Assessment of Ecosystem services with considering impact of Climate change on Godavari basin

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- Methodology and study area
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Introduction

• Hydrological simulation models are being used to address an extensive array of water resources problems across the globe, including the effects of alternative best management practices (BMPs) and future climate change on stream-flow.

• Global climate models (GCMs)/regional climate models (RCM’s) downscaled data is used as input to hydrologic models to simulate the corresponding future flow regime in the catchment.

• To drive a hydrological model, reliable information on climatological variables (e.g. temperature, precipitation, evapotranspiration, etc.) and their distribution in space and time are required.
Study area

Godavari Basin extends over an area of 3,12,812 km², which is nearly 9.5% of the total geographical area of the country.

Figure 1: Godavari basin
• The Godavari, Perennial River of India is the Second largest river in India.
• It flows in the southern India and is considered to be one of the seven sacred rivers.
• The annual rainfall of Godavari basin varies from 3000 mm to 600 mm.
• The Godavari basin receives major part of its rainfall during the Southwest monsoon period. They contribute about 16% of the total annual rainfall in the Godavari basin.
Motivation to take up this study

- The present status of the Godavari river basin, considering the drought and upcoming projects it is clear that the effects of all these will be on eco-system of the river and surrounding areas.
- A coupled atmospheric and hydrological modeling is necessary to understand the quality and quantity of flow in river
- This study we consider the effect of climate change on the river basin, concerning to the flow in the river using QSWAT and intern to study the effect on the ecosystem.
Objectives

• Developing a Hydrological model for Godavari basin using QSWAT
• Calibrate and validation of stream flow using SWAT-CUP
• Prepare simulated climate change data for watershed-based hydrologic impact studies using the CMhyd (Climate Model data for hydrologic modelling) tool
• Use of downscaled (bias corrected) atmospheric parameters in hydrological model to predict future climate scenarios
• To support decisions towards sustainable water management in the Godavari basin, by quantitatively estimating the availability of water-related ecosystem services in the basin
• Use of the outputs from QSWAT, for mapping ecosystem services
Methodology

Figure 2: Overview of methodology
CMhyd (Climate Model data for hydrologic modeling)

- Prepare simulated climate change data for watershed-based hydrologic impact studies
- It identifies biases between observed and simulated historical climate variables to parameterize a bias correction algorithm that is used to correct simulated historical climate data
- CORDEX achieve was considered for regional climate model
- CMIP5 (South Asia) climate projection data was used for entire Godavari basin
- Pr, Tmax, and Tmin variables were considered for historical time period of 1995-2005, and future data (RCP85) for 2091-2100
- Observed data (Pr, Tmax, and Tmin) used considering 279 weather stations falling in Godavari basin
Figure 3: Bias correction framework
(Source: Cmhyd user manual)
Figure 4: PCP time series for gauge station 244
Figure 5: PCP monthly summary for gauge station 244
Figure 6: PCP time series for gauge station 270
Figure 7: PCP monthly summary for gauge station 270
Figure 8: TMP monthly summary for gauge station 270
Figure 9: TMP time series for gauge station 270
Figure 10: TMP monthly summary for gauge station 244
Figure 11: TMP time series for gauge station 244
QSWAT – The QGIS interface for SWAT

• 120 sub-basins were formed in the entire Godavari basin
• The model was run from the period 1970 to 2014
• 5 years of warm period was considered
• For calibration of stream flow period of 1984-2004 was considered
• Validation was done for stream flow was from 2005-2014
• 5 parameters namely CN, GW_REVAP, REVAPMN, ESCO and EPCO was considered for optimization
LULC map of godavari basin
Sub-basins
Flow in the river basin

Results
sim1 FLOW_OUTcms Monthly means
- 0 - 204
- 204 - 600
- 600 - 1112
- 1112 - 4824
- 4824 - 6599
Surface runoff obtained

Results

sim1 SURQmm Monthly means
- 0.0 - 10.5
- 10.5 - 25.2
- 25.2 - 31.5
- 31.5 - 39.9
- 39.9 - 53.7
Organic N (kg/ha)
Organic P(kg/ha)

Results

<table>
<thead>
<tr>
<th>sim1 ORGPhg_ha Annual means</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.00 - 0.00</td>
</tr>
<tr>
<td>0.00 - 0.72</td>
</tr>
<tr>
<td>0.72 - 0.98</td>
</tr>
<tr>
<td>0.98 - 1.24</td>
</tr>
<tr>
<td>1.24 - 1.83</td>
</tr>
</tbody>
</table>
Hydrology of basin

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PET 2.149.1

Evaporation and Transpiration 545.5

Precipitation 1,402.5

Average Curve Number 79.01

Root Zone

Vadose (unsaturated) Zone

Shallow (unconfined) Aquifer

Confining Layer

Deep (confined) Aquifer

Infiltration/plant uptake/Soil moisture redistribution

Revap from shallow aquifer 42.8

Percolation to shallow aquifer 427.91

Flow out of watershed

Lateral Flow

Surface Runoff

Return Flow 363.6

Recharge to deep aquifer 21.4

All Units mm
Sediment loss

![Diagram showing sediment loss in a watershed system.](image-url)
Nitrogen cycle

<table>
<thead>
<tr>
<th>Nitrogen Losses</th>
<th>(Kg/ha)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total N loss</td>
<td>12.71</td>
</tr>
<tr>
<td>Organic N</td>
<td>8.52</td>
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<tr>
<td>Nitrate surface runoff</td>
<td>0.021</td>
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<tr>
<td>Nitrate leached</td>
<td>4.06</td>
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Phosphorous Losses (Kg/ha)

<table>
<thead>
<tr>
<th>Loss Type</th>
<th>Value</th>
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<tr>
<td>Total P loss</td>
<td>1.09</td>
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<tr>
<td>Organic P</td>
<td>1.03</td>
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<tr>
<td>Phosphorous surface runoff</td>
<td>0.058</td>
</tr>
<tr>
<td>Solubility ratio in runoff</td>
<td>0.053</td>
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</table>
Table 1: Average monthly basin values

<table>
<thead>
<tr>
<th>Mon</th>
<th>Rain (MM)</th>
<th>Snow Fall (MM)</th>
<th>SURF Q (MM)</th>
<th>LAT Q (MM)</th>
<th>Water Yield (MM)</th>
<th>ET (MM)</th>
<th>Sed. Yield (MM)</th>
<th>PET (MM)</th>
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<tr>
<td>1</td>
<td>13.08</td>
<td>0.00</td>
<td>0.50</td>
<td>1.34</td>
<td>10.53</td>
<td>17.91</td>
<td>0.01</td>
<td>145.46</td>
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<td>2</td>
<td>7.34</td>
<td>0.00</td>
<td>0.41</td>
<td>0.99</td>
<td>3.74</td>
<td>15.71</td>
<td>0.03</td>
<td>174.16</td>
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<tr>
<td>3</td>
<td>8.84</td>
<td>0.00</td>
<td>0.51</td>
<td>0.90</td>
<td>2.72</td>
<td>67.41</td>
<td>0.01</td>
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<td>4</td>
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<td>0.04</td>
<td>0.71</td>
<td>1.75</td>
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<td>5</td>
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<td>0.58</td>
<td>0.60</td>
<td>1.84</td>
<td>10.38</td>
<td>0.00</td>
<td>329.45</td>
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<td>6</td>
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<td>39.05</td>
<td>0.57</td>
<td>26.86</td>
<td>55.84</td>
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<td>7</td>
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<td>135.78</td>
<td>1.18</td>
<td>134.11</td>
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<td>8</td>
<td>380.60</td>
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<td>137.47</td>
<td>2.14</td>
<td>206.00</td>
<td>79.65</td>
<td>5.89</td>
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<tr>
<td>9</td>
<td>235.35</td>
<td>0.00</td>
<td>67.15</td>
<td>2.60</td>
<td>187.38</td>
<td>80.02</td>
<td>2.81</td>
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<tr>
<td>10</td>
<td>103.81</td>
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<td>25.91</td>
<td>2.55</td>
<td>135.85</td>
<td>57.06</td>
<td>1.13</td>
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<td>70.48</td>
<td>31.49</td>
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<tr>
<td>12</td>
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<td>0.59</td>
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<td>34.34</td>
<td>18.18</td>
<td>0.03</td>
<td>131.26</td>
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Parameter value v/s objective function
Summary of parameters

<table>
<thead>
<tr>
<th>Variable</th>
<th>p-factor</th>
<th>r-factor</th>
<th>R2</th>
<th>NS</th>
<th>bR2</th>
<th>MSE</th>
<th>SSQR</th>
<th>PBIAS</th>
<th>KGE</th>
<th>RSR</th>
<th>VOL_FR</th>
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<tbody>
<tr>
<td>Mean_sim(Mean_obs)</td>
<td>0.29</td>
<td>0.21</td>
<td>0.66</td>
<td>0.51</td>
<td>0.64</td>
<td>8.4e+006</td>
<td>1.1e+06</td>
<td>59.7</td>
<td>0.70</td>
<td>0.70</td>
<td>0.87</td>
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<tr>
<td>StdDev_sim(StdDev_obs)</td>
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<tr>
<td>FLOW_OUT_60</td>
<td>2961.02(2589.23)</td>
<td>4948.23(4145.98)</td>
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</table>

Results for behavioral parameters

Behavioral threshold = 0.300000

Number of behavioral simulations = 500
FLOW_OUT_60
Conclusion

- QSWAT can be used to map the ecosystem component and visualize the output, the model predicted excessive runoff and water yield.
- The model predicted streamflow/Precipitation ratio as 0.5, Surface Runoff/Total flow as 0.52, ET/ Precipitation as 0.39.
- Flow calibrated shows a root mean square error of 0.66 and NS coefficient of 0.56.
- Total nitrogen losses are greater than 40% of applied N.
- Nitrate losses in surface runoff is low.
- Solubility ratio for nitrogen and phosphorus in runoff is low.
- Further work is required to incorporate reservoir component and predict sediment loads.
- Bias-corrected precipitation and temperature should be used to predict the future flow.
Thank You

Any questions?