Assessing the impact of climate change on the water intake of the headworks on the Red River Basin in Viet Nam

Lan Pham Thi Huong[1,*], *Nguyet* Le Minh[1,**]
[1]Faculty of Hydrology and Water Resources, Thuy Loi University, Hanoi, Vietnam

Abstract. The irrigation systems for the Red River Delta usually get water by pumping and gravity.The results determine the possible minimum water level line in the dry-season months under climate change scenarios (B2, SC5 and SC6 and current scenario is B2, SC4) on the river system of the Red River – Thai Binh River in study areas of project as below: Water levels on the Red River in the dry season under climate change scenarios significantly reduced compared with 2010. At Ha Noi station on Red River, the water levels reduce in 2050 about 6.5cm (B2) and 7.5cm (A2) and 6cm (B1). At Nam Dinh station on Dao River, the water levels reduce in 2050 about 4cm (B2) and 5cm (A2) and 3cm (B1). At Cat Khe on Thai Binh River, the water levels reduce in 2050 about 2cm (B2) and 3cm (A2) and 1.5cm (B1). At An Bai on Kinh Thay River, the water levels reduce in 2050 about 5cm (B2) and 6cm (A2) and 4cm (B1). At Truc Phuong on Ninh Co River, the water levels reduce in 2050 about 6.5cm (B2) and 7.2cm (A2) and 5.8cm (B1). In the scenario in which 50% of the socio-economic development plans are achieved (SC6), the water demand is lower than the scenario of full development (SC5). The decrease in the average water level in the whole Red River system is about 1.3-1.8 cm less than in SC5, and in Thai Binh river this figure is about 1.4-2.1cm. The lowering of the water level under climate change in the river has caused problems for irrigation during the dry season, in order to reach the target level in Hanoi.

Key Words

Climate change, water intake, Red River Basin

1 Introduction

The Red River Basin is a trans-boundary river basin flow through three countries Vietnam, China and Laos with the total area of approximately 170.000km2 in which around 88.000 km2 in the territory of Vietnam, accounting for 51% of the entire basin area. The river ends in a delta area, located entirely within the territory of Vietnam, which

* Corresponding author: lanpth@wru.vn
** nguyetlm410@wru.vn

covers about 17.000km2.

The length of the Red river in the territory of Vietnam is about 328km. The area located in China is 81.000 km2, accounting for 48% of the entire basin area. The part of the catchment located in Laos is 1,000km2, accounting for 0.7% of the entire basin.

The Red river delta consists of 11 provinces: Hanoi, Hai Phong, Hai Duong, Hung Yen, Bac Ninh, Vinh Phuc, Quang Ninh, Thai Binh, Ha Nam, Nam Dinh, Ninh Binh. This study focuses on four of them: Hai Duong, Nam Dinh, Hai Phong and Thai Binh.

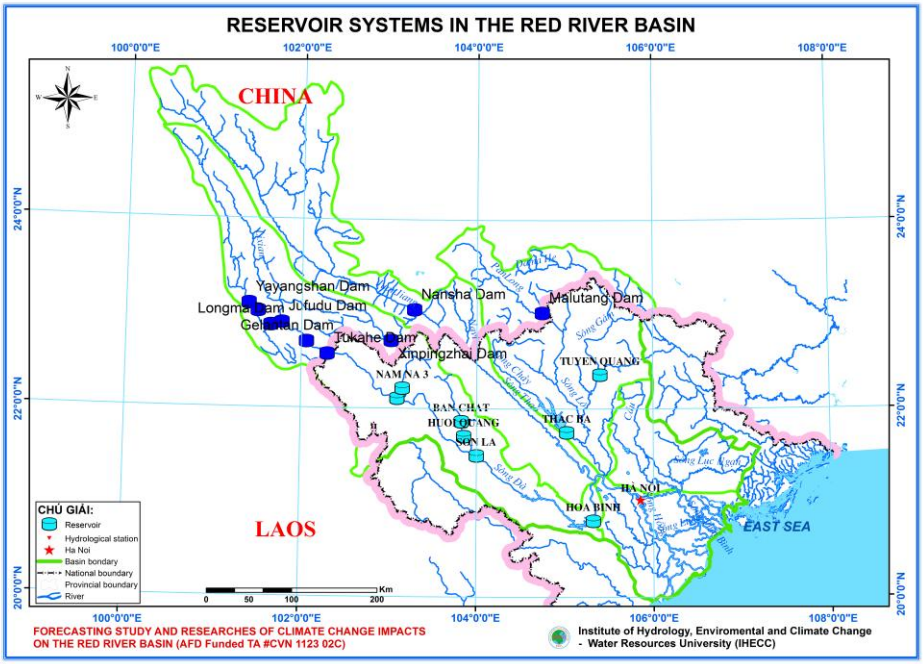

Fig 1. The Red River basin

The climate of the Red River Basin is characterised by high humidity and temperature typical of the tropic climate with a clear seasonal division. At the higher latitudes of the catchment, however, the climate has some similarities with the subtropical area.

The flow in the Red River – Thai Binh River basin is generally abundant. The mean annual total amount of the flows is about 118 billion m3 in Son Tay corresponding to 3743 m3/s. When the Thai Binh river, Day river and the delta area are considered, the total flow reaches to 135 billion m3 per year, of which 82.54 billion m3 (approximately 61.1%) produced in Vietnam and 52.46 billion m3 (approximately 38.9%) produced in the territory of China. However, due to terrain and uneven distribution of rainfall, the flow in different parts of the basin is also very different. As a major branch of the Red River, the Da River has the largest flow that accounts for 42% of the total flow measured in Son Tay. The Thao River covers a drainage area approximately equal to that of the Da River but has the smallest flow, which accounts for 19%. The Lo River has the smallest drainage area but has a significant flow after the Da River, accounting for 25.4%.

The main dams: In China have been build 9 reservoirs in Đà river and 2 reservoirs in Thao river, mainly built in 2007 (Đà river), 2005 (Lô Gâm river), 2010 (Thao river) with a capacity of about 4 billion in which total capacity on Da River about 2,251 billion billion m3. The reservoirs in China are mainly used for hydroelectric power generation, not downstream flood protection; In Viet Nam: In the Red Thai Binh system in Vietnam there are now 4 large multi-purpose reservoirs namely Thac Ba, Hoa Binh, Tuyen Quang and Son La is responsible for downstream flood control and Ban Chat, Huoi Quang, Lai Chau has no task downstream flood prevention, only power production tasks. The total active storage capacity is about 18,53 billion m3, in which the capacity to flood control about 8,45 billion billion m3, and the installed hydropower capacity of 6722 MW. Systems for

integrated use reservoirs for water supply, downstream flood control, power generation, combined transport, aquaculture and eco-environmental protection on the main line of the Red River systeminclude:

- Thac Ba Reservoir on the Chay river with flood control capacity is 0.45 billion m3.
- Hoa Binh and Son La Reservoir on the Da River with flood control capacity is 7 billion m3.
- Tuyen Quang Reservoir on the Gam River with flood control capacity is 1 billion m3.

The total flood control capacity for RRD's existing reservoir systemis 8.45 billion m3.

In addition to the large reservoir above the Red River basin, there are some other large reservoirs but only electricity production tasks, no task Flood control, including:

- Reservoir Lai Chau, a capacity is 1,215 million m3 full, useful capacity is 711 million m3
- Reservoir Ban Chat, a capacity is 2137.7 million m3, usefulcapacity is 1720 million m3.

The total area required for irrigation is 883 578 ha, the irrigation designed area is 857 735 ha, actively irrigated area is 609 877 ha, accounting for 69% of requirement (mainly for paddy-rice areas, while the perennial is no irrigation). The irrigated area is shown in the following figure 2:

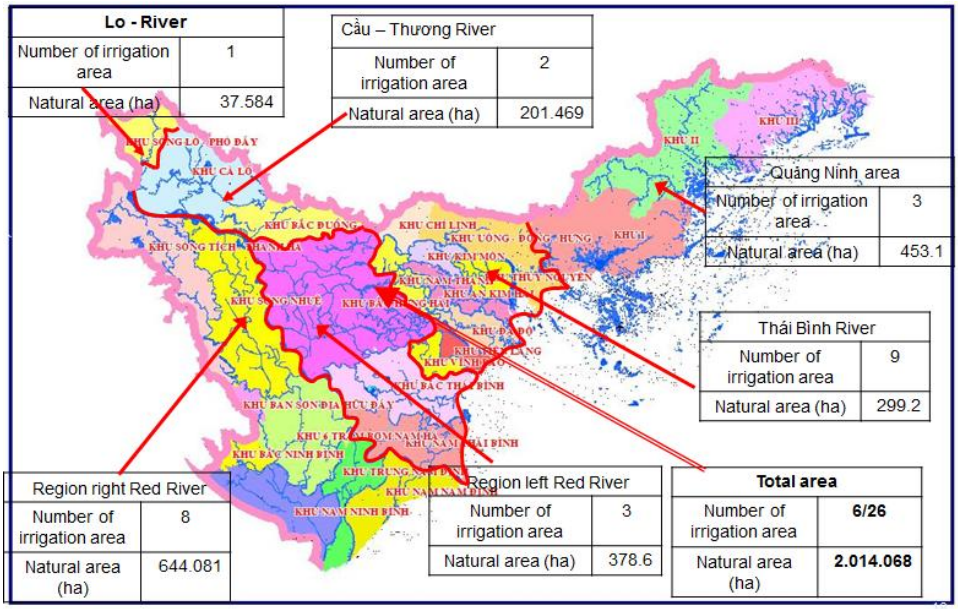

Fig 2. The irrigated area

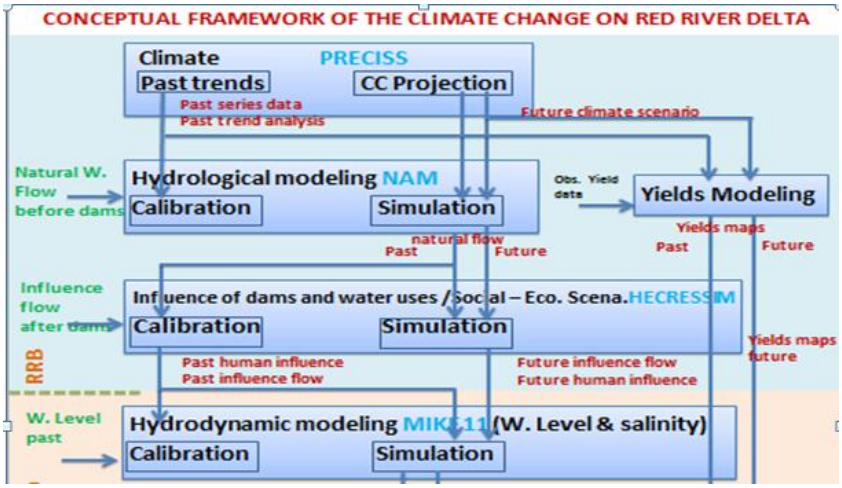

Fig 3. Methodology

2 Methodology

We used three models—Rainfall-Runoff, Hydrodynamic, and Salinity models—to capture the effects of all the factors that affect salinity in the downstream of Red River basin (fig. 3)

3 The results

The irrigation systems for the Red – Thai Binh River Delta usually get water by pumping and gravity:

- The systems with the high terrain, lying inland (inland system) are usually provided with water by pump stations in the pumping method. The pump stations get water from the rivers through the water intakes below the dykes and directly carry water into the irrigational canal system(floating canal).
- The irrigational systems with the low terrain and lying on the seaside often get water in the gravity method through water intakes by sluice.
- The water is carried from the canals into the buried canal system, and then it runs or is pumped into the irrigational canals (floating canal).

Some systems combine gravity method and pumping.

The intake operates as follows: - When water level in river lower than in the field: intake is closed. - When water level in river higher than in the field and salinity level less than or equal to 0.1%: intake is opened. (Crops can tolerate salinity of less than 0,1%, hence when river salinity is greater than 0.1%, the intake has to be closed).

The results determine the possible minimum water level line in the dry-season months under climate change scenarios (B2, SC5 and SC6 and current scenario is B2, SC4) on the river system of the Red River – Thai Binh River in study areas of project as below:

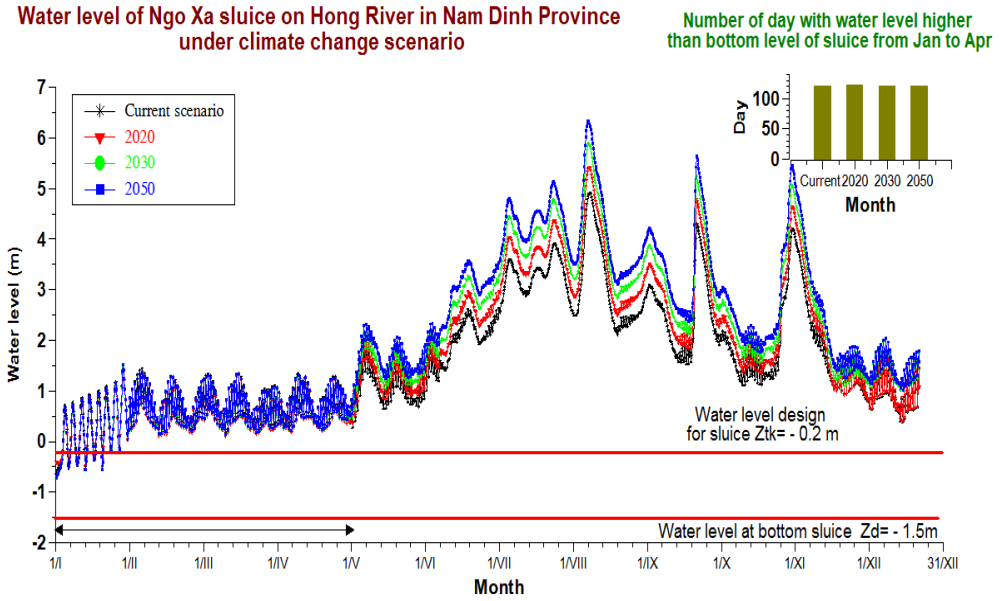

Fig 4. Water level of Ngo Xa sluice on Hong River in Nam Dinh Province under climate change scenario

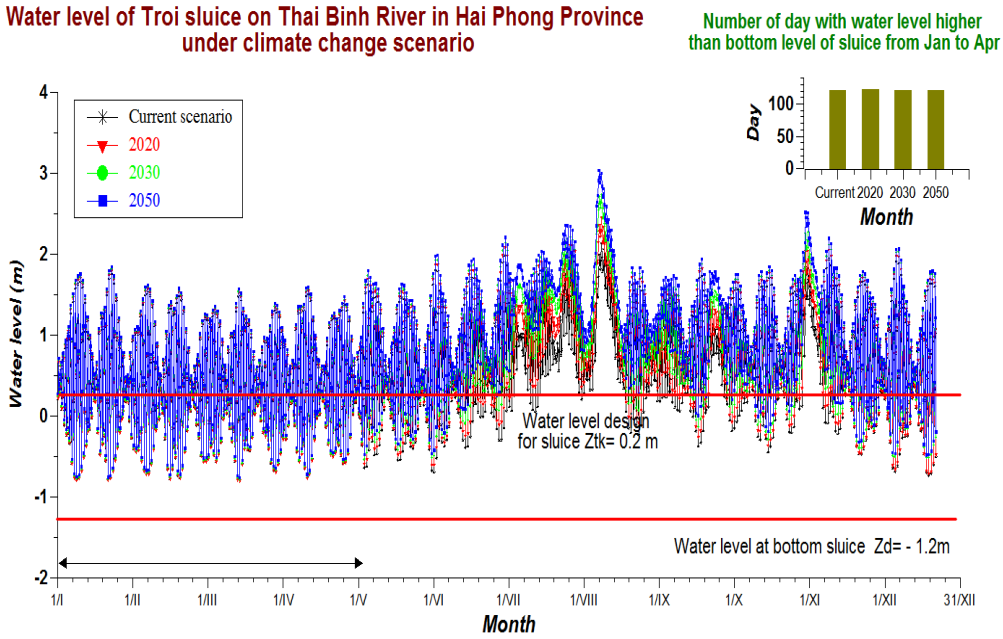

Fig 5. Water level of Troi sluice on Thai Binh River in Hai Phong Province under climate change scenario

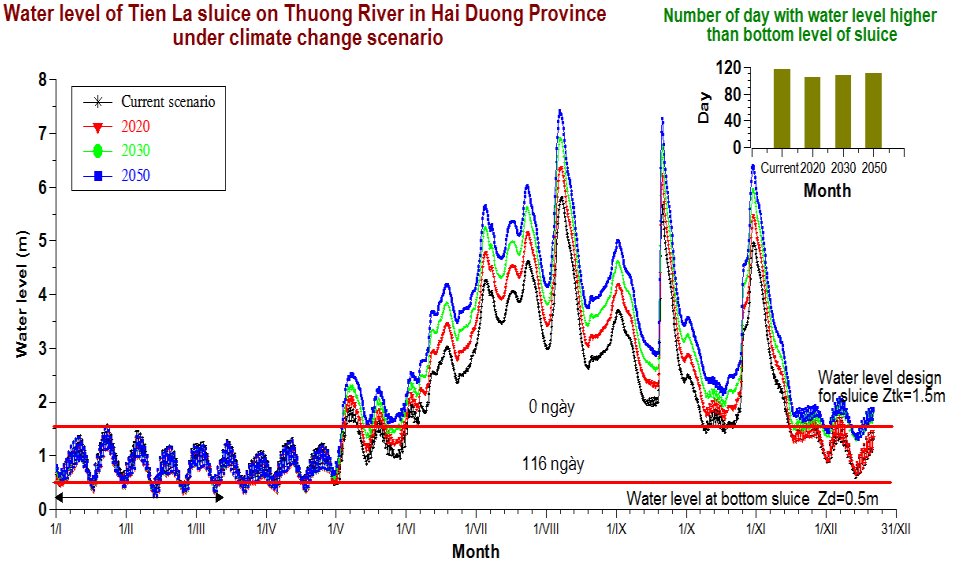

Fig 6. Water level of Tien La sluice on Thuong River in Hai Duong Province under climate change scenario

Some commented as follows:
- Water levels on the Red River in the dry season under climate change scenarios significantly reduced compared with 2010. At Ha Noi station on Red River, the water levels reduce in 2050 about 6.5cm (B2) and 7.5cm (A2) and 6cm (B1). At Nam Dinh station on Dao River, the water levels reduce in 2050 about 4cm (B2) and 5cm (A2) and 3cm (B1). At Cat Khe on Thai Binh River, the water levels reduce in 2050 about 2cm (B2) and 3cm (A2) and 1.5cm (B1). At An Bai on Kinh Thay River, the water levels reduce in 2050 about 5cm (B2) and 6cm (A2) and 4cm (B1). At Truc Phuong on Ninh Co River, the water levels reduce in 2050 about 6.5cm (B2) and 7.2cm (A2) and 5.8cm (B1).
- In the scenario in which 50% of the socio-economic development plans are achieved (SC6), the water demand is lower than the scenario of full development (SC5). The decrease in the average water level in the whole Red River system is about 1.3-1.8 cm less than in SC5, and in Thai Binh river this figure is about 1.4-2.1cm.
- In January and February is the time to use the most water for agriculture, the water level at some sluice is smaller than culvert high, thus leading to a number of days in January and February did not take enough water. Water levels on the Red River in the dry season under climate change scenarios significantly reduced compared with 2010. At Ha Noi station on Red River, the water levels reduce in 2050 about 6.5cm (B2) and 7.5cm (A2) and 6cm (B1). At Nam Dinh station on Dao River, the water levels reduce in 2050 about 4cm (B2) and 5cm (A2) and 3cm (B1). At Cat Khe on Thai Binh River, the water levels reduce in 2050 about 2cm (B2) and 3cm (A2) and 1.5cm (B1). At An Bai on Kinh Thay River, the water levels reduce in 2050 about 5cm (B2) and 6cm (A2) and 4cm (B1). At Truc Phuong on Ninh Co River, the water levels reduce in 2050 about 6.5cm (B2) and 7.2cm (A2) and 5.8cm (B1).

The lowering of the water level under climate change in the river has caused problems for irrigation during the dry season, in order to reach the target level in Hanoi.

4 Discussion and conclusions

The outputs from the MIKE 11 model steady state runs used to derive rating curves at each gauge location. It was typically found that the MIKE 11 model results matched well with gauged estimates of streamflow. The MIKE 11 model produced good calibrations and verification to all hydraulic stations on the Red River.

The model was used to model the impacts of climate change on flow regime in the Red River basin. In order to operate the MIKE 11 model, several data inputs are required, including the river network alignment, channel and floodplain cross sections, boundary data, and roughness coefficients. In hydraulic modeling, boundary conditions are required

to provide the model input at the edges of the domain. Upper boundary is hydrographs formulated by MIKE NAM model from the RRB in the following 11 sub-catchment and the lateral discharge of the model is the process lines of flow Q = f(t) entering the middle sub catchment calculated by hydrological model in currents condition and the future climate change.

References

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