VNU Journal of Science, Earth Sciences 26 (2010) 202-209

Assessment of climate change impacts on water resources in Hong-Thai Binh river basin

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Received 12 November 2010; received in revised form 26 November 2010

Abstract. Rapid socio–economic development leads to a great increase in water demand of many sectors and conflicts between water users. Moreover, studies have warned about serious degree of influence of climate change (CC) on Vietnam, particularly on the water resources. Therefore, assess CC impacts on water balances are very necessary task. The Ministry of Natural Resources and Environment has completed the appropriate climate change scenarios in Vietnam [1]. In this study, water balance results will be presented including three scenarios: high emissions scenario (A2), medium emission scenario (B2), and low emission scenario (B1). The water balanced in Hong-Thai Binh river basin was calculated, which is one of the largest basins in Vietnam. The basin is very complicated: Under the influence of flow regime of international rivers [2], a system of reservoirs and irrigation structures serving diverse purposes, such as of water supply, irrigation, flood control and hydropower [3-5]. MIKE BASIN model was applied to describe exploitation, utilization and to identify the water shortage areas according to the climate change scenarios.

Keywords: climate change, water resources, Hong-Thai Binh river.

1. Introduction about the study area

Hong-Thai Binh river basin is an international river basin that flows through three countries: China, Laos, Vietnam with a total natural area is 169,000 km^2. The area of basin located in Vietnam is: 86,680 km^2, occupying 51.3% of the total.

This is the second largest river basin, (after the Mekong basin) in Vietnam which flows into East sea. Hong-Thai Binh river is formed from 6 major tributaries: Da, Thao, Lo, Cau, Thuong and Luc Nam rivers.

Figure 1. Topographic map of Hong-Thai Binh river basin.

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2. Research method

In this study, two methods were used as follows:

(i) Document synthesis and data analysis; and

(ii) Mathematical model.

MIKE BASIN model was used to calculate water balance in Hong-Thai Binh river basin, where MIKE NAM model was also used for inflow calculation in this basin.

MIKE BASIN is a tool for water resources management, and more exactly it is a tool to calculate the optimal balance between water demand and available water amount. It supports the managers in choosing suitable development scenarios, exploitation and protection of water resources in the future.

3. Application of MIKE BASIN model to calculate the water balance in Hong-Thai Binh river basin

3.1. Water balance scheme and irrigation system

Based on characteristics of the basin such as: topography, climate, irrigation systems, and distribution of population, the river basin was divided into six sub-basins (Da, Thao, Lo, Cau, Nhue-Day, downstream Hong-Thai Binh River) including 91 sub-areas.

The simulated irrigation system in MIKE BASIN model are: reservoirs and hydro-powers parameters of which are: reservoirs relationship (Z ~ F ~ V), reservoir water level, capacity of hydro-plants, reservoir water level changes, regulation of reservoir operation.

Baseline and scenario simulation: 25 reservoirs and five hydroelectric powers.

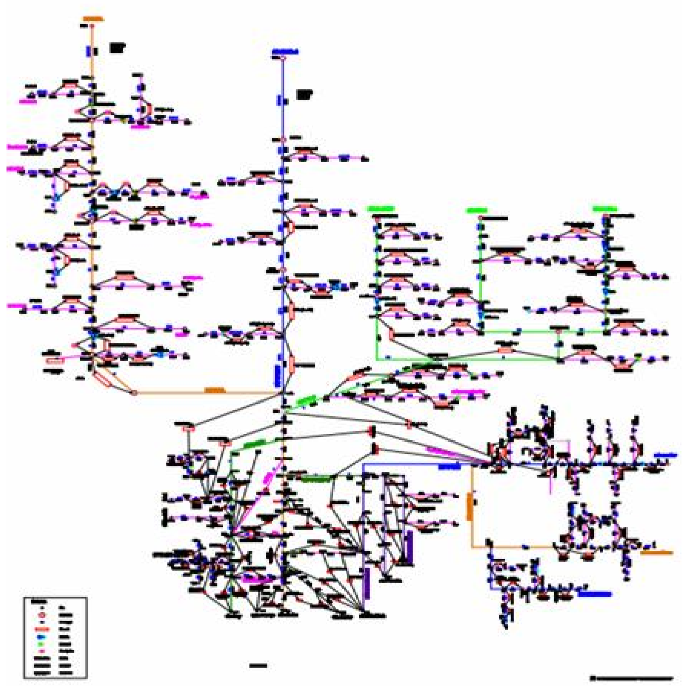


Figure 2. Water balance scheme of Hong-Thai Binh river basin.

Table 1. The parameters of hydropowers in the Hong-Thai Binh river basin.

Nam of hydropower	Year of beginning	Year of operation	Install capacity (MW)	Energy production (10^6 KWh)	Function
Lai Chau	2010	2017	1200	4700	Electricity generation
Son La	2005	2012	2400	10246	Electricity generation
Hoa Binh	1979	1994	1920	8160	Flood control Irrigation Electricity generation
Tuyen Quang	2002	2008	342	1329	Flood control Electricity generation
Thac Ba	1961	1971	120	414	Flood control Irrigation Generate electricity

3.2. Input data

3.2.1. Inflow

Inflows in the hydro stations and on the sub-basins were calculated according to three climate change scenarios A2, B1, B2 for the following periods: baseline (1980-1999), 2020-2039, 2040-2059, 2060-2079, and 2080-2099.

MIKE NAM model was used to calculate the inflow according to three climate change scenarios A2, B1, B2. The total annual flow increases slightly in all the three scenarios. However, variation rates of annual flow in each tributary are not different.

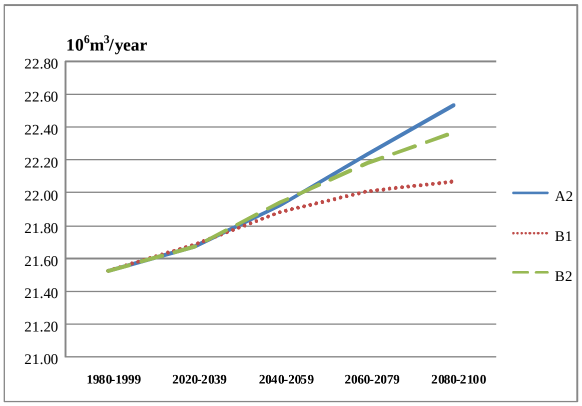
3.2.2. Water demand

On the basin, water demand was calculated in Hong-Thai Binh: agriculture, aquaculture, industry, domestic sector, public services and tourism. To assess the influence of climate change on water demand two Cases were considered.

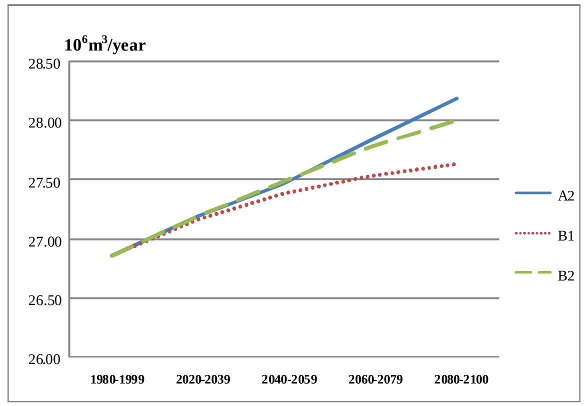
Due to limitations of published data, the water requirement of livestock, industry, aquaculture, domestic sector, public services and tourism were calculated to 2020 according to the Statistical Year Book 2000 (Case 1) and the planning of socio-economic development plan to 2020 of provinces in the basin (Case 2), with the assumption that these demands would not be changed by 2100. This means there is only water demand for the main user (agriculture) that will be changed throughout the periods. For each Case, the water demand for agriculture was calculated for 20 years from 1980 to 2000 and for 80 years from 2020 to 2100 with the assumption that agricultural area and cultivated crop structure were constant. Thus, the changes of water demand for agriculture only would depend on precipitation and evaporation.

Case 1 (WD1): Calculation of water demand for the periods 1980-1999 and 2020-2100 based on the Statistical Year Book 2000 for the data on agricultural and industrial areas, livestock, population and the data of rainfall and temperature scenarios for projected agricultural demand.

Case 2 (WD2): Calculation of water demand for the periods 1980-1999 and 2020-2100 based on the planning of socio-economic development plan to 2020 for the data on agricultural and industrial areas, livestock, aquaculture, population, tourism and the data of rainfall and temperature scenarios for projected agricultural demand.



(a) Water demand - Case 1



(b) Water demand - Case 2

Figure 3. The trend of water demand in the 2 Cases.

3.3. Choosing option for water balance calculation

In order to calculate water balance on Hong-Thai Binh river basin, the options were chosen based on (i) the planning of socio-economic development of the region, of each provinces and of each sector [4,6,7]; (ii) climate change scenarios [1]. The main criteria considered choosing option were: (i) inflow, (ii) water demand, (iii) irrigation system. The options for water balance calculation are shown in Table 2.

Table 2. Options for water balance calculation.

Water balance (WB) Cases	CC scenarios	System of water resources structures	Water demand	Inflow
WB - Case 1	A2	25 reservoirs, 5 hydropower plants	WD1 – A2	A2
	B2		WD1 – B2	B2
	B1		WD1 – B1	B1
WB - Case 2	A2		WD2 – A2	A2
	B2		WD2 – B2	B2
	B1		WD2 – B1	B1

4. Results and discussion

4.1. Water balance results

According to calculation results, water shortage in the sub-basins and the whole basin more and more increase. Total of water demand in the Case 2 is bigger approximately 5 billion m³ per year than that in Case 1. In addition, because inflows in both Cases are constant, so water shortage in Case 2 is 4.2 to 4.8 billion m³ per year, occupying 15% -17% of water demand in the whole basin. There are no differences between two Cases in terms of quantity and percentage of water deficit. Trend of water shortage in Da, Thao, Lo, Cau Thuong, Luc Nam, Nhue, Day basins and the downstream of Hong-Thai Binh river are quite similar.

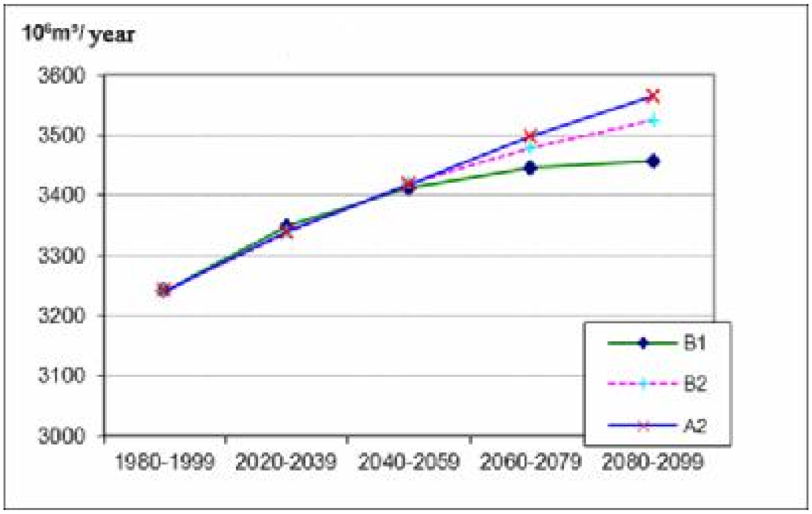


Figure 4. Water shortage in the whole region under three scenarios- WB Case 1.

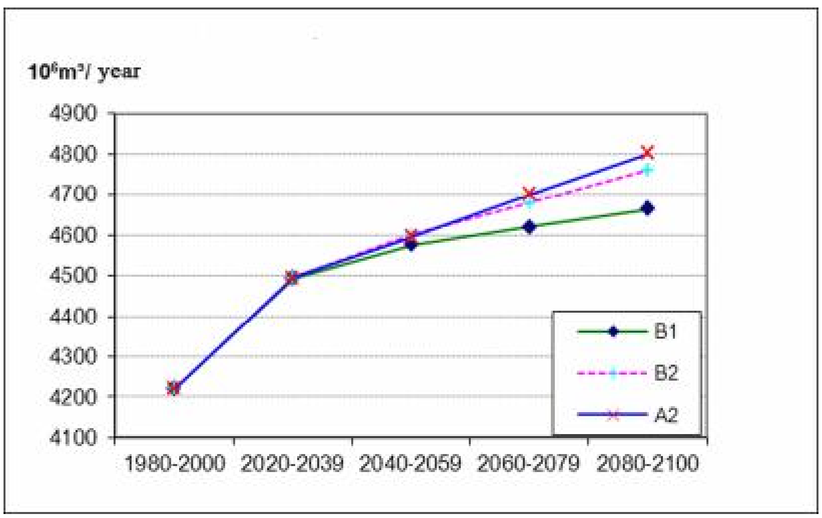


Figure 5. Water shortage in the whole region under three scenarios – WB Case 2.

Table 3. The total average water shortage in period- WB Case 1.

(Unit: 10^6 m^3 / year)

Scenario	1980-1999	2020-2039	2040-2059	2060-2079	2080-2099
	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$
B1	3,241.1	3,347.8	3,412.0	3,445.6	3,455.9
B2	3,241.1	3,338.1	3,420.1	3,478.7	3,524.5
A2	3,241.1	3,339.1	3,418.2	3,497.8	3,564.6

Table 4. The total average water shortage period - WB Case 2.

(Unit: 10^6 m^3 / year)

Scenario	1980-1999	2020-2039	2040-2059	2060-2079	2080-2099
	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$	$V_{deficit}$
B1	4,220.6	4,492.8	4,575.2	4,619.0	4,663.3
B2	4,220.6	4,493.9	4,599.8	4,677.6	4,759.9
A2	4,220.6	4,494.4	4,595.2	4,699.0	4,801.2

4.2. Energy production

The calculation result shows that the average monthly energy production of hydropower plants during the dry season has a decreasing tendency and in flood season has increasing tendency in comparison with the baseline scenario. For all hydropower plants, annual energy production is on the increase in the periods 1980-1999, 2020-2039, 2040-2059, 2060-2079, and 2080-2099. However, this change is not significant.

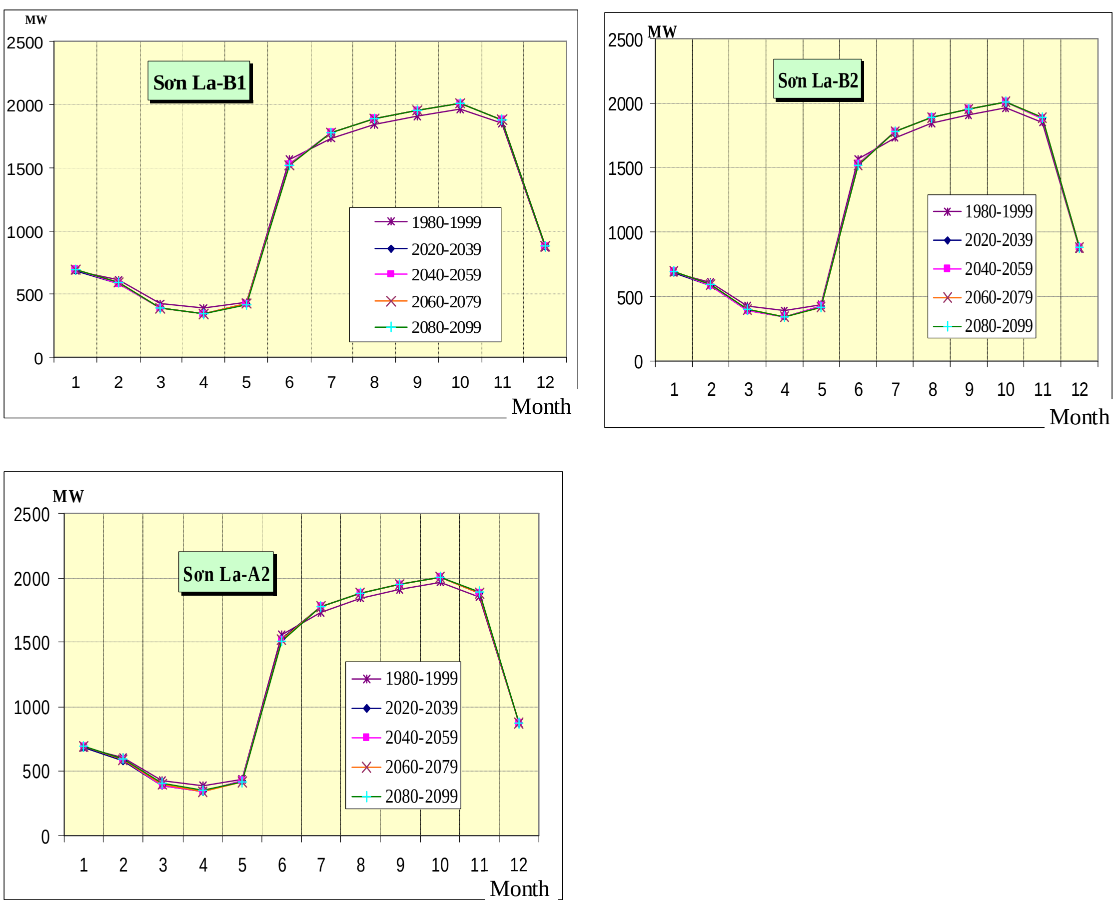
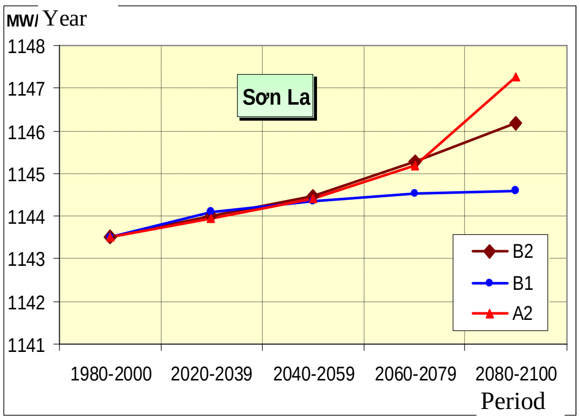
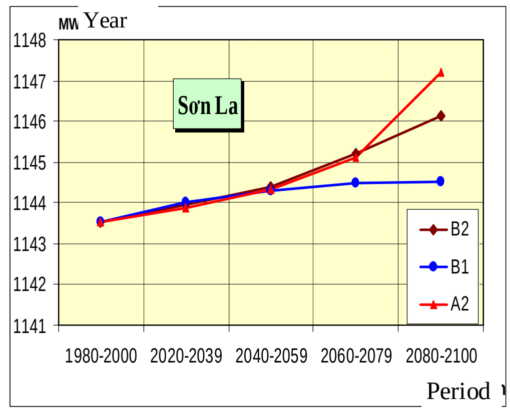


Figure 6. Monthly average energy production of Son La hydropower plant under 3 scenarios – WB Case 1.



Case 1



Case 2

Figure 7. Annual energy production of Son La hydropower plant under 3 scenarios.

5. Conclusions

1) Climate change causes the increase in the total annual the whole basin. The inflow increases in flood season and decreases in dry season, which would influence on water balance in the basin. The increase temperature causes increase in evaporation, while rainfall decreases in the dry season, therefore water demand is higher and higher, so water shortage is more and more seriously.

2) According to the forecast, the water demand in the period 2020 to 2100 from 21.52 to 22.54 billion m^3 per year for Case 1 and from 27.17 to 28.19 billion m^3 per year for Case 2 can be met.

3) In general, annual energy production is on the increase in the periods as compared to the baseline. However, this change is not significant.

4) In the context of climate change, under unfavorable conditions for water use and, water allocation and use become extremely difficult and complicated. If some reservoirs were built in the upstream in the future, it would influence on the capacity of meeting the water demand in downstream. Therefore it needs to pay attention to reservoir operation especially cascade operation, regulating water resources use to meet water demand in the future.

Acknowledgments

The author acknowledges the financial support by Danish International Development Agency (DANIDA) for the project "Impacts of climate change on water resources and adaptation measures".

References

[1] Ministry of Natural Resources and Environment, *Climate change, sea level rise scenarios for Vietnam*, 2009.

[2] Tran Thanh Xuan, *Hydrological features and water resources in Vietnam rivers*, Agriculture publishing house, 2007 (In Vietnamese).

[3] Water Resources University, *Research on scientific and practical bases for water supply in the dry season for the Hong River Delta*, 2007 (In Vietnamese).

[4] Water Resources Planning Institute, *The synthetic use of water resources in Hong – Thai Binh River*, 2005 (In Vietnamese).

[5] Water Resources Planning Institute, *Developing operating regulation for cascade in Da and Lo Rivers in the dry season for downstream of Hong-Thai Binh River*, 2007 (In Vietnamese).

[6] General Statistic Office, *Socio-Economic Statistic Data of 671 districts, towns and cities belong to authority of provinces in Vietnam*, Statistical Publishing House, 2006.

[7] Ministry of Construction, *The development direction of urban water supply by 2020*, Construction Publishing House, 1998 (In Vietnamese).