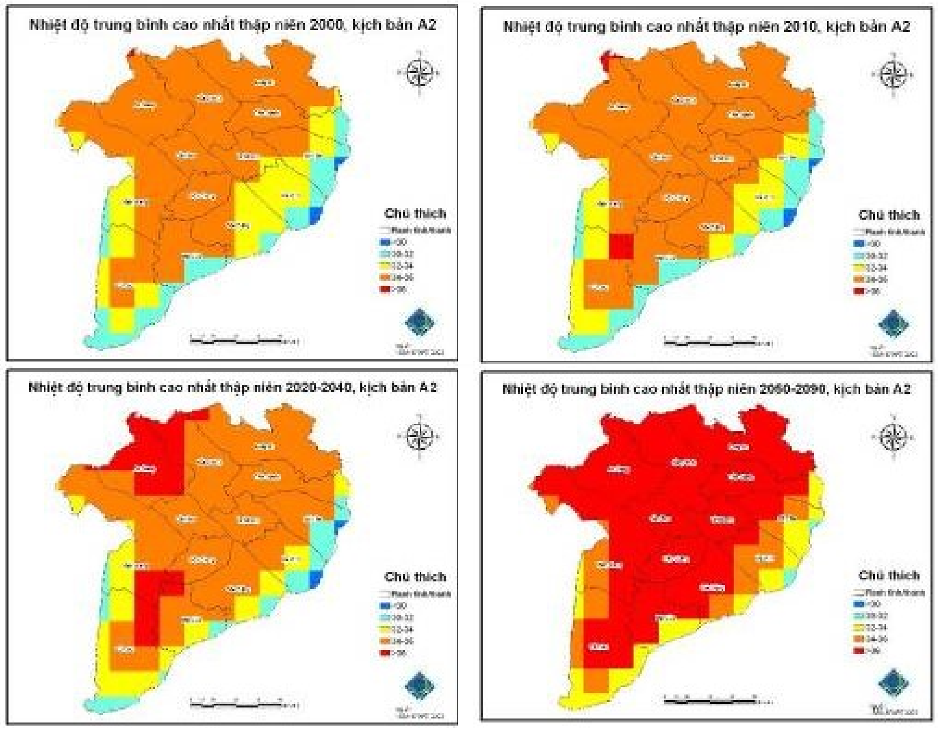

Figure 6: The change of maximum average temperature in the MD under the GHG scenario A2 (Source: SEA-START-RC, modified).

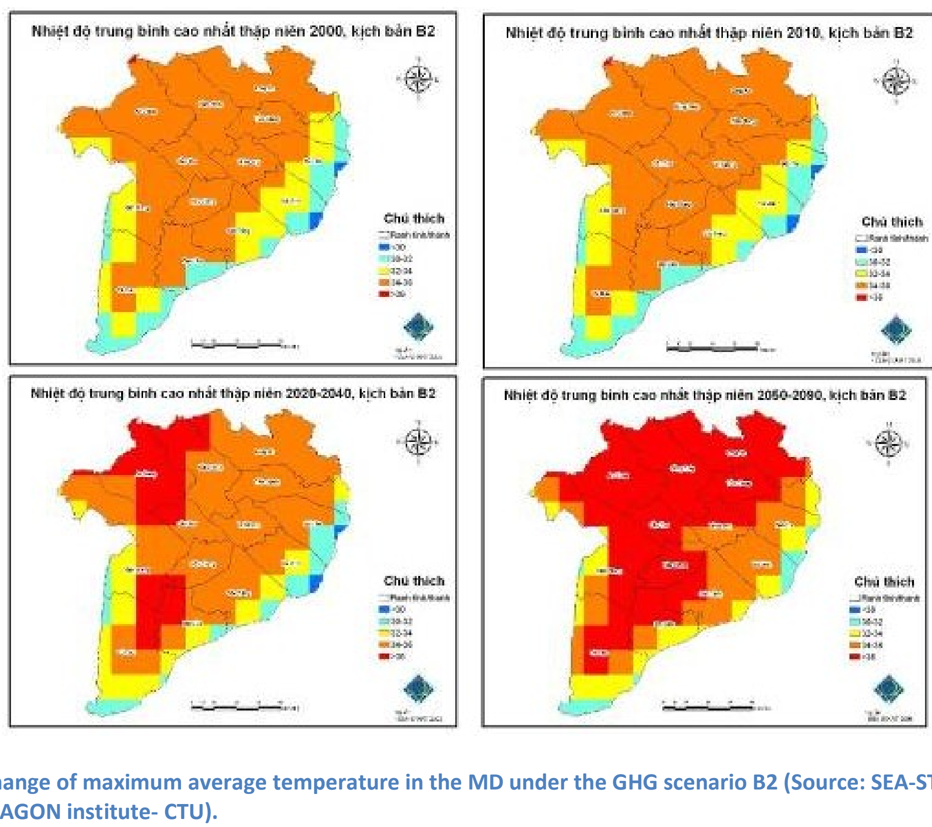

Figure 7: The change of maximum average temperature in the MD under the GHG scenario B2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

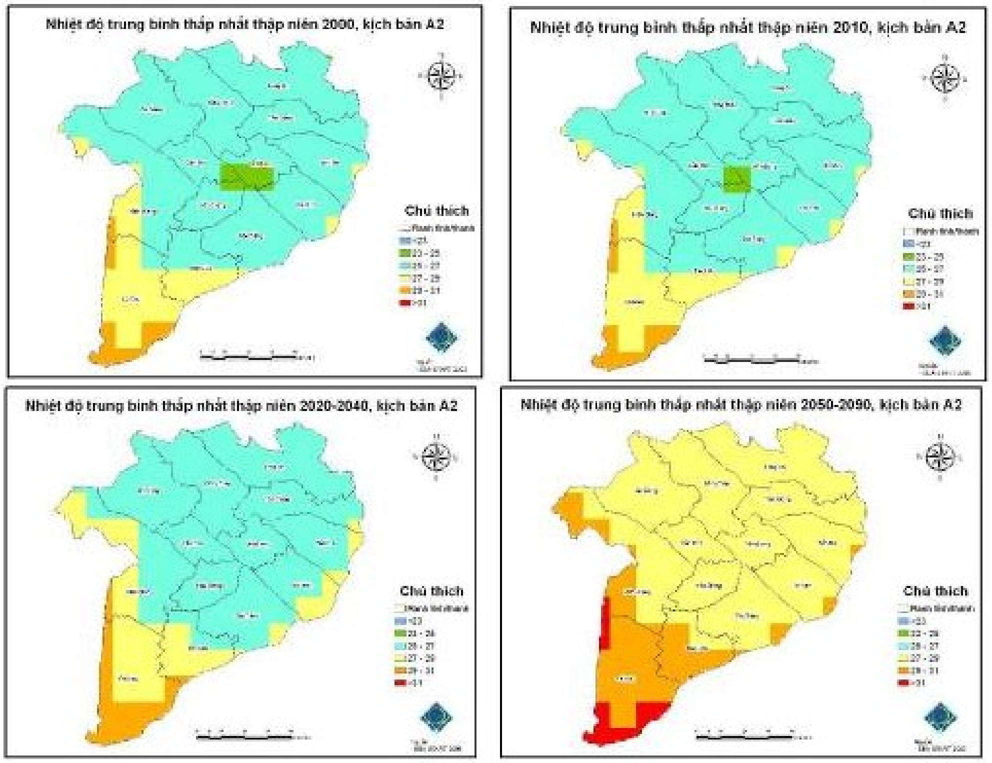

Figure 8: The change of minimum average temperature in the MD under the GHG scenario A2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

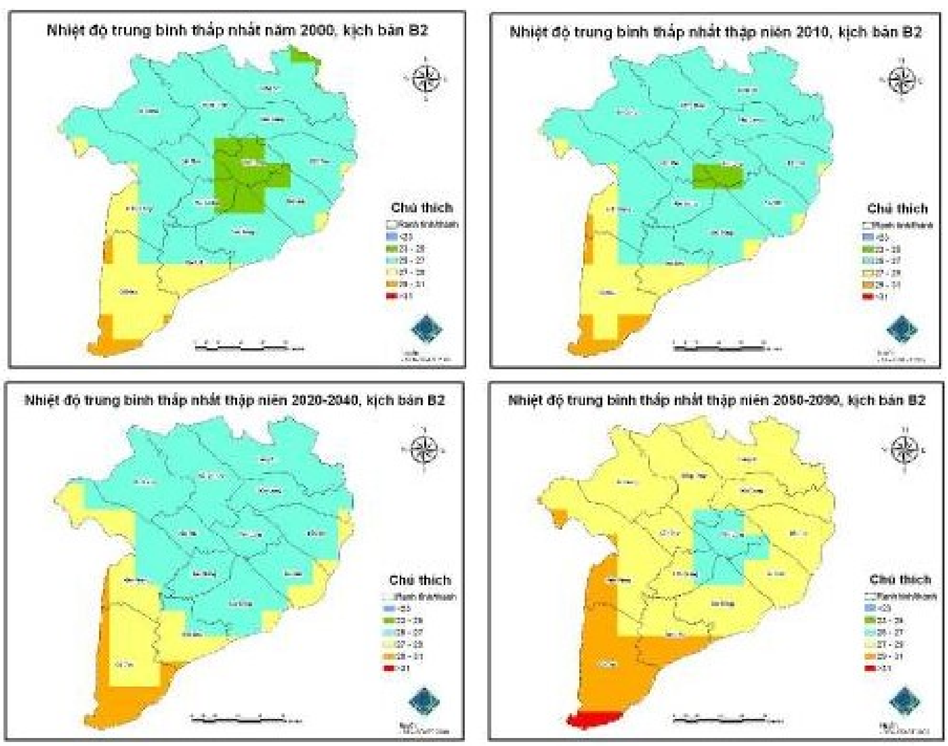

Figure 9: The change of minimum average temperature in the MD under the GHG scenario B2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

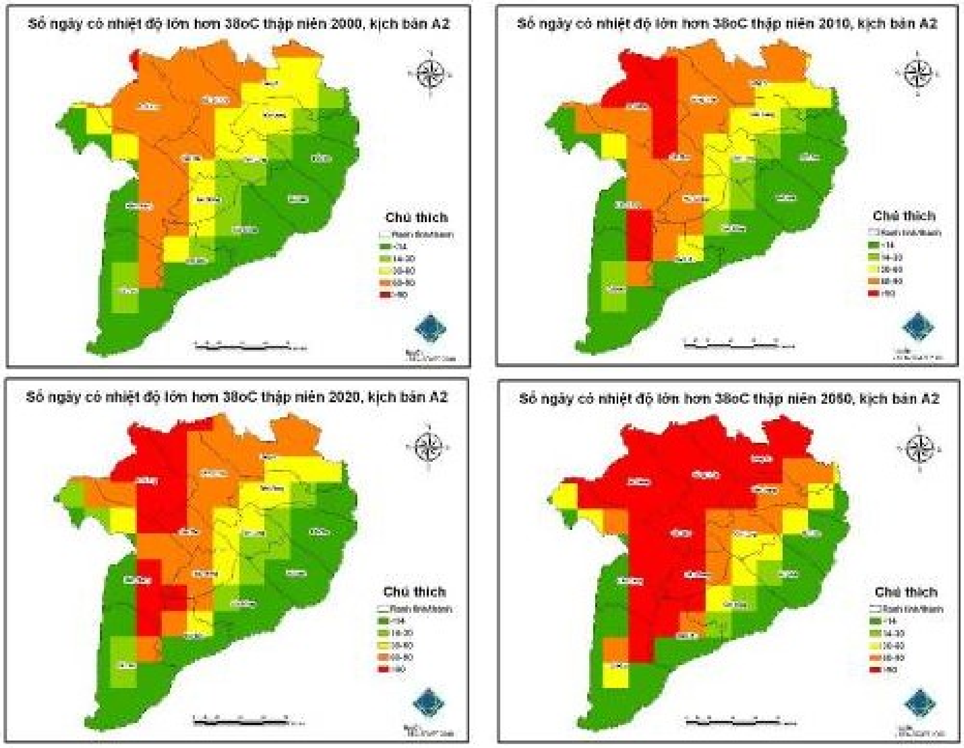

Figure 10: The change of number of over38°C-hot days in the MD under the GHG scenario A2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

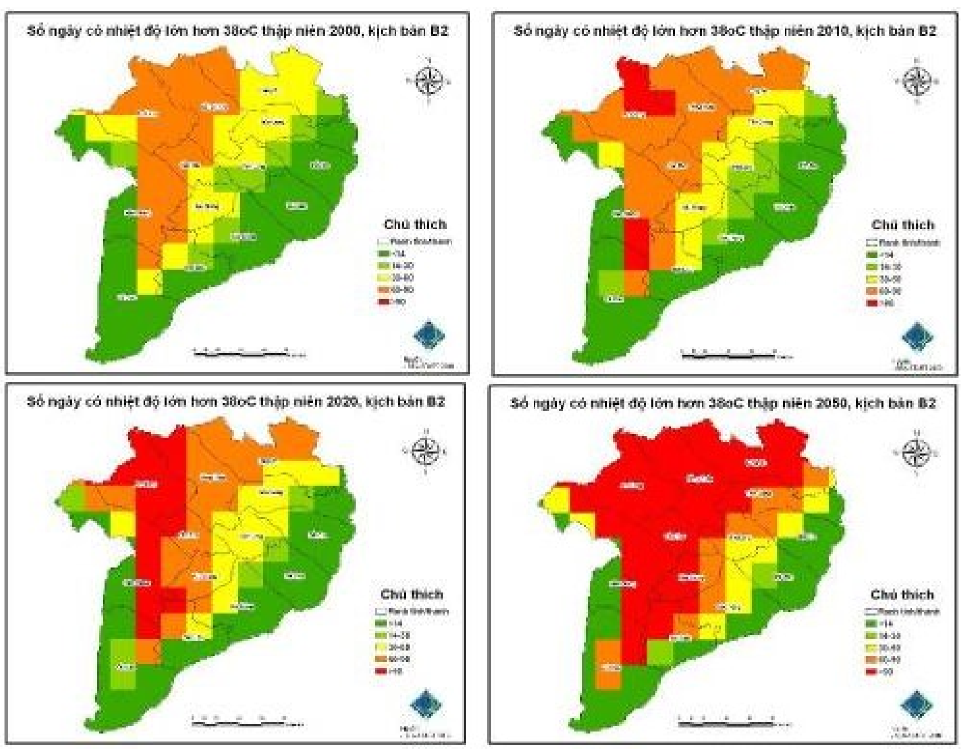

Figure 11: The change of number of over38°C-hot days in the MD under the GHG scenario B2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

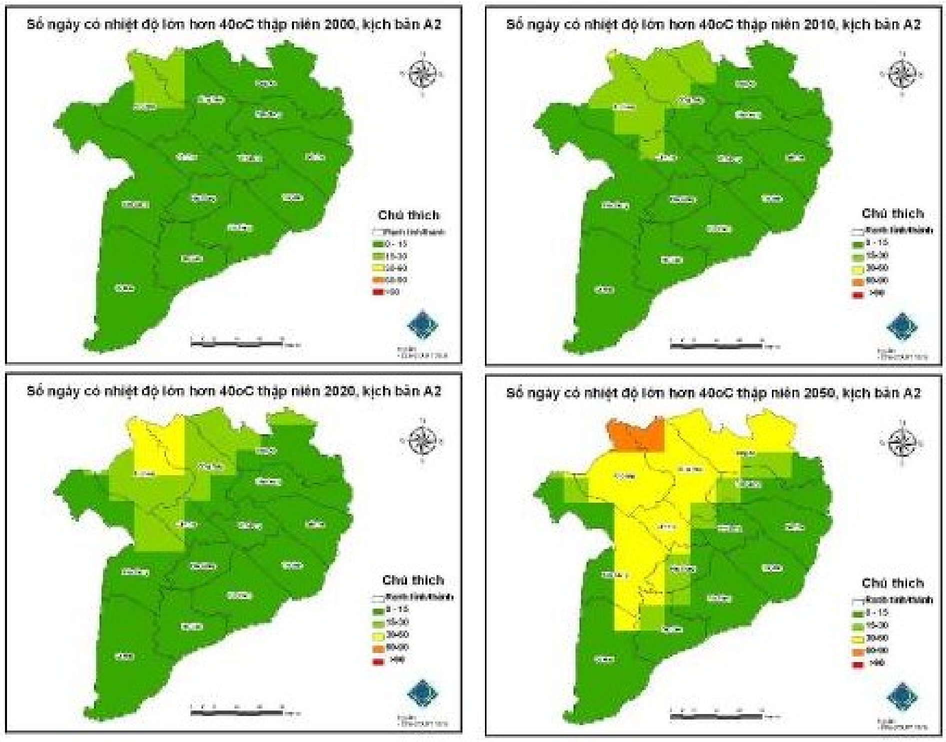

Figure 12: The change of number of over40°C-hot days in the MD under the GHG scenario A2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

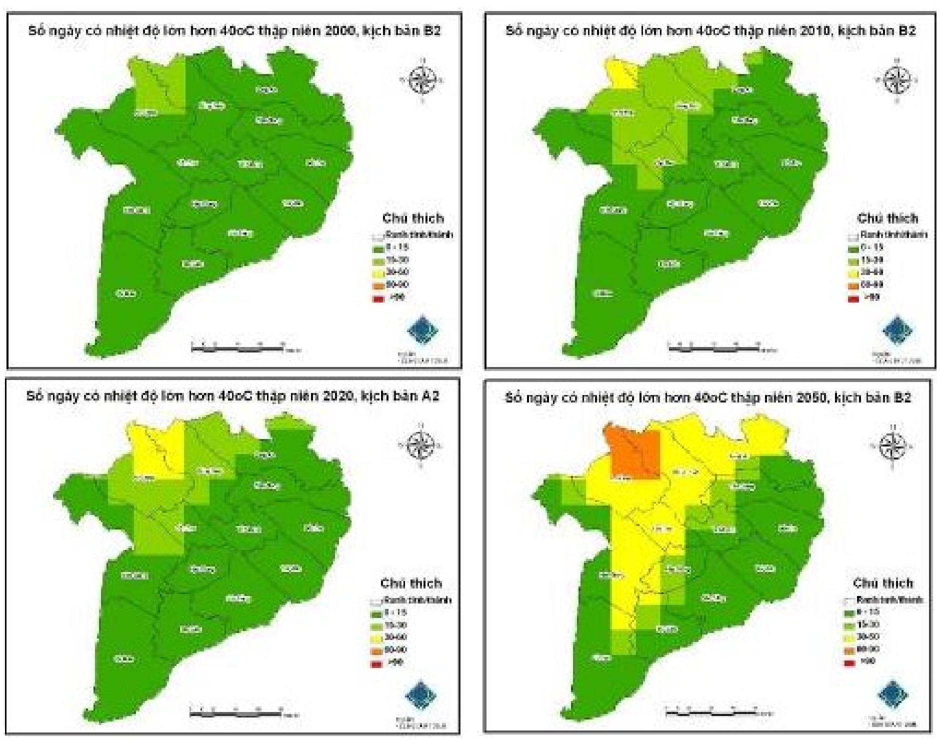

Figure 13: The change of number of over40°C-hot days in the MD under the GHG scenario B2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

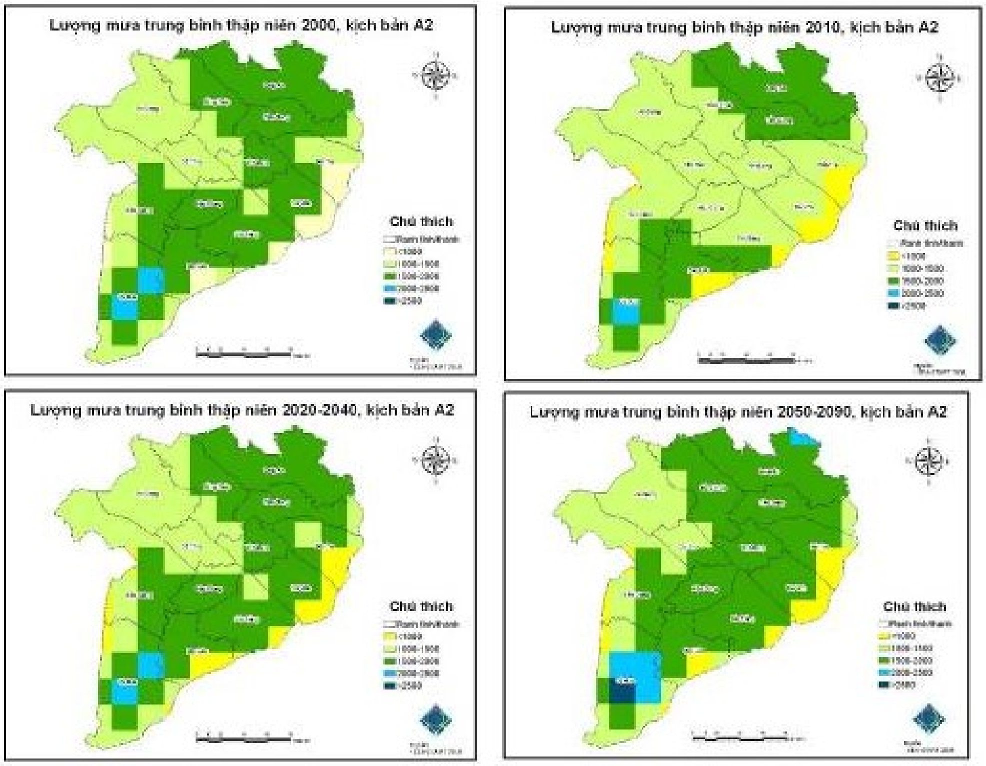

Figure 14: The change of average precipitation in the MD under the GHG scenario A2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

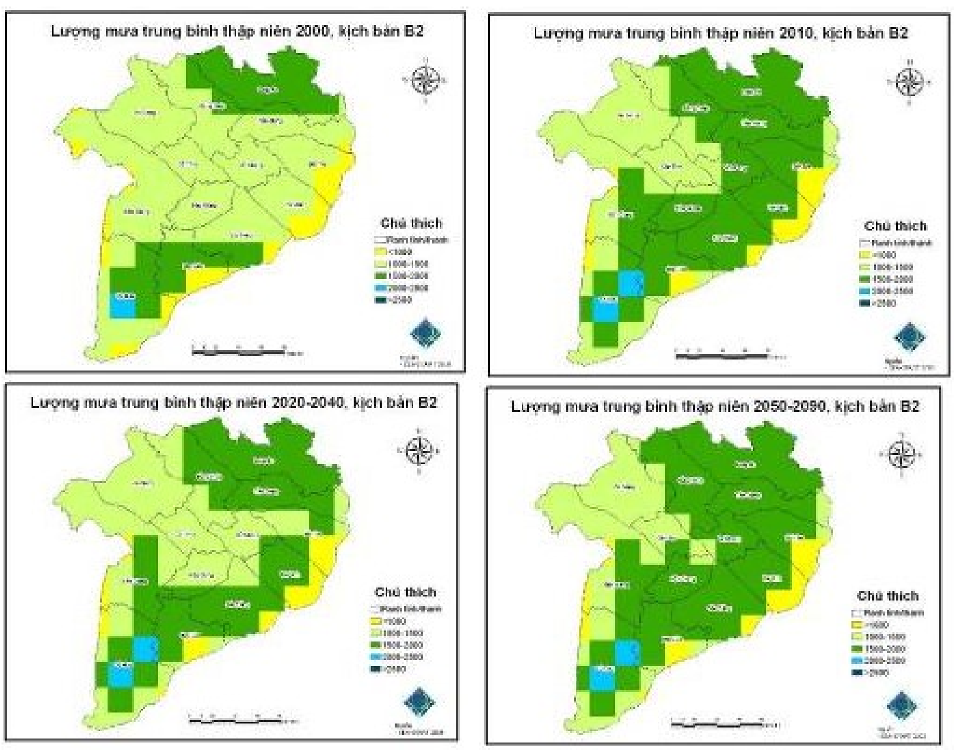

Figure 15: The change of average precipitation in the MD under the GHG scenario B2 (Source: SEA-START-RC, modified by DRAGON institute- CTU).

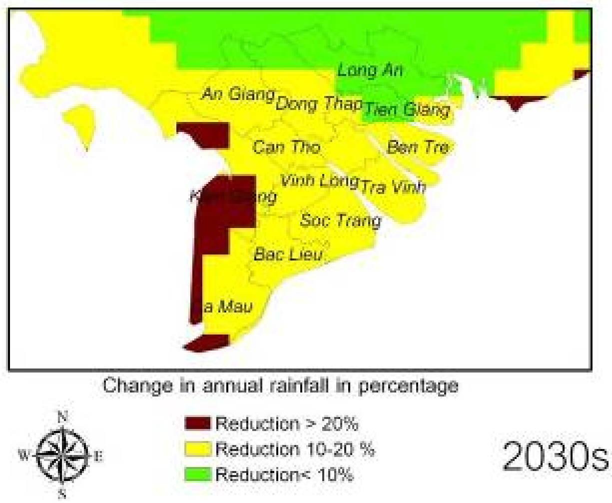

Figure 16: Comparison of change in annual precipitation in the Mekong River delta between the 1980s and 2030s (Source: SEA-START-RC).

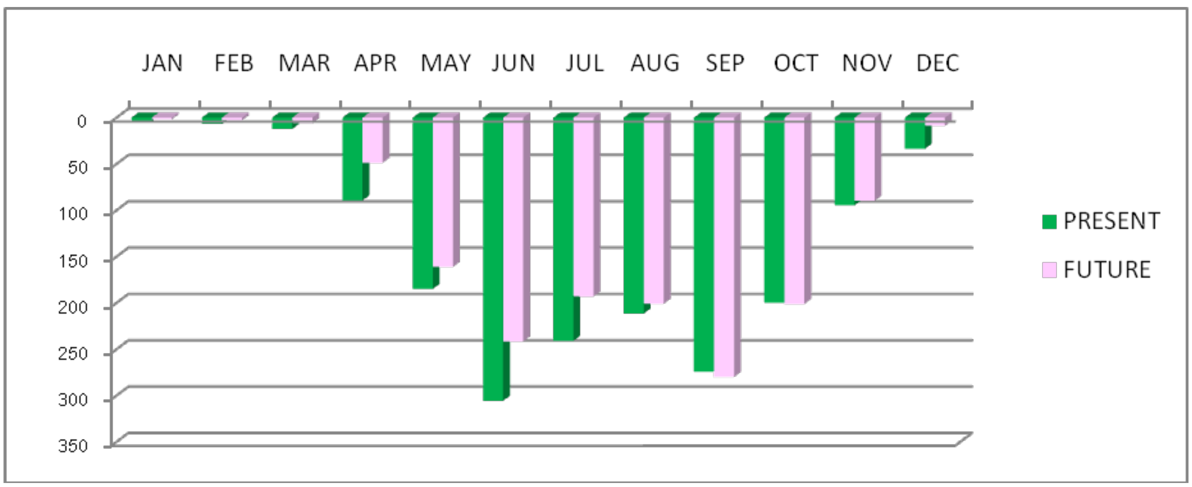

Figure 17: Change in monthly precipitation distribution in the Mekong River delta compared between the 1980s and 2030s (Source: SEA-START-RC).

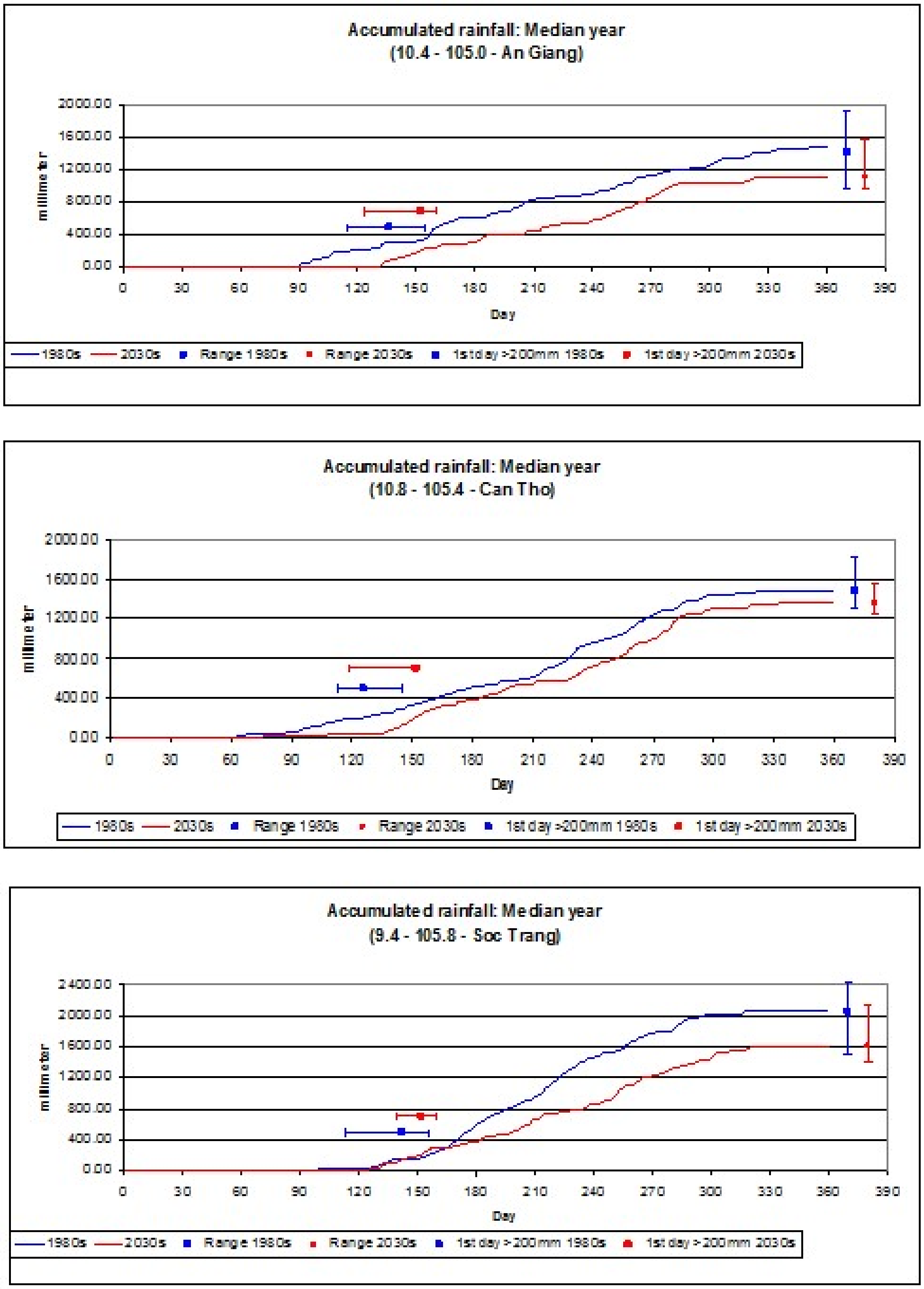

Figure 18: Change in starting days of rainfall and accumulated rainfall in median year in 3 provinces An Giang (flooding area), Can Tho (middle area) and Soc Trang (coastal area) compared between the 1980s and 2030s (Source: SEA-START-RC).

3.3. Detailed analysis of historical and projected data of rainfall and temperature in Bac Lieu

The historical and projected data of rainfall and temperature in different rainfall gauges in the VMD (Figure 19) were reviewed from SEA-START's database with the observed and simulated data ranging from 1960 to 1999 and from 2000 to 2100, respectively. This report is to reflect the trend of changes from the past to the projected situation in the future in Bac Lieu; therefore, relevant information at the gauge No. 6 is presented only.

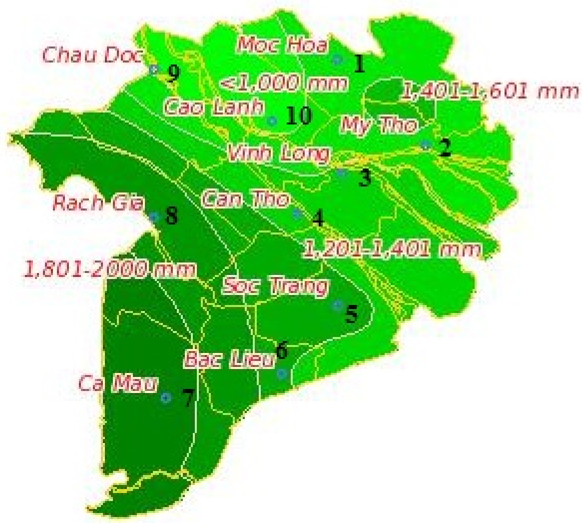

Figure 19: Locations of the main rainfall stations in the VMD.

Figure 20 and Figure 21 present the daily maximum and minimum temperature according to the past and future records. The later is accounted for both the A2 and B2 scenarios. It can be seen that the daily maximum and minimum temperature were projected to be greater in the future (in comparison to the baseline scenarios from 1960 to 1999), especially by the end of the 21st century. From 2000 to 2040, the trend of increase temperature appeared but with less magnitude in comparison to the later stage of simulation.

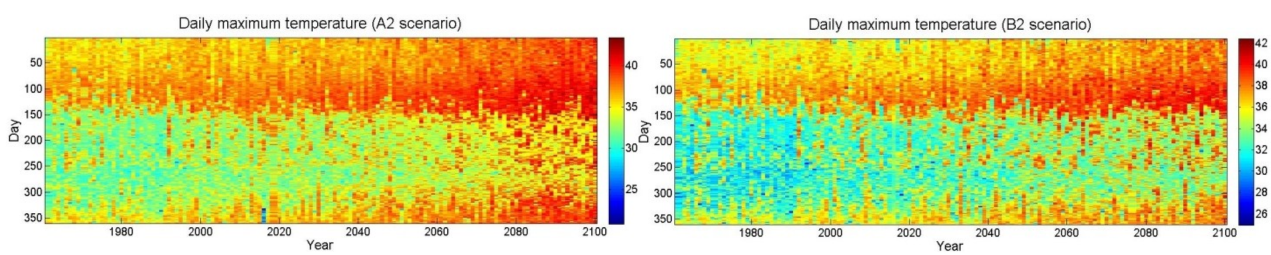

Figure 20: Daily maximum temperature at the location 6 after the A2 and B2 climate change scenario.

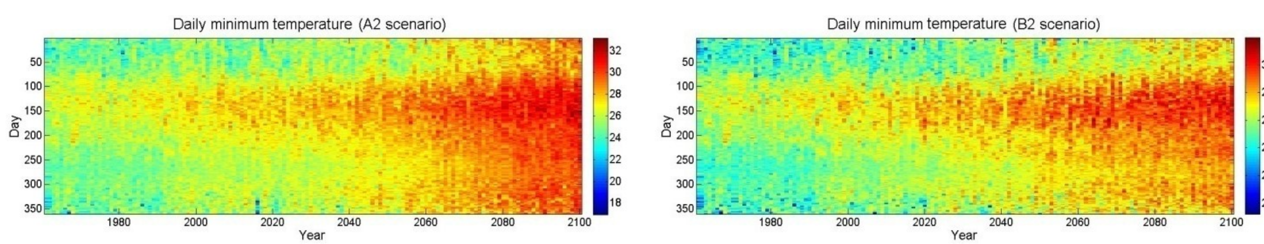

Figure 21: Daily minimum temperature at the location 6 after the A2 and B2 climate change scenario.

Figure 22 to Figure 24 present the precipitation with percentile of less than 70 %, from 70 to 90 % and greater than 90 %, respectively. The precipitation with percentile of less than 70 % in the future would not be significantly different from the past to the present. However, in the case of precipitation with percentile of less than 90 % and greater than 70 %, less rainfall would be projected in the future as it would be replace by the precipitation with percentile of greater than 90 %. In general, it can be concluded that in the future there would be the heavier rainfall concentrating on the wet season.

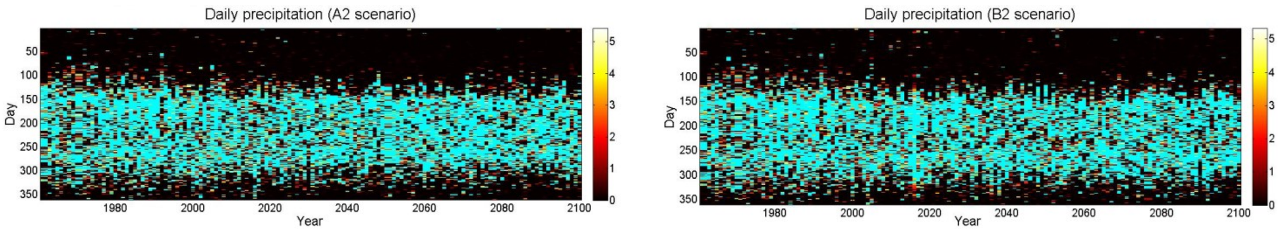

Figure 22: Precipitation with percentile of less than 70%.

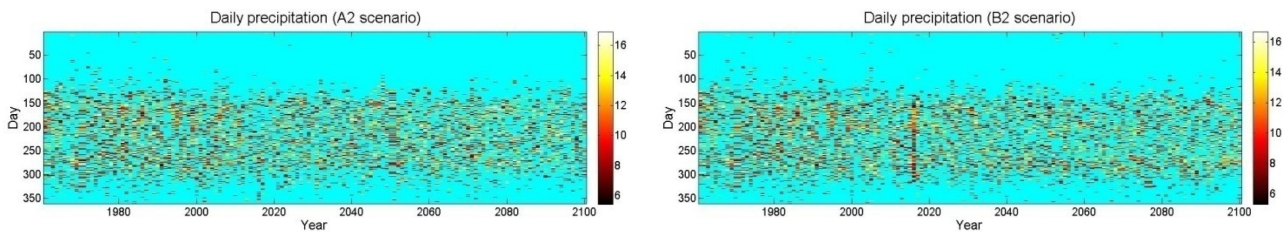

Figure 23: Precipitation with percentile of less than 90% and greater than 70%.

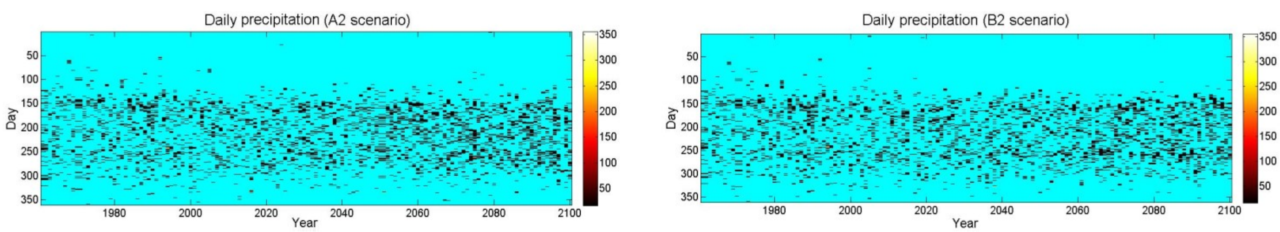

Figure 24: Precipitation with percentile of greater than 90%.

The future precipitation patterns (according to A2 and B2 scenario) are presented in Figure 25 and Figure 26, respectively. In addition, the temporal distribution of the rainfall are significant different from the two scenarios (A2 and B2) (Figure 27). In combination with the sea level regime and upstream discharge, the spatial differences of the rainfall may cause significant impacts on the water availability (for agriculture and aquaculture) of the study area. Such the findings lead to an actual requirement to generate typical future rainfall patterns.

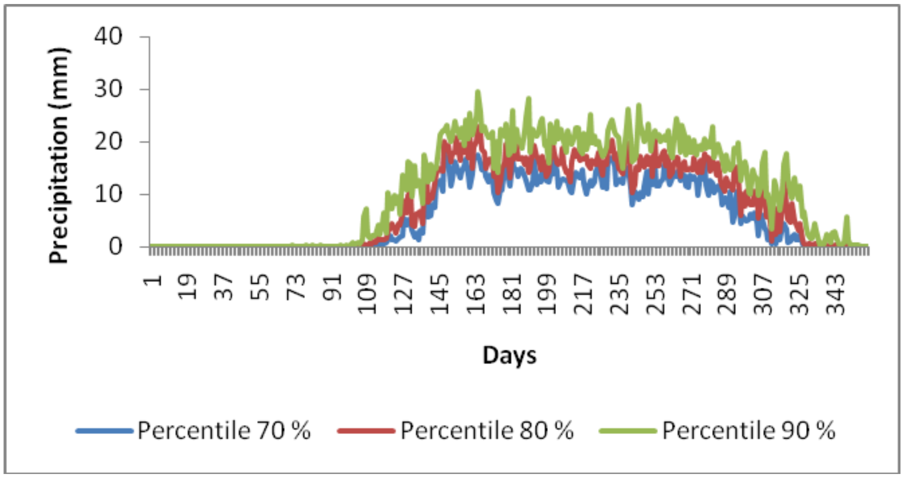

Figure 25: Future precipitation patterns according to A2 scenario.

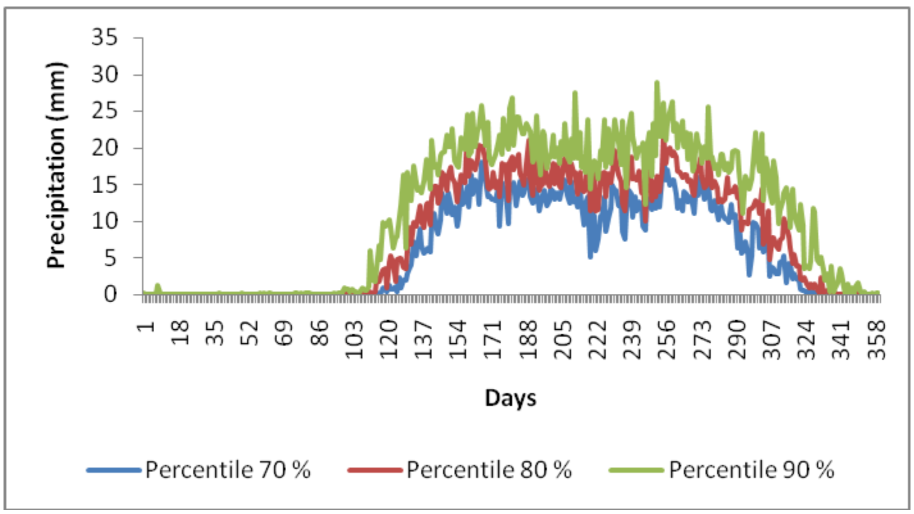

Figure 26: Future precipitation patterns according to B2 scenario.

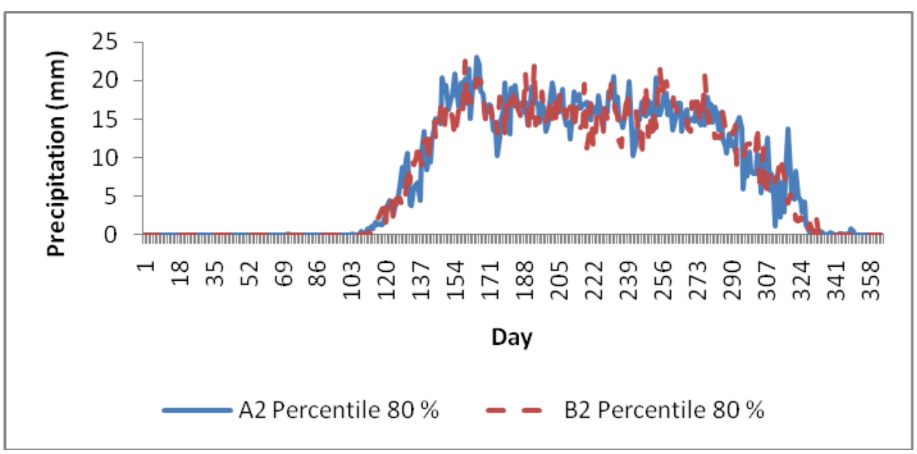

Figure 27: Comparison between the daily rainfall projected according to A2 and B2 scenarios with the percentile of 80 %.

IV. Conclusions and recommendation

The study has reviewed the available documents and data related local rainfall and temperature conditions of the Mekong Delta (mainly focusing on the Vietnamese part). However, the study so far has just qualitatively described the conditions without any specific projection which can be used to support hydrodynamic modelling. In order to integrate the future projection into a hydrodynamic modelling, the following tasks are proposed:

- Collect and organize available information of the measured and projected rainfall at 41 stations.
- Compare the measured data with the projected rainfall in the past and delineate the trends of differences and figure out the approach to minimize the differences between two data series. This task will be done for each of 41 stations.
- Apply the calibration approach to adjust the future rainfall.
- Calculate the ET_0 at each rain gauge.
- Report on the outcomes.

REFERENCES

Eastham, J., F. Mpelasoka, M. Mainuddin, C.Ticehurst, P. Dyce, G. Hodgson, R. Ali and M. Kirby, 2008. Mekong River Basin Water Resources Assessment: Impacts of Climate Change. CSIRO: Water for a Healthy Country National Research Flagship.

IPCC, 2000. Special Report on Emission Scenarios (SRES). Cambridge University Press, Cambridge.

IPCC, 2001. Climate Change 2001: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK.

IPCC, 2007. Fourth Assessment Report, Working Group II report. Impacts, Adaptation and Vulnerability.

Jones, R.G., M. Noguer, D.C. Hassell, D. Hudson, S. Wilson, G. Jenkins & J.F.B. Mitchell, 2004. Generating high resolution climate change scenarios using PRECIS, Met Office Hadley Centre, Exeter, UK, 40pp, April 2004.

Nicholls, R.J., P.P. Wong, V.R. Burkett, J.O. Codignotto, J.E. Hay, R.F. McLean, S. Ragoonaden and C.D. Woodroffe, 2007: Coastal systems and low-lying areas. Climate Change 2007: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, M.L. Parry, O.F. Canziani, J.P. Palutikof, P.J. van der Linden and C.E. Hanson, Eds., Cambridge University Press, Cambridge, UK, 315-356.

Simson, W., D. Hassell., D. Hein, R. Jones. & R. Taylor (2006). Installing using the Hadley Centre regional climate modeling system, PRECIS: version 1.4.6. Met Office Hadley Centre, Exeter, UK.

Suppakorn Chinvanno, 2008. Information for Sustainable Development in Light of Climate Change in Mekong River Basin. Southeast Asia START Regional Centre, Bangkok, Thailand.

TTK & SEA START RC, 2009. Water and Climate Change in the Lower Mekong Basin: Diagnosis & recommendations for adaptation, Water and Development Research Group, Helsinky University of Technology (TTK), and Southeast Asia START Regional Center (SEA START RC), Chulalongkorn University, Water & Developmement Publications, Helsinky University of Technology, Espoo, Finland