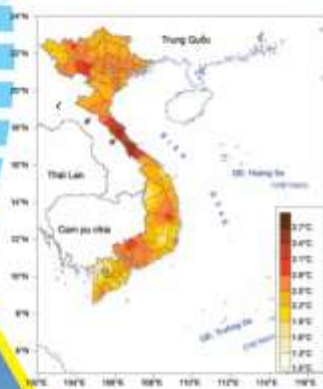


CLIMATE CHANGE, SEA LEVEL RISE SCENARIOS FOR VIET NAM



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MINISTRY OF NATURAL RESOURCES AND ENVIRONMENT

**CLIMATE CHANGE,
SEA LEVEL RISE SCENARIOS
FOR VIET NAM**

Ha Noi - 2012

CLIMATE CHANGE, SEA LEVEL RISE SCENARIOS FOR VIET NAM

1. The need of updating climate change and sea level rise scenarios for Viet Nam

In 2009, the Ministry of Natural Resources and Environment (MONRE) developed and published climate change and sea level rise scenarios for Viet Nam based on greenhouse gas emission scenarios and global climate change scenarios of the Intergovernmental Panel on Climate Change (IPCC). The scenarios play an important role in climate change assessment for constructing and implementing action plans at ministries, sectors and localities to respond to climate change. Although the scenarios provide projection estimates for seven climatic zones and coastal regions, they need to provide more details for provincial levels.

The 2011 scenarios have been updated with the latest data, methodology, and knowledge on climate system and climate downscaling to give more advanced and realistic climate change scenarios. The most updated data from meteorological, climatological, oceanographic stations, satellites, numerical models have been used to develop the 2011 scenarios. Additionally, the 2011 scenarios have downscaling information up to provincial and sub-provincial levels.

2. Methodology

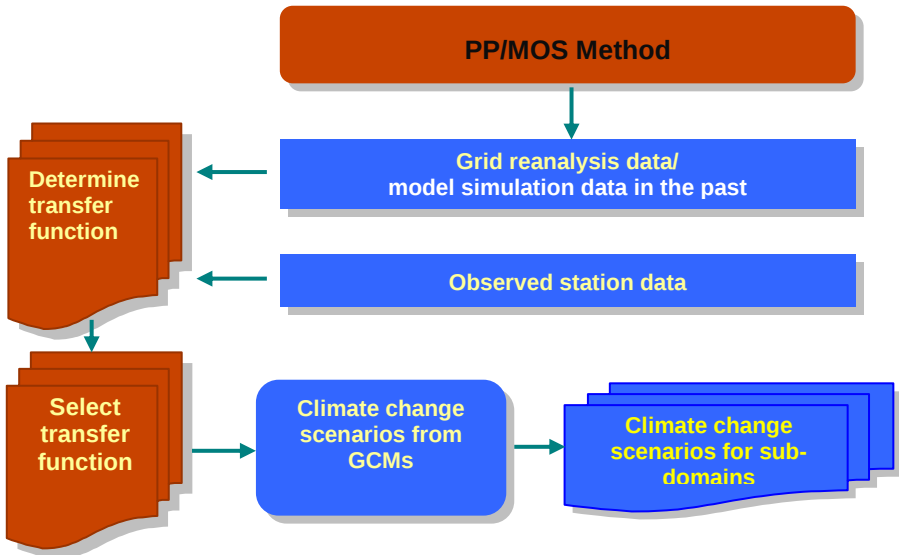


Figure 1. Schematic diagram for statistical climate downscaling method

- Statistical downscaling method is used to construct scenarios for temperature, seasonal, annual mean rainfall under low, medium and high emission scenarios. The schematic diagram is shown in **Figure 1**.

- The Meteorological Research Institute (MRI, Japan) atmospheric general circulation model is used to construct climate change maps for temperature, seasonal, annual mean rainfall under medium emission scenario.

- Met Office Hadley Centre's (MOHC, UK) regional climate modeling system (PRECIS) is used to construct climate change maps for temperature, seasonal, annual mean rainfall and climate extremes under medium emission scenario. Model domains and schematic diagram for the application of PRECIS model for Viet Nam are shown in **Figure 2**.

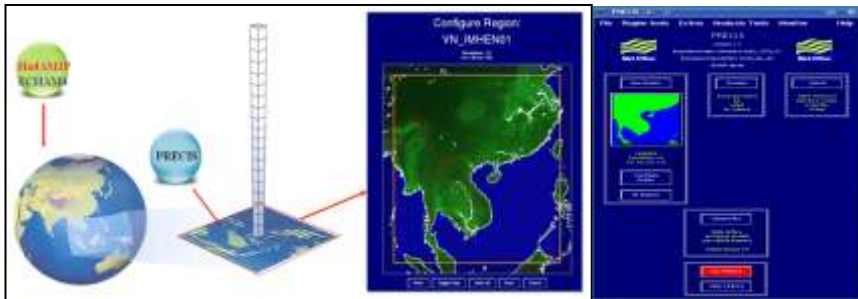


Figure 2. Model domains and schematic diagram for the application of PRECIS model for Viet Nam

- Statistical Downscaling Model (SDSM), the Simulator of Climate Change Risks and Adaptation Initiatives (SIMCLIM) are also used as tools to construct climate change scenarios.

- Sea level rise scenarios are developed using statistical downscaling method based on the statistical relationships among the observed sea level at stations, satellite estimated sea level at different regions of Viet Nam and simulated sea level from ten global models. The baseline period of 1980-1999 is selected, consistent to that of the IPCC 4th report in 2007.

Inundation risk maps due to sea level rise are constructed based on the most updated data sources including:

- Elevation maps for coastal provinces with scale 1:10,000 constructed in 2010.
- Elevation maps for Mekong Delta with scale 1:5,000 constructed in 2008.
- Elevation maps for Ho Chi Minh city with scale 1:2,000 and 1:5,000 constructed in 2004.
- Transportation maps for coastal provinces with scale 1:25,000 published in 2005.
- Data on areas, population of coastal provinces, published in 2009.

3. Climate change and sea level rise scenarios

Climate change and sea level rise scenarios for Viet Nam are constructed based on different greenhouse gas emission scenarios including: low emission scenario (B1), medium emission scenario (B2, A1B), and high emission scenario (A2, A1FI).

The factors considered in the scenarios include: increase in temperature; changes in seasonal and annual mean rainfall; climate extremes (mean maximum, minimum daily temperatures, number of days with temperature higher than 35°C, and changes in maximum daily rainfall); sea level rise at coastal regions.

Spatial horizontal resolution for climate change scenario is about 25 km which can be used at district levels. The sea level rise scenarios are constructed for seven coastal sub-regions.

3.1. Updated climate change and sea level rise scenarios

a) Temperature:

- *In the low emission scenario*, by the end of the 21th century, the annual mean temperature is projected to increase about 1.6-2.2°C over most areas of Viet Nam. The increase is relatively higher over the northern regions than that over the southern regions of Viet Nam (**Figure 3**).

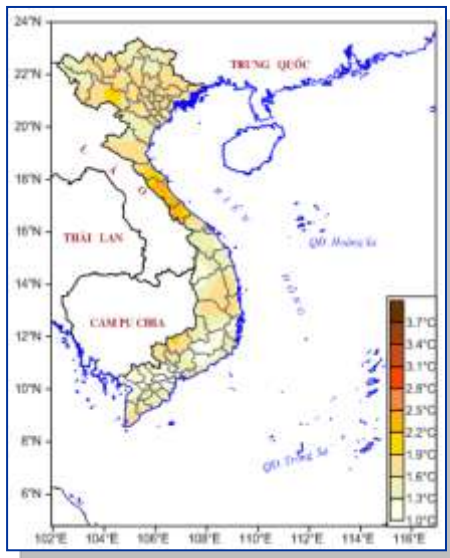


Figure 3. Changes in annual mean temperature (°C) at the end of the 21th century relative to 1980-1999 baseline under the low emission scenario (B1)

- *In the medium emission scenario:* by the end of the 21th century, the annual mean temperature is projected to increase about 2-3°C over most of the country. Comparing to other places, the region from Ha Tinh to Quang Tri has relatively higher warming rate (**Figure 4**).

- *In the high emission scenario:* by the end of the 21th century, the annual mean temperature is projected to increase about 2.5-3.7°C over most of the country (**Figure 5**).

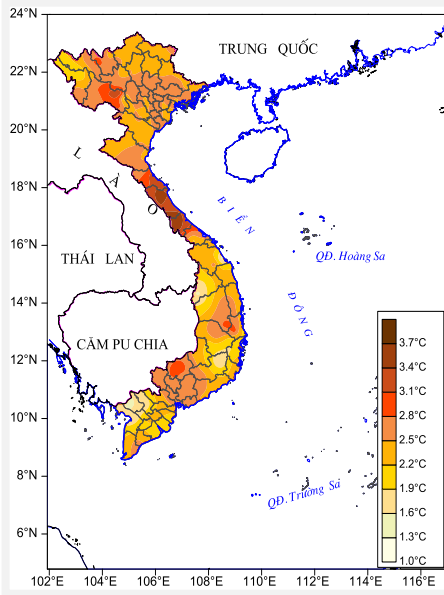


Figure 4. Changes in annual mean temperature (°C) at the end of the 21th century relative to 1980-1999 baseline under the medium emission scenario (B2)

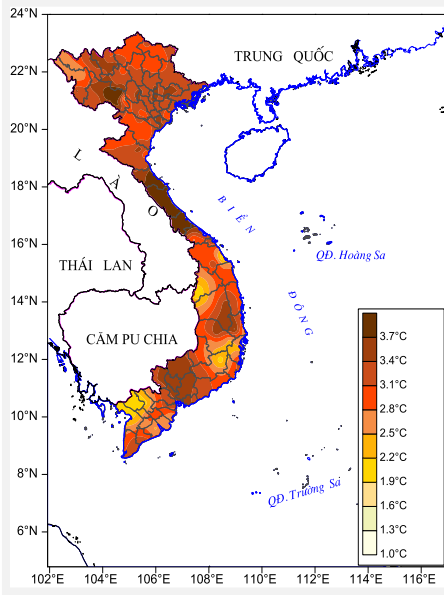


Figure 5. Changes in annual mean temperature (°C) at the end of the 21th century relative to 1980-1999 baseline under the high emission scenario (A2)

Table 1 shows the changes in annual mean temperature (°C) relative to 1980-1999 baseline under the medium emission scenario (B2) for 63 provinces/cities at different decades of the 21th century. The numbers in parentheses at the year 2050 and 2100 indicate the range of possible temperature changes. At Lai Chau province for instance, the temperature changes at different places of Lai Chau in 2050 can be in the range of 1.0 to 1.6°C, with the most possible change of 1.2 °C.

Table 1. Changes in annual mean temperature ($^{\circ}\text{C}$) relative to 1980-1999 baseline under the medium emission scenario (B2)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
1	Lai Châu	0.5	0.7	0.9	1.2 (1.0 - 1.6)	1.5	1.7	1.9	2.1	2.3 (1.9 - 2.8)
2	Điện Biên	0.5	0.7	1.0	1.3 (1.0 - 1.6)	1.6	1.9	2.2	2.4	2.6 (1.9 - 2.8)
3	Sơn La	0.6	0.8	1.1	1.5 (1.2 - 1.8)	1.8	2.1	2.4	2.6	2.8 (2.2 - 3.4)
4	Hòa Bình	0.5	0.7	1.0	1.2 (1.0 - 1.4)	1.5	1.8	2.0	2.2	2.4 (2.2 - 2.8)
5	Hà Giang	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.3	2.5	2.7 (2.4 - 2.8)
6	Cao Bằng	0.5	0.7	1.0	1.2 (1.0 - 1.4)	1.5	1.7	2.0	2.2	2.4 (2.2 - 2.8)
7	Lào Cai	0.5	0.7	1.0	1.3 (1.0 - 1.6)	1.6	1.8	2.1	2.3	2.5 (2.2 - 3.1)
8	Yên Bái	0.5	0.7	0.9	1.2 (1.0 - 1.6)	1.5	1.7	1.9	2.1	2.3 (2.2 - 3.1)
9	Tuyên Quang	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.2	2.4	2.7 (2.2 - 2.8)
10	Bắc Kạn	0.5	0.7	1.0	1.3 (1.1 - 1.4)	1.5	1.8	2.0	2.2	2.4 (2.2 - 2.8)
11	Thái Nguyên	0.5	0.7	1.0	1.3 (1.2 - 1.6)	1.6	1.9	2.1	2.3	2.5 (2.2 - 2.8)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
12	Lạng Sơn	0.5	0.7	1.0	1.3 (1.2 - 1.4)	1.6	1.9	2.1	2.3	2.5 (2.2 - 2.8)
13	Phú Thọ	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.3	2.5	2.7 (2.2 - 2.8)
14	Bắc Giang	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.2	2.5	2.7 (2.5 - 2.8)
15	Quảng Ninh	0.5	0.7	1.0	1.3 (1.2 - 1.4)	1.6	1.8	2.1	2.3	2.5 (2.2 - 2.8)
16	Vĩnh Phúc	0.5	0.7	1.0	1.3 (1.2 - 1.6)	1.6	1.9	2.1	2.4	2.6 (2.5 - 2.8)
17	Bắc Ninh	0.5	0.7	1.0	1.3 (1.2 - 1.6)	1.6	1.9	2.1	2.3	2.5 (2.5 - 2.8)
18	Hà Nội	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	1.9	2.2	2.4	2.6 (2.5 - 2.8)
19	Hưng Yên	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	1.9	2.2	2.4	2.6 (2.5 - 2.8)
20	Hải Dương	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.2	2.4	2.6 (2.2 - 2.8)
21	Hải Phòng	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	1.9	2.2	2.4	2.6 (2.2 - 2.8)
22	Hà Nam	0.5	0.7	1.0	1.3 (1.1 - 1.4)	1.6	1.8	2.1	2.3	2.5 (2.2 - 2.8)
23	Thái Bình	0.5	0.7	1.0	1.3 (1.0 - 1.4)	1.5	1.8	2.0	2.2	2.4 (2.2 - 2.8)
24	Nam Định	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.3	2.5	2.7 (2.5 - 2.8)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
25	Ninh Bình	0.5	0.7	1.0	1.3 (1.2 - 1.4)	1.6	1.9	2.1	2.3	2.5 (2.2 - 2.8)
26	Thanh Hóa	0.5	0.7	1.0	1.2 (1.0 - 1.4)	1.5	1.7	2.0	2.2	2.4 (2.2 - 2.8)
27	Nghệ An	0.5	0.7	1.1	1.4 (1.2 - 1.6)	1.6	1.9	2.2	2.4	2.6 (2.2 - 2.8)
28	Hà Tĩnh	0.6	0.9	1.3	1.7 (1.4 - 1.8)	2.0	2.4	2.7	2.9	3.1 (2.5 - 3.4)
29	Quảng Bình	0.6	1.0	1.3	1.7 (1.6 - 2.0)	2.1	2.5	2.8	3.1	3.3 (3.1 - 3.7)
30	Quảng Trị	0.6	0.9	1.3	1.7 (1.6 - 2.0)	2.1	2.4	2.7	3.0	3.2 (2.8 - 3.7)
31	Thừa Thiên - Huế	0.5	0.8	1.1	1.4 (1.0 - 1.6)	1.7	2.0	2.2	2.5	2.7 (2.2 - 3.1)
32	Đà Nẵng	0.5	0.7	1.0	1.3 (1.2 - 1.4)	1.6	1.8	2.1	2.3	2.5 (2.2 - 2.8)
33	Quảng Nam	0.5	0.8	1.1	1.4 (1.0 - 1.4)	1.7	2.0	2.3	2.5	2.7 (2.2 - 2.8)
34	Quảng Ngãi	0.5	0.7	0.9	1.2 (1.0 - 1.4)	1.5	1.7	1.9	2.1	2.3 (1.9 - 2.5)
35	Bình Định	0.4	0.7	0.9	1.2 (1.0 - 1.4)	1.5	1.7	1.9	2.1	2.3 (2.2 - 2.8)
36	Phú Yên	0.5	0.7	1.0	1.3 (1.0 - 1.6)	1.6	1.8	2.1	2.3	2.5 (2.2 - 3.1)
37	Khánh Hòa	0.5	0.7	0.9	1.2 (1.0 - 1.4)	1.5	1.7	1.9	2.1	2.3 (1.9 - 2.8)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
38	Ninh Thuận	0.4	0.7	0.9	1.2 (1.0 - 1.4)	1.4	1.7	1.9	2.1	2.3 (1.9 - 2.8)
39	Bình Thuận	0.5	0.8	1.1	1.4 (1.2 - 1.6)	1.8	2.0	2.3	2.5	2.8 (2.2 - 3.0)
40	Kon Tum	0.5	0.7	0.9	1.2 (0.8 - 1.4)	1.5	1.7	1.9	2.1	2.3 (2.2 - 2.8)
41	Gia Lai	0.5	0.7	1.0	1.2 (1.0 - 1.6)	1.6	1.9	2.1	2.3	2.5 (1.6 - 3.1)
42	Đắk Lắk	0.5	0.7	0.9	1.2 (0.5 - 1.6)	1.4	1.7	1.9	2.1	2.3 (1.9 - 2.8)
43	Đắk Nông	0.4	0.6	0.8	1.1 (0.5 - 1.4)	1.3	1.5	1.7	1.9	2.0 (1.9 - 2.8)
44	Lâm Đồng	0.4	0.8	1.2	1.5 (0.5 - 1.6)	1.8	2.1	2.4	2.6	2.8 (1.6 - 2.8)
45	Tây Ninh	0.5	0.7	1.0	1.3 (1.2 - 1.6)	1.6	1.9	2.1	2.3	2.5 (2.5 - 2.8)
46	Bình Dương	0.5	0.7	1.0	1.3 (1.4 - 1.6)	1.6	1.8	2.0	2.3	2.5 (2.5 - 2.8)
47	Bình Phước	0.6	0.8	1.1	1.4 (1.2 - 1.6)	1.7	2.0	2.3	2.5	2.7 (2.5 - 3.1)
48	Tp. Hồ Chí Minh	0.5	0.8	1.1	1.4 (1.2 - 1.4)	1.7	2.0	2.2	2.5	2.7 (2.5 - 2.8)
49	Đồng Nai	0.5	0.7	1.0	1.3 (1.2 - 1.6)	1.6	1.8	2.1	2.3	2.5 (2.2 - 2.8)
50	Bà Rịa - Vũng Tàu	0.5	0.7	1.0	1.3 (1.0 - 1.6)	1.6	1.9	2.1	2.3	2.5 (2.4 - 3.0)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
51	Long An	0.4	0.6	0.9	1.1 (1.0 - 1.4)	1.4	1.6	1.8	2.0	2.2 (1.9 - 2.8)
52	Đồng Tháp	0.4	0.7	1.0	1.3 (1.0 - 1.4)	1.6	1.9	2.1	2.3	2.5 (2.2 - 2.8)
53	Tiền Giang	0.5	0.6	0.8	1.0 (0.9 - 1.2)	1.3	1.5	1.7	1.8	2.0 (1.9 - 2.5)
54	Bến Tre	0.4	0.7	0.9	1.2 (1.0 - 1.4)	1.5	1.7	1.9	2.1	2.3 (1.9 - 2.5)
55	Vĩnh Long	0.4	0.6	0.8	1.0 (1.0 - 1.2)	1.3	1.5	1.7	1.8	2.0 (1.8 - 2.5)
56	Trà Vinh	0.4	0.6	0.9	1.2 (1.0 - 1.4)	1.4	1.6	1.8	2.0	2.2 (1.9 - 2.4)
57	An Giang	0.4	0.6	0.8	1.0 (0.5 - 1.2)	1.3	1.5	1.7	1.8	2.0 (1.8 - 2.3)
58	Cần Thơ	0.5	0.7	1.0	1.2 (1.0 - 1.4)	1.5	1.7	2.0	2.2	2.3 (1.9 - 2.5)
59	Hậu Giang	0.4	0.6	0.9	1.1 (1.0 - 1.4)	1.4	1.6	1.8	2.0	2.2 (1.9 - 2.5)
60	Sóc Trăng	0.4	0.6	0.8	1.1 (1.0 - 1.4)	1.3	1.5	1.7	1.9	2.0 (1.9 - 2.5)
61	Bạc Liêu	0.5	0.7	1.0	1.3 (1.0 - 1.4)	1.5	1.8	2.0	2.2	2.4 (2.2 - 2.8)
62	Kiên Giang	0.4	0.6	0.9	1.1 (0.9 - 1.2)	1.3	1.6	1.8	1.9	2.1 (1.5 - 2.2)
63	Cà Mau	0.5	0.7	1.0	1.4 (1.2 - 1.6)	1.6	1.9	2.2	2.4	2.6 (1.9 - 2.8)

b) Rainfall:

- *In the low emission scenario:* by the end of the 21st century, the annual rainfall is projected to increase mostly about 6%. The western highland areas expect a smaller increase compared to that of other regions (**Figure 6**).

- *In the medium emission scenario:* by the end of the 21st century, the annual rainfall would increase about 2-7% (**Figure 7**).

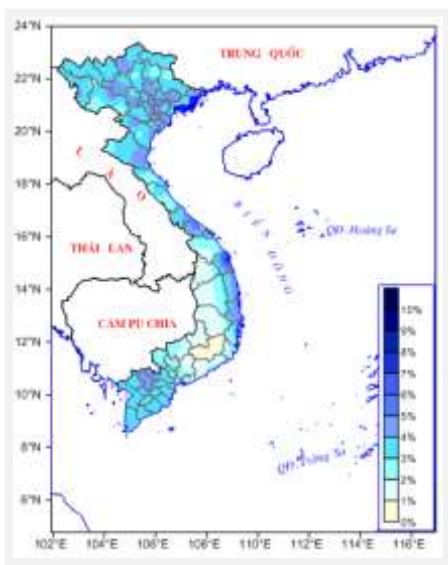


Figure 6. Changes in annual rainfall (%) at the end of the 21th century relative to 1980-1999 baseline mean under the low emission scenario (B1)

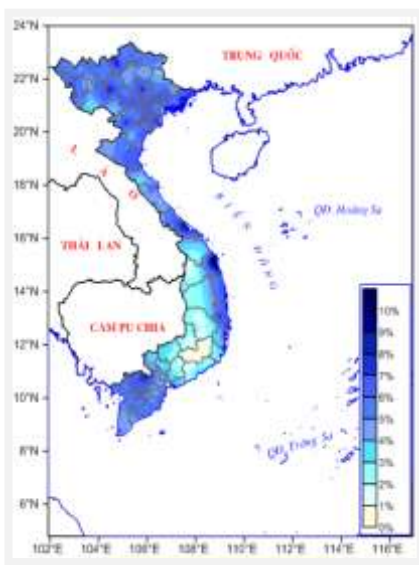


Figure 7. Projected changes in annual rainfall (%) at the end of the 21th century relative to 1980-1999 baseline under the medium emission scenario (B2)

- *In the high emission scenario:* by the end of the 21th century, the annual rainfall would increase about 2-10% (**Figure 8**).

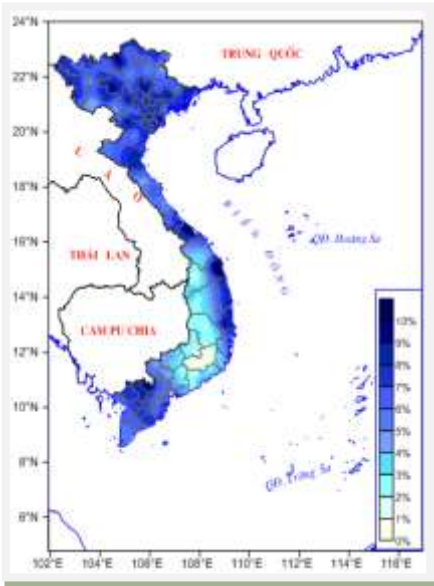


Figure 8. Projected changes in annual rainfall (%) at the end of the 21th century relative to 1980-1999 baseline under the high emission scenario (A2)

Table 2 shows the changes in rainfall (%) at decades of 21th century relative to 1980-1999 baseline under the medium emission scenario (B2) for 63 provinces/cities. Similar to Table 1, the numbers in parentheses at the year 2050 and 2100 indicate the range of possible rainfall changes. At Lai Chau for instance, the rainfall changes at different places of the Lai Chau province in 2050 can be in the range of 2.0 to 4.0 %, with the most possible rainfall change of 2.9 %.

Table 2. Projected changes (%) in rainfall relative to 1980-1999 baseline under the medium emission scenario (B2)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
1	Lai Châu	1.1	1.6	2.2	2.9 (2.0 - 4.0)	3.5	4.1	4.6	5.1	5.5 (4.0 - 6.0)
2	Điện Biên	1.1	1.7	2.3	3.0 (2.0 - 4.0)	3.7	4.3	4.8	5.3	5.8 (4.0 - 7.0)
3	Sơn La	1.0	1.4	2.0	2.6 (1.0 - 4.0)	3.1	3.6	4.1	4.5	4.9 (3.0 - 7.0)
4	Hòa Bình	1.1	1.6	2.3	2.9 (2.0 - 4.0)	3.6	4.2	4.7	5.2	5.6 (4.0 - 6.0)
5	Hà Giang	1.2	1.8	2.6	3.3 (2.0 - 4.0)	4.0	4.7	5.3	5.9	6.4 (5.0 - 8.0)
6	Cao Bằng	1.1	1.6	2.2	2.9 (2.0 - 4.0)	3.5	4.1	4.6	5.1	5.5 (4.0 - 6.0)
7	Lào Cai	1.1	1.5	2.2	2.8 (2.0 - 4.0)	3.4	4.0	4.5	4.9	5.3 (5.0 - 6.0)
8	Yên Bái	1.3	1.8	2.6	3.3 (2.0 - 5.0)	4.1	4.7	5.3	5.9	6.4 (5.0 - 8.0)
9	Tuyên Quang	0.9	1.3	1.8	2.3 (2.0 - 4.0)	2.9	3.3	3.7	4.1	4.5 (4.0 - 6.0)
10	Bắc Kạn	0.9	1.3	1.8	2.4 (2.0 - 3.0)	2.9	3.4	3.8	4.2	4.5 (4.0 - 6.0)
11	Thái Nguyên	1.4	2.0	2.9	3.7 (2.0 - 4.0)	4.5	5.2	5.9	6.5	7.1 (5.0 - 8.0)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
12	Lạng Sơn	0.9	1.3	1.9	2.4 (1.0 - 3.0)	2.9	3.4	3.9	4.3	4.6 (3.0 - 6.0)
13	Phú Thọ	1.2	1.7	2.4	3.1 (2.0 - 4.0)	3.8	4.4	5.0	5.5	6.0 (4.0 - 7.0)
14	Bắc Giang	1.3	1.9	2.6	3.4 (2.0 - 4.0)	4.1	4.8	5.4	6.0	6.5 (4.0 - 7.0)
15	Quảng Ninh	1.3	2.0	2.7	3.5 (3.0 - 4.0)	4.3	5.0	5.6	6.2	6.7 (4.0 - 7.0)
16	Vĩnh Phúc	1.2	1.8	2.5	3.3 (3.0 - 4.0)	4.0	4.6	5.2	5.8	6.3 (5.0 - 7.0)
17	Bắc Ninh	1.3	1.9	2.6	3.4 (3.0 - 4.0)	4.1	4.8	5.4	6.0	6.5 (5.0 - 8.0)
18	Hà Nội	1.3	1.9	2.7	3.4 (3.0 - 4.0)	4.2	4.9	5.5	6.1	6.6 (6.0 - 8.0)
19	Hưng Yên	1.4	2.1	2.9	3.8 (3.0 - 4.0)	4.6	5.3	6.0	6.6	7.2 (5.0 - 8.0)
20	Hải Dương	1.1	1.6	2.3	2.9 (2.0 - 4.0)	3.5	4.1	4.7	5.1	5.6 (5.0 - 6.0)
21	Hải Phòng	0.9	1.3	1.8	2.3 (2.0 - 4.0)	2.8	3.3	3.7	4.1	4.4 (4.0 - 6.0)
22	Hà Nam	1.1	1.7	2.4	3.0 (2.0 - 4.0)	3.7	4.3	4.9	5.4	5.8 (6.0 - 7.0)
23	Thái Bình	1.5	2.1	3.0	3.9 (3.0 - 4.0)	4.7	5.5	6.2	6.8	7.4 (6.0 - 8.0)
24	Nam Định	1.3	1.9	2.7	3.5 (2.0 - 4.0)	4.2	4.9	5.6	6.1	6.6 (5.0 - 7.0)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
25	Ninh Bình	1.1	1.7	2.4	3.0 (2.0 - 4.0)	3.7	4.3	4.9	5.4	5.8 (5.0 - 7.0)
26	Thanh Hóa	1.1	1.7	2.3	3.0 (2.0 - 4.0)	3.7	4.3	4.8	5.3	5.8 (4.0 - 8.0)
27	Nghệ An	1.2	1.7	2.4	3.1 (2.0 - 4.0)	3.8	4.4	5.0	5.5	5.9 (4.0 - 7.0)
28	Hà Tĩnh	0.7	1.0	1.5	1.9 (1.0 - 3.0)	2.3	2.7	3.0	3.3	3.6 (3.0 - 6.0)
29	Quảng Bình	0.9	1.4	1.9	2.5 (2.0 - 3.0)	3.0	3.5	3.9	4.3	4.7 (3.0 - 6.0)
30	Quảng Trị	1.6	2.4	3.3	4.3 (3.0 - 5.0)	5.2	6.1	6.9	7.6	8.2 (4.0 - 9.0)
31	Thừa Thiên - Huế	1.4	2.1	2.9	3.8 (3.0 - 5.0)	4.6	5.3	6.0	6.6	7.2 (4.0 - 8.0)
32	Đà Nẵng	1.0	1.4	2.0	2.6 (2.0 - 4.0)	3.2	3.7	4.2	4.6	5.0 (4.0 - 6.0)
33	Quảng Nam	0.7	1.0	1.5	1.9 (1.0 - 3.0)	2.3	2.7	3.0	3.3	3.6 (2.0 - 5.0)
34	Quảng Ngãi	1.8	2.7	3.8	4.9 (2.0 - 6.0)	5.9	6.9	7.8	8.5	9.3 (5.0 - 10.0)
35	Bình Định	1.4	2.0	2.8	3.6 (2.0 - 4.0)	4.4	5.2	5.9	6.4	7.0 (5.0 - 8.0)
36	Phú Yên	1.4	2.0	2.8	3.6 (2.0 - 4.0)	4.4	5.2	5.8	6.4	6.9 (5.0 - 8.0)
37	Khánh Hòa	1.1	1.6	2.3	2.9 (1.0 - 3.0)	3.6	4.2	4.7	5.2	5.7 (3.0 - 6.0)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
38	Ninh Thuận	0.6	0.9	1.2	1.6 (1.0 - 3.0)	1.9	2.3	2.5	2.8	3.0 (2.0 - 5.0)
39	Bình Thuận	0.6	0.8	1.2	1.5 (0.0 - 2.0)	1.8	2.1	2.4	2.7	2.9 (1.0 - 4.0)
40	Kon Tum	0.4	0.6	0.9	1.1 (0.0 - 2.0)	1.4	1.6	1.8	2.0	2.1 (1.0 - 5.0)
41	Gia Lai	0.9	1.4	1.9	2.5 (1.0 - 3.0)	3.1	3.6	4.0	4.4	4.8 (2.0 - 5.0)
42	Đắk Lắk	0.5	0.7	1.0	1.2 (0.0 - 2.0)	1.5	1.7	2.0	2.2	2.4 (1.0 - 4.0)
43	Đắk Nông	0.3	0.5	0.7	0.9 (0.0 - 2.0)	1.1	1.3	1.4	1.6	1.7 (1.0 - 3.0)
44	Lâm Đồng	0.1	0.2	0.2	0.3 (0.0 - 1.0)	0.4	0.4	0.5	0.5	0.6 (0.0 - 2.0)
45	Tây Ninh	0.8	1.2	1.7	2.2 (1.0 - 3.0)	2.7	3.1	3.5	3.8	4.2 (3.0 - 5.0)
46	Bình Dương	0.7	1.0	1.4	1.8 (1.0 - 3.0)	2.1	2.5	2.8	3.1	3.3 (3.0 - 5.0)
47	Bình Phước	0.6	0.8	1.2	1.5 (1.0 - 2.0)	1.9	2.2	2.4	2.7	2.9 (2.0 - 4.0)
48	Tp. Hồ Chí Minh	0.9	1.4	1.9	2.5 (2.0 - 3.0)	3.0	3.5	4.0	4.4	4.8 (3.0 - 5.0)
49	Đồng Nai	0.6	0.9	1.2	1.5 (0.0 - 3.0)	1.9	2.2	2.5	2.7	3.0 (1.0 - 5.0)
50	Bà Rịa - Vũng Tàu	1.1	1.6	2.2	2.9 (1.0 - 3.0)	3.5	4.1	4.6	5.0	5.5 (2.0 - 6.0)

No.	Province/ City	Decades in the 21 th century								
		2020	2030	2040	2050	2060	2070	2080	2090	2100
51	Long An	1.6	2.3	3.2	4.2 (1.0 - 5.0)	5.1	5.9	6.7	7.4	8.0 (4.0 - 8.0)
52	Đồng Tháp	1.3	1.9	2.6	3.4 (3.0 - 5.0)	4.1	4.8	5.4	6.0	6.5 (6.0 - 8.0)
53	Tiền Giang	0.8	1.2	1.7	2.1 (2.0 - 4.0)	2.6	3.0	3.4	3.8	4.1 (4.0 - 7.0)
54	Bến Tre	1.3	1.8	2.6	3.3 (2.0 - 4.0)	4.0	4.7	5.3	5.8	6.3 (4.0 - 7.0)
55	Vĩnh Long	1.0	1.5	2.1	2.7 (2.0 - 4.0)	3.2	3.8	4.3	4.7	5.1 (4.0 - 6.0)
56	Trà Vinh	0.9	1.3	1.8	2.3 (2.0 - 4.0)	2.8	3.2	3.7	4.0	4.4 (4.0 - 6.0)
57	An Giang	1.1	1.7	2.4	3.0 (2.0 - 4.0)	3.7	4.3	4.9	5.4	5.8 (5.0 - 7.0)
58	Cần Thơ	1.2	1.8	2.5	3.2 (3.0 - 4.0)	3.9	4.5	5.1	5.6	6.1 (5.0 - 7.0)
59	Hậu Giang	1.2	1.8	2.5	3.2 (2.0 - 4.0)	3.9	4.5	5.1	5.6	6.1 (5.0 - 7.0)
60	Sóc Trăng	1.1	1.7	2.4	3.0 (2.0 - 4.0)	3.7	4.3	4.9	5.4	5.8 (5.0 - 6.0)
61	Bạc Liêu	1.0	1.5	2.1	2.7 (2.0 - 3.0)	3.3	3.9	4.4	4.8	5.2 (4.0 - 6.0)
62	Kiên Giang	1.0	1.5	2.1	2.8 (2.0 - 3.0)	3.4	3.9	4.4	4.9	5.3 (4.0 - 6.0)
63	Cà Mau	0.9	1.3	1.9	2.4 (2.0 - 3.0)	2.9	3.4	3.8	4.2	4.6 (4.0 - 5.0)

c) Climate extremes:

In the medium emission scenario, by the end of the 21th century, the average minimum temperature is projected to increase about 2.2-3.9°C; the average maximum temperature is projected to increase about 2.0-3.2°C over the whole country. The Northeast region of Viet Nam and the South of Central highland areas expect relatively higher increase in temperature than that of other regions (**Figure 9 a, b**).

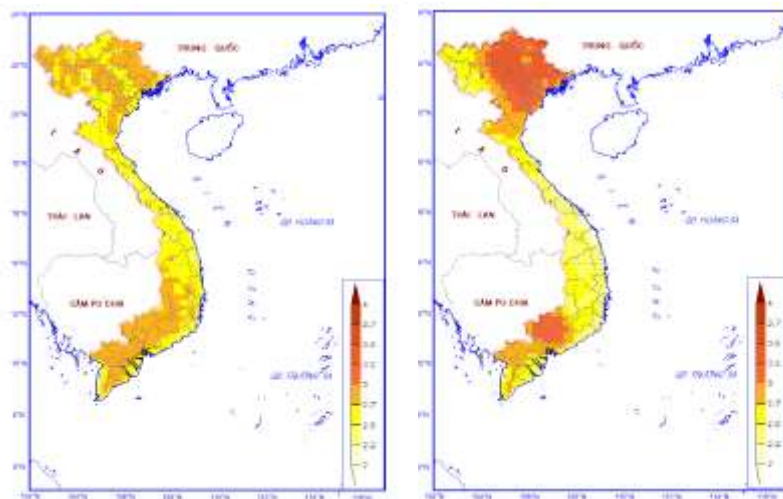


Figure 9. Changes in annual mean of daily minimum temperature (a), and annual mean of daily maximum temperature (b) at the end of the 21th century under the medium emission scenario (B2)

By the end of the 21th century, the number of days with maximum temperature over 35°C is projected to increase from 15 to 30 days over most parts of Viet Nam under the medium emission scenario A1B (**Figure 10**).

In the next 100 years, it is likely that maximum values of daily rainfall increase in North to North-Central regions of Viet Nam, decrease in the South-Central, Central Highlands, and South region of Viet Nam (**Figure 11**).

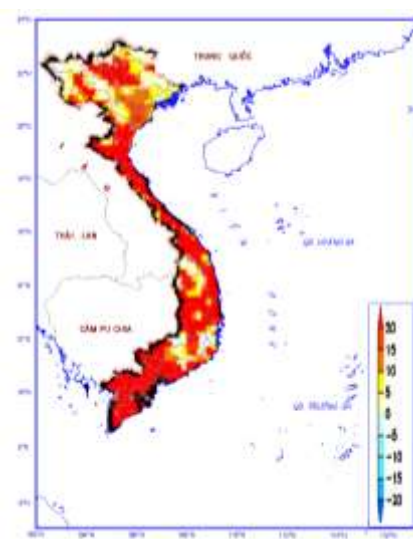


Figure 10. Changes in the number of days with temperature higher than 35°C at the end of the 21th century, relative to the baseline under the medium emission scenario

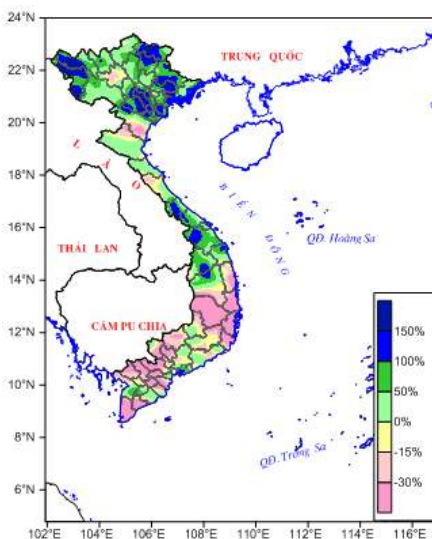


Figure 11. Changes (%) in the maximum daily rainfall at the end of the 21th century, relative to the baseline under the medium emission scenario (B2)

d) Sea level rise:

Three sea level rise scenarios are constructed for seven coastal regions of Viet Nam (**Figure 12**) including:

- (1) Mong Cai to Hon Dau;

- (2) Hon Dau to Deo Ngang;
- (3) Deo Ngang to Deo Hai Van;
- (4) Deo Hai Van to Mui Dai Lanh;
- (5) Mui Dai Lanh to Mui Ke Ga;
- (6) Mui Ke Ga to Mui Ca Mau; and
- (7) Mui Ca Mau to Ha Tien.

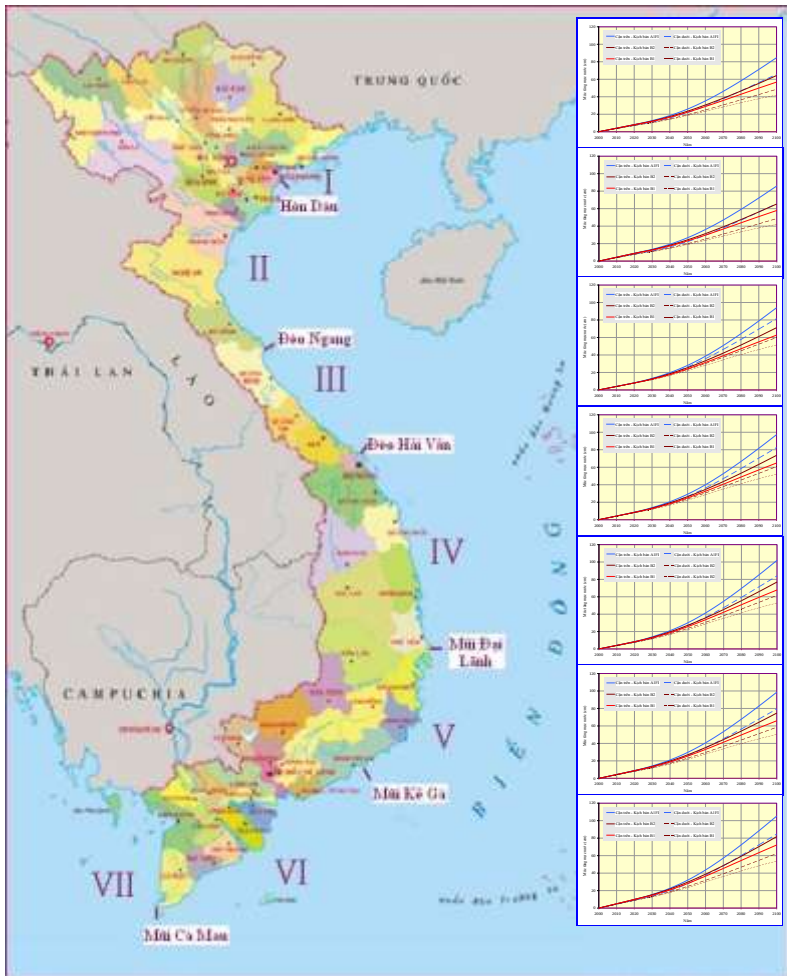


Figure 12. Sea level rise for coastal regions of Viet Nam

- *In the low emission scenario (B1)*: by the end of 21th century, average sea level along Viet Nam coast is projected to rise about 49-64 cm.

- *In the medium emission scenario (B2)*: by the end of 21th century, average sea level along Viet Nam coast is projected to rise about 57-73cm. Sea-level rise at regions from Ca Mau to Kien Giang is relatively higher than that at other regions (**Table 3**).

- *In the high emission scenario (A1FI)*: by the end of 21th century, average sea level along Viet Nam coast is projected to rise about 78-95cm. The highest sea level rise at regions from Ca Mau to Kien Giang can reach 105cm.

Table 3. Projected sea level rise (cm) relative to 1980-1999 baseline under the medium emission scenario (B2)

Region	Decades in the 21 th century								
	2020	2030	2040	2050	2060	2070	2080	2090	2100
Móng Cái-Hòn Dấu	7-8	11-12	15-17	20-24	25-31	31-38	36-47	42-55	49-64
Hòn Dấu-Đèo Ngang	7-8	11-13	15-18	20-24	25-32	31-39	37-48	43-56	49-65
Đèo Ngang-Đèo Hải Vân	8-9	12-13	17-19	23-25	30-33	37-42	45-51	52-61	60-71
Đèo Hải Vân-Mũi Đại Lãnh	8-9	12-13	18-19	24-26	31-35	38-44	45-53	53-63	61-74
Mũi Đại Lãnh-Mũi Kê Gà	8-9	12-13	17-20	24-27	31-36	38-45	46-55	54-66	62-77
Mũi Kê Gà-Mũi Cà Mau	8-9	12-14	17-20	23-27	30-35	37-44	44-54	51-64	59-75
Mũi Cà Mau-Kiên Giang	9-10	13-15	19-22	25-30	32-39	39-49	47-59	55-70	62-82

3.2. Inundation risk maps

Inundation risk maps are constructed corresponding to the sea level rise scenarios for sub-regions: Red River Delta and Quang Ninh province; 15 coastal central provinces from Thanh Hoa to Ba Ria - Vung Tau with scale of 1:10,000 (detailed to district level); Ho Chi Minh city and Mekong Delta with scale of 1:5,000.

The results show that with 1 m sea level rise, about 39% of the Mekong River Delta, more than 10% of Red River Delta and Quang Ninh province, 2.5% of coastal provinces in central regions, and more than 20% of Ho Chi Minh city areas are at risk of inundation (**Figures 13, 14 and 15**). Almost 35% of Mekong Delta population, 9% of population of Red River Delta, Quang Ninh, 9% of coastal provinces in Central region, 7% of Ho Chi Minh city population would be directly affected; More than 4% of railway system, more than 9% of national roads and 12% of provincial roads of Viet Nam are likely to be affected.



Figure 13. Inundation risk map for Vietnam coastal areas with 1m sea level rise



Figure 14. Inundation risk map for Red River Delta and Quang Ninh with 1 m sea level rise

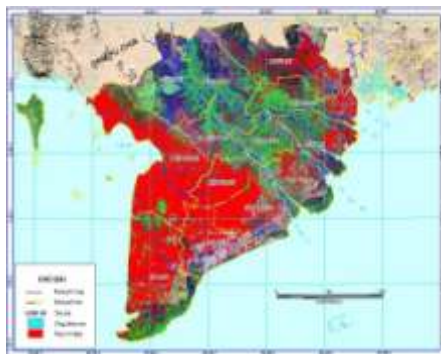


Figure 15. Inundation risk map for Mekong Delta with 1m sea level rise

4. Recommendations on using the climate change and sea level rise scenarios

The use of climate and sea level rise scenarios in impact assessment and action plan development to respond to climate change should be considered and selected to suit specific sector and locality with criteria including: characteristics of sectors and localities; social, economic and environmental efficiency; sustainability; feasibility and ability to integrate climate change issues into strategies, policies and development plans.

The following steps for application of the scenarios in a particular region or sector are recommended:

- Identify key climate parameters for sectors, regions;
- Select suitable climate change and sea level rise scenarios for the sectors, regions from the national scenarios;

Hydrological, hydraulic models and impact assessment models can be used to provide important input information such as changes in flow regime, flooding, salinity intrusion, storm surges, shoreline changes, geological rise/subsidence, etc. for building and implementing action plans to respond to climate change.

The development, construction and implementation of solutions to respond to climate change should be with specific phases. Priorities need to be identified based on practical needs and available resources in each phase in order to select the most appropriate scenario. The low emission and medium emission scenarios should be applied in designing short-term projects and plans; the high emission scenario should be applied for the permanent projects, long-term plans.

The Intergovernmental Panel on Climate Change plan to publish global and regional climate change scenarios in the 5th assessment report by the end of 2014. Therefore, the scenarios for Viet Nam will be updated in 2015. Methods for the climate change impact and vulnerability assessment need to be reviewed and updated when the new scenarios are released.