HYDROLOGICAL MODELLING OF GOI RIVER WATERSHED OF NARMADA BASIN USING SOIL & WATER ASSESSMENT TOOL (SWAT)

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Contents

- Introduction
- Importance of Watershed Modelling
- Problem Statement
- Objectives
- Study area
- Data used & Methodology
- SWAT Modelling Process
- Calibration, Uncertainty & Parameter Sensitivity, Validation
- Results & Conclusion
- Limitations & Future plans
Introduction

- The Watershed complexity at all levels that pushes us to move towards the advancement in modelling & its components.
- The occurrence of climate change scenarios and uncertainties arising from different aspects needs to be inculcated and many such parameters associated are to be easily handled by modelling techniques only.
- The watershed management activities that are planned for the regional to local administration level needs a good scale difference model respectively.
- Apart from above, the changing landuse/land cover, industrialization activities that are dynamic in pattern has remarkable impact on the watershed and it needs to be addressed very precisely.
Importance of Watershed Modelling

- It meant for formalizing knowledge about hydrological systems.
- The ultimate aim is to improve decision making process about a hydrological problem e.g. drinking water, agricultural needs, water resources planning, flood protection, mitigation of contamination, etc., by keeping sustainability as a goal.
- The models are the useful tools and default choice for predicting future from the current & past scenarios.

Future Management activities such as Water & other resources management, Ecological restoration, etc., in the Watershed at different scale with different Data resolutions that directly or indirectly related with Socio-economic and political processes associated with it.
A Schematic outline of the steps in the modelling process

1. Revise perceptions
   - The perceptual Model: Deciding on the processes

2. Revise equations
   - The Conceptual Model: Deciding on the equations

3. Debug code
   - The Procedural Model: Getting the code to run on a computer

4. Check for data errors
   - Model Calibration: Getting values of the parameters

5. Revise parameter values
   - Model Validation: A good idea but difficult in practice

Success ?

No

Yes
Problem Statement

- Geographically, the problems identified at local scale level and their solutions, provides really an optimal sustainable development, maintenance of quality and efficient use of water resources to match with growing demands.

- By keeping this in mind, the area covered by Goi Watershed of Narmadha Basin in West Central India which has problems of flooding, irrigation and drought in different years with evident is taken into consideration.
Objectives

- Development of Hydrological model using SWAT
- Model Calibration, Uncertainty Prediction, Parameter Sensitivity Analysis and Validation of model.
The Study area is Goi River Watershed of Narmada basin in India. This Goi river is considered to be one of the friends river of Narmada River. The delineated watershed area is about $1690.52 \text{ km}^2$.

It lies in the Lat, Lon range of $21° 30’N$ to $22° 0’N$ and $74° 30’E$ to $75° 25’E$ respectively.

The discharge measuring station is at Pati established by CWC, India.

The minimum and maximum elevation range is from $131m$ to $950m$. 
Data Used

- **LandUse/Land Cover**
  - The landuse/land cover is obtained from NRSC/ISRO (2005)

- **Soil**
  - NBSS&LUP Soil Information

- **Slope**
  - Cartosat-DEM Version-3DR

- **Weather Data**
  - IMD(PCP) & NASA(other)
Weather Data

- Precipitation
  - IMD 0.25° X 0.25° Gridded Rainfall(2003-2010)
- Temperature
  - NASA Merra 0.5° X 0.5° Gridded Temperature(2003-2010)
- Relative Humidity
  - NASA Merra 0.5° X 0.5° Gridded RH(2003-2010)
- Solar Radiation
  - NASA Merra 0.5° X 0.5° Gridded SR(2003-2010)
- Wind Speed
  - NASA Merra 0.5° X 0.5° Gridded Wind Speed(2003-2010)
IMD Rainfall (2003-2006)
IMD Rainfall (2008-2010)
Methodology

Data Used
- Landuse
- Soil
- Slope
- Weather Data
  - Precipitation
  - Temperature
  - Relative Humidity
  - Solar Radiation
  - Wind Speed

SWAT MODEL

Calibration
Sensitivity Analysis
Validation

SWAT-CUP
SUFI-2 Algorithm

Uncertainty Analysis

Model Application for Various Planning & Watershed Management Activities

SWAT Model Output
SWAT Modelling Process

- Watershed Delineation
- Physical land data input
  - HRU Generation
- Weather data & other SWAT input’s
- SWAT simulation run
Water Balance - Simulation Monthly

Water Balance Ratios

- Streamflow/Precip: 0.54
- Baseflow/Total Flow: 0.59
- Surface Runoff/Total Flow: 0.41
- Perc/Precip: 0.34
- Deep Recharge/Precip: 0.02
- ET/Precipitation: 0.4

PET: 2.493.5

Evaporation and Transpiration: 562.5
Precipitation: 1.397.2

Average Curve Number: 80.55

Root Zone
Vadose (unsaturated) Zone
Shallow (unconfined) Aquifer
Confining Layer
Deep (confined) Aquifer

Infiltration/plant uptake/Soil moisture redistribution
Revap from shallow aquifer
Percolation to shallow aquifer
Flow out of watershed
Recharge to deep aquifer

Return Flow: 404.21
Lateral Flow: 43.3
Surface Runoff: 311.02

All Units mm
Uncertainty Analysis

- The Uncertainty in any part of modelling process and calibration process should be addressed and the error propagation in the model should be minimized. Hence, it will be implemented for solving the real world problems.

- The SWAT Automatic Calibration & Uncertainty Prediction program (SWAT-CUP) is used here.

- This uses the widely practiced SUFI-2 Algorithms for optimization of the values.
Calibration using Discharge Data

- The Model is calibrated using the Discharge data available for a period of 2003-2006 and validated for a period of 2008 - 2010.
- Probably, the Discharge data collected are not completely reliable since there might be an error in data recording (Unclassified data, CWC).
- This calibration datasets are checked twice before input in analysis. The doubtful or erroneous data of particular date can be skipped from the analysis.
Rainfall Vs Discharge (2008-2010)

Observed Rainfall

Discharge (umecs)

Years (2008-2010)
Calibration Years (2003-2006)

Y = 0.833X + 0.794
R² = 0.791

Observed Vs Simulated Discharge (Input IMD data)
Sensitivity Analysis

Significant parameters in Model
Parameter Sensitivity

The diagram illustrates the sensitivity of various parameters to t-stat values. The parameters include:

- 6: V_REVAPMIN.gw
- 7: R_SOL_AWC(..).sol
- 10: V_ESCO.hru
- 9: R_SOL_BD(..).sol
- 2: V_ALPHA_BF.gw
- 11: V_EPCO.hru
- 13: V_SLSUBBSN.hru
- 14: V_CH_N2.rte
- 15: V_SURLAG.bsn
- 1: R_CN2.mgt
- 8: R_SOL_K(..).sol
- 12: V_OV_N.hru
- 3: V_GW_DELAY.gw
- 5: V_GW_REVAP.gw
- 4: V_GWQMN.gw

The x-axis represents the t-stat values, while the y-axis lists the parameters. The height of each bar indicates the sensitivity level of each parameter.
Validation Years (2008-2010)

Observed Vs Simulated Discharge (Input IMD Data)

\[ Y = 0.865 X + 2.903 \]

\[ R^2 = 0.835 \]
Validation Years (2008-2010)

Observed Vs Simulated Discharge (2008-2010)
## Calibrations & Validation Statistics

<table>
<thead>
<tr>
<th>Test</th>
<th>$R^2$</th>
<th>NSE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration 1 (500 Simulations)</td>
<td>0.68</td>
<td>0.63</td>
</tr>
<tr>
<td>Calibration 2 (500 Simulations)</td>
<td>0.78</td>
<td>0.74</td>
</tr>
<tr>
<td>Calibration 3 (500 Simulations)</td>
<td>0.79</td>
<td>0.79</td>
</tr>
<tr>
<td>Validation (500 Simulations)</td>
<td>0.84</td>
<td>0.78</td>
</tr>
</tbody>
</table>
Results and Conclusions

- The Calibration and Validation statistics of the model shows that the model is performing good in predicting the observed discharges.
- This in turn can state that the model can be applied for various watershed management studies, etc.,
- This study briefs about the Development of Hydrological model at a watershed scale with the data limitation at its side and how well the planning and managerial activities can be addressed using it.
Limitations & Future plans on this study

- As far as this study is concerned the data constrains are major factors.

- The period of data taken can be revised for further improvements in the model and the use of higher resolution of data.

- The Results from the model can be applied & integrated with many of the Remote Sensing Applications in the real scenario and various inferences could be extracted.
Future plans and extensions of the study

- The major focus is on planning and management oriented applications such as
- Watershed Prioritization,
- Land & Water resources management,
- Flood control, Drought & Irrigation management,
- Drinking water facilities,
- Agricultural practices & management activities,
- Integrated watershed management
- Water sharing and water disputes
- Other Socio-economic and political related problems and issues.
Save Water ...