Hydrological modeling of a semi urbanized catchment with limited data availability using SWAT model

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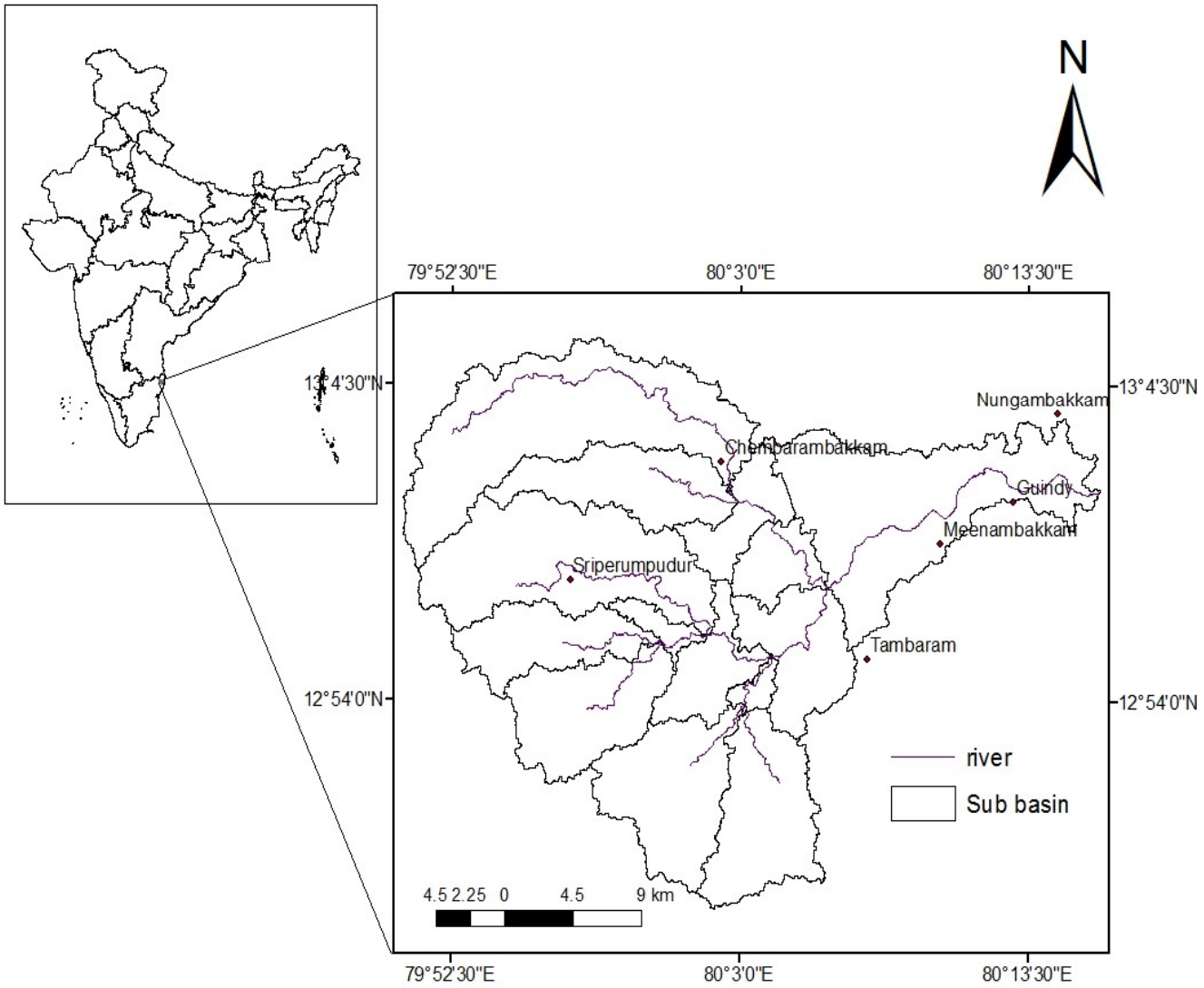
Introduction

- Chennai is a coastal city where the two rivers, namely Adayar and Cooum flowing
- The Adayar River originates at an elevation of about 40 m above Mean Sea Level (MSL) at Guduvanchery reserve forest
- River Adyar serves as a surplus course for the irrigation tanks (water bodies) on the upstream
- Flood and drought are common problems in Adyar basin
- It is an ungauged basin
- Water balance study is essential to understand the hydrologic system of the river basin

Study area- Adyar

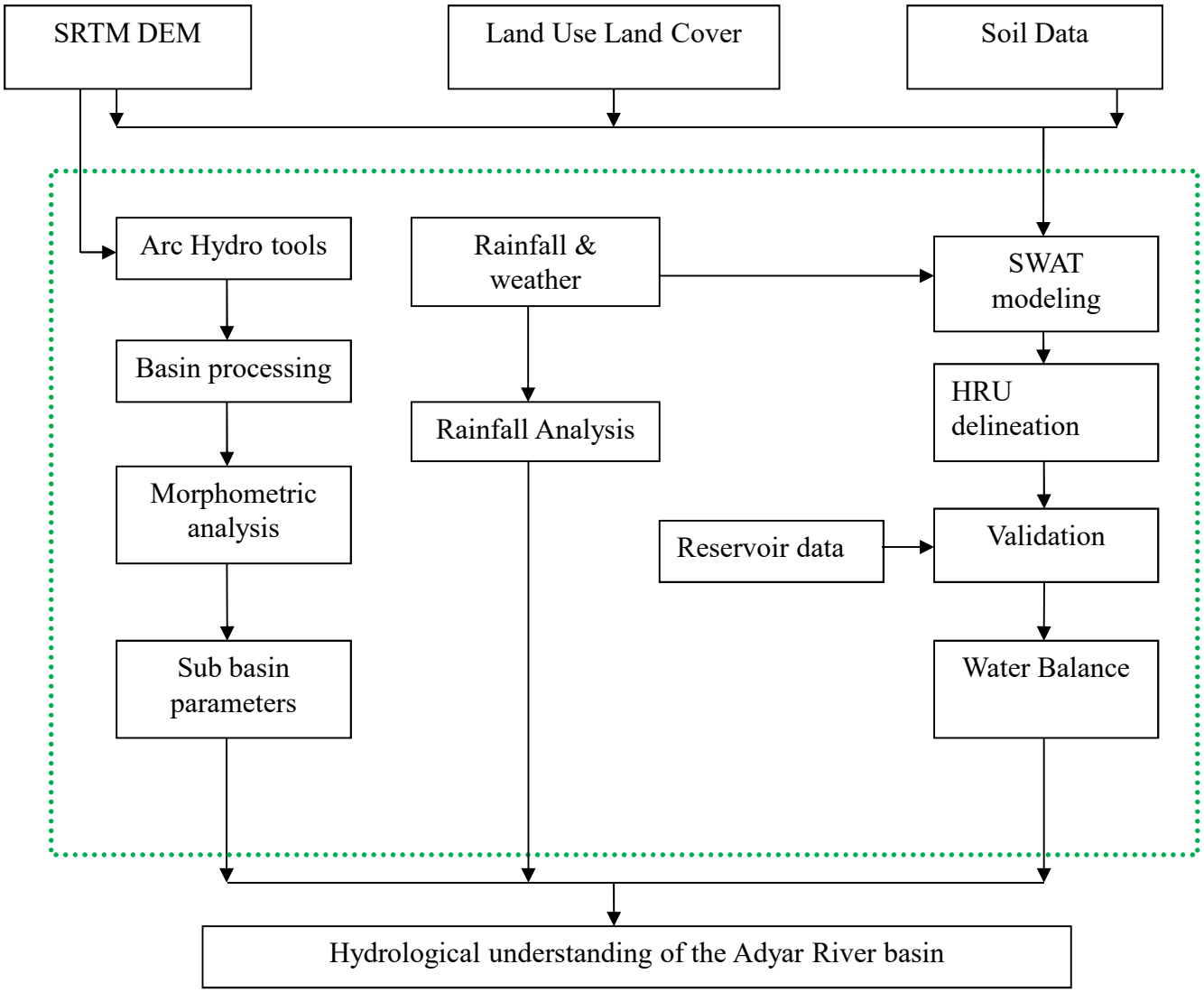


- Catchment area -824.4 Sq.Km
- River length - 42 Km
- Chembarambakkam, Sriperumpudur, Pillapakkam and over 100 minor tanks

Objective

- To model the surface water flow in ungauged river basin

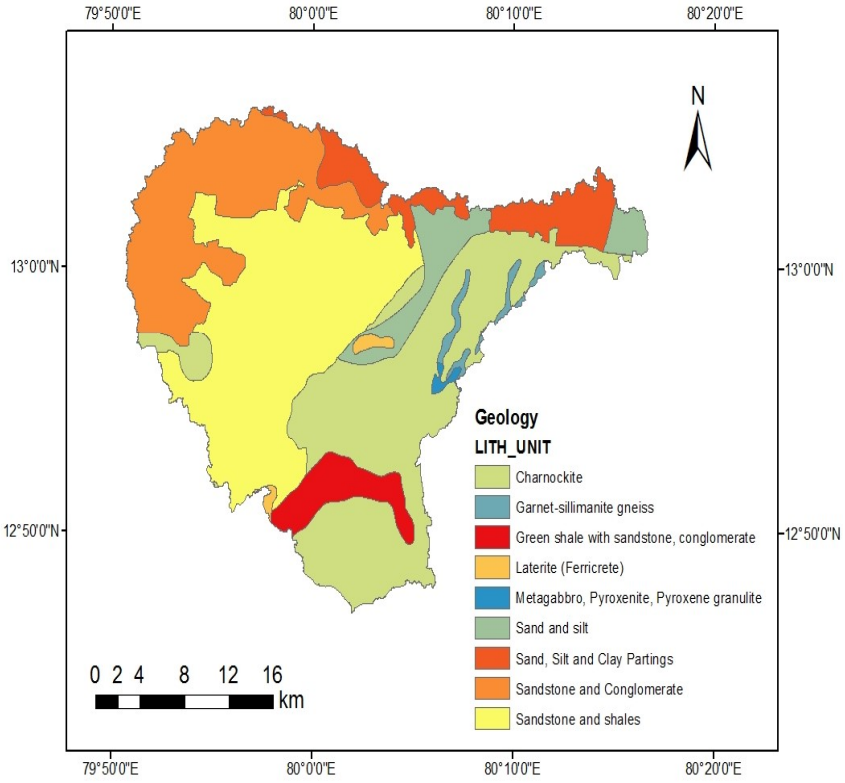
Methodology



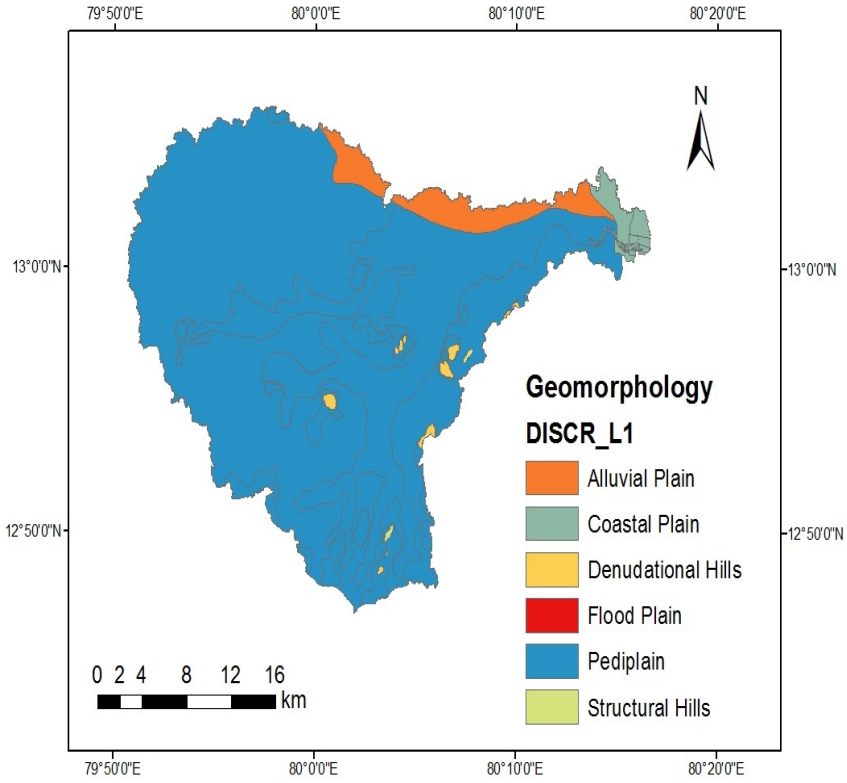
Data Collection

- SRTM DEM
- LULC- LISS III image of 2005
- Soil data from TNAU
- Rainfall , Geology, Geomorphology, climate data from PWD
- Chembarambakkam reservoir storage data(2004-2017)
- Inflow, outflow and Rainfall collected from Chennai Metro Water Supply and Sewerage Board

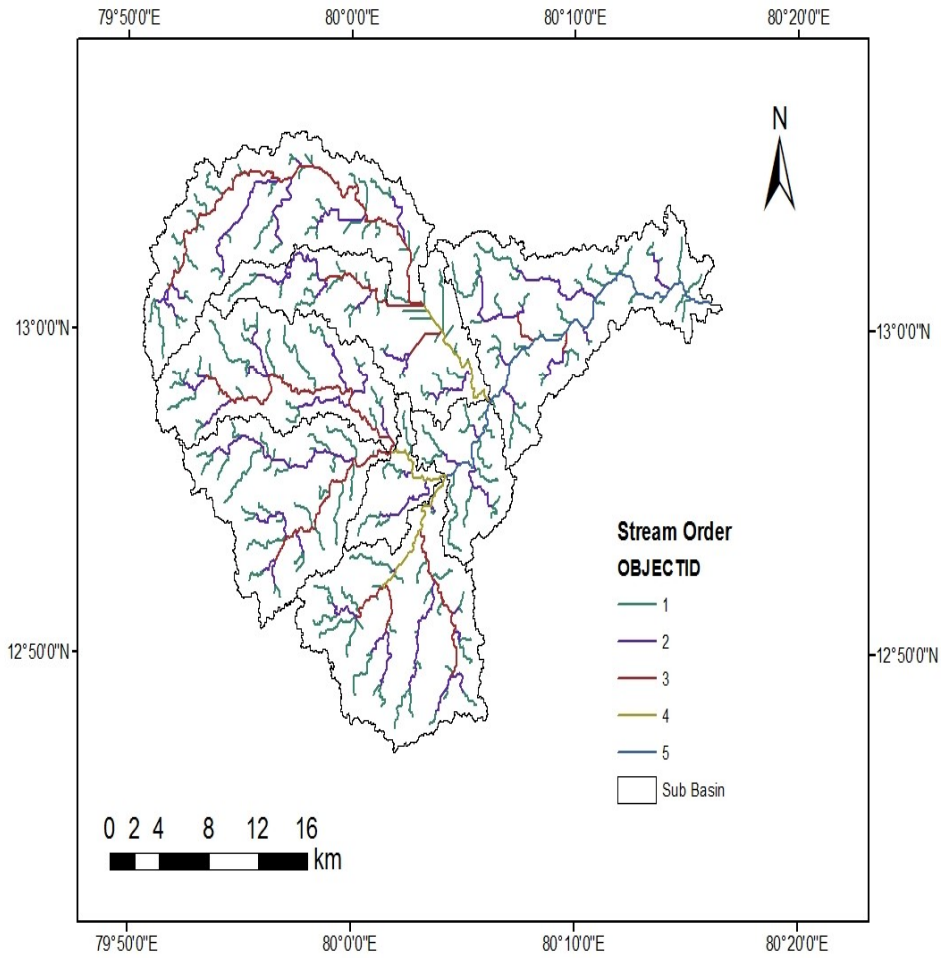
Geology



Geomorphology

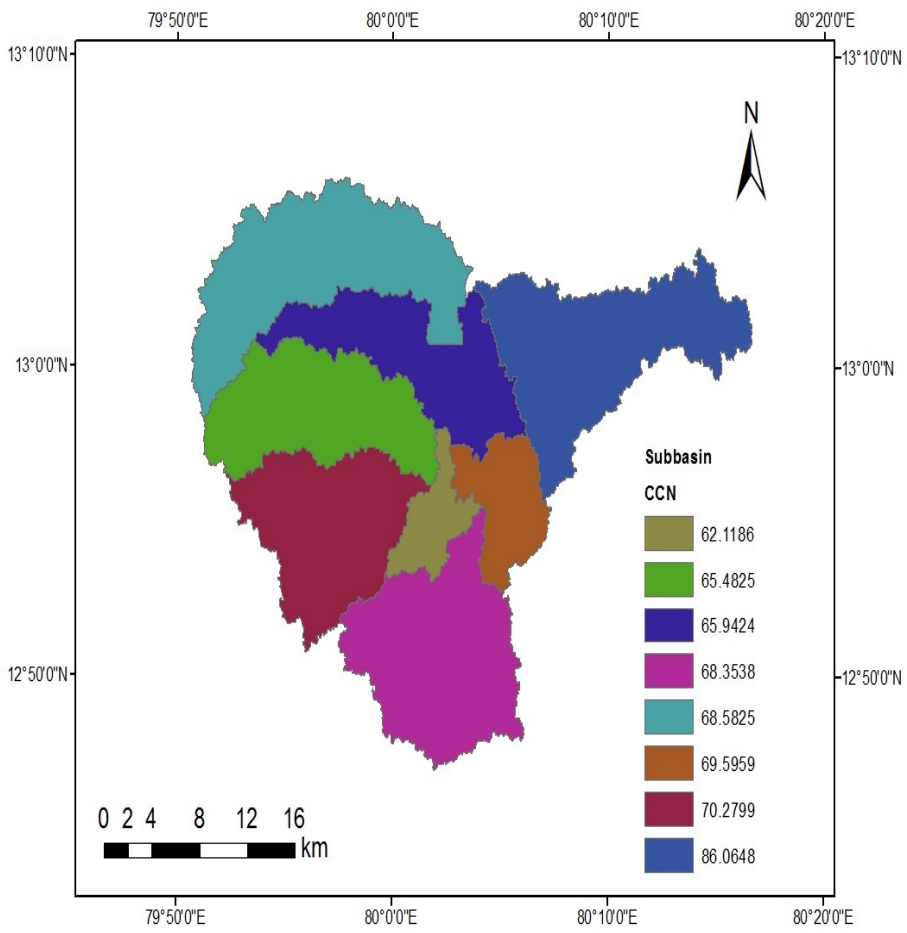


Morphometric Analysis

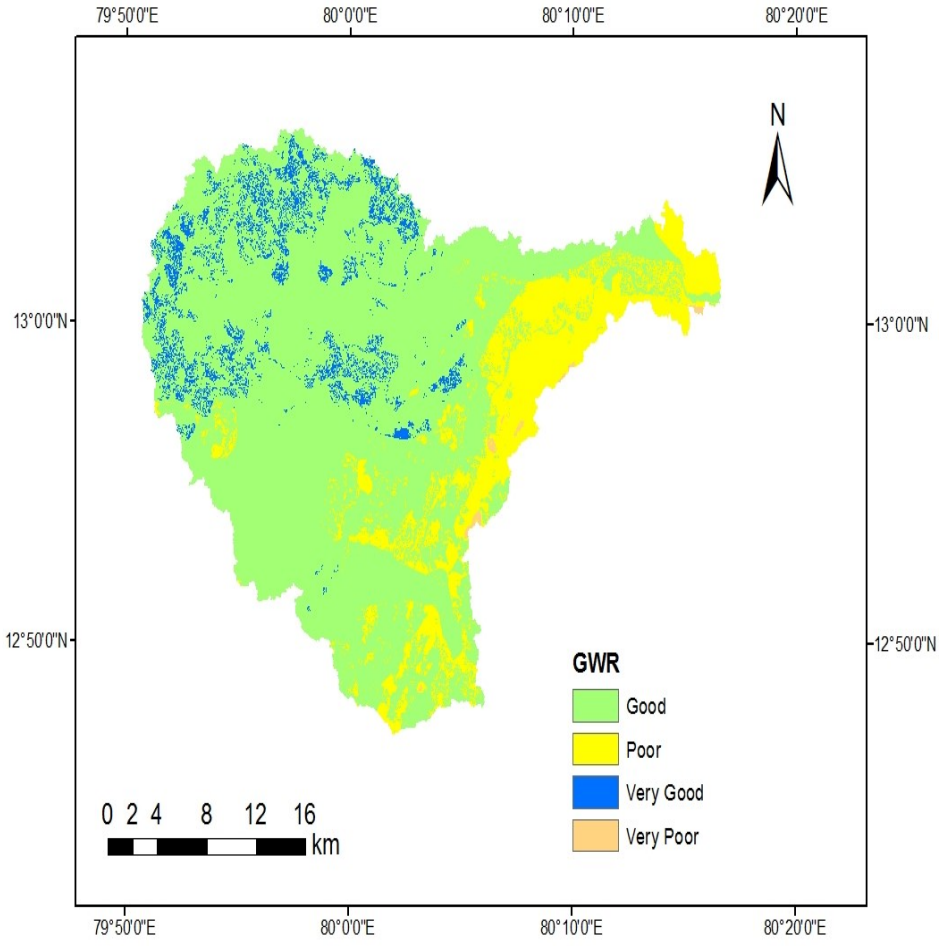


Total order number (N)	(∑Nu)	5	4	3	2	1	Total
Number of streams		2	6	35	67	288	398
Cumulative length of streams (L)	(∑L)	33.215	26.593	110.897	174.289	342.824	687.818
Mean Stream Length	∑L/Nu	6.643	6.64825	36.96567	87.1445	342.82	
Stream frequency (F_s)	Fs =∑Nu/A	0.480693745					
Drainage density (D_d)	Dd =∑L/A	0.830728166					
Drainage Texture (T)	T = ∑Nu/P	1.751066919					
Bifurcation ratio (R_b)	Rb = Nu/Nu + 1	3	5.833333	1.914286	4.298507		
Form factor(Rf)	Rf=A/Lb*Lb	0.408					
Elangation ratio	Re=sqrt(4*A/3.14)/Lb	0.721					
Circulatory Ratio	Rc=4*3.14(A/P*P)	0.201					
Relief ratio	Rh=H/Lb	0.0037					
length of overland flow	Lg=1/(2D)	0.601					

Composite Curve Number

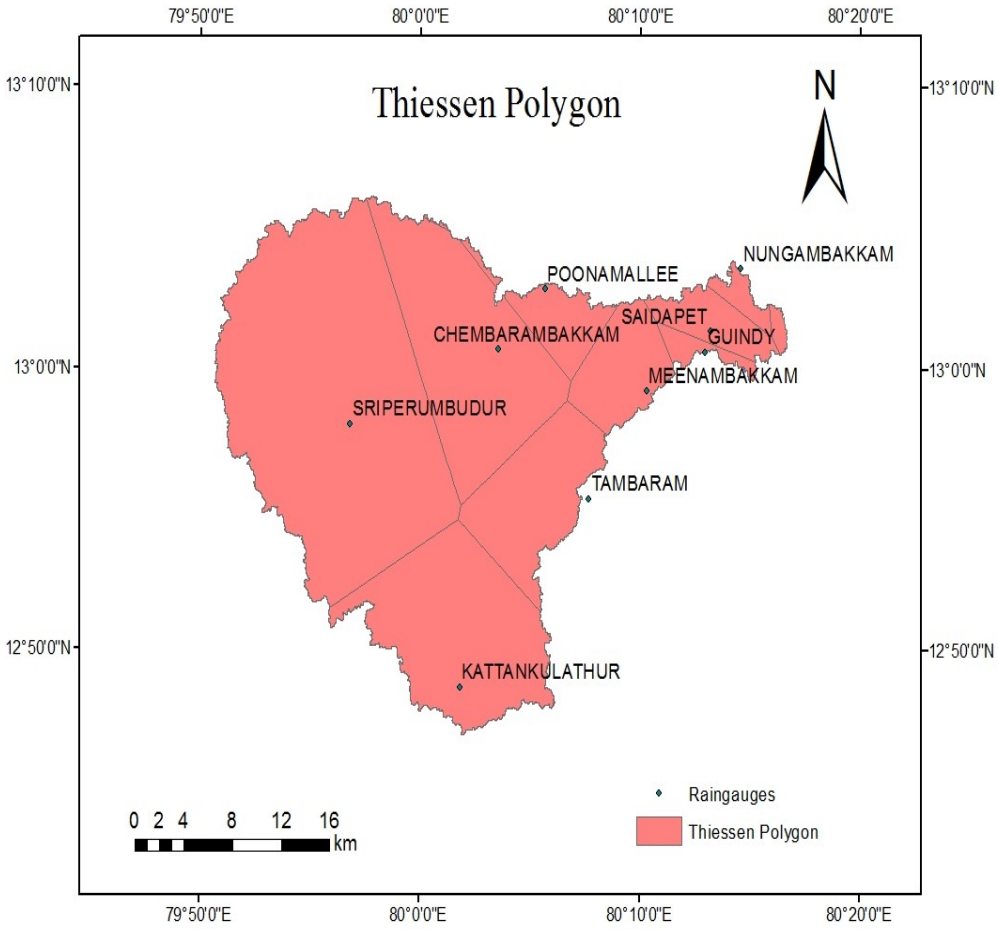


Weighted Overlay Analysis

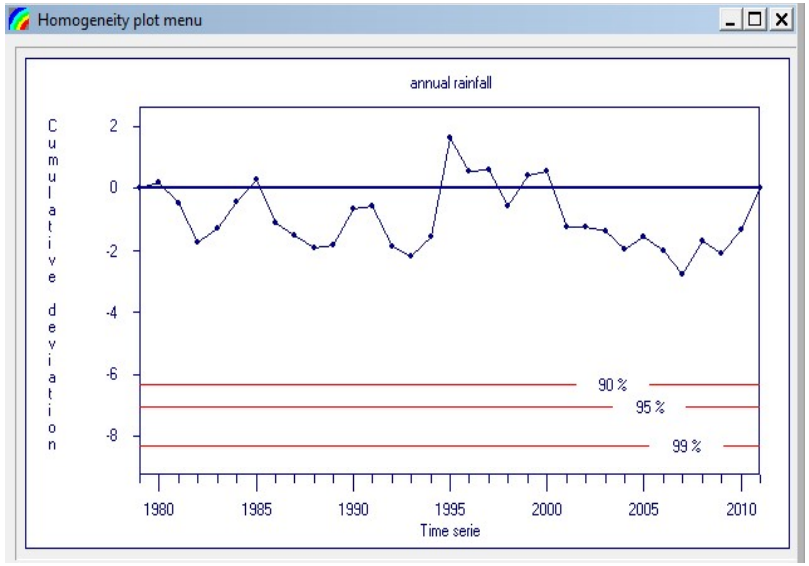


Rainfall analysis

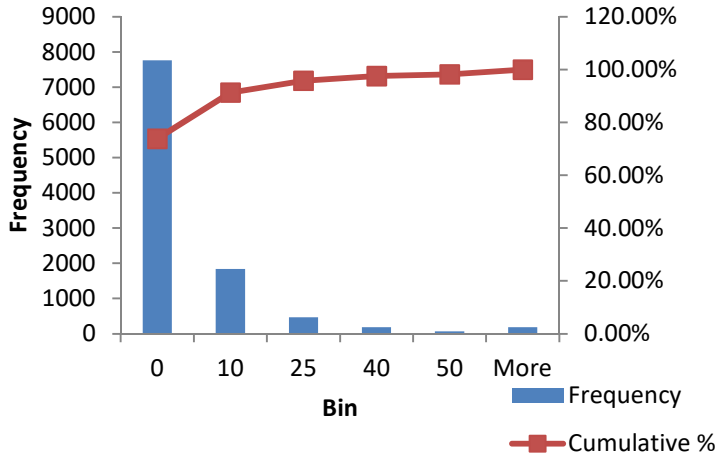
Raingauges



Homogeneity test



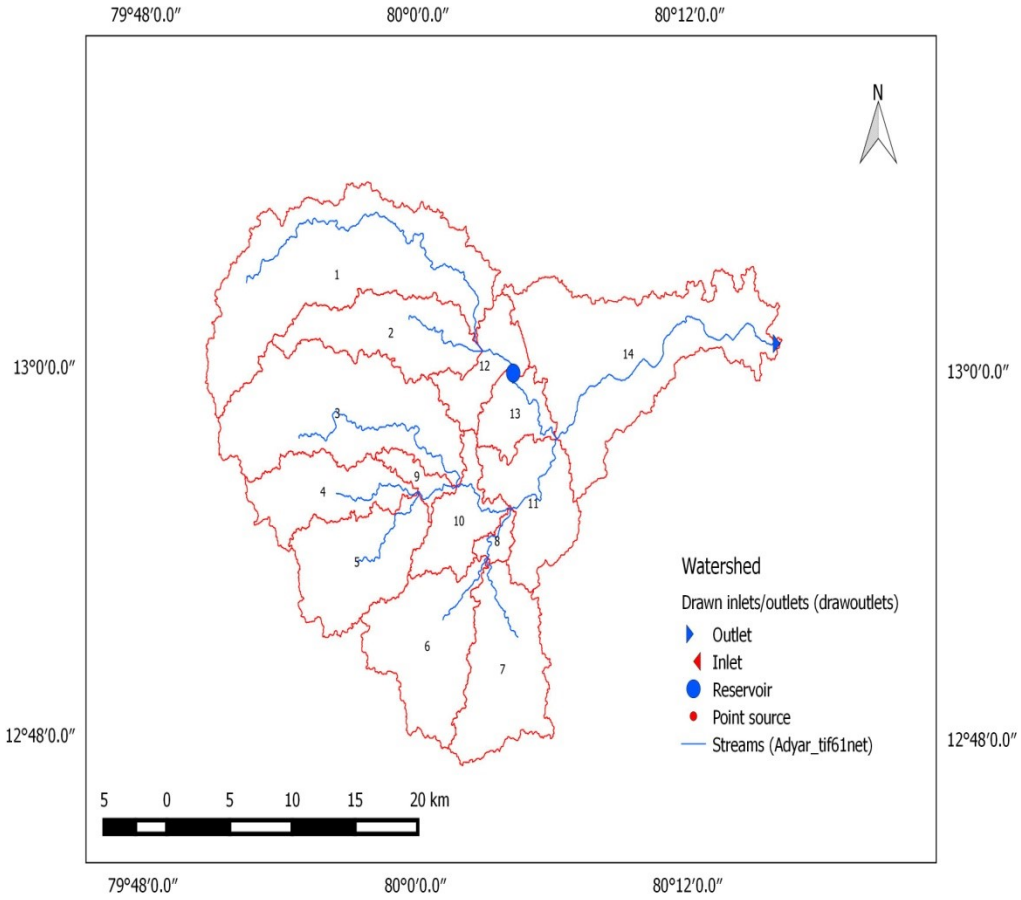
Frequency Analysis



Trend Analysis

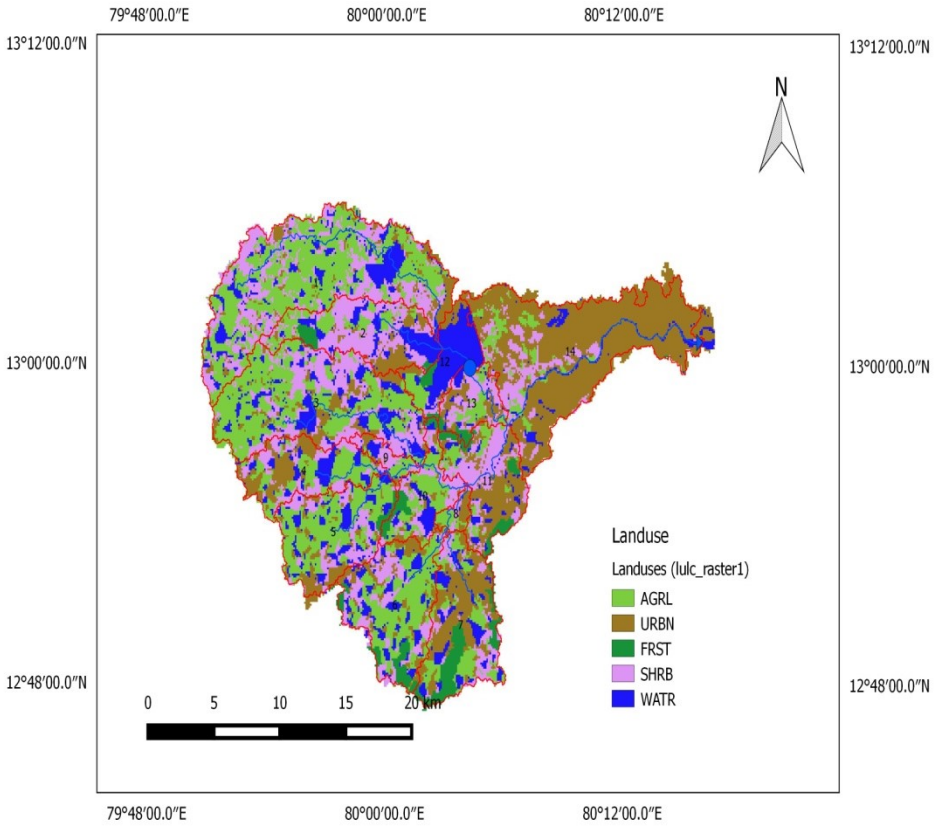
1901-2002(mm)	Min	Max	Mean	Std.Dev	MannKendall's Tau	P value	Sen Slope
Jan	0.023	82.928	17.557	20.797	-0.175	0.009	-0.108
Feb	0	62.435	12.458	18.204	-0.045	0.526	0
Mar	0	36.343	4.915	8.67	-0.009	0.9	0
Apr	0	76.624	14.846	18.975	0.018	0.792	0
May	0.712	176.742	40.157	42.326	0.075	0.264	0.079
Jun	2.536	157.982	50.131	27.627	0.135	0.044	0.19
Jul	18.853	235.349	95.789	45.731	0.05	0.459	0.098
Aug	19.177	372.275	140.436	68.183	0.104	0.123	0.288
Sep	27.168	330.309	138.368	66.569	0.027	0.686	0.086
Oct	12.397	713.067	238.923	125.16	-0.031	0.648	-0.168
Nov	4.124	768.912	279.284	171.787	0.023	0.733	0.171
Dec	1.435	640.322	129.844	127.843	0.054	0.423	0.205
Pre Monsoon	0.712	223.241	59.918	46.060	0.101	0.239	2.153
SW Monsoon	70.489	621.989	286.356	93.007	0.137	0.108	3.818
NE Monsoon	309.754	1556.315	786.418	238.944	0.071	0.411	2.380
Post Monsoon	0.023	107.472	30.016	28.140	-0.295	0.000	-2.992
Annual Rainfall	611.492	1996.9	1162.709	265.862	0.048	0.481	0.599

SWAT MODELLING

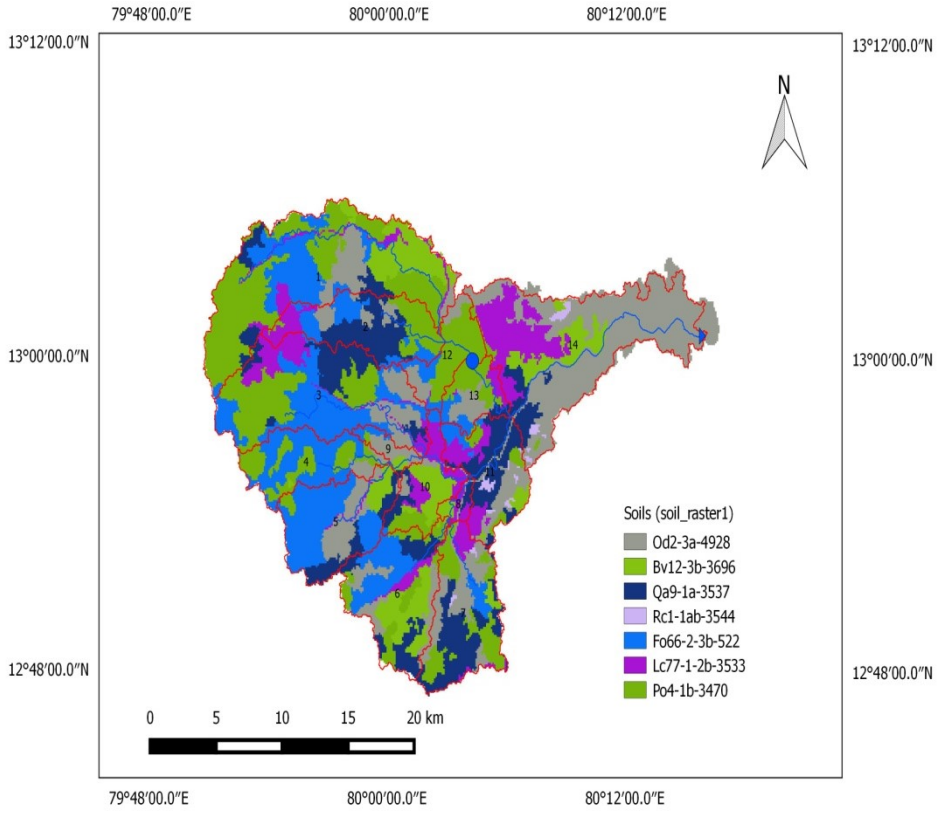


- 14 sub basins, 708 HRU's
- 1 reservoir(Chembarambakkam)
- Simulation period- 2002 to 2016
- Warm up period (2002-2004)
- LULC and Soil data- First level description
- Raingauges- Measured data from PWD and IMD stations
- Weather data- Weathergen data from SWAT database
- Volumetric validation with reservoir data

Land use Land Cover



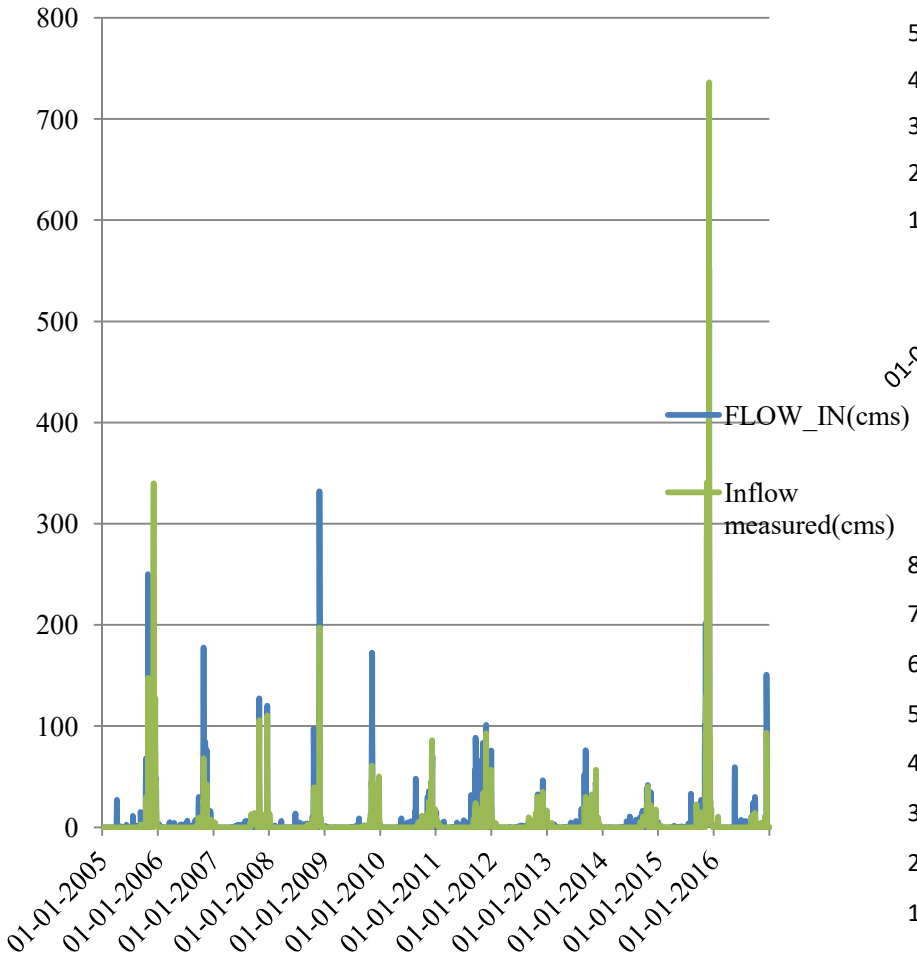
Soil

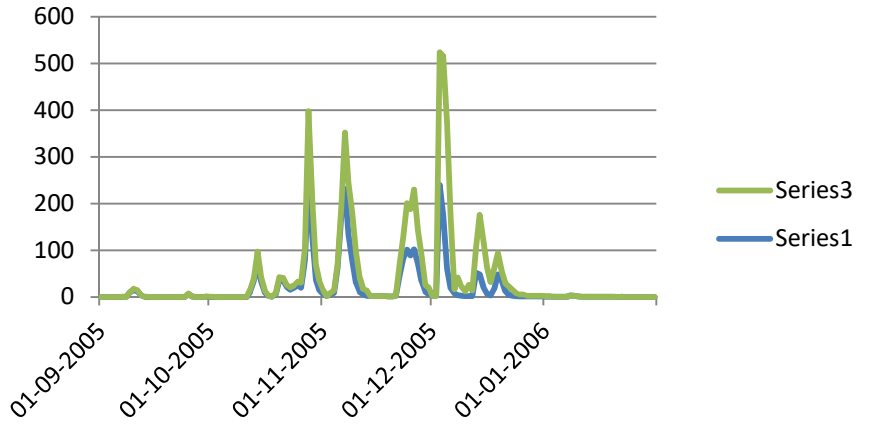


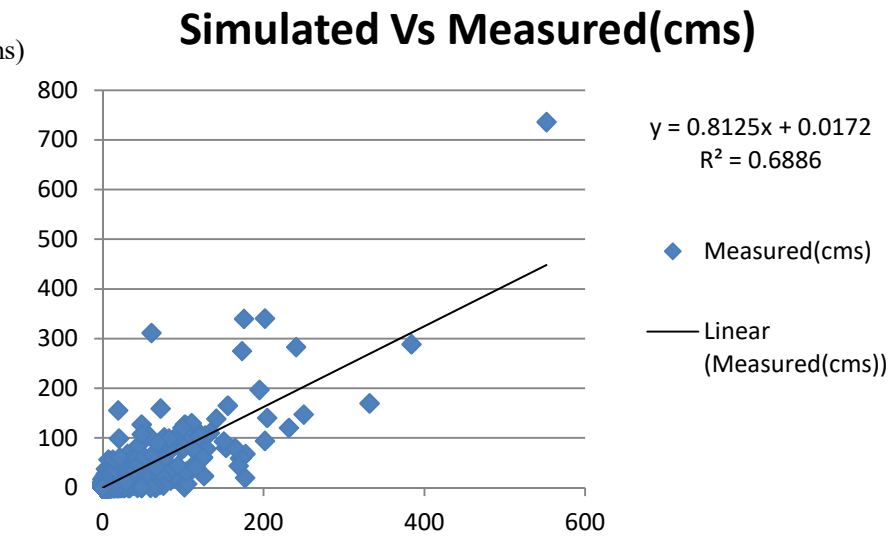
Parameters

Sl.no	Parameters Adjusted	Lower and upper bound	Given value
1	Base flow alpha factor (Alpha_Bf)	0.0 to 1.0	0.85
2	Maximum canopy storage(Canmx)	0.0 to 10	6.5
3	Initial curve number cn2	(+/-)25	+5
4	Soil Evaporation compensation factor(ESCO)	0.0 to 1.0	0.16
5	Ground water delay(GW_delay)	(+/-)10	5.2
6	Available Water Capacity(Sol_AWC)	(+/-)25	15
7	Manning's n	0.02 to 0.03	0.025
8	Surface runoff lag time	0.0 to 10.0	5.09
9	Saturated hydraulic conductivity(Sol_k)	(+/-)25	20.66
10	Deep aquifer percolation fraction(Rchrg_DP)	0.0 to 0.1	0.46

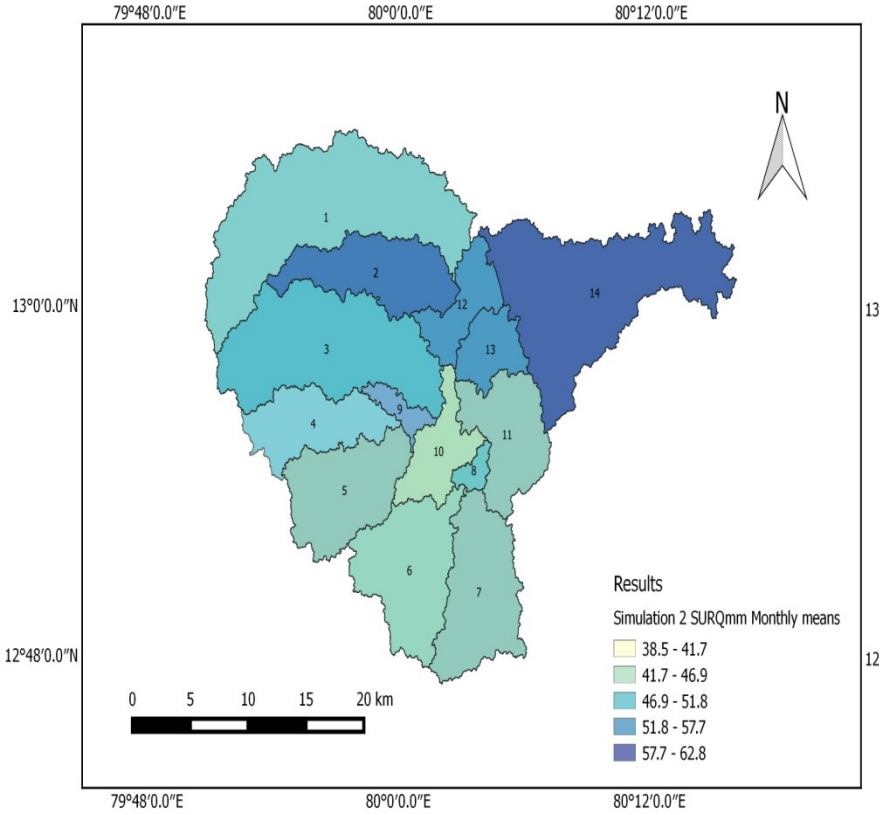
Reservoir Simulated Vs Measured



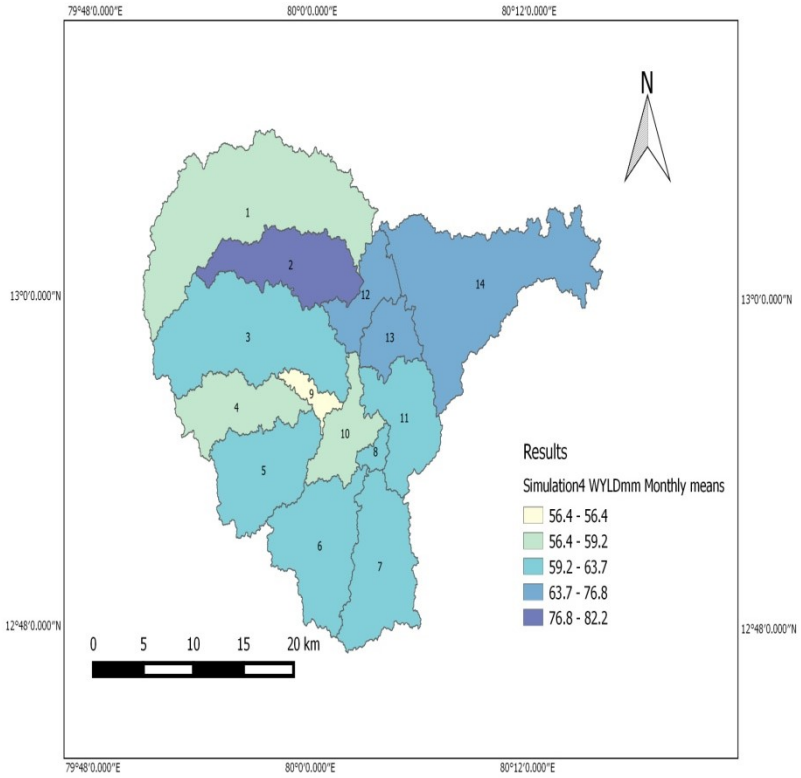




Surface runoff



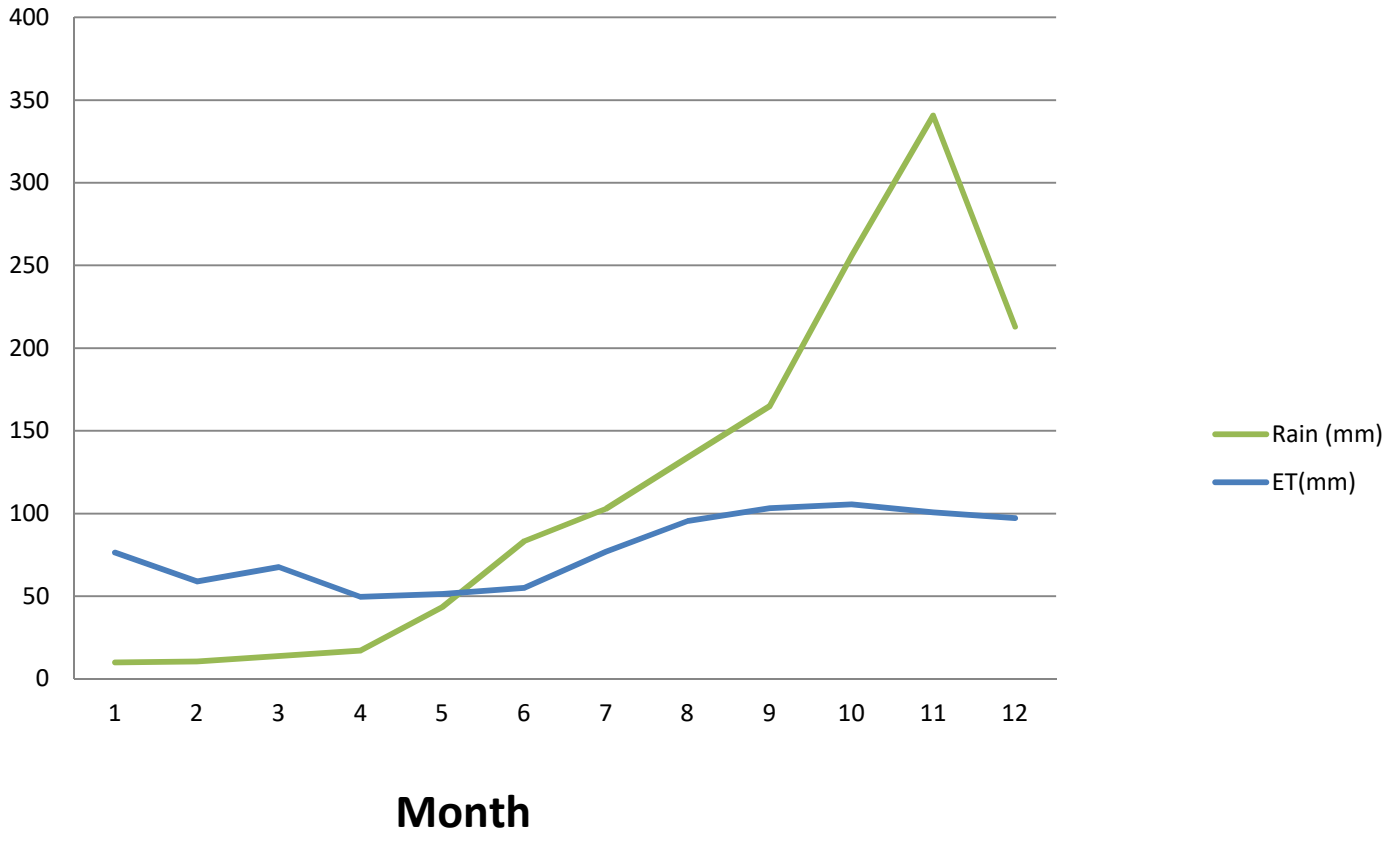
Water yield



Monthly average water balance

Month	Rain (mm)	Surf Q (mm)	LAT Q (mm)	Water Yield(mm)	ET(mm)
1	9.98	1.4	0.21	5.72	76.35
2	10.61	0.68	0.07	1.82	58.92
3	13.85	1.73	0.1	2.19	67.73
4	17.1	3.66	0.16	3.96	49.63
5	43.53	7.6	0.3	7.98	51.35
6	83.25	7.65	0.48	7.87	55.11
7	102.82	9.11	0.72	10.03	76.92
8	134.03	19.45	1.02	20.34	95.51
9	164.9	34.21	1.23	35.57	103.22
10	255.88	100.53	1.88	100.73	105.49
11	340.68	198.07	2.18	206.82	100.77
12	212.92	106.46	1.32	115.92	97.33

Monthly average Rainfall and Evapotranspiration



Conclusion

- Surface water flow of an ungauged basin is done
- The model is validated with the reservoir inflow data for the contributing sub basins
- It has to be verified with ET
- The sub basin parameters are transformed to other sub basins

Thank you