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Assessment of climate change impacts on salinity intrusion in Hong-Thai Binh and Dong Nai river basins

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Abstract. Climate change (CC) is a global problem that not only affects the developed countries but also the developing ones as Vietnam. With a coastal line of approximately 3,260 km, Vietnam is expected to be affected considerably by climate change including salinity intrusion. Through the assessment of impacts of climate change on water resource in Hong-Thai Binh and Dong Nai river basins which located in two key economic zones, in the paper a general picture of impacts of climate change on salinity intrusion in Vietnam is presented, where MIKE 11 was used for Hong – Thai Binh basin and HydroGIS for Dong Nai basin. The study gives out some results of salinity intrusion in the two basins according to three climate change scenarios in three typical years: 2030, 2050, and 2100. Finally, both the short and long terms adaptation measures to salinity intrusion caused by climate change in Vietnam are summarized.

Keywords: Climate change, salinity intrusion, Hong-Thai Binh river, Dong Nai river.

1. Introduction

During the past 50 years, in Vietnam, the average temperature has increased by about 0.7 ^{0}C and sea level has risen by about 20cm. According to the forecast of Ministry of Natural Resources and Environment, by 2100, sea levels will rise up to 1 m, temperature increases by about 3°C. Vietnam has a long coastline of 3,260 km and 75% of the population lives in coastal areas, so it may be affected seriously by climate change. According to calculations, if sea level rises a meter, about 40 thousands km^2 of flat plain in Vietnam will be flooded every year, of which 90% of the provinces of Cuu Long River Delta be almost completely flooded. Hong – Thai Binh and Dong Nai river basins are two major basins located in two key economic zones of the country with large coastal area, may seriously be impacted by sea level rise.

One of the impacts of climate change and sea level rise is salinity intrusion. Therefore, in this paper, the effects of climate change on salinity intrusion are presented.

Salinity intrusion is a natural phenomenon occurring in the lands, estuaries, and aquifers being adjacent to the sea. The main cause of salinity intrusion is a difference of flow energy (both potential and kinetic energy) as well as of current density between freshwater and saltwater. There are many factors affecting the salinity intrusion: discharge and river flow periods, topography, morphology, river bed slope, tides on the sea, wind velocity and direction, water temperature, the friction on the flow, etc.

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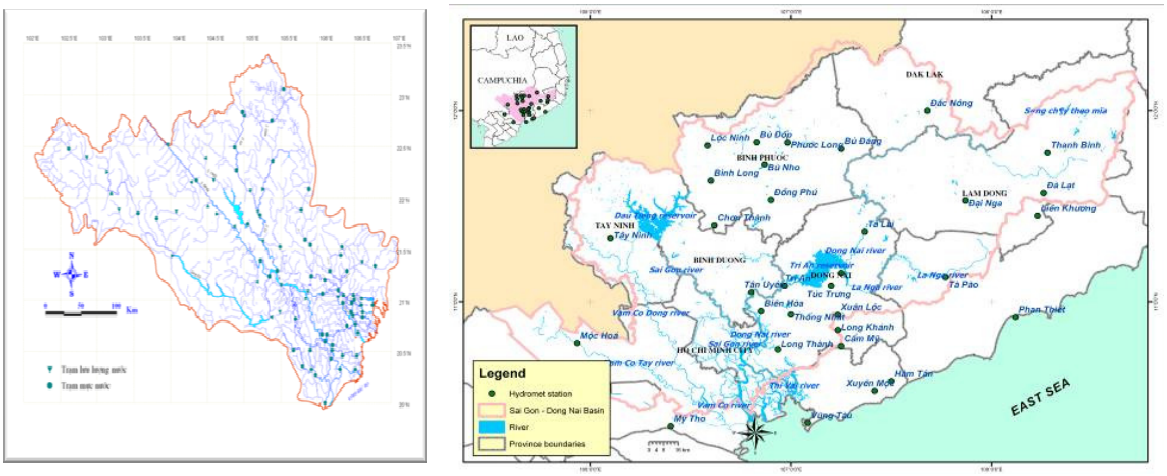


a) Hong - Thai Binh river basin. b) Dong Nai river basin

Figure 1. Maps of two studied basins.

2. Study method

2.1. Methodology

Many studies on the process of salinity intrusion into the mainland have been conducted. However, in Vietnam two major methods are used that are statistical and mathematical model ones. This article, some research results of the process of saline intrusion impacted by climate change applying mathematical models are presented. A calculation schema is showed in Figure 2.

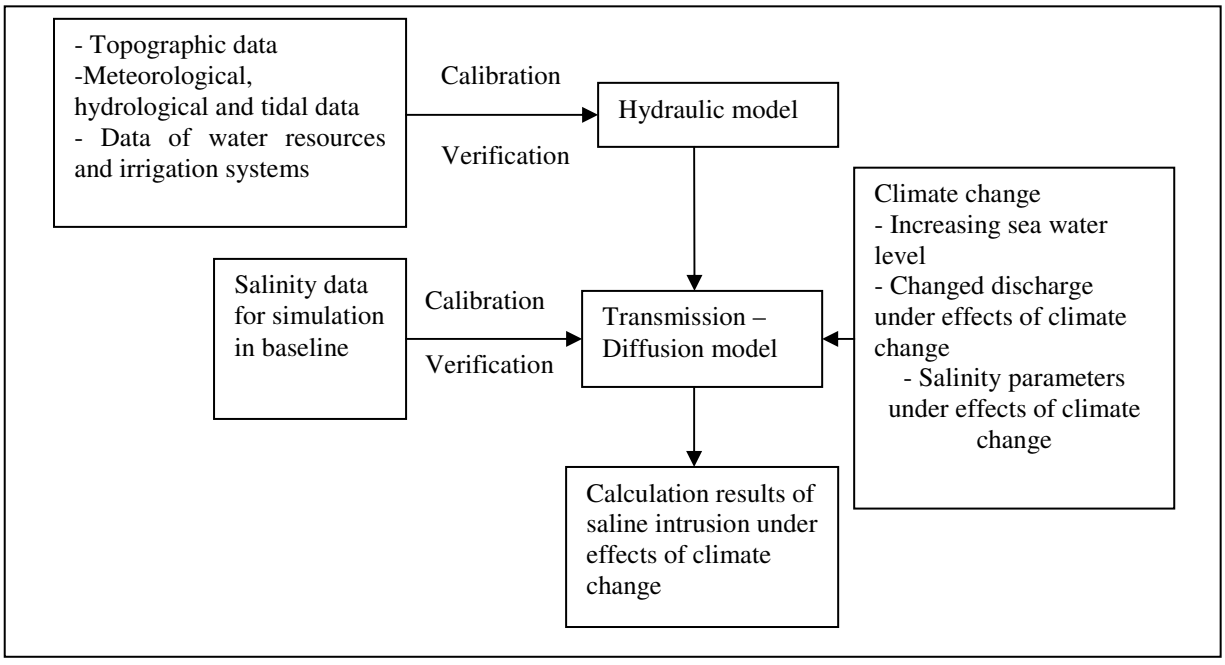


Figure 2. Calculation schema of salinity intrusion under the impacts of climate change.

2.2. Applied tools

The MIKE 11 model was applied for Hong-Thai Binh river basin and HydroGIS model for Dong Nai river basin to calculate salinity intrusion under climate change scenarios.

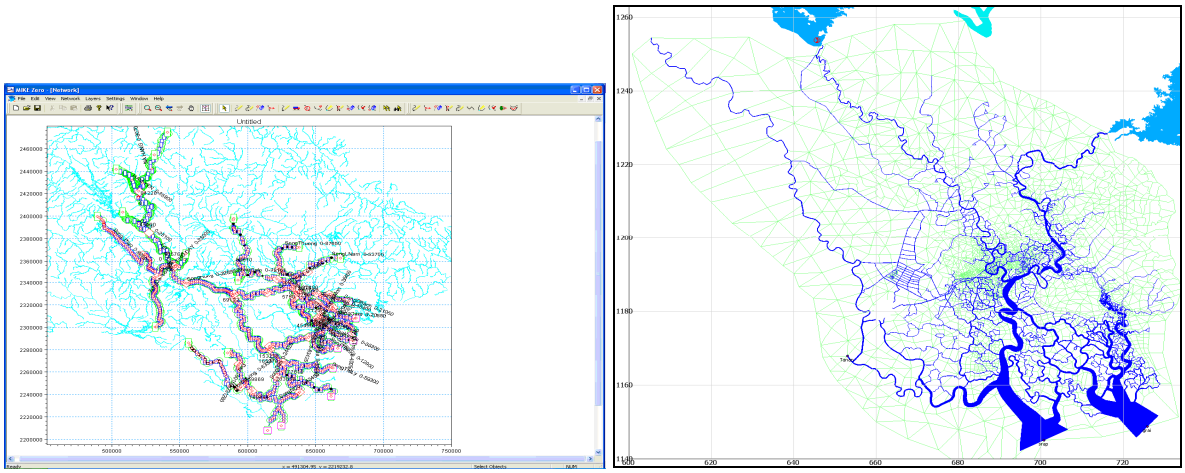
Application of mathematical models to predict saline intrusion was carried out as follow:

- Set up a hydraulic network for the basins (Figure 3);

- Calibration and verification of hydraulic model [1, 2];

- Calibration and verification of salinity intrusion model (Figure 4 and 5) [1, 2];

- Prediction of boundaries and saline intrusion under climate change and sea level scenarios.



a) Hong-Thai Binh river basin in MIKE 11 model. b) Dong Nai river basin in HydroGIS.

Figure 3. Schema of hydraulic network of the river systems.

2.3. The calculation scenarios

Salinity intrusions in the two basins under three climate change scenarios (B1, B2, A2) were forecasted to assess the impacts of climate change on salinity intrusion in the two basins.

In order to calculate salinity intrusion in the future, it is necessary to determine the upper boundary conditions in accordance to climate change scenarios. In this study, the upper boundaries of the saline intrusion model under climate change scenarios and water demand were calculated based on the socio-economic development planning to 2020.

With a long period from 2020 to 2100, the study could not be conducted for each year. On the other hand, changes in salinity intrusion year by year are not great. Therefore, to minimize the amount, it can be calculated for years. Thus, the study is carried out for three representative years: 2030, 2050, and 2100.

3. Results

3.1. Salinity intrusion in climate change scenarios B1

Lower emission scenario B1 describes a perfectly developed world towards the least greenhouse gas emissions, population growth rate is very low, the economic structure changes rapidly in the direction of services and information; the international agreements to minimize greenhouse gas emissions are implemented fully and seriously on a global scale [3].

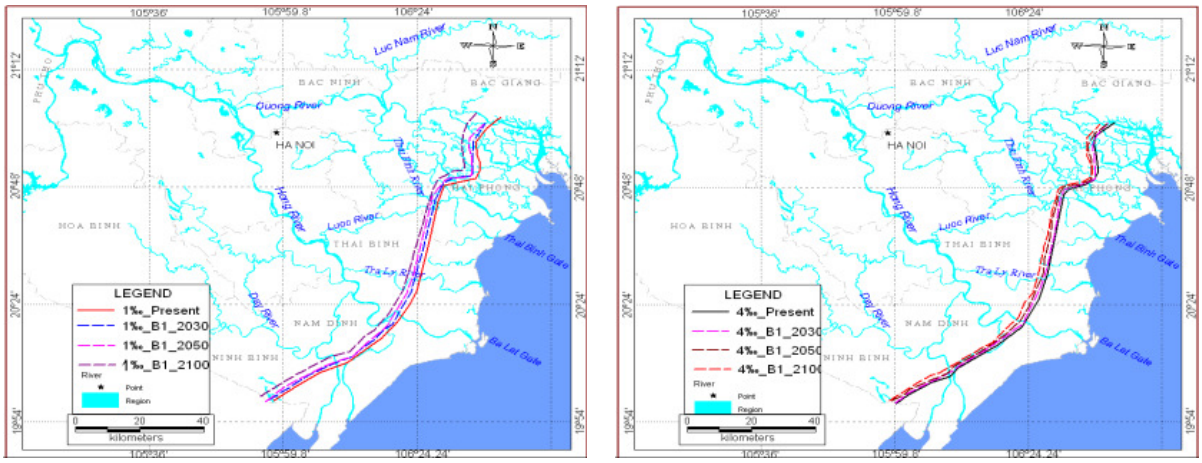


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Figure 4. Simulated salinity intrusion in Hong-Thai Binh river basin in scenario B1 for the years 2030, 2050, 2100.

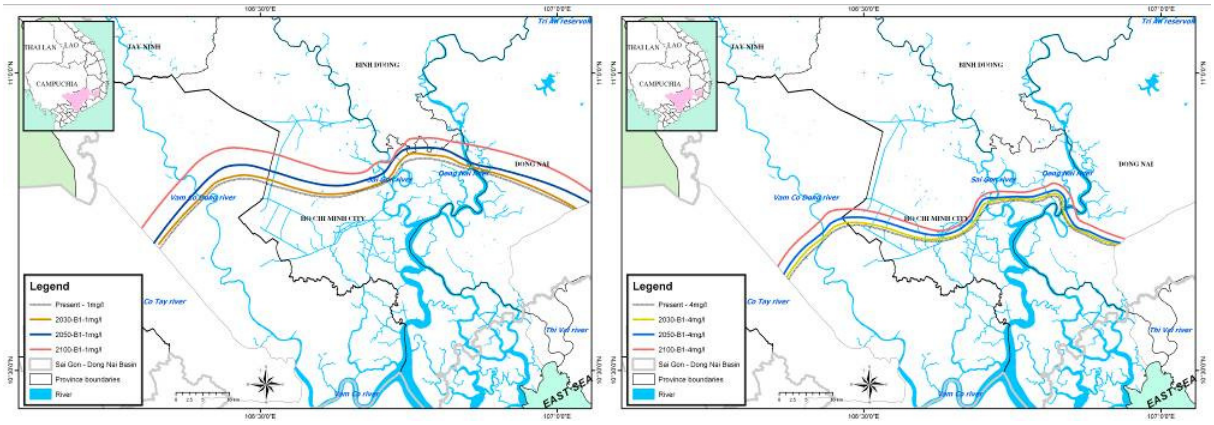

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Figure 5. Simulated salinity intrusion in Dong Nai river basin in scenario B1 for the years 2030, 2050, 2100.

3.2. Salinity intrusion in climate change scenario B2

Average emission scenario is corresponding to the continuous population growth being smaller than A2; focusing on local solutions instead of global socio-economic and environmental stability; average economic growth; more fragmented and slower technological change than the B1 and A1 [3].

Table 1. Salinity intrusion in Dong Nai river (km).

	Vam Co Dong river		Sai Gon river		Dong Nai river	
	1‰	4‰	1‰	4‰	1‰	4‰
Scenario B1						
2030	97.8	84.9	84.9	74.5	78.8	71.6
2050	98.7	85.6	85.9	75.1	79.4	72.3
2100	101.8	87.6	88.2	77.8	80.9	73.8
Scenario B2						
2030	98.1	85.1	85.3	74.6	78.9	71.8
2050	98.9	85.8	86.1	75.3	79.6	72.5
2100	102.5	88.6	88.9	78.2	81.5	74.2
Scenario A2						
2030	98.3	85.3	85.4	74.8	79.1	72.0
2050	99.2	86.1	86.3	75.4	79.8	72.6
2100	105.2	92.5	92.3	81.7	83.1	75.9

Table 2. Salinity intrusion in Hong –Thai Binh River (km).

	Salinity					
Scenarios	**1‰**			**4‰**		
B1						
River	**2030**	**2050**	**2100**	**2030**	**2050**	**2100**
Day	25.2	25.7	27.4	20.4	20.9	22.5
Ninh Co	27.1	27.4	28.9	22.3	22.5	23.9
Hong	27.4	29.3	31.1	22.1	23.5	24.9
Tra Ly	28.9	29.0	29.7	22.4	22.7	23.1
Thai Binh	36.2	40.0	44.1	28.3	28.8	31.4
Van Uc	31.7	35.2	38.4	26.2	27.7	30.6
Lach Tray	26.5	29.2	32.1	20.3	22.2	24.1
Kinh Thay	43.8	44.1	45.8	37.8	39.5	41.0
Da Bach	31.6	32.2	34.0	26.7	27.2	28.1
B2						
Day	25.4	26.3	27.4	20.6	21.5	23.5
Ninh Co	27.4	27.4	28.9	22.6	22.6	23.9
Hong	28.1	29.4	31.1	22.4	23.6	24.9
Tra Ly	29.2	28.5	29.7	22.6	22.5	23.1
Thai Binh	37.5	40.8	44.2	28.4	29.1	30.7
Van Uc	32.1	35.5	38.5	25.6	27.8	30.9
Lach Tray	26.6	29.3	32.1	20.4	22.3	24.1
Kinh Thay	44.1	44.5	46.0	38.4	39.6	41.7

Scenarios	Salinity					
	1‰			4‰		
Da Bach	32.1	32.4	34.2	26.9	27.3	28.4
A2						
Day	25.4	26.4	28.6	20.7	21.9	23.8
Ninh Co	27.5	27.7	29.7	22.5	22.8	24.5
Hong	28.1	29.5	33.6	22.6	24.0	26.5
Tra Ly	29.0	29.2	30.2	22.7	22.9	23.4
Thai Binh	37.5	41.2	45.0	28.5	29.2	31.3
Van Uc	32.4	35.9	39.0	25.6	28.2	31.4
Lach Tray	26.6	29.6	32.5	20.5	22.3	24.3
Kinh Thay	44.7	44.5	49.4	39.2	40.5	45.5
Da Bach	32.0	33.2	34.5	27.0	27.6	29.1

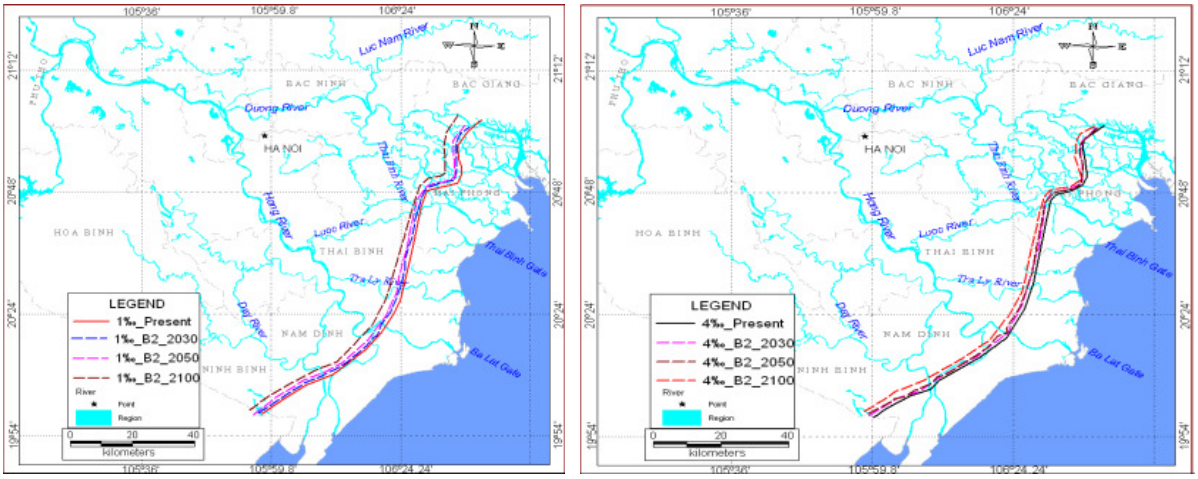

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Figure 6. Salinity intrusion in Hong –Thai Binh river basin in scenario B2 for the years 2030, 2050, 2100.

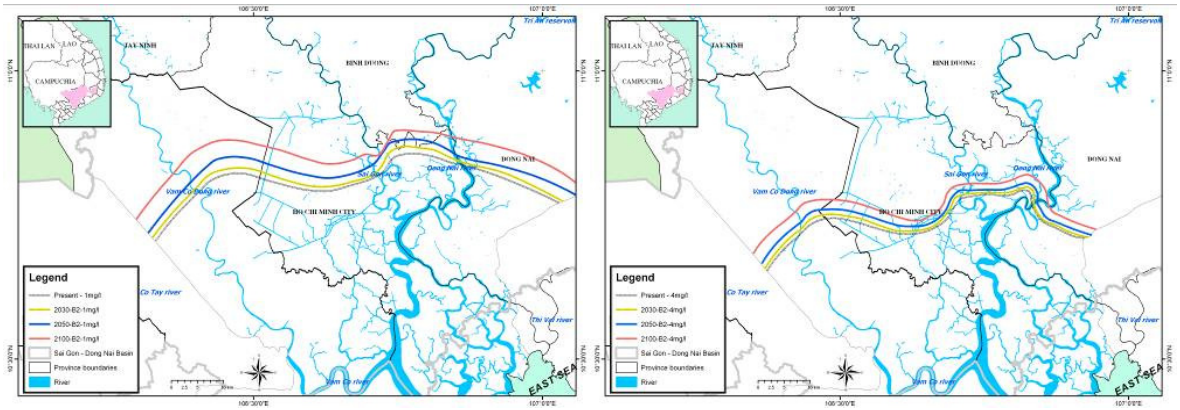

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Figure 7. Salinity intrusion in Dong Nai river basin in scenario B2 for the years 2030, 2050, 2100.

From the calculated results in three climate change scenarios for representative years 2030, 2050 and 2100, it can be recognized:

- The furthest distance of salinity intrusion occurs in high emission scenario A2 and the shortest occurs in low emission scenario B1.

- The impacts of climate change and sea level rise on salinity intrusion in Dong Nai river basin is stronger than Hong –Thai Binh river basin, as the tidal regime and topography condition in Dong Nai river basin is more complex than in Hong –Thai Binh river basin.

- The average rate of salinity intrusion in Hong –Thai Binh river basin is 50 m/year, while in Dong Nai river basin is 65 m/year.

- The distance between the salinity line of 1 mg/l and 4 mg/l in the scenarios is stable and no significant changes in the period from 2000 to 2100. Distances between the two salinity lines on Vam Co Dong, Sai Gon and Dong Nai rivers are 13km, 10km, and 8 km respectively.

- Salinity intrusion in the early periods is relatively small and stable. However, in the later periods, the salinity intrusion distances will be further.

3.3. Salinity intrusion in climate *change scenario A2*

A2 high emission scenario describes a heterogeneous world in a global scale, the high population growth rate, maximum utilization of fossil energy [3]. This is the worst that human beings need to think about.

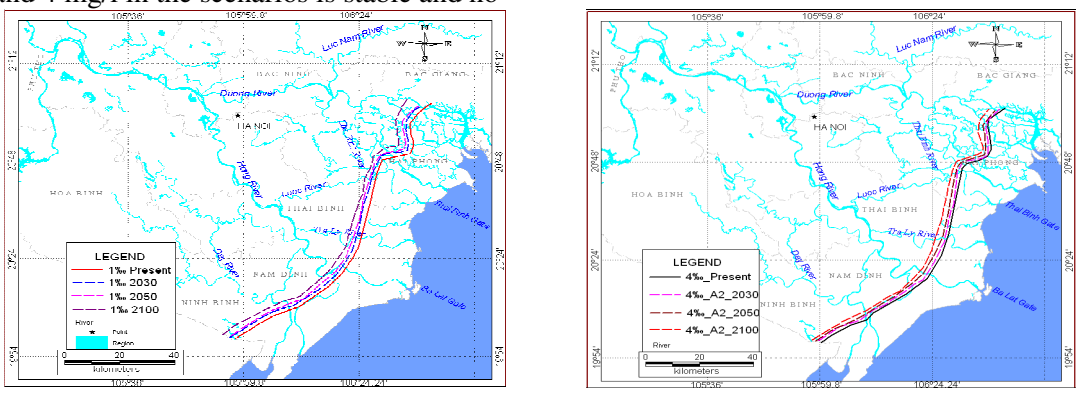

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Figure 8. Salinity intrusion in Hong – Thai Binh river basin in scenario A2 for the years 2030, 2050, 2100.

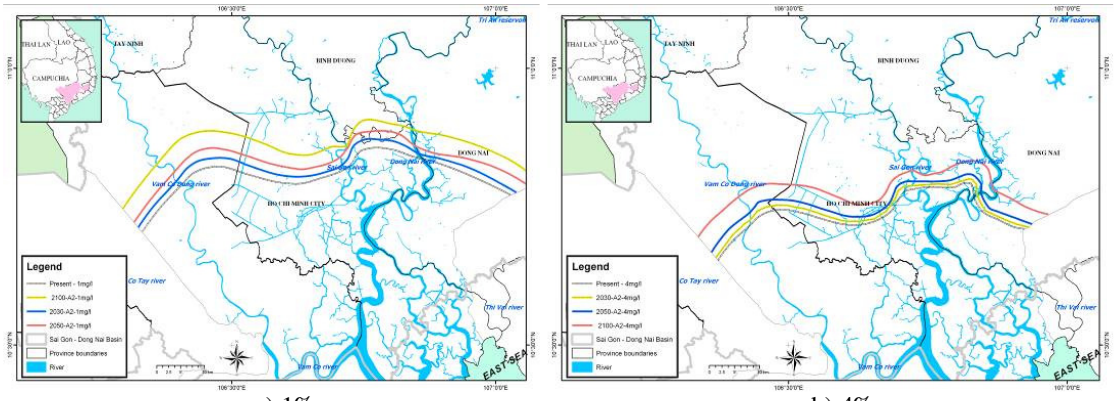

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Figure 9. Salinity intrusion in Dong Nai river basin in scenario A2 for the years 2030, 2050, 2100.

4. Conclusions

Impacts of climate change and sea level rise on salinity intrusion in the two basins is very evident, especially in Dong Nai river basin.

To mitigate the consequences of salinity intrusion caused by climate change, it is necessary to carry out the following measures: i) development of appropriate adaptation measures; ii) formation of inter-provincial agencies to develop responding programs in the whole region; and iii) public capacity building to respond to climate change.

In developing countries as Vietnam, it is very importance to invest in climate change adaptation for sustainable development, because the risk mitigation measures will support Vietnam responding to the long-term effects.

Acknowledgements

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