ASSESSMENT OF SALINITY INTRUSION IN THE RED RIVER UNDER THE EFFECT OF CLIMATE CHANGE

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Introduction

- Red River System is the second largest river system in Vietnam.
- Large river basin with a complex topography: mountains and hills, delta and coastal areas.
- It is a population density area with high economic potential, hosting a diverse, makes a significant contribution to the national economy.
The Red River Delta is in reality the delta of two river systems: the Red River System and Thai binh River System.

In the dry season, water level in Red River fall down very low.
Tidal Regime and Salinity Intrusion

- The mixing of fresh and marine waters also is accelerated by tidal action.
- Tidal regime: irregularly diurnal, more regularly diurnal upstream.
- Maximum tidal range: approximately 4 m.
- The tidal transfer speed: 95-150 cm/sec.
- Tidal influence: 150-180 km from the river mouths.

Seawater and salinity are easy to go Red River Delta in almost of annual.
Objectives

- To estimate the longitudinal salinity dispersion at different branches in the Red River;
- To assess the effect of Hoabinh reservoir and Sonla reservoir to salinity intrusion;
- To assess the effect of “climate change” to salinity intrusion.
EFFECT OF HYDROPOWER PLANTS
Hoabinh Hydropower Plant

**Major objectives**
- Flood prevent
- Electricity generation
- Water supply for irrigation in dry season.

**Some characteristics**
- Surface of the reservoir $F=200$ km$^2$
- Length $L=230$ km
- Average width $B=1$ km
- Average depth $H=50$ m
- Volume $V=9.5$ billion m$^3$
- Capacity $P=1,920$ MW
- Average annual production of electricity $E=8$ billion KWh
Sonla Hydropower Plant: On-Going Construction

- **Major objectives**
  - Energy production: 14.16 bil.KWh/year
  - Regulation flood stream: very important for Hoabinh Dam and downstream areas.
  - Water supply: providing to the Red River Delta about 6 billion m³; during dry season will ensuring a sanitary run-off of 300-600m³/sec.

- **Some characteristics**
  - Normal water level: 265 m
  - Dam height: 177 m
  - Volume of reservoir: 25.4 billion m³
  - Surface of reservoir: 440 km²
  - Installment capacity: 3.600 MW
**Effect of Hoabinh and Sonla Hydropower Plant**

<table>
<thead>
<tr>
<th>Case Study</th>
<th>Discharge at Hoabinh Station</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>$Q = Q_0 - 400 \text{ m}^3/\text{s}$</td>
</tr>
<tr>
<td>2</td>
<td>$Q = Q_0$</td>
</tr>
<tr>
<td>3</td>
<td>$Q = Q_0 +115 \text{ m}^3/\text{s}$</td>
</tr>
</tbody>
</table>

($Q_0$: Discharge at present: by the year 2007)
EFFECT OF CLIMATE CHANGE
Effects

- Annual average temperature increases about 0.10°C per decade. In some summer months, temperature increases about 0.1-0.3°C per decade.
- More heavy rainfalls causing severe floods; High floods occur more frequently in the Central and Southern Vietnam.
- Drought happen every year in most regions of the country.
- Sea level rises from 2.5-3 cm per decade in the last century.

Viet Nam will be one of the five worst countries affected by SLR, especially hard hit by frequent affected by SLR.
Analysis of climate change in Vietnam - Temperature

Vietnam Annual Temperature, 1901-1998
Analysis of climate change in Vietnam - Precipitation

Vietnam Annual Precipitation, 1901-1998
Countries most affected by sea level rise 1 meter

Land area

Population

GDP %

Agricultural land

Source: (WB 2007)
Effect of SLR 1 meter

Diện tích bị ngập: 347,680 km²
Dân số bị ảnh hưởng: 46,683,288 người
Hanoi City living with floods! (November 2008)
Sea level rise

- loss of land;
- increased vulnerability to flooding, including storm events;
- accelerated erosion along the coasts and in river mouths;
- changes in the physical characteristics of tidal rivers.
- and increased salinization
Impacts on Coastal Zone

- Large areas of the Red River delta would be inundated due to SLR.
- Economic sea production capacity would be reduced by at least one third.
- Aquaculture farms will have to be relocated; coastal fisheries might disappear;
- Loss of habitat for fresh water creatures.
- The cost of sea dike maintenance will increase.
EFFECT OF CLIMATE CHANGE

- Vietnam is one of the most threatened by sea-level rise under climate change effects (IPCC).
- It is estimated that the sea level will rise at a rate between 0.3 and 1.0 m over the next 100 years.

**Zo: Sea level in 2007**

<table>
<thead>
<tr>
<th>Scenarios</th>
<th>2010</th>
<th>2050</th>
<th>2100</th>
</tr>
</thead>
<tbody>
<tr>
<td>Reference Best Guess</td>
<td>Z_{sea}=Z_{o}+0.13</td>
<td>Z_{sea}=Z_{o}+0.28</td>
<td>Z_{sea}=Z_{o}+0.58</td>
</tr>
</tbody>
</table>
Evaluate the effect of Hoabinh and Sonla Hydropower Plant

The length of intruded salt in Red River with salinity concentration values of 4psu

Case 1: 42km
Case 2: 35km
Case 3: 34km
Salinity Concentration along Thaibinh River in Different Case Studies
Evaluate the effect of Sea Level Rise Scenarios

Model output on Sea Level Rise in Red River Delta:

- At present:
  - Partial inundation: 14,000 ha
  - Completed inundation: 1,400 ha

- Scenario 0.58m SWL rise:
  - Partial inundation: 37,000 ha
  - Completed inundation: 18,500 ha
Evaluate the effect of Sea Level Rise Scenarios

- The freshwater distribution for different branches seems to be the governing factor for the salt concentration value.
- A small change in upstream discharge may vary the distribution of discharge in estuaries. It leads to appreciable change in salinity intrusion.
- For the Balat estuarine (Red River), at the distance of 41km from the sea, the salinity concentration varied from 2.78-4.03 psu for three scenarios.
- With salinity boundary is 4 psu, the length of intruded salt in Red River is about 40km from river mouth for all scenarios.
- The range of increase of salinity at every distance varied within value of 0.5-1 psu.

The variation of salinity concentration along the estuaries in Red-River System seems to be significant.
Conclusions

- The MIKE11 can be applied well to formulate salt intrusion into the estuary. The computed results are mostly fitted to the observed data.
- The outlet discharge from Hoabinh and Sonla Hydropower Plant plays an important role in pushing saltwater.
- Passed flow from Red River to Thaibinh River through Duong River and Luoc River plays an important role in salinity prevention in Thaibinh River.
- Under consideration of three scenarios with climate change conditions, it could be fairly said that the salinity intrusion into the Red River and Thaibinh River would be intensively affected under the effect of Sea Level Rise.
THANK YOU FOR YOUR ATTENTION
East Asia: Country area impacted

East Asia: Population impacted

The graph shows the percentage impact on the total population for various countries in East Asia, categorized by the depth of inundation (1 meter to 5 meters). The countries are listed from left to right as: Vietnam, Thailand, Myanmar, Taiwan, China, Cambodia, Philippines, Indonesia, China, Malaysia, North Korea, South Korea, Brunei, and Papua New Guinea. The bars indicate the population impacted at each depth level.
East Asia: GDP impacted
East Asia: Urban extent impacted

[Diagram showing urban extent impact by country in East Asia, with bars indicating percentage of urban extent impacted at different depth levels (1 meter to 5 meters)].
East Asia: Agricultural extent impacted
East Asia: Wetlands impacted

![Graph showing wetland impact in East Asia countries](image-url)