

## Chapter 2

# Climate Change in Vietnam

**Abstract** Vietnam is considered as one of the countries to be severely affected by climate change and thus response to climate change is of crucial importance to Vietnam, particularly in coastal areas. Rises in average temperatures have been observed over the last decades, as well as substantial changes to precipitation patterns. The average temperatures have been rising and the total precipitation has increased, especially during the rainy seasons, which is important for flood water management. In northern Vietnam the precipitation during the dry seasons has decreased, which poses important challenges to water management.

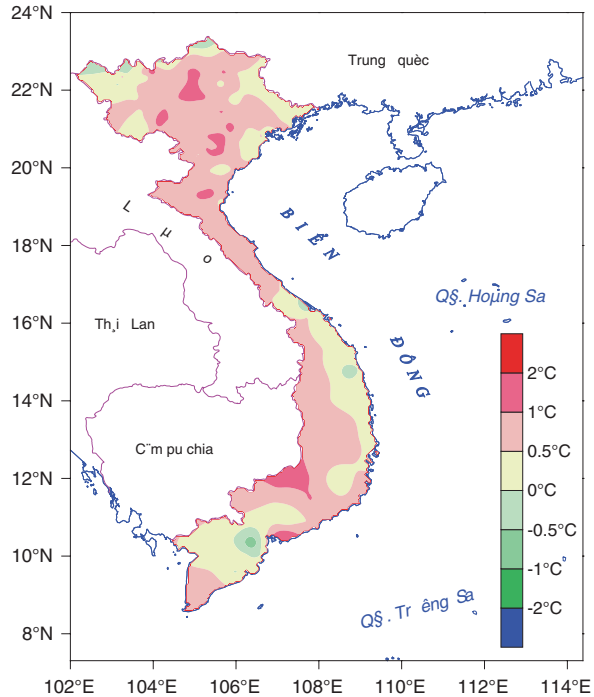
Climate change is one of the most significant challenges facing human being today. Climate change has already affected agricultural production and socio-economic structures and will extensively and intensively alter the development process and security issues including food, water, energy and social safety as well as political, cultural, economic, diplomatic and commercial security (MONRE 2008, 2010, 2012 a, b, 2013).

Vietnam is considered as one of the countries to be severely affected by climate change (IPCC 2001), and thus response to climate change is of crucial importance to Vietnam, particularly in coastal areas. Therefore, the development of suitable adaptation solutions for Vietnamese coastal provinces is extremely essential.

## 2.1 Recent Climate Change Observations in Vietnam

Vietnam's temperature and precipitation trends have been greatly different among regions during the last 50 years. Annual average temperature has increased by 0.5 °C nationwide and annual precipitation has decreased in the North and increased in the South (see Figs. 2.1 and 2.2) (MONRE 2012a, b, 2013).

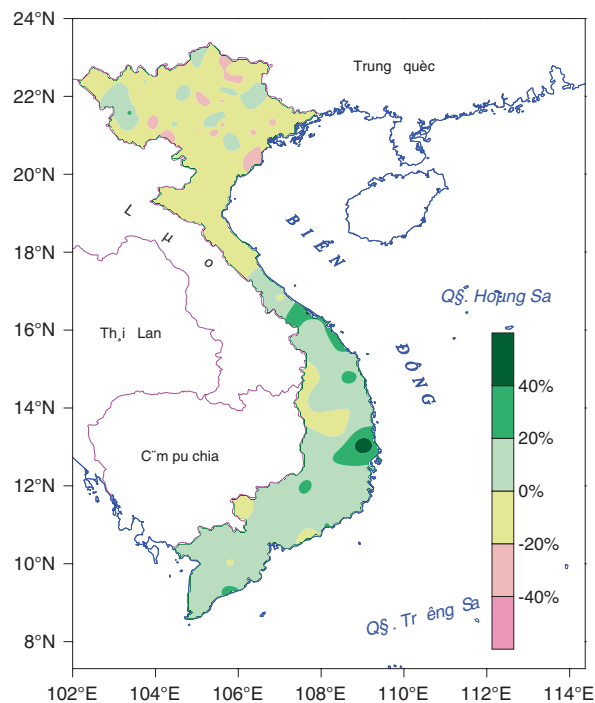
**Fig. 2.1** Change in annual average temperature ( $^{\circ}\text{C}$ ) during the last 50 years in Vietnam [source MONRE (2012a, b)]



Temperature has increased in almost all regions nationwide, however smaller areas in Central and Southern coastal regions such as Thua Thien–Hue, Quang Ngai, and Tien Giang have seen a decrease in temperature. It is worth noting that precipitation in these areas has increased in both dry and wet seasons.

Changes in maximum temperature in Vietnam varied in the range from  $-3$  to  $3^{\circ}\text{C}$ . Changes in minimum temperatures mostly varied in the range from  $-5$  to  $5^{\circ}\text{C}$ . Both maximum and minimum temperatures have tended to increase, with minimum temperatures increasing faster than maximum temperatures, reflecting the trend of global climate warming.

Precipitation during dry season (November–April) has increased slightly or is almost unchanged in the northern regions and increased dramatically in the southern regions during the last 50 years. Precipitation during the rainy season (May–October) has decreased by 5 to over 10 % in most of Vietnam’s northern area and increased by 5–20 % in the southern regions. The pattern of change in annual precipitation is similar to the precipitation during the rainy season, i.e. increasing in the southern climate regions and decreasing in the northern climate regions. Annual precipitation in the South Central Region has increased most dramatically compared with other regions in the country during the last 50 years, even by 20 % in some places.



**Fig. 2.2** Change in precipitation (%) during the last 50 years in Vietnam [source MONRE (2012a, b)]

**Table 2.1** Increases in temperature and changes in precipitation during the last 50 years in the climate regions of Vietnam

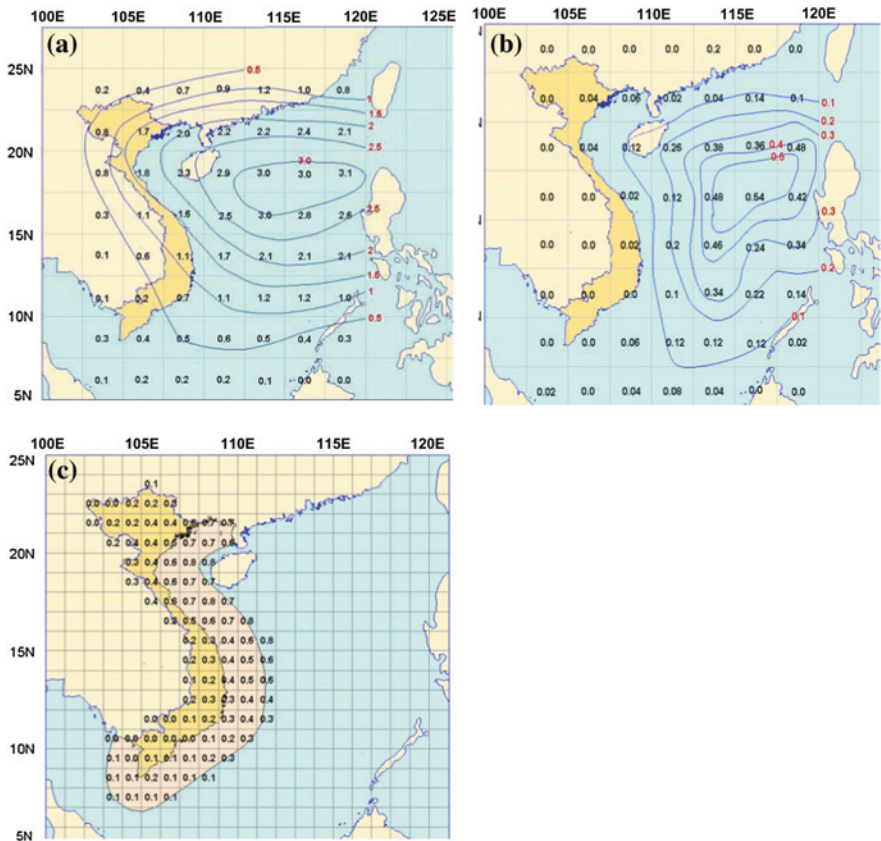
| Climate regions                           | Temperature (°C) |      |      | Precipitation (%) |                |      |
|-------------------------------------------|------------------|------|------|-------------------|----------------|------|
|                                           | January          | July | Year | Nov–Apr period    | May–Oct period | Year |
| Northwest                                 | 1.4              | 0.5  | 0.5  | 6                 | –6             | –2   |
| Northeast                                 | 1.5              | 0.3  | 0.6  | 0                 | –9             | –7   |
| Red river delta                           | 1.4              | 0.5  | 0.6  | 0                 | –13            | –11  |
| North central coast                       | 1.3              | 0.5  | 0.5  | 4                 | –5             | –3   |
| South central coast                       | 0.6              | 0.5  | 0.3  | 20                | 20             | 20   |
| Central highlands                         | 0.9              | 0.4  | 0.6  | 19                | 9              | 11   |
| South region (southeast and Mekong delta) | 0.8              | 0.4  | 0.6  | 27                | 6              | 9    |

Source MONRE (2012a, b)

Maximum daily precipitation has increased in almost all regions, particularly during the recent years. The number of days with heavy rain seems to have increased similarly, with significant changes in the central regions (MONRE 2012a, b, 2013) (Table 2.1).

In terms of tropical cyclones there are annually on average about 12 tropical storms on the East Sea (Vietnamese name for the South China Sea), of which about 45 % form in the East Sea and 55 % stem from the Pacific Ocean. There are about seven storms affecting Vietnam annually, five of which hit or directly affect the country’s mainland. The areas where storms or tropical depressions occur most frequently are in the middle of the Northern East Sea. In the central coastal area from 16°N to 18°N and in the northern coastal area from 20°N northwards, the storms or tropical depressions occur most frequently along the coastal region, with a storm or tropical depression landfall every 2 year in average (see Fig. 2.3).

The number of tropical cyclones occurring in the East Sea seems to have increased slightly, while the number of cyclones affecting or hitting Vietnam’s mainland does not have an obvious changing pattern. Over the past decades,



**Fig. 2.3** Map of recurrence of tropical cyclones operating (a) and forming in the east sea (b), and hitting Vietnam’s mainland (c) [source MONRE (2012a, b)]

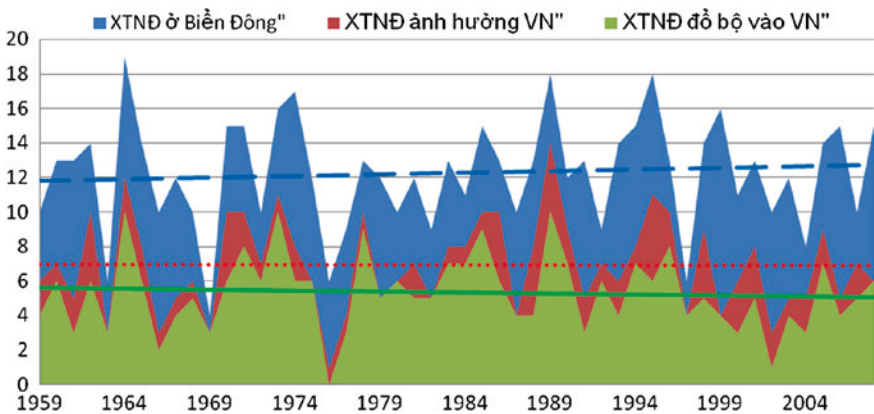
tropical storms approaching Vietnam seem to move southwards, the number of very strong storms seems to increase and the storm season tends to last longer. Overall, storm impacts on the country seem to increase (MONRE 2012a, b) (Fig. 2.4).

Drought, including monthly and seasonal drought, seems to increase in differing patterns among the climate regions. Hot and sunny weather has shown signs of increasing dramatically in various regions in the country, particularly in the North Central and in southern regions (MONRE 2012a, b).

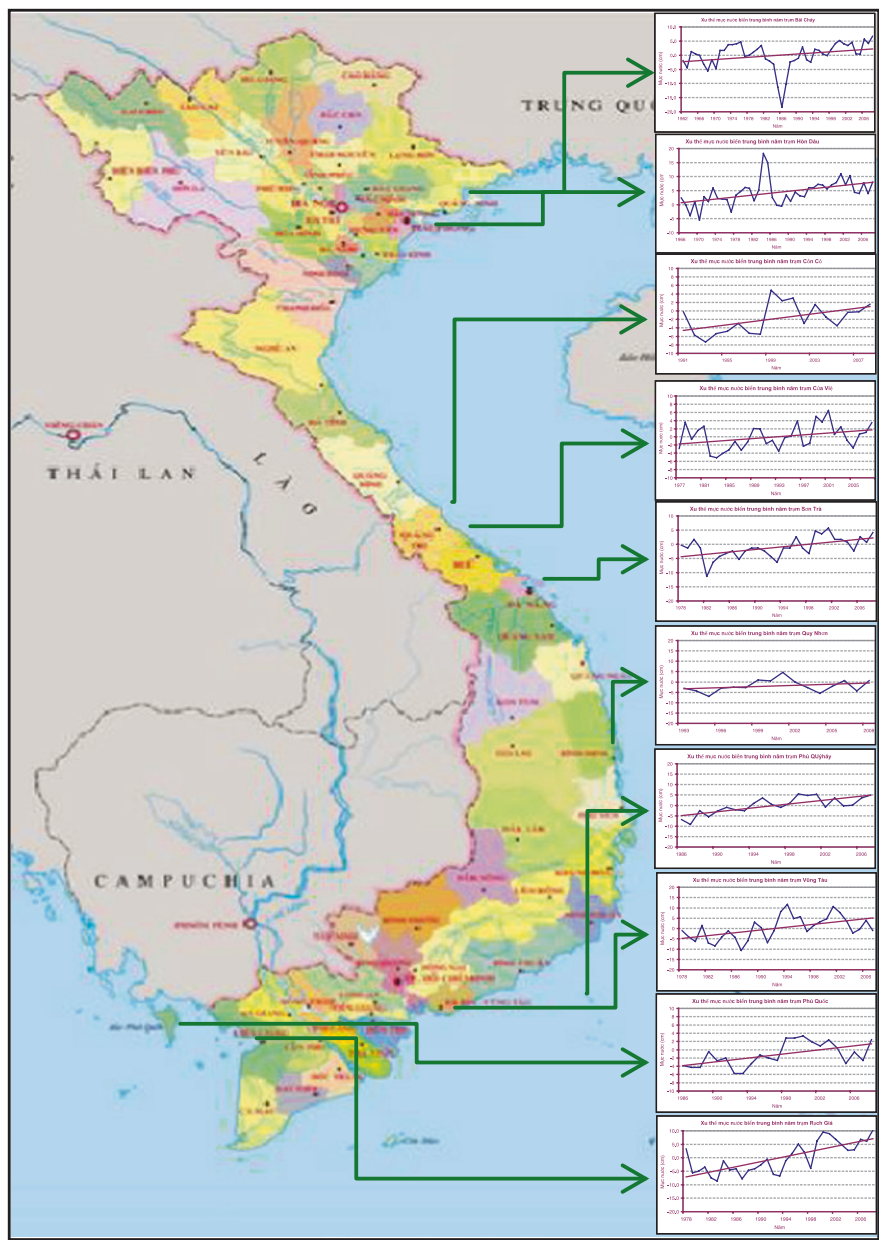
The water level monitored at Vietnam coastal gauges has shown that the pattern of changes in annual average sea level is different over the years (starting 1960) (Fig. 2.5). Almost all the stations have shown an increasing trend, however, some stations do not show this trend. Based on data collected from the monitoring stations the mean sea level rise along the Vietnamese coastal area is about 2.8 mm/year during the period 1993–2008 (MONRE 2009).

Sea level data derived from satellite images from 1993 to 2010 have shown that the change in sea level in the whole East Sea is 4.7 mm/year, and it has increased quicker in the east than in the west of the East Sea. Along Vietnam’s coastal zone, the sea level in the mid-central coastal region and southwestern region seems to have increased more, with average sea level rise of the whole coastal zone of about 2.9 mm/year approximated from satellite images (MONRE 2009).

The sea level pattern for the coastal zone is almost the same using actual measured data at coastal gauges and data derived from satellite images. This has been verified when comparing actual measured data at coastal gauges and satellite data. Comparison results have shown a good correlation of phase and amplitude of average water level variations (MONRE 2012a, b).



**Fig. 2.4** Patterns of the number of tropical cyclones operating (blue) and affecting (red) in the east sea, and hitting (green) Vietnam’s mainland during the last 50 years [source MONRE (2012a, b)]



**Fig. 2.5** Change in sea level based on data from measuring stations (1960–2010) [source MONRE (2009, 2012a, b)]

## 2.2 Climate Change Scenarios for Vietnam

Climate change and sea level rise scenarios developed for Vietnam are based on different greenhouse gas emission scenarios of IPCC's 4th report (IPCC 2007), namely a low scenario (B1), medium scenarios (B2, A1B), and scenarios of the high anthropogenic greenhouse gas emission (A2, A1FI).

Climate change scenarios for temperature and precipitation are developed for seven climate regions in Vietnam: North West, North East, Northern Delta, North Central Region, South Central Region, Central Highlands, and Southern Region.

*Temperatures at the end of 21st century in Vietnam* (MONRE 2012a, b)

- Low emission scenario (B1): annual average temperature increases by 1.6–2.2 °C.
- Medium emission scenario (B2): annual average temperature increases by 2–3 °C.
- High emission scenario (A2, A1FI): annual average temperature increases by 2.5–3.7 °C.

*Precipitation at the end of 21st century in Vietnam* (MONRE 2012a, b)

- Low emission scenario (B1): annual precipitation increases 2–6 %.
- Medium emission scenario (B2): annual precipitation increases 2–7 %.
- High emission scenario (A2, A1FI): annual precipitation increases 2–10 %.

*Sea level rise at the end of 21st century in Vietnam* (MONRE 2012a, b)

- Low emission scenario (B1): average sea level may increase by 49–64 cm.
- Medium emission scenario (B2): average sea level may increase by 57–73 cm.
- High emission scenario (A2, A1FI): average sea level may increase by 78–95 cm

*Climate extremes in Vietnam*

By the end of the 21st century, the number of days with maximum temperature of over 35 °C increases from 15 to 30 days in almost all regions in the country based on the medium emission scenario A1B (MONRE 2012a, b).

In the future, the general trend is that the maximum daily precipitation increases in the North West, North East, Red River Delta and North Central Regions, and decrease in the South Central Coastal, Central Highlands, and the South Regions (MONRE 2012a, b).

If the sea level rises by one meter, about 39 % of the Mekong river delta area (MRD), over 10 % of the Red River delta, over 10 % of the Quang Ninh province, 20 % of the Ho Chi Minh City area (HCMC) are flooded, which constitute 6.3 of the total land area. According to this scenario 35 % of the MRD population and 7 % of HCMC population will be affected (MONRE 2012a, b, 2013).



## 2.3 Climate Change Impacts on Water Resources

Climate change has effects on the average river runoff and annual distribution of peak flows (both high and low). The impacts of climate change on these flow patterns in future periods are simulated by the rainfall-runoff modelling under different climate change scenarios.

Impacts of climate change on annual flows vary between regions and river systems across Vietnam. In the medium CC scenario (B2), the annual flow of rivers in the Red River Delta and the northern part of the North Central region tend to increase by less than 2 % in 2040–2059 and by from 2 to 4 % in the period 2080–2099. In contrast, the projected annual flow of rivers from the southern part of the North Central region to the northern part of the South Central Region and the Southeastern region (Dong Nai river system) tend to decrease at different levels, by 2 % in Thu Bon river and Ngan Sau river, and more significantly by 4–7 % in the period 2040–2059 in the Dong Nai river and the Be river basins, and up to 7–9 % in the period 2080–2099.

Flood events of most rivers tend to increase by 2–4 % in the period 2040–2059 and by 5–7 % in the period 2080–2099, but to varying degrees. In the Thu Bon and Ngan Sau Rivers, flood flow tends to increase by less than 2 % in the period 2040–2059 and less than 3 % in the period 2080–2099.

After 2020, groundwater levels may decrease considerably due to both overexploitation and decreased groundwater recharge during the dry season. In the south, if the flow of the rivers decreases by 15–20 % in the dry season, the corresponding groundwater level may decrease by 11 m as compared to the current level (MONRE 2013).

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Climate Change Adaptation Measures in Vietnam

Development and Implementation

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Nuottimäki, K.

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