Climate Change in the Mekong River Delta and Key Concerns on Future Climate Threats

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Chapter 12
Climate Change in the Mekong River Delta and Key Concerns on Future Climate Threats

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Abstract The Mekong River Delta in Vietnam is the largest agriculture and aquaculture production region of the nation. As the most downstream part of the Mekong River to both the East Sea and the Gulf of Thailand, the majority of the Delta is slightly under 2 m above sea level. Historically and practically, the people of the Delta have settled in the highest densities along the river and banks of the connected canals. Human life, agriculture and aquaculture production, and domestic water supplies in the Delta depend highly on the meteorological and hydrological regimes of the region. However, Delta livelihoods are sensitive and could be threatened by climate change and hydrological cycles. Future climate projection from the regional climate model indicates that the Mekong River Delta region will likely be warmer in the future with longer and drier summers. Seasonal patterns could be altered under the influence of global warming. Moreover, changes in climate patterns in the upstream region of the Mekong River may affect the flood regime of the Mekong Delta, which may lead to an extension of the current boundaries of flooding patterns. These changes raise many concerns, especially in terms of those who make their living from agriculture and aquaculture, because of their significant potential for creating new environmental challenges in the Mekong River Delta.

Keywords Climate change • Scenarios • The Mekong River Delta • Flood • Threats

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12.1 Introduction: Future Climate Projections of the Mekong River Delta Through a Modeling Approach

Climate change, an inevitable effect of global warming, has become a global concern due to its potential consequences on various systems and sectors and because of its threat to human well-being (IPCC 2001). Understanding climate change is crucial to the 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 patterns of future climate change (IPCC 2007) and the impact of these on certain sectors within a specific area. Global circulation models (GCMs) have been developed (The IPCC Data distribution Centre 2003, available access on http://cera-www.dkrz.de/IPCC_DDC/IS92a/) and are commonly used to simulate future climate projections. However, the majority of simulation results available today from most GCMs are of a coarse scale due to technological limitations, and these are 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 scale requirements 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 chapter 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 according to horizontal scales of a few hundred kilometers, regional models can resolve features down to a much smaller scale of 50 km 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, the sizes of these would associate their climate with that of the surrounding ocean. RCMs are full climate models, and as such, are based on physical data. 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).

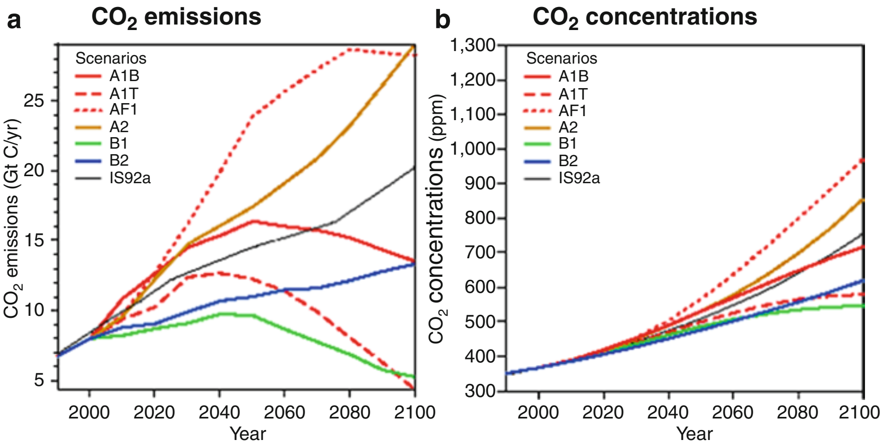

Fig. 12.1 Emissions and concentrations of CO_2 for the various reference scenarios by IPCC (**a**) CO_2 emissions, (**b**) CO_2 concentrations

Water vapor and carbon dioxide (CO_2) are the main gases responsible for the greenhouse gas (GHG) effect. The Intergovernmental Panel on Climate Change (IPCC) has considered the modulation of carbon dioxide emissions and concentrations as a fundamental factor in controlling climate variations over this time scale. Increasing atmospheric greenhouse gases is the key factor in global warming, and it is expected that GHGs will continue to increase in the future. Changes in the level of atmospheric GHGs depend on the level of human activity, which will affect GHGs emission in the future. The IPCC has developed CO_2 emission and concentration scenarios which project changing socio-economic conditions and associated emission levels to measure different plausible GHG emission and concentration outcomes (SRES 2000). See Fig. 12.1.

This study conducted dynamic downscaling based on an initial dataset from ECHAM4[1] 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° grid (approximately 25×25 km^2) with daily time step.

12.2 Climate Change in the Mekong River Delta

Simulation results from the PRECIS regional climate model show that the Mekong River Delta will likely be a few degrees Celsius warmer in the 2030s than in the 1980s, the baseline period for comparison. Warmer temperatures can be seen in

[1]209ECMWF Atmospheric General Circulation Model coupled with University of Hamburg Ocean Circulation Model (http://www.ipcc-data.org/is92/echam4_info.html).

both the average maximum and minimum temperatures. Moreover, the extreme maximum temperature, that is, the maximum temperature of the hottest day in the year, will also be warmer by a few degrees Celsius (see Figs. 12.2–12.4).

Changes in the climate in the Mekong River Delta can also be seen in temporal terms, as well as in terms of magnitude. From the simulation, results show that it will not only be warmer, but the hot period is also expected to be longer. Figure 12.5 shows that the hot period, defined in this chapter as the number of days annually where the maximum temperature is over 35°C, will extend to about 2 months longer in the 2030s compared to that of the 1980s.

Annual precipitation is likely to decrease by 10–20% in the future throughout the Delta area (see Figs. 12.6 and 12.7).

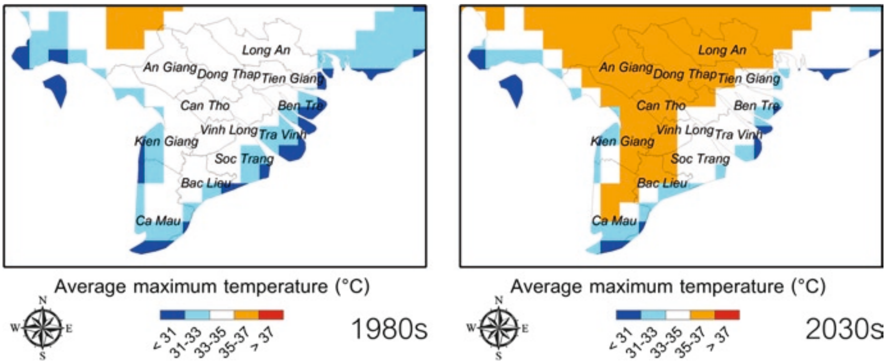

Fig. 12.2 Average maximum temperature in the Mekong River Delta in the 1980s and 2030s (simulated)

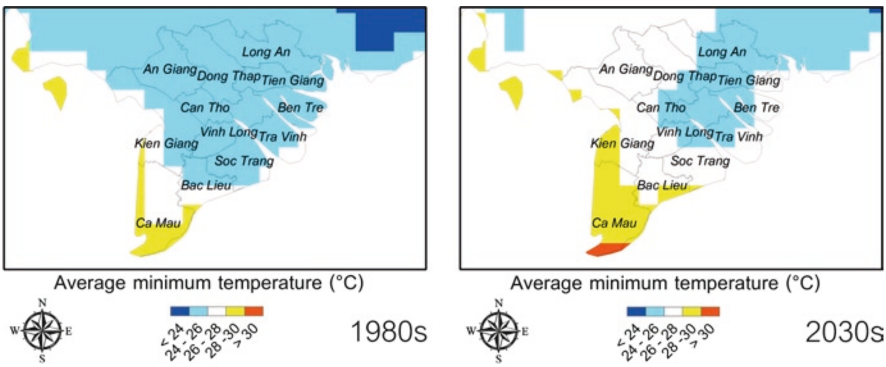

Fig. 12.3 Average minimum temperature in the Mekong River Delta in the 1980s and 2030s (simulated)

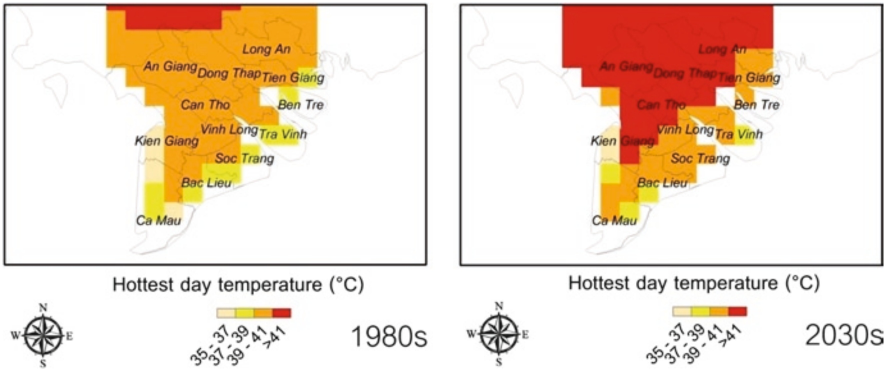

Fig. 12.4 Average maximum temperature of the hottest day of the year in the Mekong River Delta in the 1980s and 2030s (simulated)

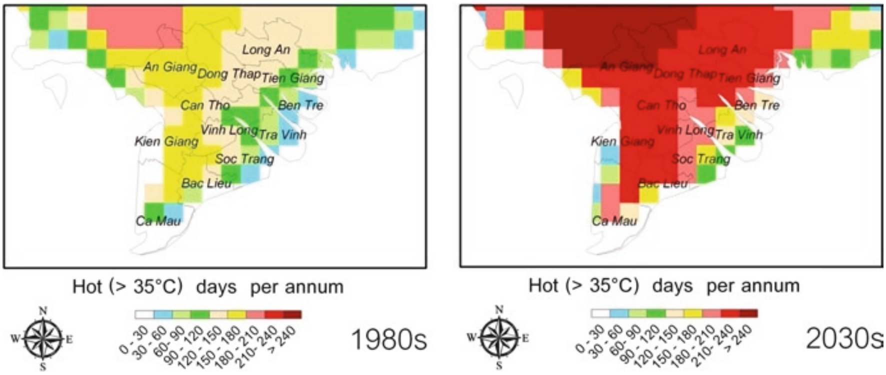

Fig. 12.5 Hot period (number of hot days in a year) in the Mekong River Delta in the 1980s and 2030s (simulated)

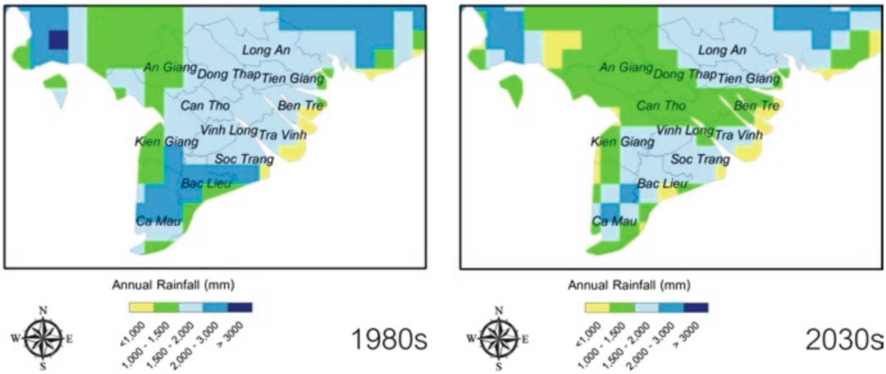

Fig. 12.6 Annual precipitation in the Mekong River Delta in the 1980s and 2030s (simulated)

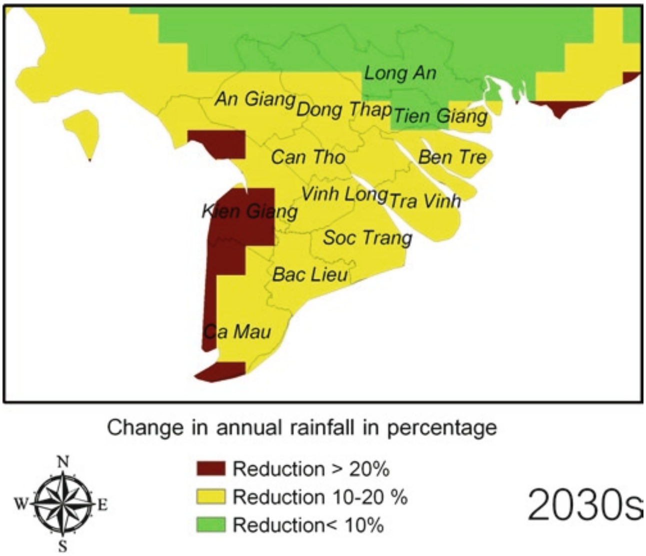

Fig. 12.7 Comparison of change in annual precipitation in the Mekong River Delta between the 1980s and 2030s (simulated)

12.3 Climate Change and Impact on the Flood Regime in Mekong River Delta

One of the key concerns with climate change in the Mekong River Delta is its impact on the flood regime, which may influence many economic sectors in the Delta area. The flood regime in the Mekong River Delta is determined by the regional flow variation that results from the influence of climate change, especially the change in annual precipitation, on the upper parts of the basin. Moreover, sea level rise induced by global warming would also affect the flood regime in the Delta, as well as produce more significant salinity intrusions and coastal erosion; these latter have also become major concerns in the Delta.

The impact of these climate-related phenomena on the hydrology of the studied areas was analyzed using the modeling approach. The schematic overview of the interactions among climatic, hydrological, and hydrodynamic models is presented in Fig. 12.8 (Water and Development Research Group, Helsinki University of Technology, Finland and Southeast Asia START Regional Center [SEA START RC], Chulalongkorn University, Thailand 2009).

As explained above, the future climate projection data was simulated by ECHAM4 Global Circulation Model under the IPCC SRES A2 GHG scenario and downscaled to high resolution using the PRECIS regional climate model, which was used as an input to the hydrological and ocean circulation model to determine changes in the future flood regime in the Mekong River Delta.

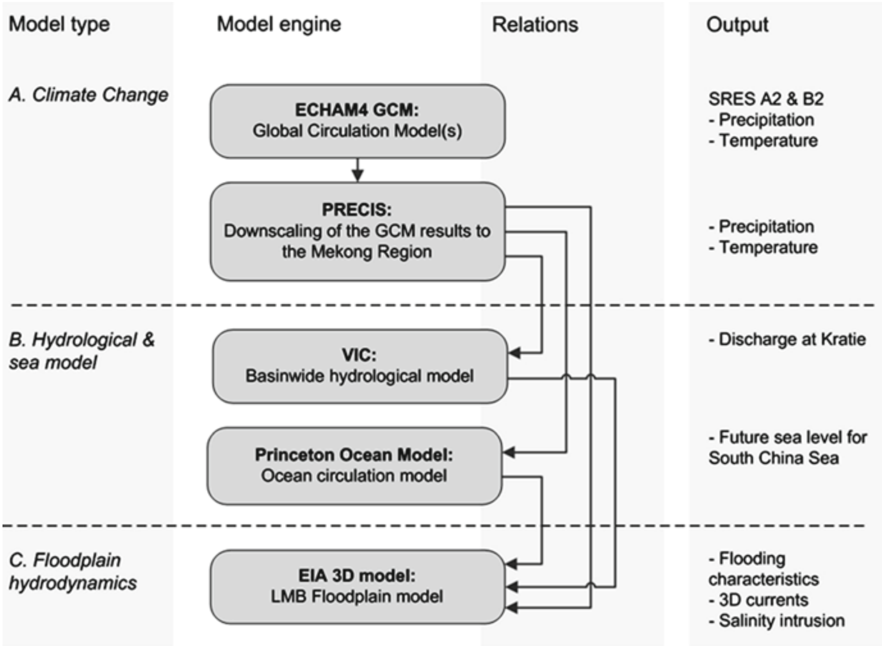

Fig. 12.8 Schematic overview on the interactions among climatic, hydrological, and hydrodynamic models

Regional climate projection data was used in a simulation of a basin-wide hydrological regime under the influence of future climate projections. The simulation was based on the Variable Infiltration Capacity (VIC) hydrological model, which is a macro-scale hydrologic model that solves full water and energy balances, originally developed by Xu Liang at the University of Washington (Liang et al. 1994). In addition, regional climate projection data was also used as an input to the Princeton Ocean Model in the simulation of future sea levels at the mouth of the Mekong River; these may vary under the influence of changing wind speed and wind direction (Blumberg and Mellor 1987). Future projections of changing sea levels due to the direct effect of global warming, for example, ocean water expansion, as indicated in the IPCC Fourth Assessment Report, was also taken into account in the analysis (IPCC 2007). Results from the regional climate model, the regional hydrological simulation, and the ocean circulation model were then fed into the hydrodynamic model, the EIA 3D model, for more detailed hydrological analysis of the Mekong River floodplain system. The model is able to describe the three-dimensional characteristics of the flooding, flow, water quality, and erosion and sedimentation in the lakes, reservoirs, river channels, and floodplains of the study area (Koponen et al. 2004).

Results from the 3-D hydrodynamic model provide guideline data to determine future changes in the flood regime in the Mekong River Delta. The model simulations

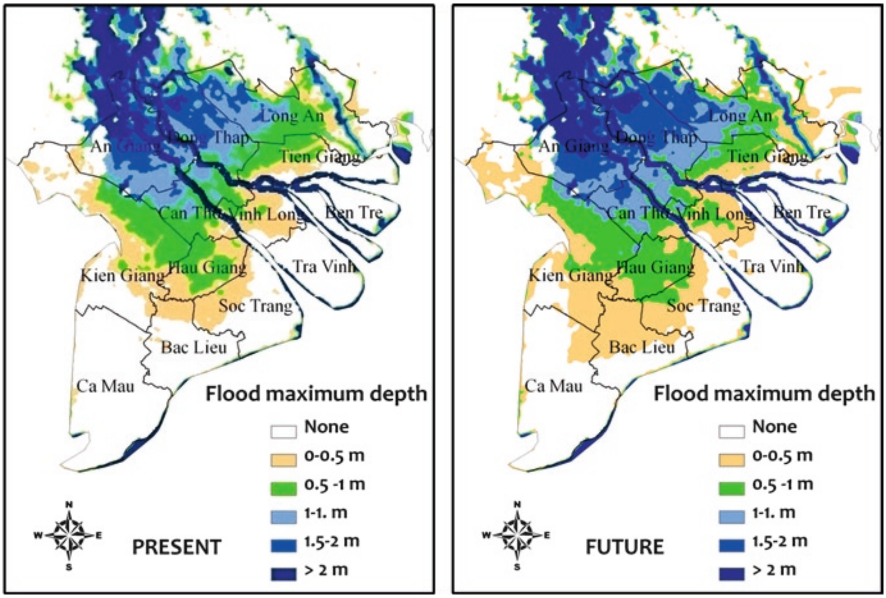

Fig. 12.9 Flood boundary in the Mekong River Delta in the 1980s and 2030s (simulated)

show an increasing trend in the annual maximum water depth and flooded area during the average and driest years. On the other hand, a clear trend is not visible in the wettest years. This change may have a significant impact on both agriculture and aquaculture (see Fig. 12.9).

12.4 Concerns About Future Changes in Climate and Flood Regimes in the Mekong River Delta

Many scientists and international organizations have classified the Mekong River Delta as a vulnerable area of climate change and sea level rise (Peter and Ruysschaert 2008; Dasgupta et al. 2007; IPCC 2007; UNDP 2007; ADB 1994). Climate change will have complex and significant impacts on rural production and the quality of life in general in the region. The increase in average maximum temperatures during the dry season in the future will lead to high evapo-transpiration. Salinity intrusions from the East Sea to land will become more serious. Secondary crop cultivation and freshwater aquaculture will face challenges due to the declines in water supply and irrigation sources. People will be more exposed to weather-related diseases. The reduction in precipitation, especially at the beginning and in the middle of the rainy season, will strongly affect the summer–autumn rice crop, leading to higher production costs. Yet, the increase of precipitation in the latter periods of the rainy season combined with early flooding will threaten the rainy season crop harvest. The boundary of significant floods is projected to expand to the southern part of the Mekong River Delta, toward areas in Bac Lieu and Ca Mau peninsula, which will then threaten current aquaculture operations. Shrimp farmers will face higher costs to install protection dykes around their shrimp ponds. The inundation periods in the upstream provinces will decrease. This flood regime will shorten the fishing period for the poor in the An Giang and Dong Thap flooding areas.

The future of the Mekong River Delta in terms of these consequences can be described generally as the following: areas devoted to agricultural production, such as rice fields, secondary crop fields, fruit orchards, and aquaculture will shrink and production and capacity will decrease, which in turn may threaten the food security of the nation. Rice farmers, shrimp farmers, salt farmers, and small agricultural businessmen will be significantly impacted due to the lack of essential nutrient sources, changes in the meaning of land ownership, and possibly access to information necessary for adaptation to changes in the climate and flood regime. The consequence will be that regional forest, land, water, wildlife, and mineral resources will be over-exploited. Many wetland protected areas such as Tram Chim, Upper U Minh, Lang Sen, Tra Su, Ha Tien, Vo Doi, Bai Boi, Dat Mui, and Lung Ngoc Hoang may also be exploited negatively. Certain organisms may face extinction while the populations and range of some insects, such as mosquitoes, may increase. Farmers in coastal regions seriously impacted by climate change and sea level rise may migrate to urban areas in the north and west of the Mekong River Delta (such as Chau Doc, Long Xuyen, Can Tho, Vinh Long, My Tho, Tan An). Migrations could lead to significant population increases, affect urban planning, and create new social problems, which in turn will have an environmental impact on urban areas.

12.5 Discussion and Conclusion

The Mekong River Delta is considered to be the most seriously impacted area in South East Asia in terms of intense environmental, social, and economic change. The changes in this area need to be studied and explained to strategy planners, policy makers, scientists, businessmen, local officers, and local people: all of those who will be affected by problems created by future changes as well as those who are trying to solve them. The development of policy for information sharing and of measures to mitigate and adapt to environmental changes are crucial. Hesitation, suspicion, and irresponsibility will yield ill consequences for future generations. While scientists have recognized the phenomenon of climate change and sea level rise, further analysis is still being carried out. It is essential to organize collaborative research on simulations of climate change in various time frames with different scenarios and equally essential to identify subjects who will be affected by climate change as well as the kinds of impacts they are likely to suffer. Some of the most important variables that must be considered at the same time are:

- The uncertainty of future change scenario-based study: this study, for example, is based on a single scenario which represents only a single plausible future.
- The risk and vulnerability of economic sectors in the Mekong River Delta: climate change impacts make up a chain of consequences which will affect sectors ranging from the bio-physical to the socio-economic. However, each sector may be at risk differently and may respond to future changes differently.
- Other long-term change under influences from other forces, especially those related to development and globalization, will affect the social and economic context of environmental change in the future and will affect the interaction among various social and economic sectors and sub-sectors and alter future vulnerability.
- The holistic approach in the development of adaptation strategies in the future will have to take changes in the social and economic contexts into consideration by looking into the impact of climate change on various systems and sectors and understanding how each sector's response to climate change may affect other sectors in order to come up with appropriate strategies for the region.

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