Estimating catchment sediment yield, reservoir sedimentation and reservoir effective life using SWAT Model

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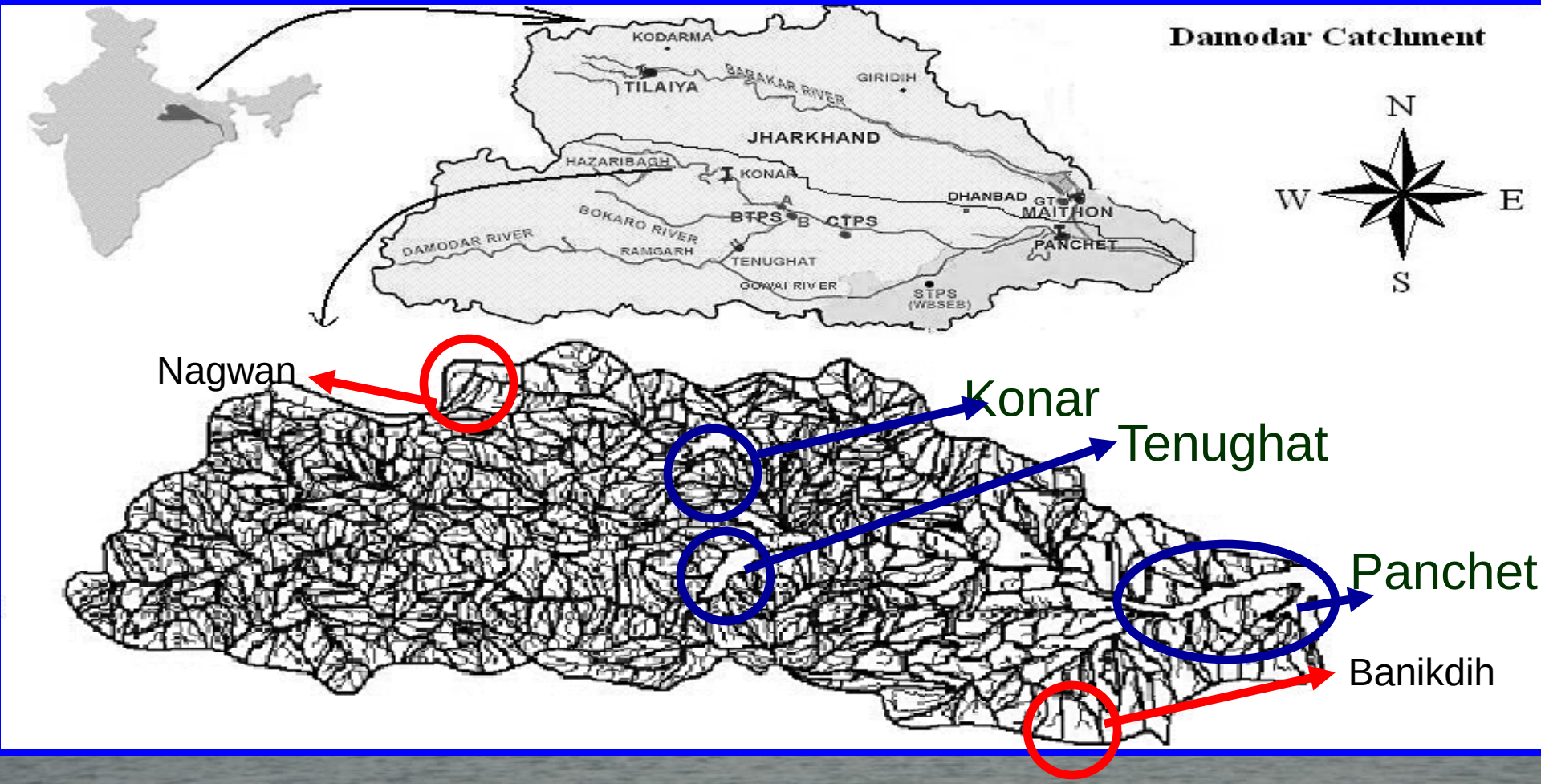
Soil and Water Assessment Tool

Introduction

- Land and water are two basic natural resources
- Monsoon season is the primary source of water in India
- Dams are constructed across the river to craft the reservoirs
- Sedimentation is common phenomenon in all reservoir
- Necessity to have strategy and tools to manage and accesses the sedimentation in reservoir to ensure the long use of reservoir
- Modeling the runoff and sediment of the catchment

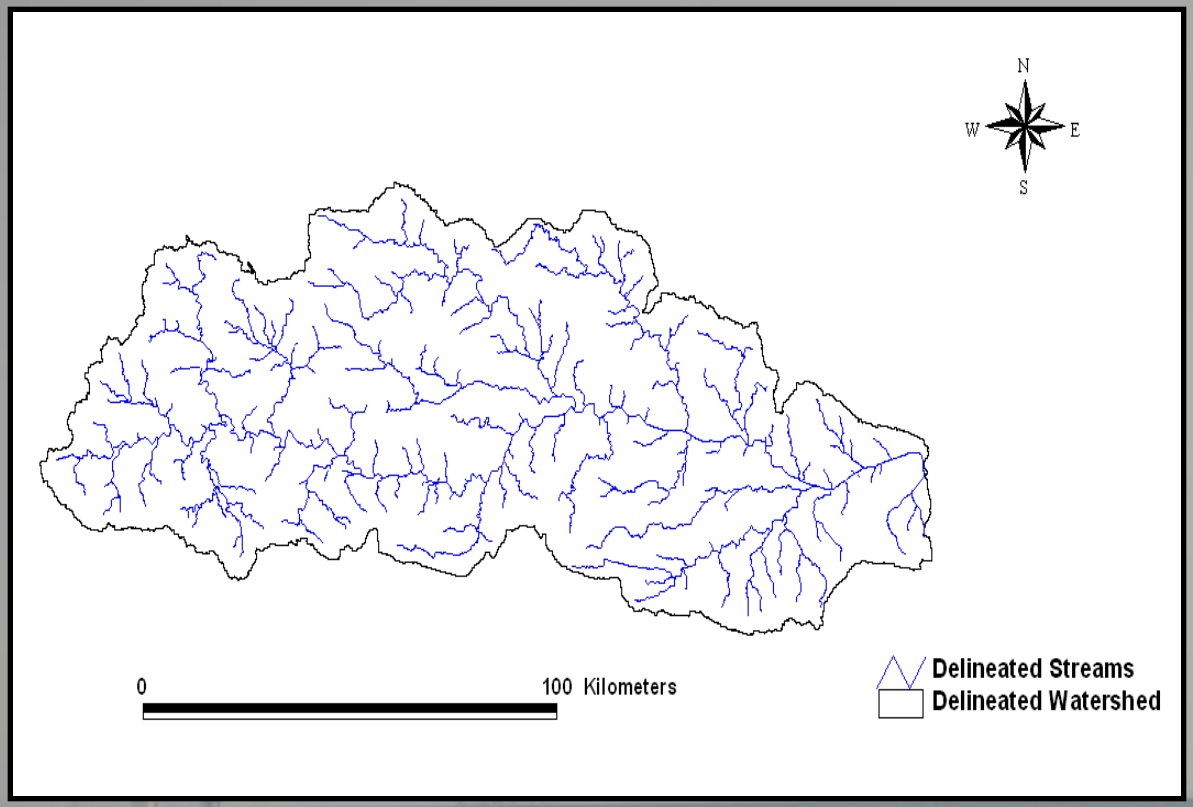
STUDY AREA



- Drainage Area: 11153.10 km^2
- Watersheds: 472
- Average annual rainfall: 1250 mm
- Temperature variation: 4°C to 43°C

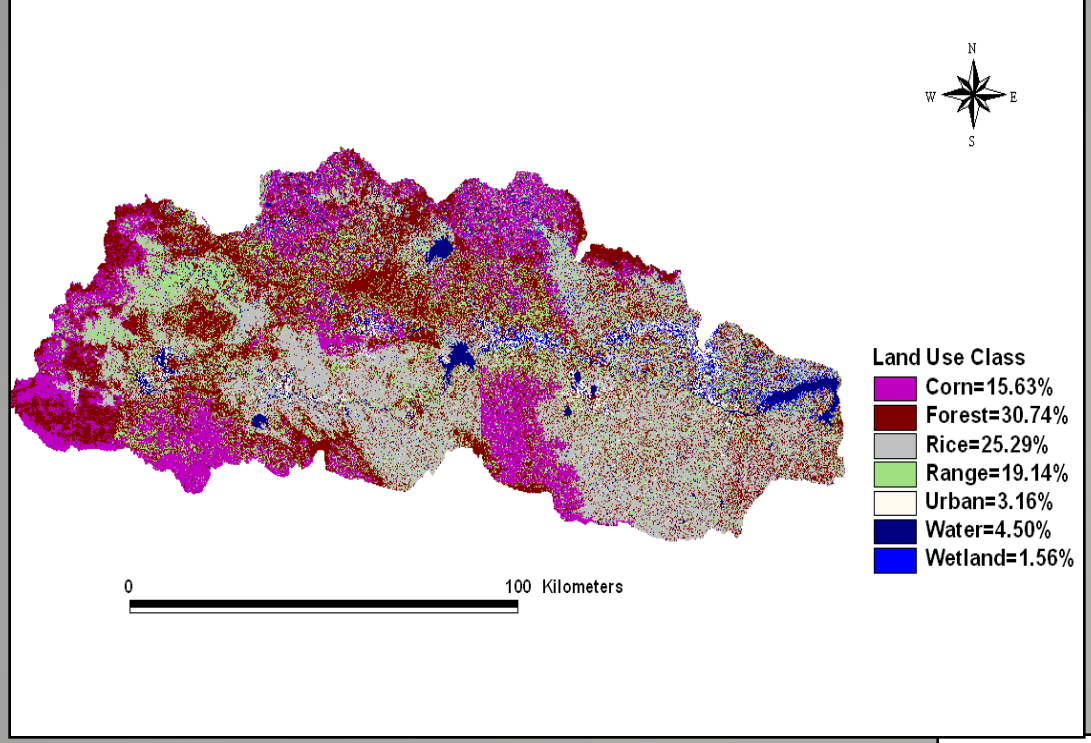
- Two Reservoir
  - Konar: 1955 (997.15km^2)
  - Panchet: 1959 (10155.15 km^2)
- Nagwan(92..48 km^2) and Banikdih (88.53km^2)

Materials and Methods



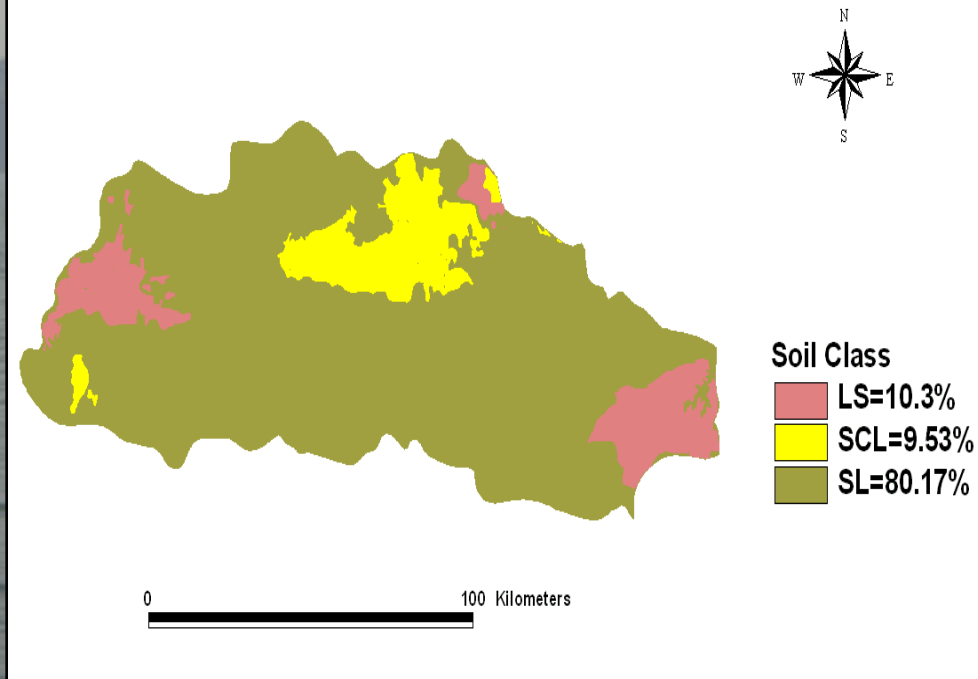
Stream network

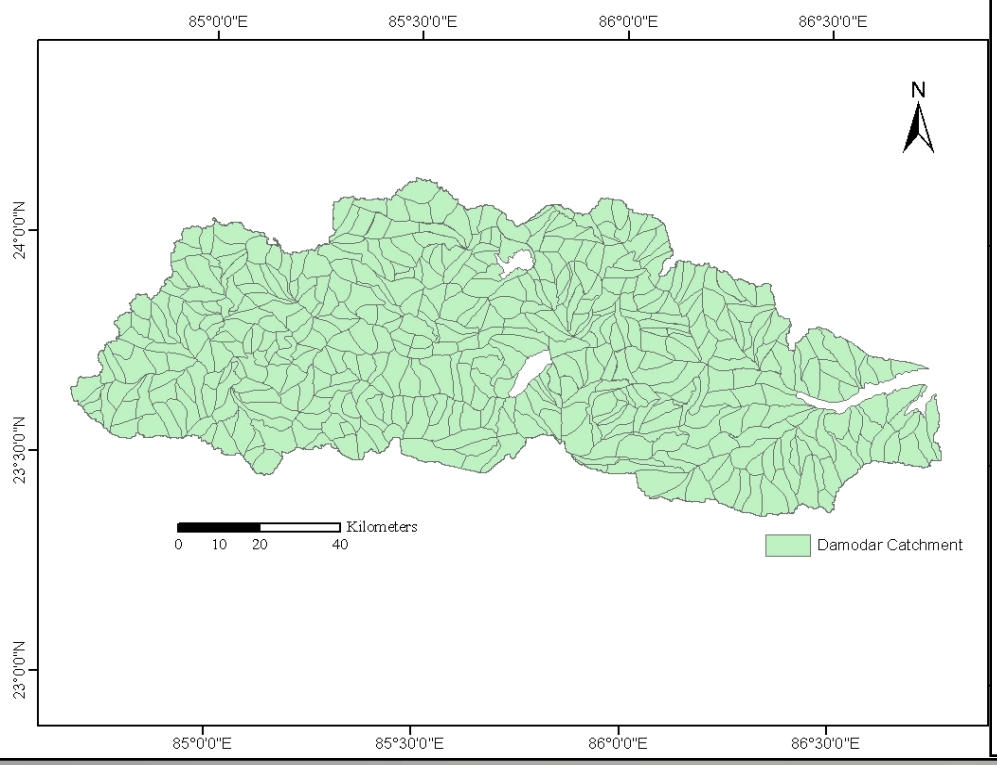
- DEM
  - SRTM
  - Resolution 90m
  - Range 37m-1344m

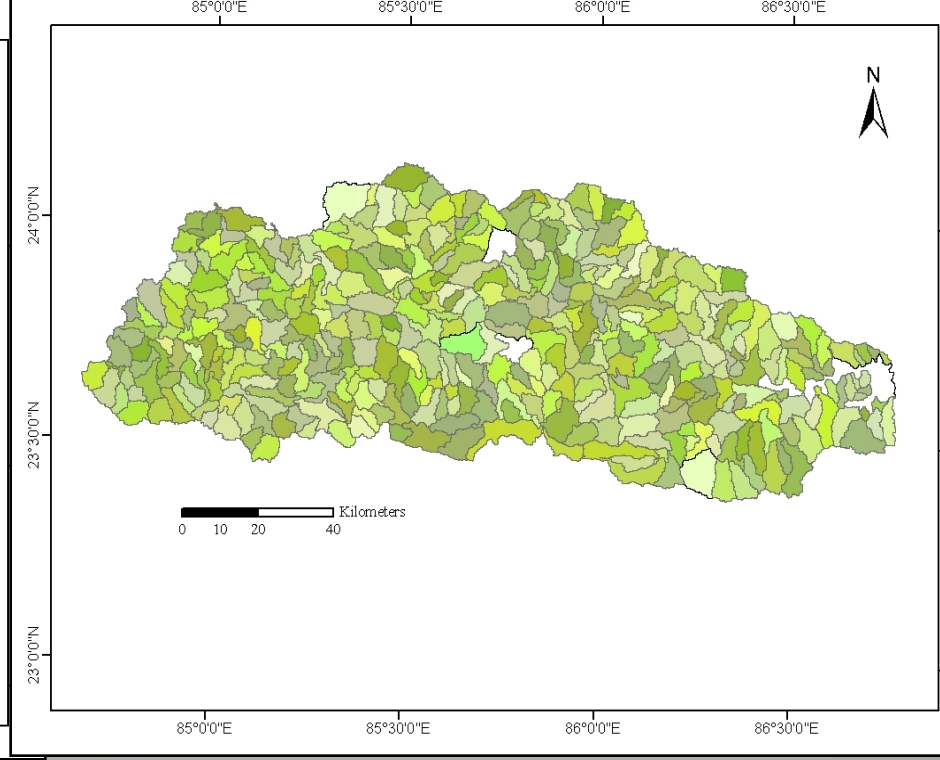


Landuse / land cover of the study area (Landsat 7)

Soil map of the study area (NBBSS&LP Kolkata)







	Domdar catchment DVC	Domdar catchment SWAT model
No. of watersheds	472	406
Area	11153.10 km^2	11322.65 km^2 (-1.5%)
Average area of watersheds	23.04 km^2	27.42 km^2
Range, area of watersheds	4.00 km^2 to 92.48 km^2	4.65 km^2 to 93.94 km^2

Data Collected

Type of data	Source
Hydro-Meteorological Data Daily precipitation, temperature, Daily & Monthly runoff and sediment yield data of two watersheds (1993-2001)	DVC, Hazaribagh
watersheds Map Watershed treatment map and boundary map for the upper Damodar valley , soil conservation measure	DVC, Hazaribagh
Reservoir Data Monthly reservoir inflow-outflow data and reservoir sedimentation reports for Konar and Panchet reservoir and capacity of reservoir at different level(1993-2001)	DVC, Maithon

Model Calibration and Validation

- **Calibration(1993-1996) and Validation (1997-2001)**
  - **Nagwan and Banikdih watershed (Surface runoff and Sediment yield)**
  - **Konar and Panchet reservoir (Inflow)**

- **Model Evaluation**
  - **Coefficient of determination(r^2)**
  - **Percent deviation (D_V)**

❖ Identification and prioritization of critical watersheds

- Calibrated values was upscaled to catchment
- Simulated average annual sediment yield (1993-2001) used for prioritization of watersheds
- Three erosion classes low (0-5 ton/ha/year), medium (5-20 ton/ha/year) and high (>20 ton/ha/year)

❖ Sedimentation rate

- Reservoir trap efficiency from Brune's curve
- Trap efficiency from SWAT Model (sediment inflow and out flow)
- Average trap efficiency (Brune'curve and SWAT Model)
- Sediment deposition rate is computed by multiplying sediment inflow rate with average trap efficiency.

❖Reservoir life estimation

Life of dead storage= Capacity of dead storage (Mm^3)
/ Sedimentation deposition rate(Mm^3 / year)

❖ Management plan

- ➢ Life of reservoir was calculated for base peroid(1993-2001)
- ➢ Seven management scenarios was included in the model
- ➢ Management scenarios (pond and weighted conservation practice factor P)

S.NO	Scenario (both Catchment)	No of watersheds
1	High around reservoir	26
2	Above>40	42
3	(30-40)	53
4	(25-30)	59
5	(20-25)	85
6	(15-20)	19
7	(5-15)	62

Results and Discussion

❖ Sensitive parameter used to calibrated the model and there value

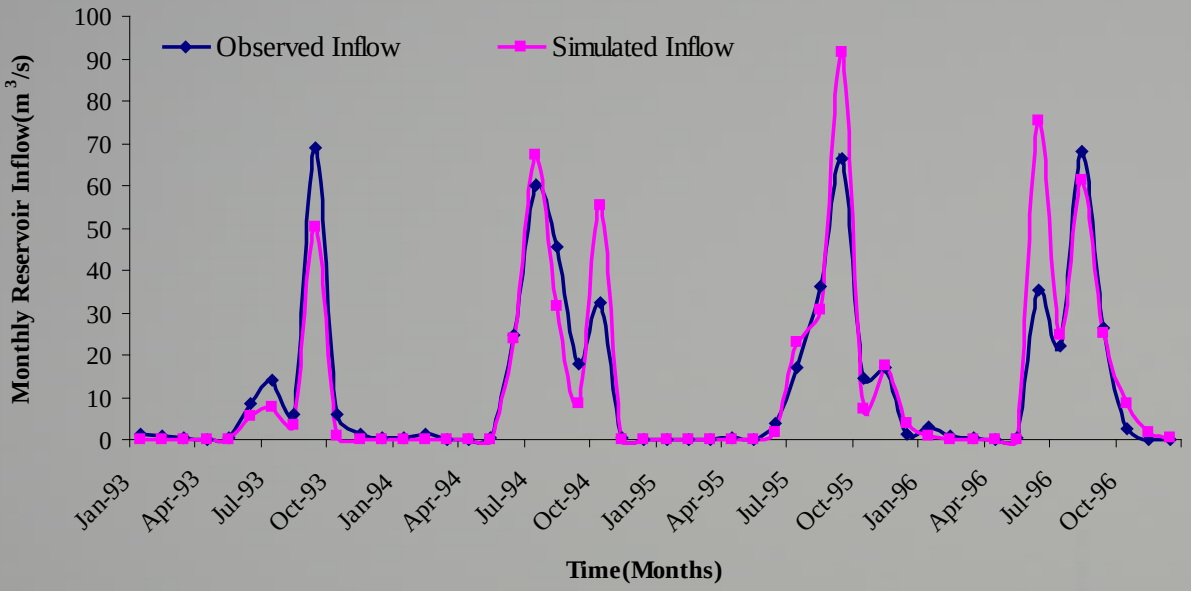
	Calibrated Parameters	Nagwan	Banikdih
1	Manning's 'n' for overland flow (OV_N)	0.065	0.068
2	Manning's 'n' for main channel flow (CH_N2)	0.04	0.19
3	Manning's 'n' value for the tributary Channels (CH_N1)	0.09	0.18
4	Effective hydraulic conductivity in main channel alluvium (CH_K2)	3.0	1.0
5	Effective hydraulic conductivity in tributary channel alluvium (CH_K1)	3.5	4.5
6.	Surface Runoff lag Time (SURLAG)	2.5	2.5

❖ Calibration and Validation results for Nagwan and Banikdih watersheds

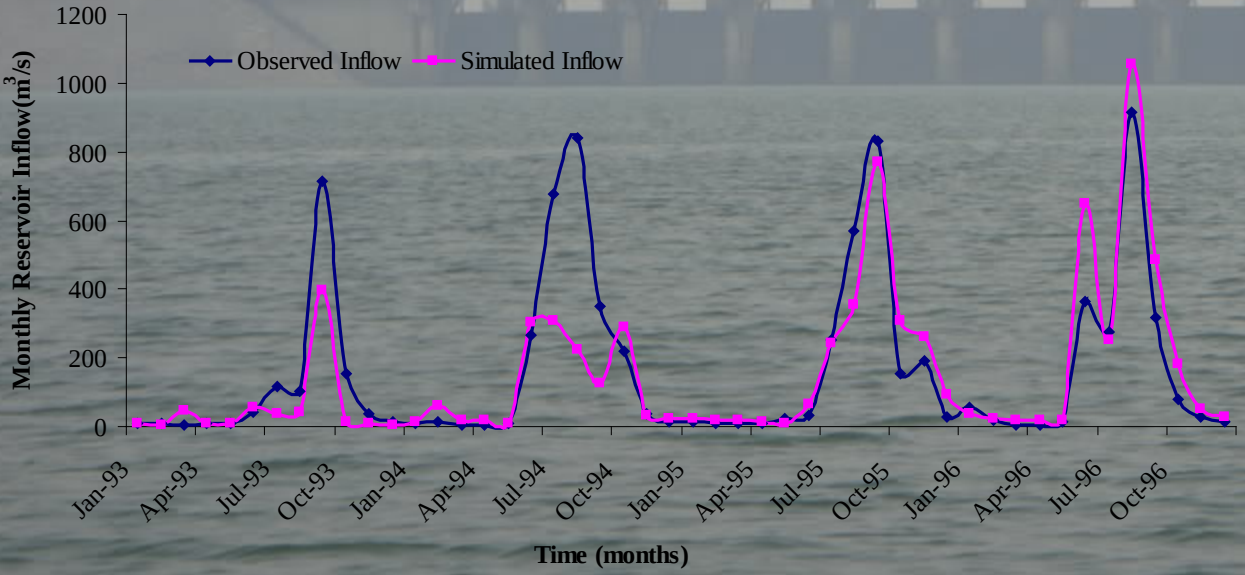
	Calibration				Validation			
	Nagwan		Banikdih		Nagwan		Banikdih	
	SR	**SYLD**	**SR**	**SYLD**	**SR**	**SYLD**	**SR**	**SYLD**
(r^2)	0.87	0.78	0.51	0.79	0.52	0.55	0.59	0.58
D (%)	0.53	1.64	-1.98	2.64	-7.0	4.56	3.70	-5.43
RMSE (mm/t/ha)	30.64	0.44	71.81	0.29	34.73	0.59	38.75	0.84

Model Calibration: Reservoir Inflow

A. Konar reservoir

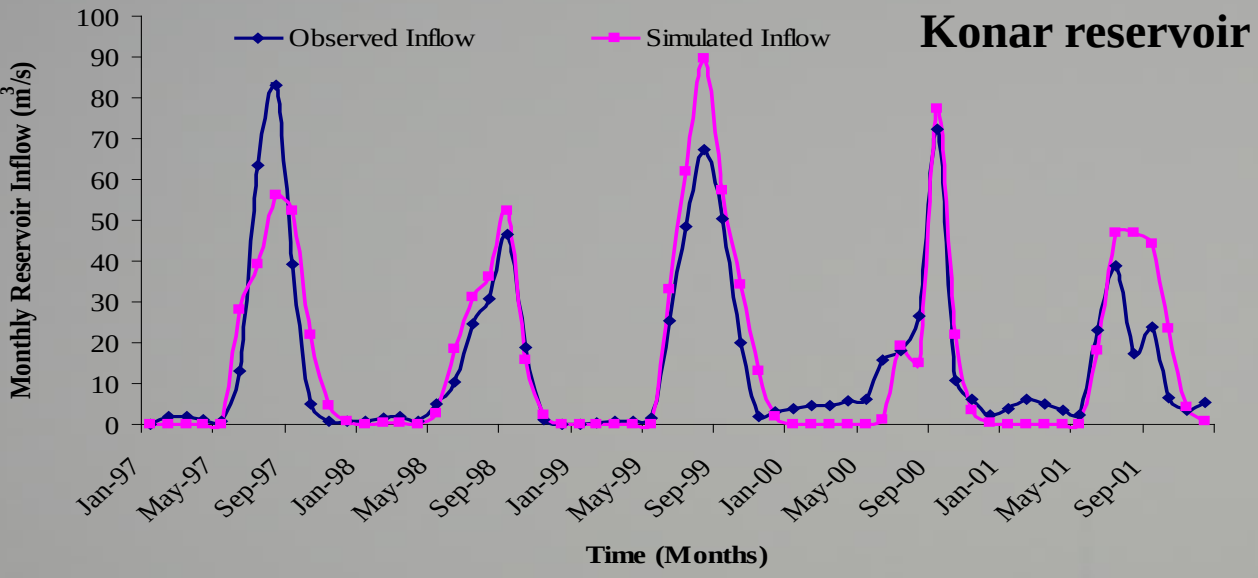


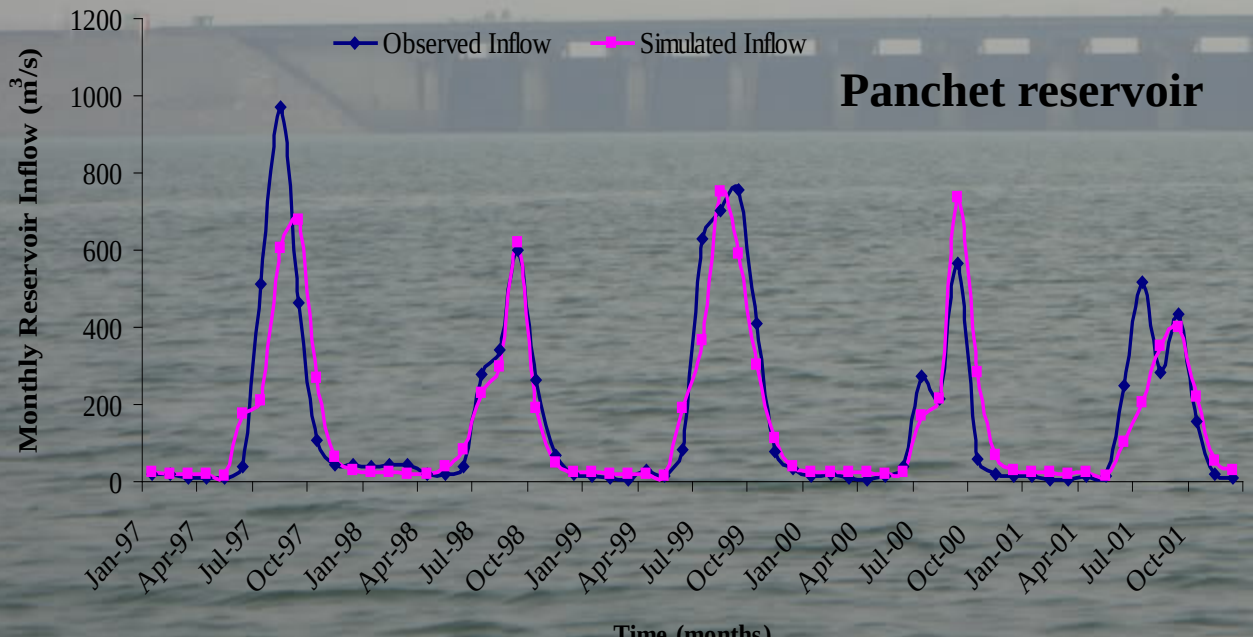
B. Panchet reservoir



	Konar	Panchet
r^2	0.85	0.74
D %	-3.20	10.40

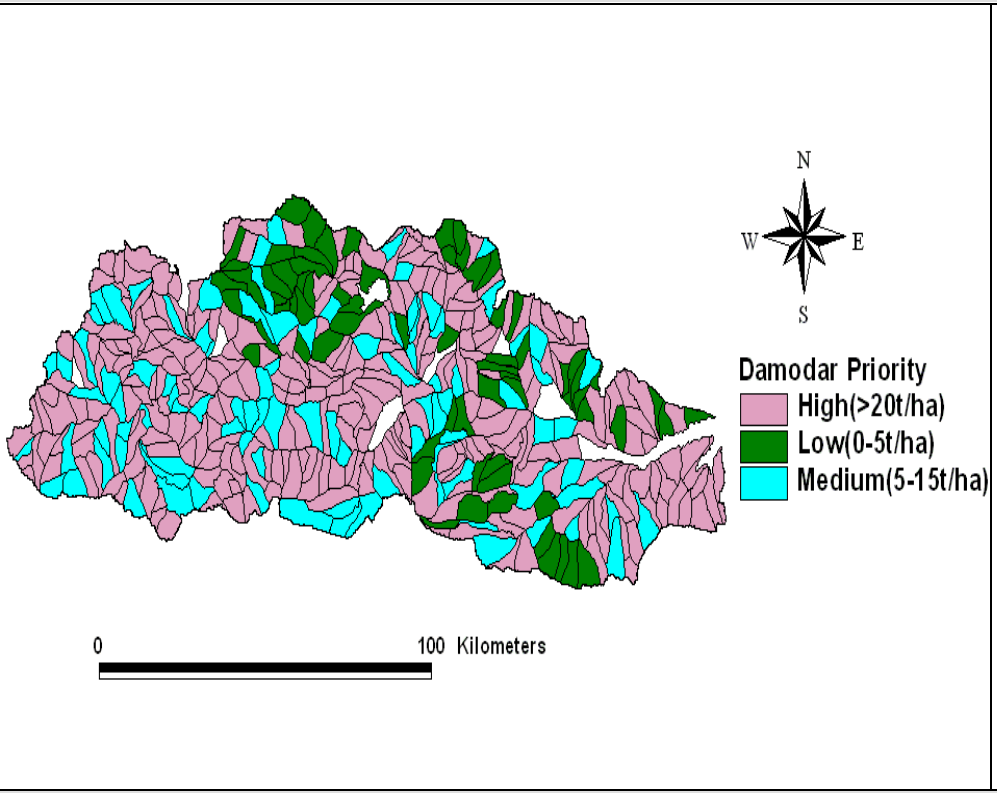
Model Validation: Reservoir Inflow



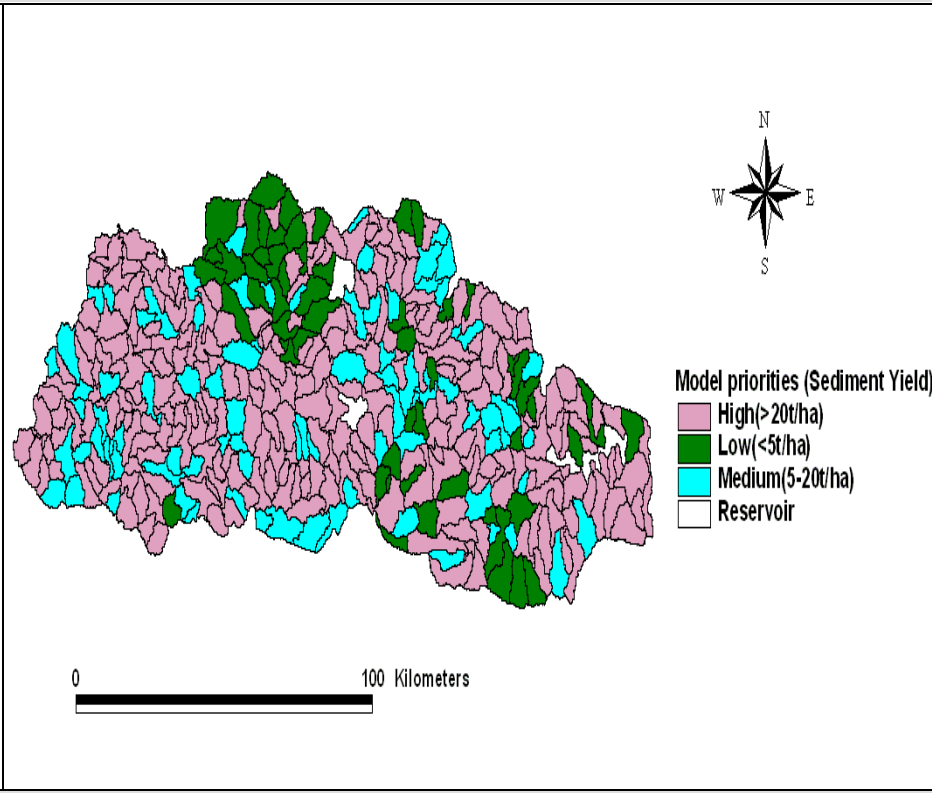


	Konar	Panchet
r^2	0.81	0.79
D %	-9.40	4.80

Identification and prioritization of critical watersheds



DVC priorities Damodar catchment



Model priorities Damodar catchment

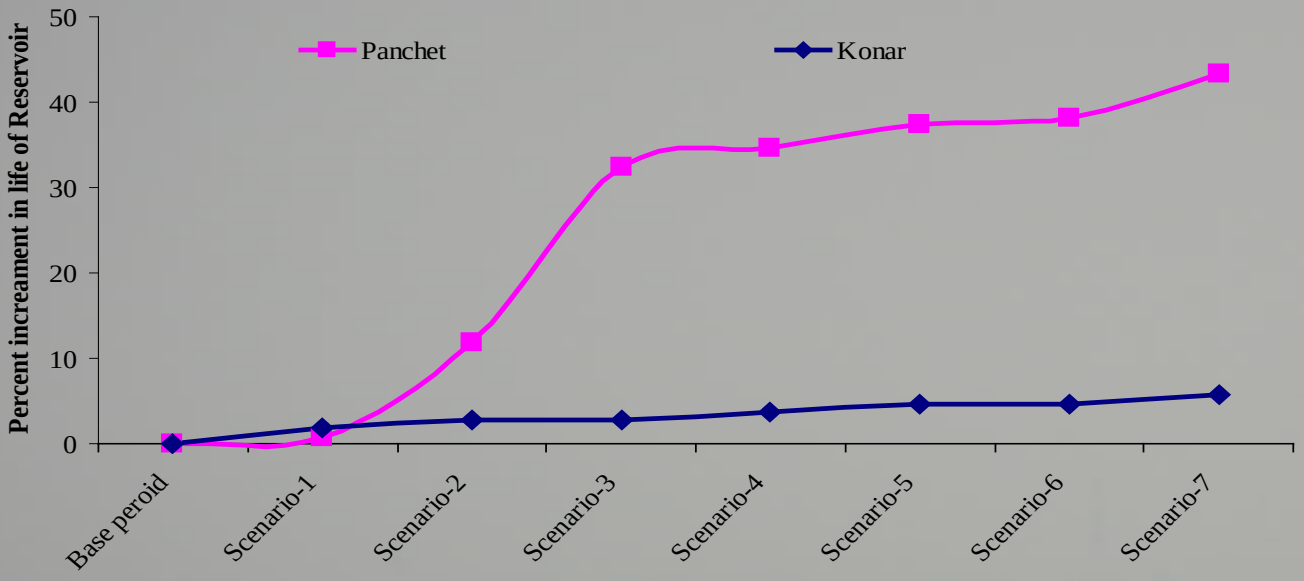
Soil and Water Assessment Tool

Sedimentation Rate and Life of Reservoirs

- The average sediment deposition rate calculated from the model output was 1.12Mm^3/yr and 3.65 Mm^3/yr respectively for the Konar and Panchet for the base period (1993-2001) with trapping efficiency of 94.25% and 84.4 %, respectively .

- Konar and Panchet reservoirs will be expected to silted up to dead storage in another 65 and 79 years from 1997

Management criteria and its effect on reservoir life



- Marginal increased in life of Konar reservoir because the catchment is saturated with respect to soil conservation work
- Overall there is increment in life of reservoir during scenarios implementation

Conclusions

- Study confirmed that 103, 94, 209 watersheds fall under low, medium and high erosion classes
- The average sediment deposition rate calculated from the model output was 1.12Mm^3/yr and 3.65 Mm^3/yr respectively for the Konar and Panchet
- Konar and Panchet reservoirs will be expected to silted up to dead storage in another 65 (2062) and 79 (2076) years from 1997 if sediment rate is maintained at the above level
- If Konar and Panchet catchment are treated with conservation measures the reservoirs would be filled completely up to dead storage level in 71 (2068) and 138 (2135) years from 1997

Further work

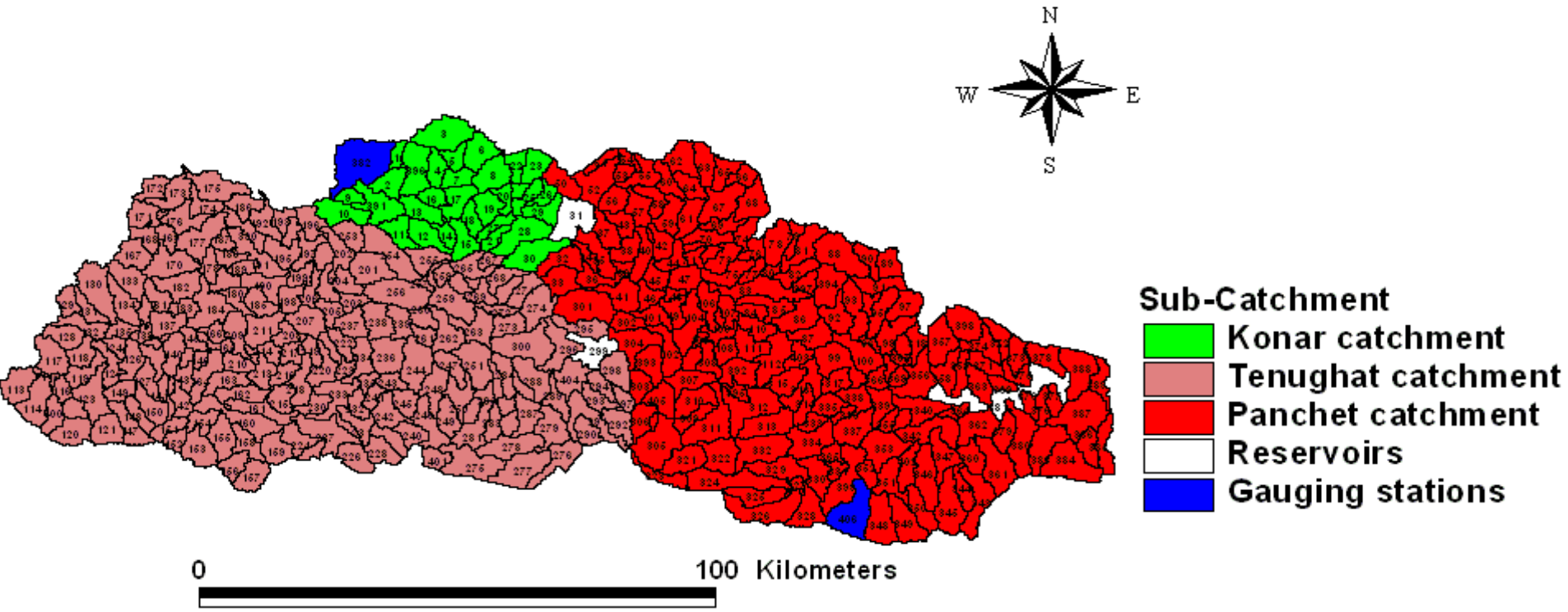
- Incorporate of more weather station to improve the results.
- Incorporate of Tenughat reservoir in the model for better simulation of sedimentation rate
- Calibration and validation of more watersheds , for better upscaling of parameter


Thanks for your attention !
Any question?

Capacity for Konar and Panchet reservoir reported by CWC

S.No	Title	Capacity(Mm^3)	
		Konar reservoir	Panchet reservoir
1	Present Capacity	209.64	1358.09
2	Live storage	175.45	148.97
3	Dead Storage	34.20	118.99
4	Total loss in capacity	71.58	222.91
5	Total loss in live storage	45.38	103.33
6	Total loss in Dead storage	26.24	117.21

Damodar catchment



Watershed Delineation with reservoir positions