Assessment of potential effect of surface water withdrawal in the Delta region on water flow and salinity level considering various climate change scenarios

Contributors:
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Objectives of the Study

Assess the potential effects of surface water withdrawal on water flow and salinity levels in the south central coastal hydrological zone (largely within Barisal Division) considering various climate change scenarios.
Geographical Location of Bangladesh

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Study Area

Shiliguri
Meghalaya
Dhaka
Tripura

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Primary Data Collection

Total 440 nos. Structure collected in Site-A

Non functional regulator in Gozalia village, Babugonj, Barisal

Bridge on Rayer khal at Kashipur, Barisal

Irrigation pump cum regulator in Rayer khal at Kashipur, Barisal
Tidal Characteristics

Seasonal variation in Study Area River Basin ranges from 0.73m to 1.18 m
Cropland of the Basin Area

Five Major River Basin

Cropland of Five Major River Basin
Measured Salinity Level

Measured Salinity at Batage

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Application of Modelling System

Mathematical Modelling Tools
- MIKE 21 FM (Bay of Bengal Tide Model and Salinity Model)
- MIKE 11 (Water Flow Model for South-West Region Model)

Flow Chart for Water Flow and Salinity Modelling Technique

- Global Tide Model
  - Water Level at d/s Boundary
- Hydrodynamic Model
  - Water Flow
- Salinity Model
  - Salinity Boundary at u/s
- 2-D Bay of Bengal Model (BoBM): Water Flow & Salinity
- 1-D River Water Flow & Salinity Model
  - Water Flow at u/s Boundary
  - Water Level at d/s Boundary
  - Cross-Section
  - Salinity Boundary at u/s
  - Rainfall, Evaporation & Water extraction
  - Catchment Runoff
  - Water Flow at u/s Boundary
  - Water Flow at Upstream
  - Salinity Intrusion & Mapping
Water Flow and Salinity Modelling System

- Input Parameter
  - River Network
  - River Bathymetry
  - Model Boundary
    - Water Level at US
    - Water Flow at DS
    - Salinity Level at DS
  - Rainfall Runoff

- Calibration Parameter
  - River Roughness
Calibration of Salinity Model

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Variation of Salinity Level during Dry Season

Legend (4 ds per m salinity contour line)
- 4 ds per m salinity line_Jan (2015)
- 4 ds per m salinity line_Feb (2015)
- 4 ds per m salinity line_Mar (2015)
- 4 ds per m salinity line_Apr (2015)
Exposure of Area to different salinity Level (Existing Condition)

Exposure of Area (February, 2015)

Exposure of Area (March, 2015)
Future Conditions and Climate Change for simulations of Alternative Options

Future Conditions and Climate Change for simulations of Alternative Options

- Different Hydrological Events (Frequency of Exceedence) at Upstream Flow Boundary (Baruria);
- Water Withdrawal for Irrigation from the Five River Basin;
- Decrease in Flow at Upstream Flow Boundary;
- Sea Level Rise Effects on the Downstream Water Level Boundary;
- Increase in Salinity Level at the Downstream(along the coast) Salinity Boundary;
- Change in Precipitation for the South-Central Coastal Region of Bangladesh;
- Change in Temperature for the South-Central Coastal Region of Bangladesh;

Climate Change Scenarios

- Extreme Climate Change Scenario (RCP 8.5, 2050)
- Extreme Climate Change Scenario (RCP 8.5, 2030)
- Moderate Climate Change Scenario (RCP 4.5, 2050)
Future Conditions and Climate Change for simulations of Alternative Options
Future Conditions and Climate Change for simulations of Alternative Options

Different Hydrological Events at Upstream Flow Boundary (Baruria)

10 Percentile dependable flow condition at Baruria [m^3/s]
50 Percentile dependable flow condition at Baruria [m^3/s]
90 Percentile dependable flow condition at Baruria [m^3/s]
Water flow hydrograph of 2015 at Baruria [m^3/s]
## Water Withdrawal from the Five River Basin

<table>
<thead>
<tr>
<th>Application no.</th>
<th>Date of application</th>
<th>Irrigation Time (Min)</th>
<th>Applied irrigation water (m³)</th>
<th>Irrigation Area (ha)</th>
<th>Applied irrigation water (m³/ha/day) according to FAO</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>22/01/2016</td>
<td>120</td>
<td>85.32</td>
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<td>605.11</td>
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<td>2</td>
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<td>55.76</td>
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<td>395.46</td>
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<tr>
<td>5</td>
<td>05/02/2016</td>
<td>77.4</td>
<td>57.32</td>
<td>0.141</td>
<td>406.52</td>
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<tr>
<td>6</td>
<td>11/02/2016</td>
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<td>55.43</td>
<td>0.141</td>
<td>393.12</td>
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<tr>
<td>7</td>
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<td>62.39</td>
<td>0.141</td>
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<tr>
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<td>29/02/2016</td>
<td>121.5</td>
<td>85.13</td>
<td>0.141</td>
<td>603.76</td>
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<tr>
<td>9</td>
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<td>85.32</td>
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<td>55.76</td>
<td>0.141</td>
<td>395.46</td>
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<tr>
<td>11</td>
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<td>76.5</td>
<td>69.71</td>
<td>0.141</td>
<td>494.40</td>
</tr>
<tr>
<td>12</td>
<td>30/03/2016</td>
<td>77.5</td>
<td>57.56</td>
<td>0.141</td>
<td>408.23</td>
</tr>
<tr>
<td>13</td>
<td>03/04/2016</td>
<td>75.4</td>
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<td>406.52</td>
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<td>84.3</td>
<td>85.13</td>
<td>0.141</td>
<td>603.76</td>
</tr>
</tbody>
</table>

| Total          |                     | **1057.24**           | **7498.16**                 |                     | **13271.74**                                        |
Future Conditions and Climate Change for simulations of Alternative Options

Water Withdrawal from the River Basin

Water Withdrawal from Baleswar River Basin

Water Withdrawal from Lohalia River Basin

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Future Conditions and Climate Change for simulations of Alternative Options

Decrease in Flow at Upstream Flow Boundary

Discharge Projection for extreme climate change condition (RCP 8.5)

<table>
<thead>
<tr>
<th>Month</th>
<th>% change in Discharge (2050)</th>
<th>% change in Discharge (2030)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>-8%</td>
<td>-7%</td>
</tr>
<tr>
<td>Feb</td>
<td>-9%</td>
<td>-8%</td>
</tr>
<tr>
<td>Mar</td>
<td>-13%</td>
<td>-10%</td>
</tr>
<tr>
<td>Apr</td>
<td>-8%</td>
<td>-5%</td>
</tr>
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</table>

Discharge Projection for Moderate climate change condition (RCP 4.5)

<table>
<thead>
<tr>
<th>Month</th>
<th>% change in Discharge (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jan</td>
<td>-4%</td>
</tr>
<tr>
<td>Feb</td>
<td>-5%</td>
</tr>
<tr>
<td>Mar</td>
<td>-6%</td>
</tr>
<tr>
<td>Apr</td>
<td>-9%</td>
</tr>
</tbody>
</table>
Future Conditions and Climate Change for simulations of Alternative Options

Sea Level Rise Effects on the Downstream Water Level Boundary

<table>
<thead>
<tr>
<th>Climate Change Scenarios</th>
<th>Year</th>
<th>Sea Level Rise (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extreme Climate Change Event (RCP 8.5)</td>
<td>2050</td>
<td>43</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>22</td>
</tr>
<tr>
<td>Moderate Climate Change Event (RCP 4.5)</td>
<td>2050</td>
<td>33</td>
</tr>
<tr>
<td></td>
<td>2030</td>
<td>20</td>
</tr>
</tbody>
</table>

Change in Precipitation at Extreme Climate Change Condition (2050)

<table>
<thead>
<tr>
<th>Month</th>
<th>% change of Precipitation in the South-Central Coastal Zone</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>-14.53</td>
</tr>
<tr>
<td>February</td>
<td>3.24</td>
</tr>
<tr>
<td>March</td>
<td>-0.40</td>
</tr>
<tr>
<td>April</td>
<td>-10.70</td>
</tr>
</tbody>
</table>
# Future Conditions and Climate Change for simulations of Alternative Options

## Increase in Salinity Level at the Downstream Salinity Boundary

<table>
<thead>
<tr>
<th>Station</th>
<th>River Name</th>
<th>RCP 8.5 (2030)</th>
<th>RCP 8.5 (2050)</th>
<th>RCP 4.5 (2050)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DS at Jamuna</td>
<td>Jamuna</td>
<td>0.0</td>
<td>0.0</td>
<td>0.0</td>
</tr>
<tr>
<td>DS at Malancha</td>
<td>Malancha</td>
<td>0.06</td>
<td>0.20</td>
<td>0.10</td>
</tr>
<tr>
<td>DS at Pussur</td>
<td>Pussur</td>
<td>0.13</td>
<td>0.30</td>
<td>0.20</td>
</tr>
<tr>
<td>DS at Pussurkhal</td>
<td>Pussurkhal</td>
<td>0.19</td>
<td>0.40</td>
<td>0.30</td>
</tr>
<tr>
<td>DS at Selagang</td>
<td>Selagang</td>
<td>0.25</td>
<td>0.50</td>
<td>0.40</td>
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<tr>
<td>DS at Betmaragang</td>
<td>Betmaragang</td>
<td>0.31</td>
<td>0.50</td>
<td>0.45</td>
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<tr>
<td>DS at Supotikhal</td>
<td>Supotikhal</td>
<td>0.38</td>
<td>0.80</td>
<td>0.60</td>
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<tr>
<td>DS at Haringhata</td>
<td>Baleswar</td>
<td>0.44</td>
<td>1.02</td>
<td>0.70</td>
</tr>
<tr>
<td>DS at Andharmanik</td>
<td>Andharmanik</td>
<td>0.50</td>
<td>1.20</td>
<td>0.80</td>
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<tr>
<td>DS at Khappravanga</td>
<td>Khappravanga</td>
<td>0.55</td>
<td>1.22</td>
<td>0.90</td>
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<tr>
<td>DS at Tentulia</td>
<td>Tentulia</td>
<td>0.56</td>
<td>1.50</td>
<td>0.90</td>
</tr>
<tr>
<td>DS at Shabazpur</td>
<td>Shabazpur</td>
<td>0.58</td>
<td>1.50</td>
<td>1.0</td>
</tr>
</tbody>
</table>
Alternative Options for Impact of water withdrawal and climate change

Option:1
Water Withdrawal based on field water requirement for different dependable flow
- 10 Percentile dependable flow at upstream;
- 50 Percentile dependable flow at upstream;
- 90 Percentile dependable flow at upstream;

Option:2
Water withdrawal based on field water requirement and Extreme and moderate Climate Change condition for different dependable flow
- 10 Percentile dependable flow at upstream;
- 50 Percentile dependable flow at upstream;
- 90 Percentile dependable flow at upstream;
- Sea Level Rise at downstream water level boundary;
- Increase in salinity level at the downstream salinity boundary;
- Decrease in flow at upstream flow boundary;
Impact of water withdrawal and climate change on Salinity Level
Impact of water withdrawal and climate change

Change of Exposure of Cropland to salinity Level during Extreme and Moderate climate change condition (February)

- No significant change on salinity intrusion due to only water extraction and extraction with moderate climate change condition and extraction with extreme climate change condition (2050);
- Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)
Impact of water withdrawal and climate change

- No significant change on salinity intrusion due to only water extraction and extraction with moderate climate change condition (2050);
- Significant changes under extraction with extreme climate change condition (2050);
- Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)

Change of Exposure of Cropland to salinity Level during Extreme and Moderate climate change condition (March)
Impact of water withdrawal and climate change

- (a) 90% dependable flow
- (b) 90% dependable flow + Extraction
- (c) 90% dependable flow + Extraction + RCP 8.5 (2050)
- (d) 90% dependable flow + Extraction + RCP 4.5 (2050)

Change of Exposure of Cropland to salinity Level during Extreme and Moderate climate change condition (April)

- No significant change on salinity intrusion due to only water extraction and extraction with moderate climate change condition (2050);
- Significant changes under extraction with extreme climate change condition (2050);
- Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)
Impact of water withdrawal and climate change

- No significant change on salinity intrusion due to only water extraction and extraction with extreme climate change condition (2030) and extraction with extreme climate change condition (2050);
- Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)

Change of Exposure of Cropland to salinity Level during Extreme climate change condition for different period (February)
Impact of water withdrawal and climate change

- (a) 90% dependable flow
- (b) 90% dependable flow + Extraction
- (c) 90% dependable flow + Extraction + RCP 8.5 (2050)
- (e) 90% dependable flow + Extraction + RCP 8.5 (2030)

Change of Exposure of Cropland to salinity Level during Extreme climate change condition for different period (March)

- No significant change on salinity intrusion due to only water extraction and extraction with moderate climate change condition (2030);
- Significant changes under extraction with extreme climate change condition (2050);
- Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)
Conclusions

- Currently, abundant fresh water is available in the major five river basin for intensification of agriculture
- The critical issues are fresh water availability and salinity intrusion with withdrawal of water in times of climate change
- Simulation of option shows
  - no significant change on salinity intrusion due to only water extraction and extraction with moderate climate change condition (2050);
  - Significant changes under extraction with extreme climate change condition;
  - Low saline area (0-2 ds/m) decreases increasing the high saline area (2.1-4 ds/m)
Thank You