HYDROLOGICAL ASSESSMENT OF GRIDHAMAL BASIN AND SENSITIVITY ANALYSIS USING **SWAT**

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Madurai

PROBLEM FORMULATION

- Urban water usage/management and Food production has to be addressed in the perspective of sustainable approach but there is a lagging of this approach in our present scenario.
- WATER CRISES at GRIDHAMAL Basin.
- No Irrigation (crop production) & Groundwater depletion
- Increasing of urban water stress and Inefficient usage of treated wastewater.

Tamil Nadu Worst North East Monsoons in 150 years	
Years	October 1st - December 31st Rainfall in mm
1876	163.5
2016	168.4
1892	186.2
1938	194.5
1897	197.2
1878	220.6
1904	229.9
1974	233.4
1988	234.6
1949	235.4
1909	239.1
1947	239.1
1995	260.0
1950	275.9
1889	277.6
1927	287.5
1986	289.2
1886	293.0
1952	302.6
1879	303.3

AIM: To establish the treated wastewater as an reliable source for Crop production, Groundwater Recharge.

OBJECTIVES :

- To study the treated wastewater along with surface runoff respect to different crops
- To establish a model that would generate framework in different scenario using **SWAT**.
- To generate the output as CROP GROWTH, GW Recharge, SOCIO-ECONOMIC Benefits.

SWAT

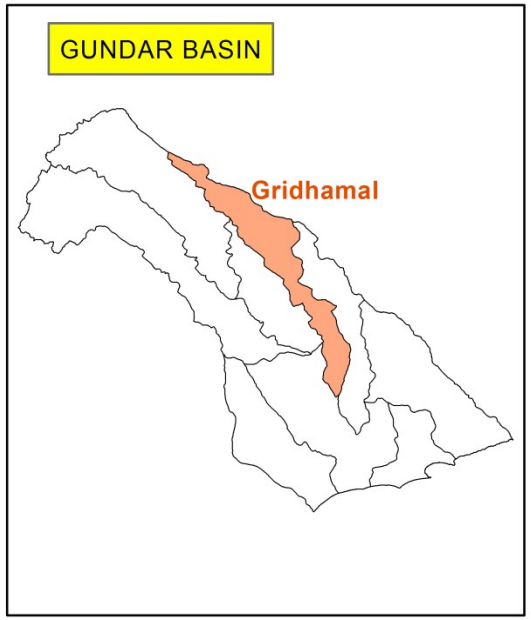
- SWAT (Soil and Water Assessment Tool)

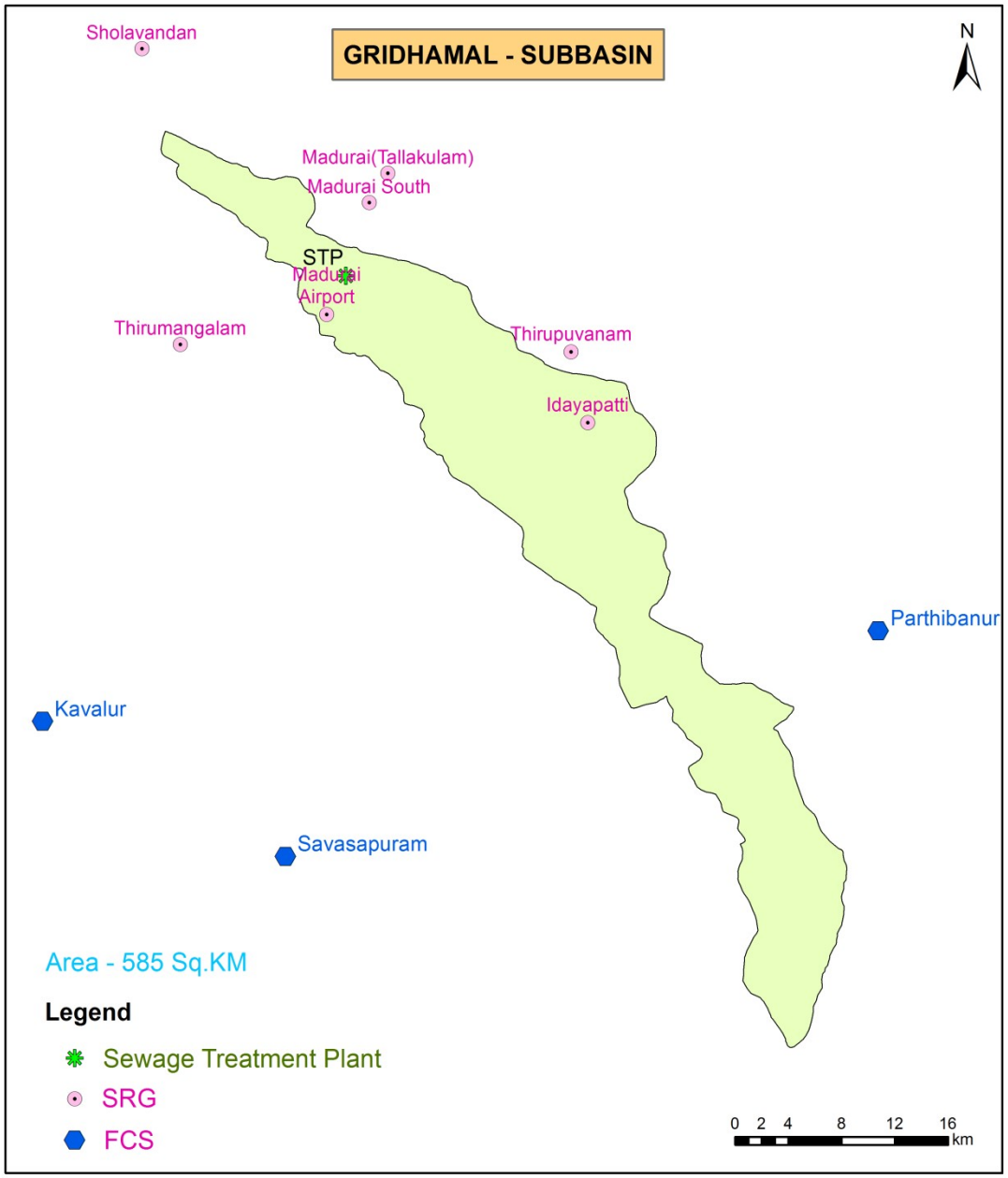
  - A Semi-Distributed hydrological model with world wide acceptance for watershed projects.

SWAT is developed to predict the impact of land management practices on hydrologic components, crop growth, sediment load and water quality including Total nitrogen (TN) in large complex watersheds over long periods of time.

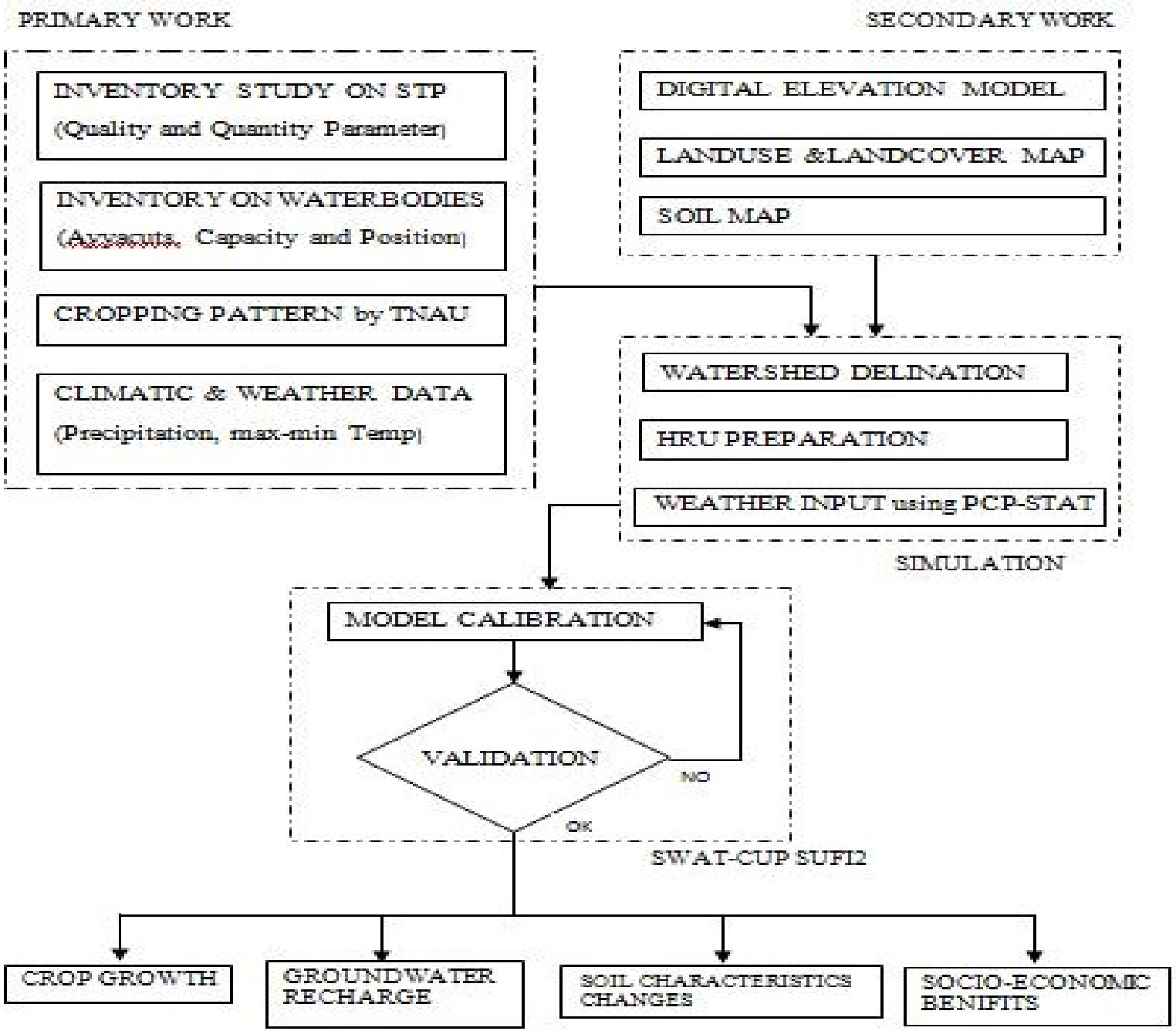
STUDY AREA

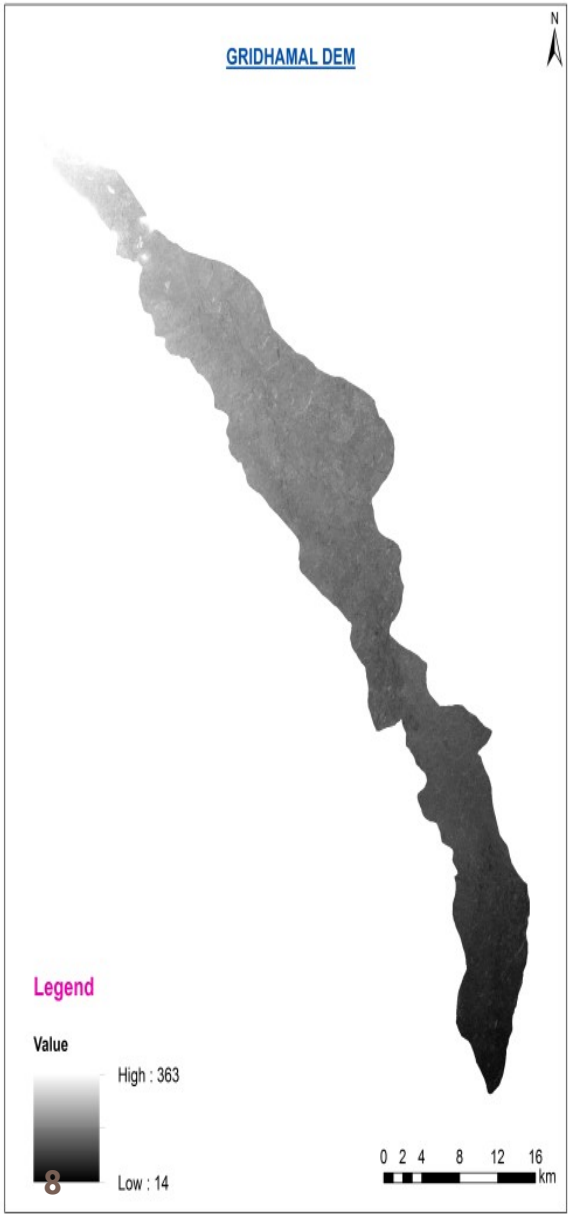

TAMILNADU - BASIN WISE
Chennai
Palar
Varahanadhi
Ponnaiyar
Vellar
Paravanar
Cauvery
Parambikulam
Aliyar
Agniyar
Vaigai
Pambar
Kottakaraiyar
Vaippar
Gundar
Kallar
Tamiraparani
Tamiraparani
Nambiyar
Kodaiyar

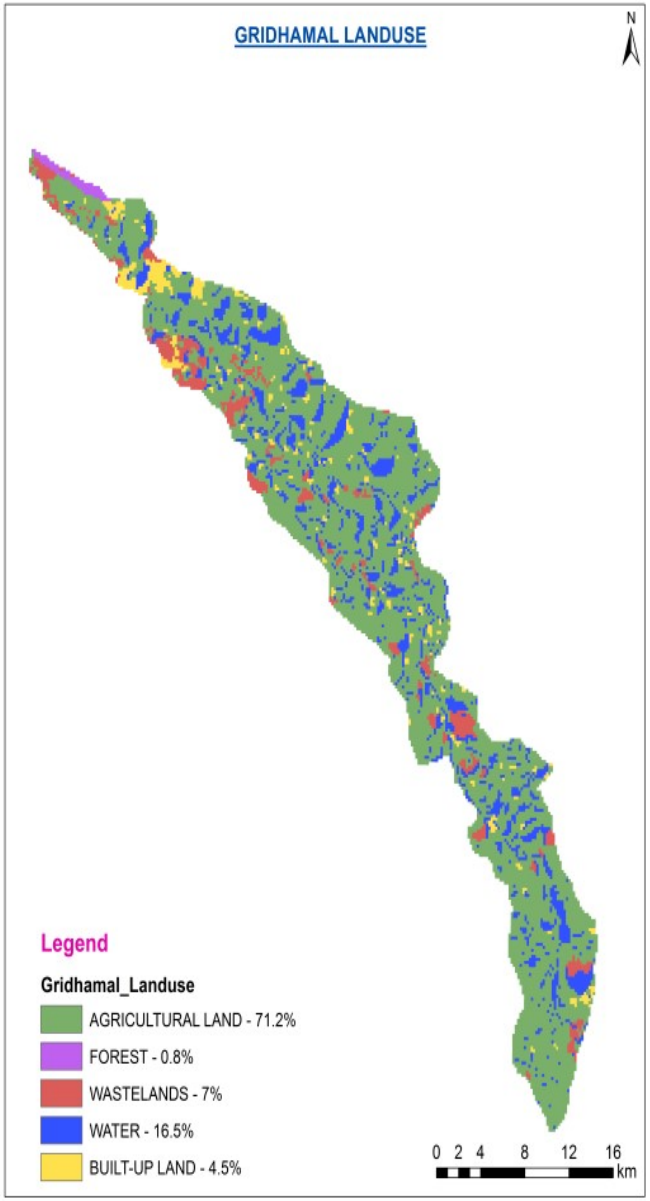

GUNDAR BASIN
Gridhamal

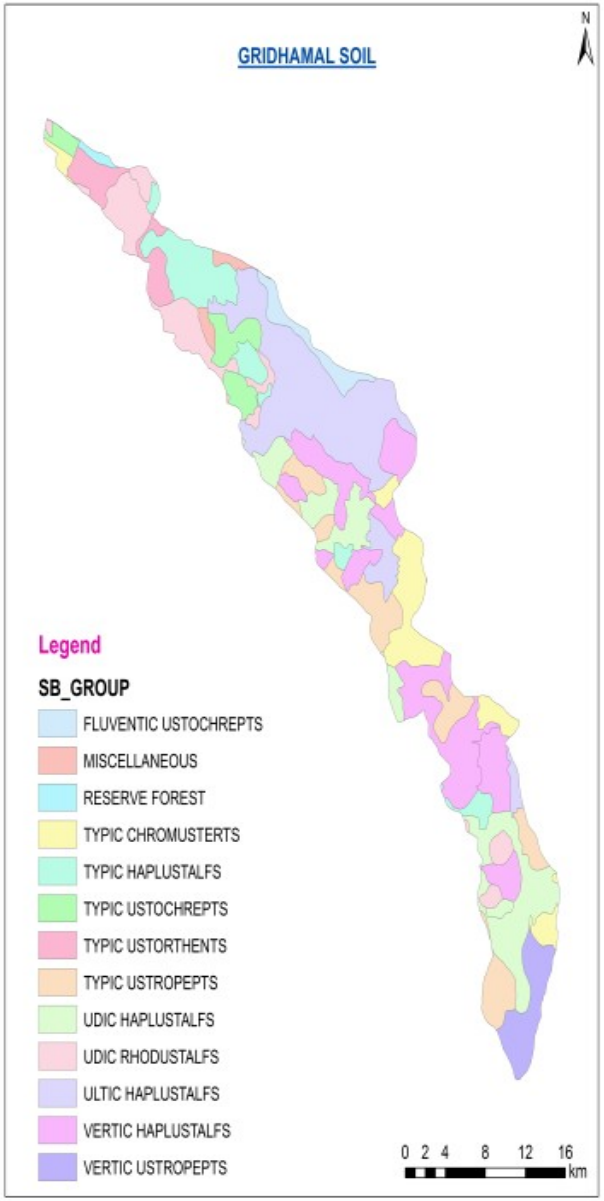

GRIDHAMAL - SUBBASIN
N
Sholavandan
Madurai(Tallakulam)
Madurai South
STP
Madurai
Airport
Thirumangalam
Thirupuvanam
Idayapatti
Parthibanur
Kavalur
Savasapuram
Area - 585 Sq.KM
Legend
Sewage Treatment Plant
SRG
FCS
0 2 4 8 12 16
km

METHODOLOGY

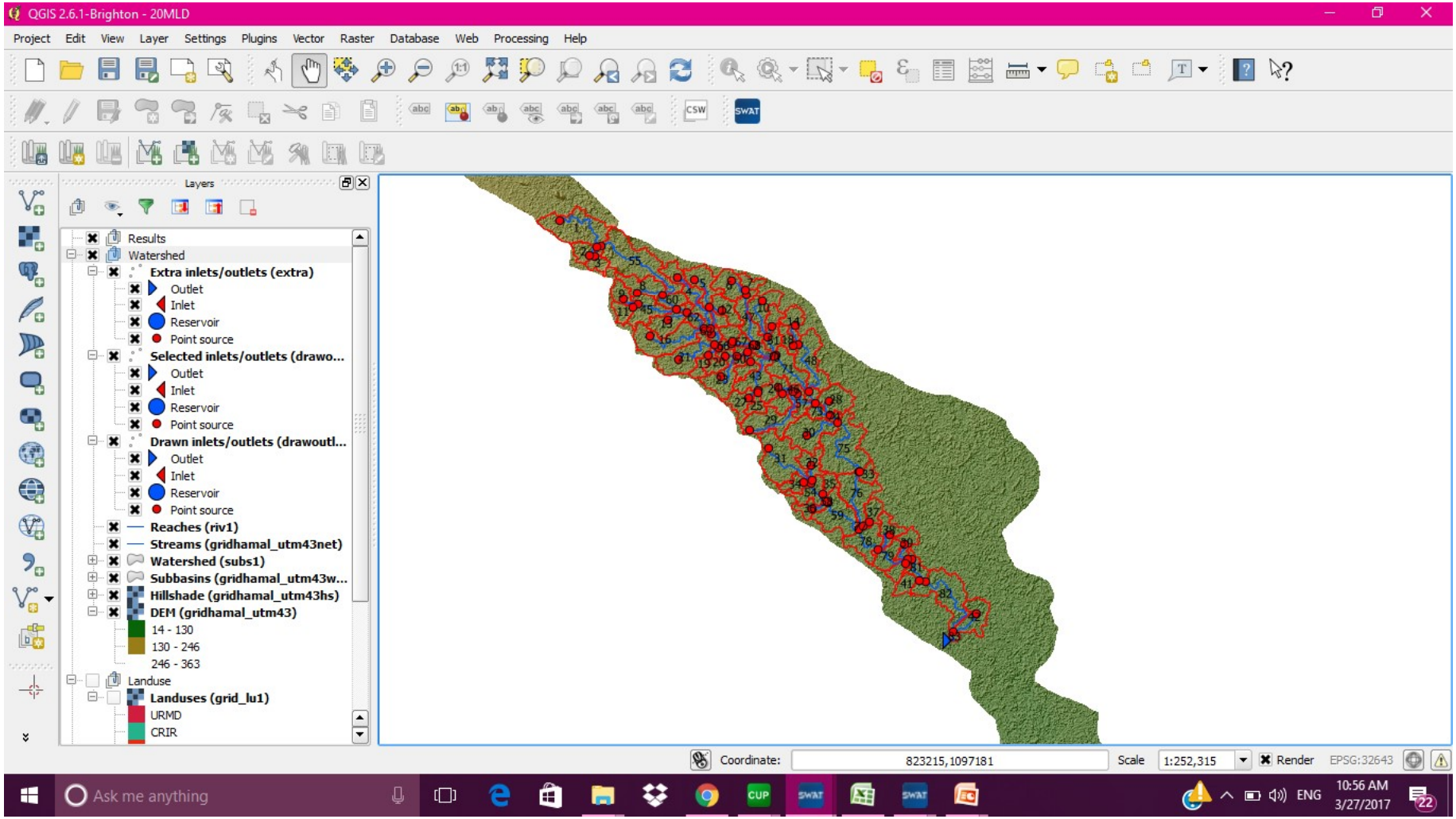



GRIDHAMAL DEM
N
Legend
Value
High : 363
Low : 14
0 2 4 8 12 16
km

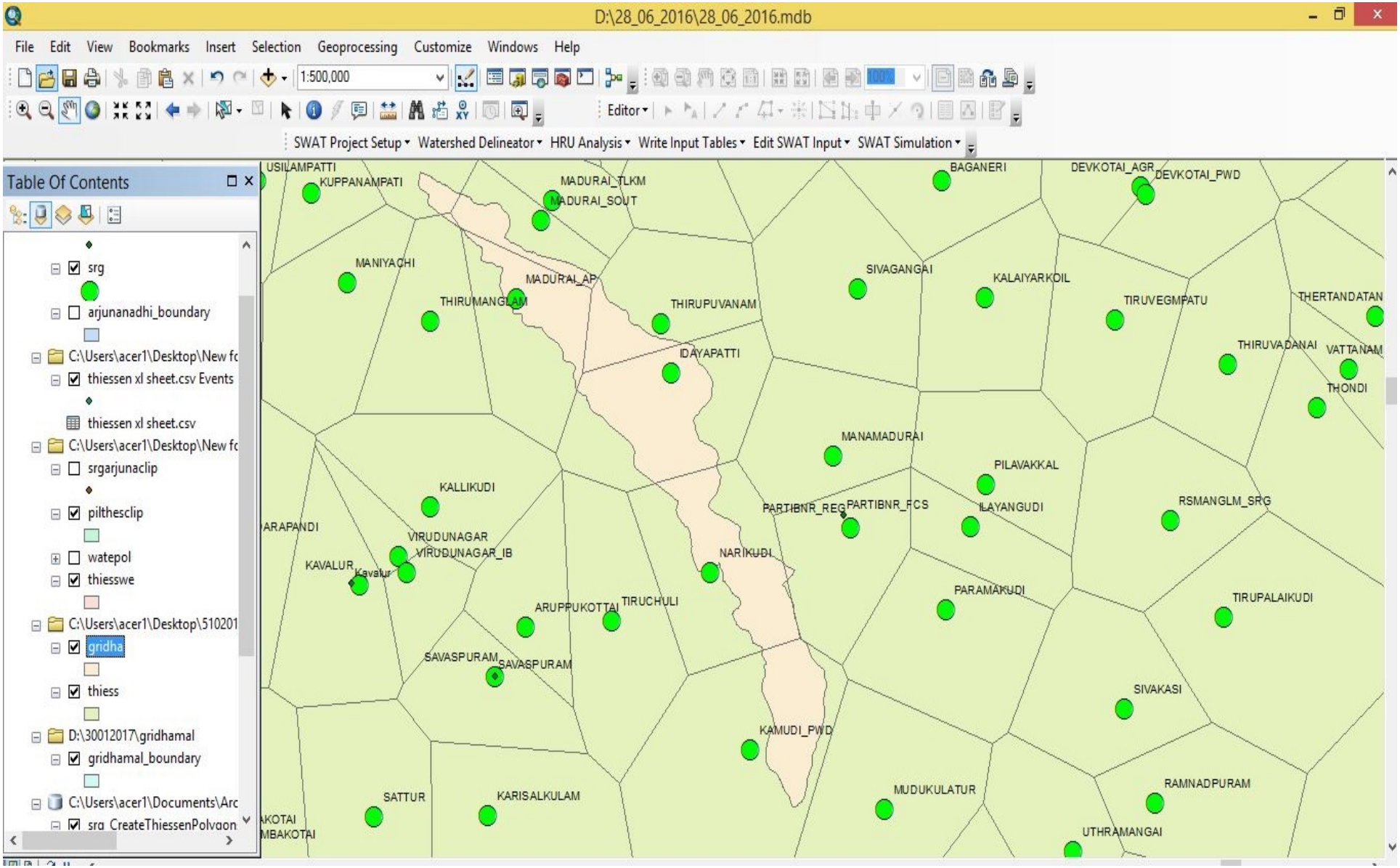

GRIDHAMAL LANDUSE
N
Legend
Gridhamal_Landuse
AGRICULTURAL LAND - 71.2%
FOREST - 0.8%
WASTELANDS - 7%
WATER - 16.5%
BUILT-UP LAND - 4.5%
0 2 4 8 12 16
km


GRIDHAMAL SOIL
N
Legend
SB_GROUP
FLUVENTIC USTOCHREPTS
MISCELLANEOUS
RESERVE FOREST
TYPIC CHROMUSTERTS
TYPIC HAPLUSTALFS
TYPIC USTOCHREPTS
TYPIC USTORTHENTS
TYPIC USTROPEPTS
UDIC HAPLUSTALFS
UDIC RHODUSTALFS
ULTIC HAPLUSTALFS
VERTIC HAPLUSTALFS
VERTIC USTROPEPTS
0 2 4 8 12 16
km

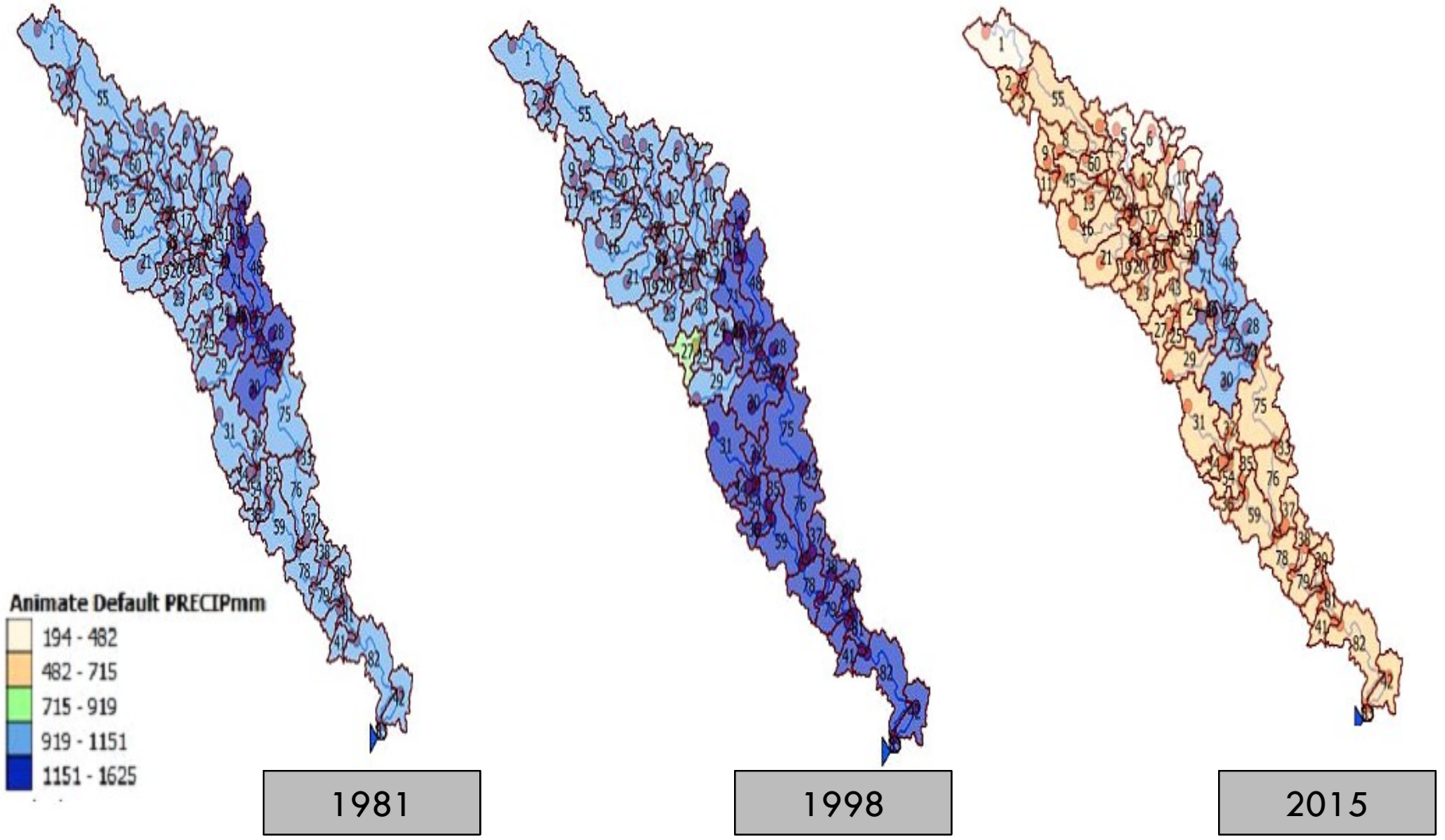
WATERSHED DELINATION and HRU COMPLETION



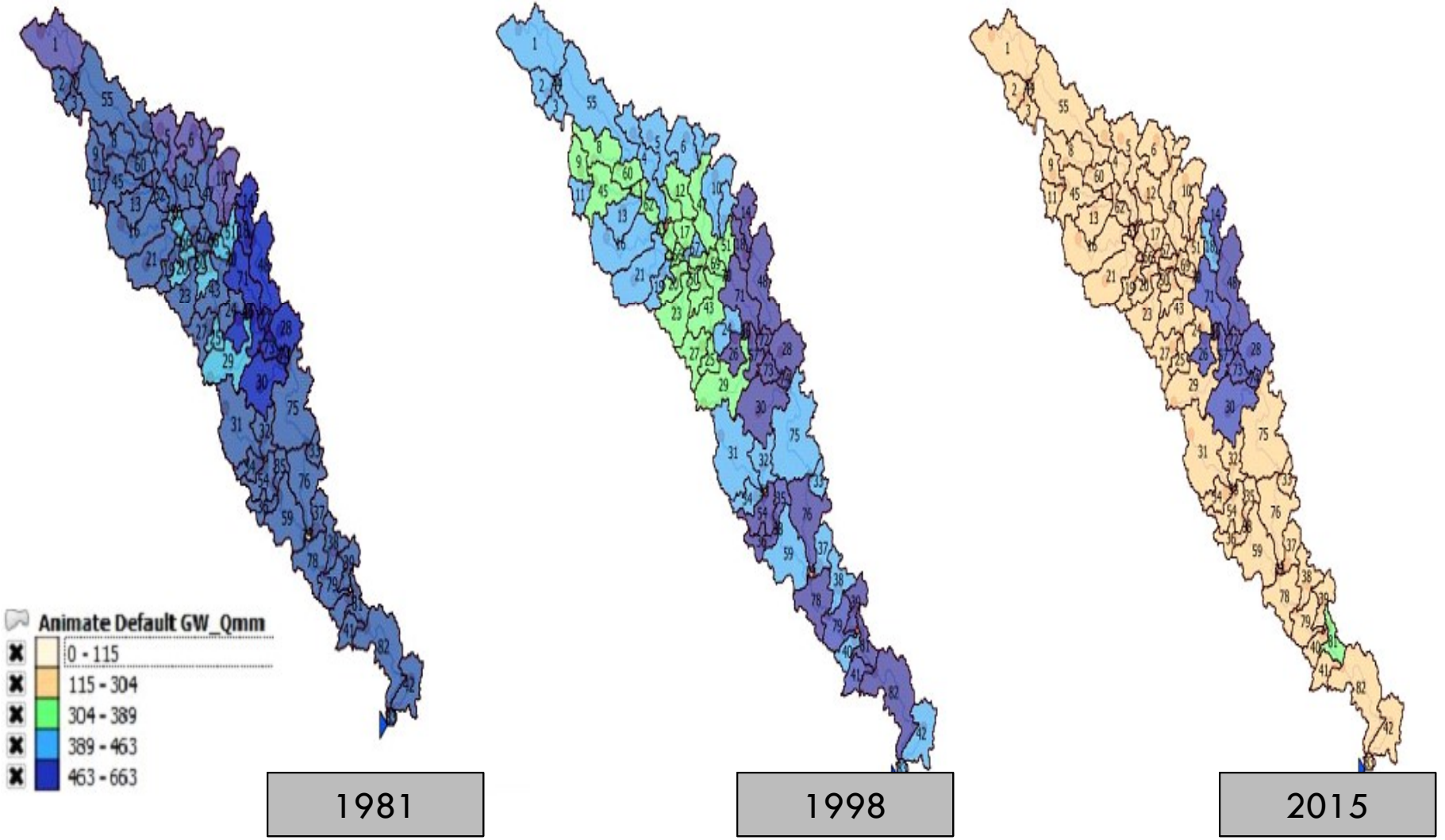
THIESSION POLYGON



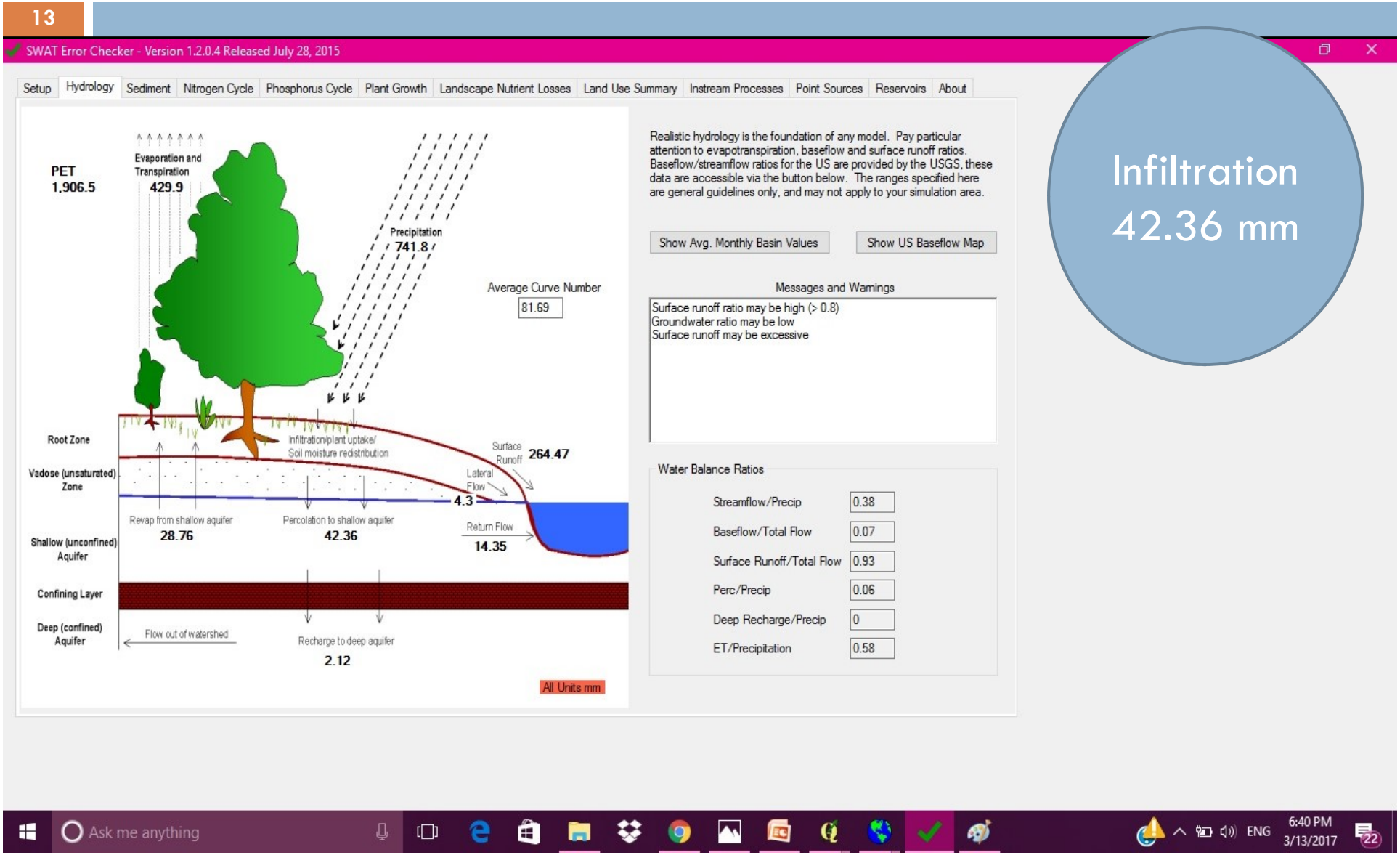
Variations in Precipitation



Variations in Ground water Recharge

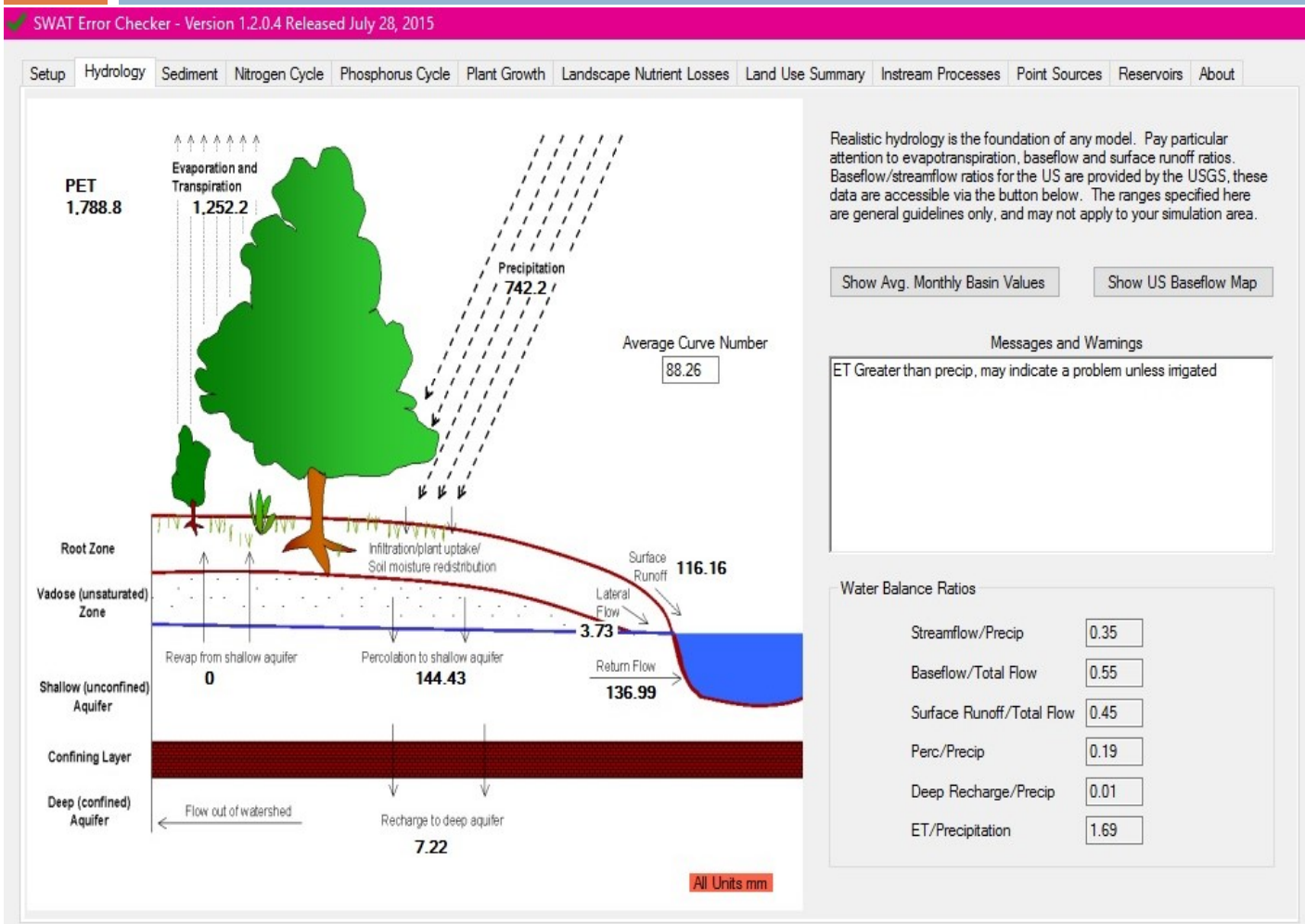


Results



Infiltration
42.36 mm

2nd Scenario



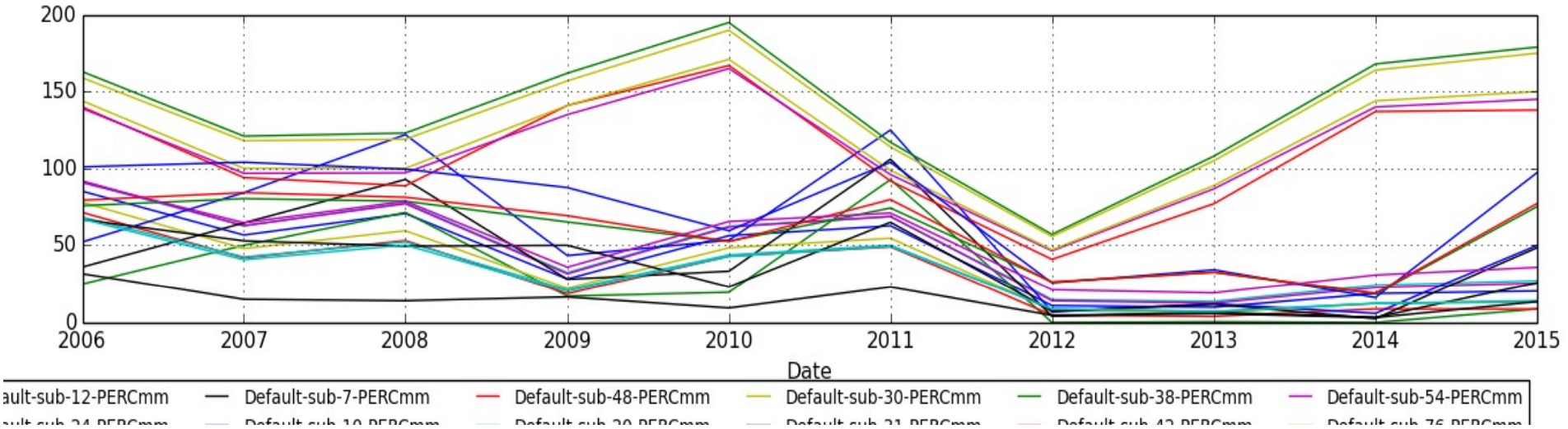
Infiltration
144.43 mm

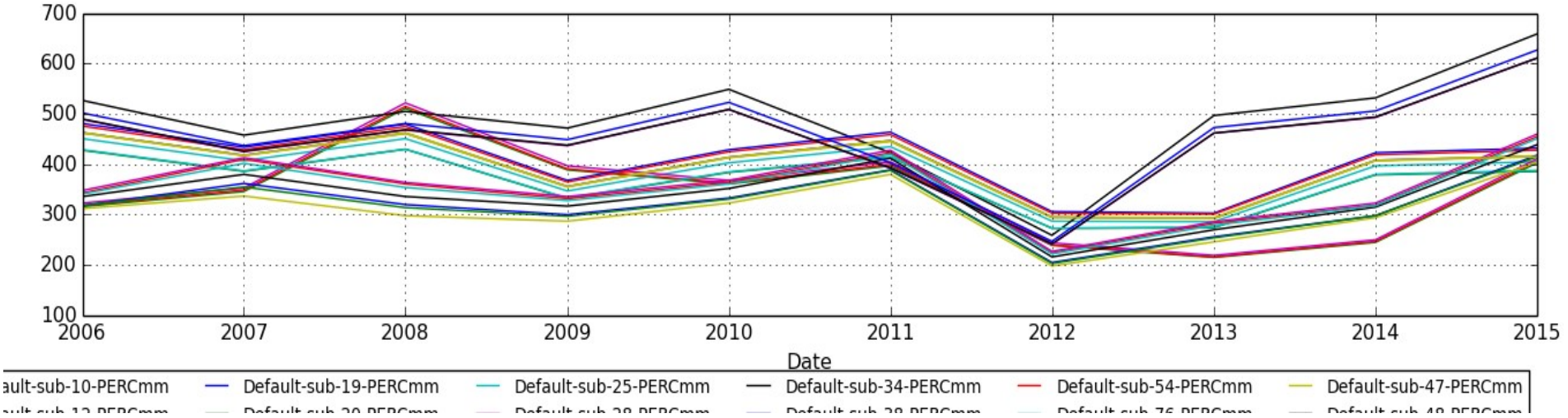
Increases as
3.4 times

Characteristics of Treated wastewater

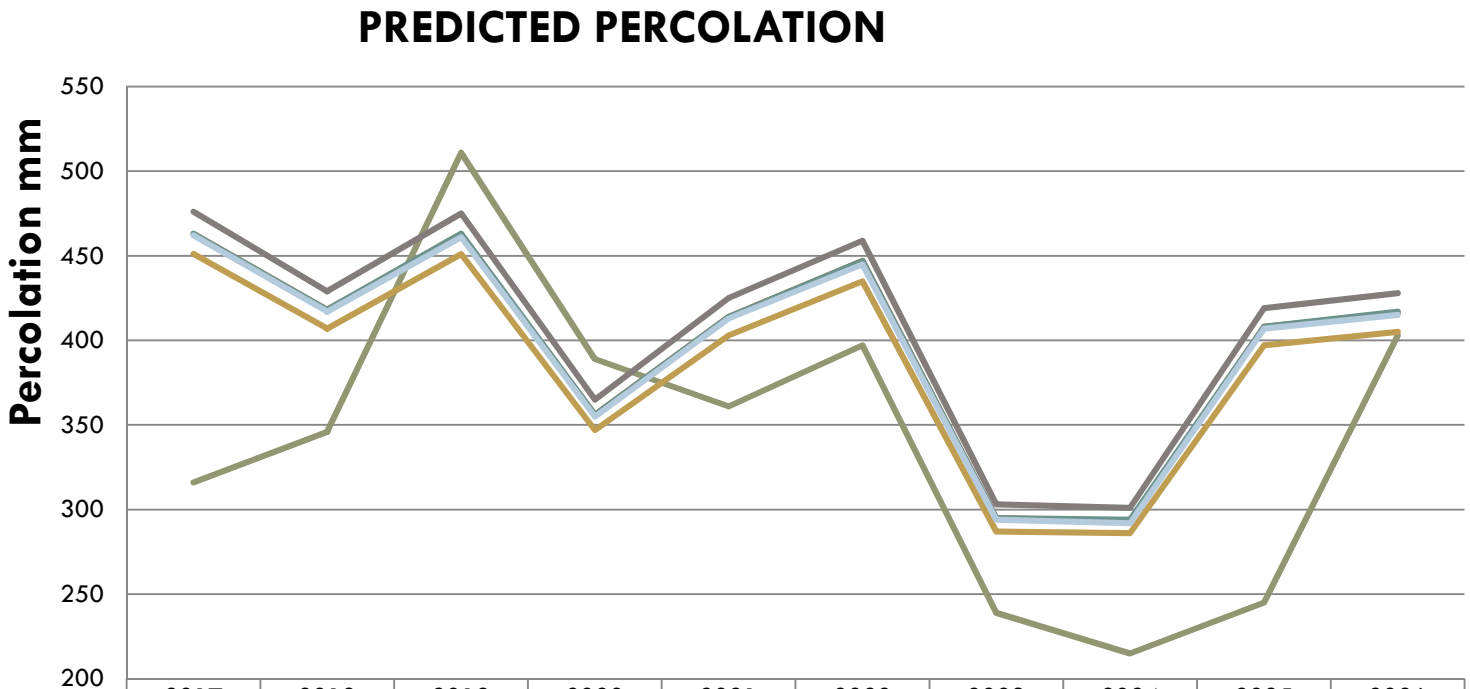
S.No	PARAMETER	CONCENTRATION (ACTUAL)	UNITS	STANDARD LEVEL
1	BOD	8	mg/l	< 30
2	COD	24	mg/l	< 250
3	TSS	6	mg/l	50-100
4	PH	7.3	---	6.5 – 8.4
5	OIL & GREASE	0.7	mg/l	< 10
6	POTASSIUM	31	mg/l	5 to 20
7	SODIUM	391	mg/l	115-230 mg/l for Sensitive crops. 230-460 mg/l Tolerant crops.
8	PHOSPHORUS	1.24	mg/l	0.1 to 0.4
9	NITROGEN	7.85	mg/l	>10

PERCOLATION Changes
Comparison of 22 Sub-basins





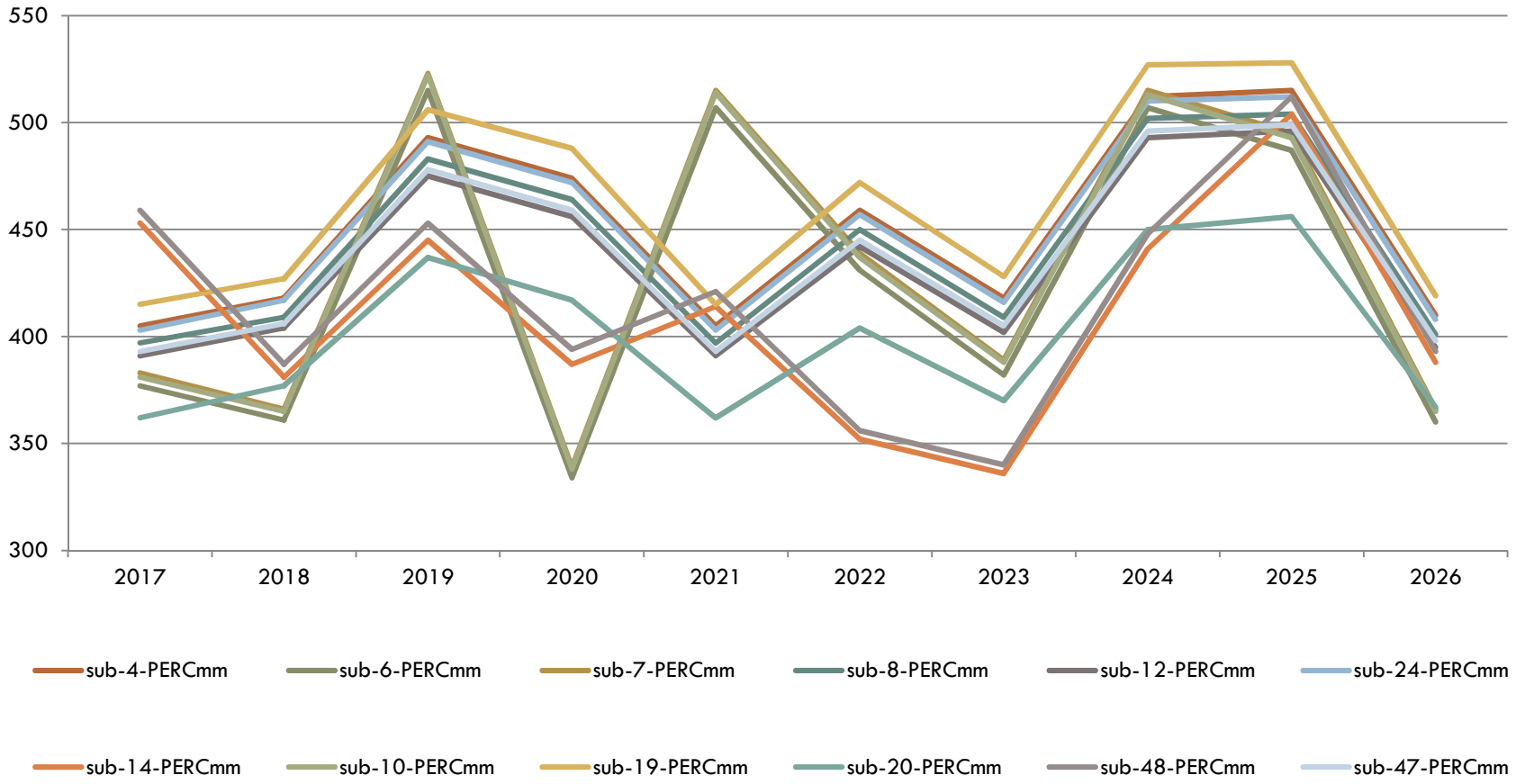
Prediction of 6 Sub-basins Percolation with 20 MLD Flow



	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026
Default-sub-4-PERCmm	463	418	462	356	414	447	295	293	408	416
Default-sub-6-PERCmm	316	346	511	389	361	397	239	215	245	403
Default-sub-8-PERCmm	451	407	451	347	403	435	287	286	397	405
Default-sub-12-PERCmm	463	418	463	356	414	447	295	294	408	417
Default-sub-24-PERCmm	476	429	475	365	425	459	303	301	419	428
Default-sub-47-PERCmm	462	417	461	355	413	445	294	292	407	415

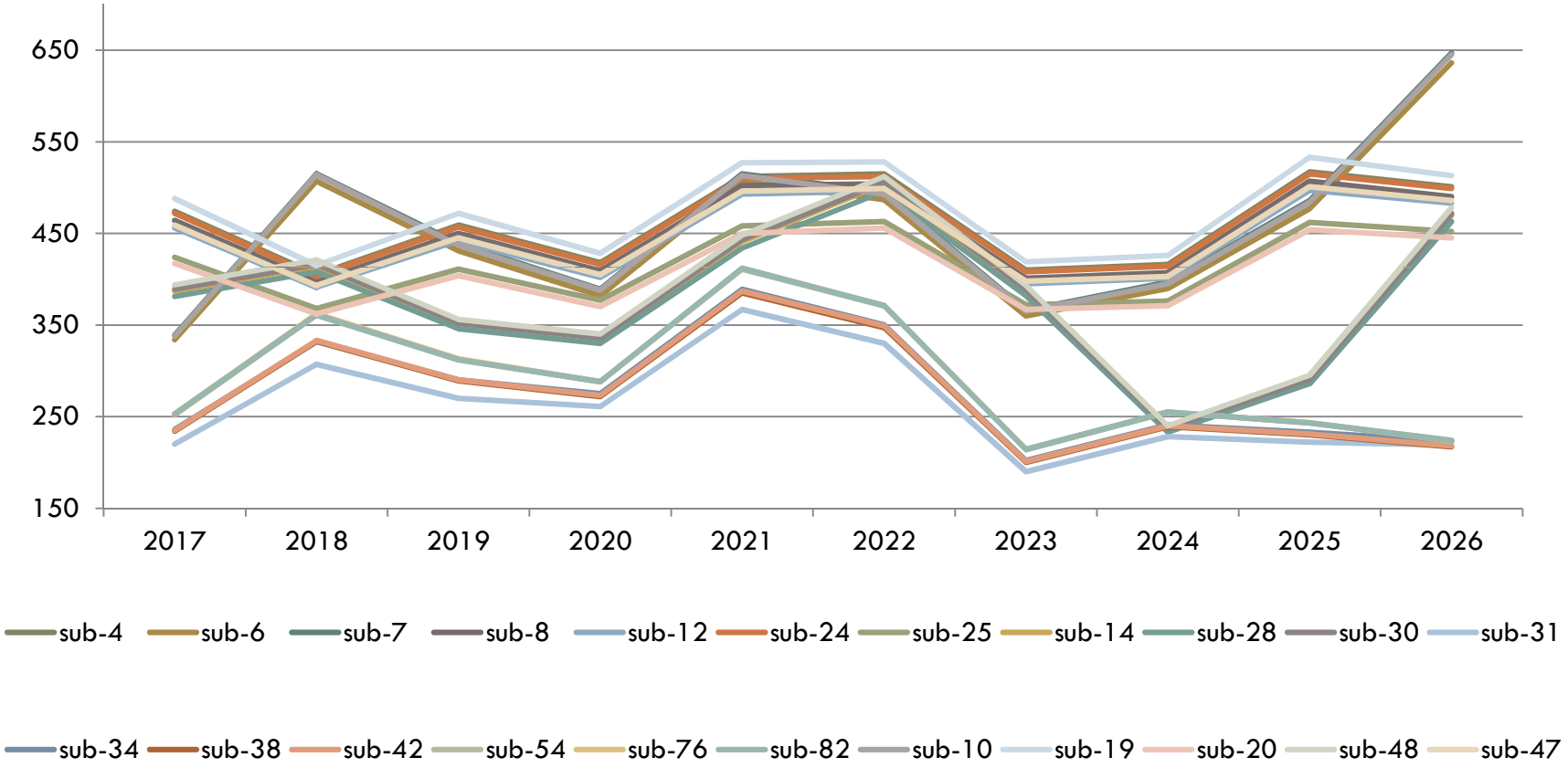
- Area of 1st 6 sub-basins was 1622 ha.
- Average recharge would be 404.2 mm

Prediction of 12 Sub-basins Percolation with 60 MLD Flow



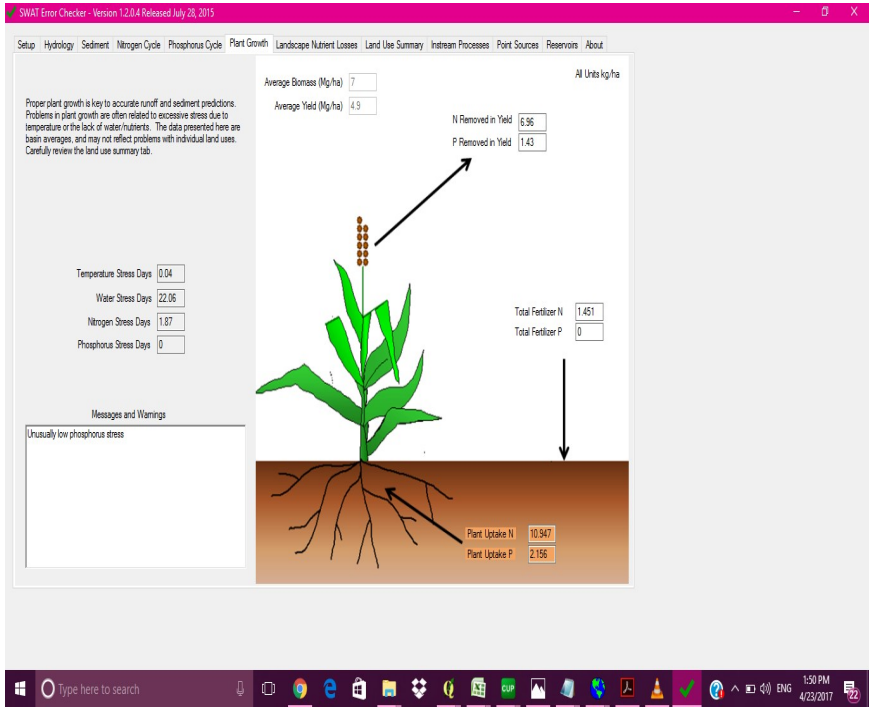
- Area of 1st 12 sub-basins was 2988 ha.
- Average recharge would be 422.5 mm

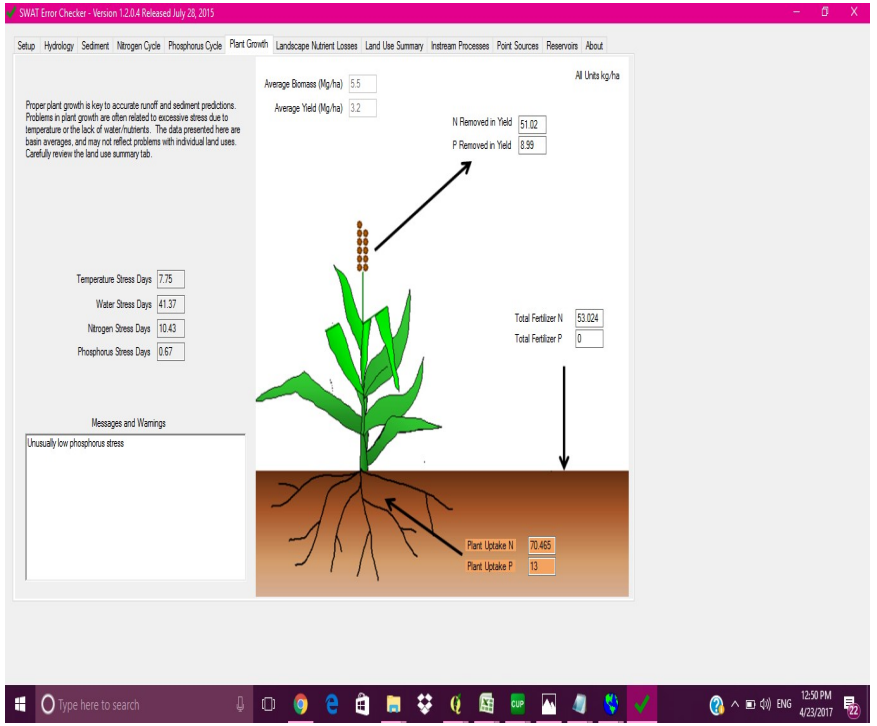
Prediction of 22 Sub-basins Percolation with 100 MLD Flow



- Area of 1st 22 sub-basins was 6489 ha.
- Average recharge would be 373.6 mm

CROP GROWTH


SWAT Error Checker - Version 1.2.0.4 Released July 28, 2015
Setup Hydrology Sediment Nitrogen Cycle Phosphorus Cycle Plant Growth Landscape Nutrient Losses Land Use Summary Instream Processes Point Sources Reservoirs About
Proper plant growth is key to accurate runoff and sediment predictions. Problems in plant growth are often related to excessive stress due to temperature or the lack of water/nutrients. The data presented here are basin averages, and may not reflect problems with individual land uses. Carefully review the land use summary tab.
Average Biomass (Mg/ha) 7
Average Yield (Mg/ha) 4.9
All Units kg/ha
N Removed in Yield 6.96
P Removed in Yield 1.43
Temperature Stress Days 0.04
Water Stress Days 22.06
Nitrogen Stress Days 1.87
Phosphorus Stress Days 0
Total Fertilizer N 1.451
Total Fertilizer P 0
Messages and Warnings
Unusually low phosphorus stress
Plant Uptake N 10.947
Plant Uptake P 2.156
Type here to search
ENG 1:50 PM 4/23/2017


SWAT Error Checker - Version 1.2.0.4 Released July 28, 2015
Setup Hydrology Sediment Nitrogen Cycle Phosphorus Cycle Plant Growth Landscape Nutrient Losses Land Use Summary Instream Processes Point Sources Reservoirs About
Proper plant growth is key to accurate runoff and sediment predictions. Problems in plant growth are often related to excessive stress due to temperature or the lack of water/nutrients. The data presented here are basin averages, and may not reflect problems with individual land uses. Carefully review the land use summary tab.
Average Biomass (Mg/ha) 5.5
Average Yield (Mg/ha) 3.2
All Units kg/ha
N Removed in Yield 51.02
P Removed in Yield 8.99
Temperature Stress Days 7.75
Water Stress Days 41.37
Nitrogen Stress Days 10.43
Phosphorus Stress Days 0.67
Total Fertilizer N 53.024
Total Fertilizer P 0
Messages and Warnings
Unusually low phosphorus stress
Plant Uptake N 70.465
Plant Uptake P 13
Type here to search
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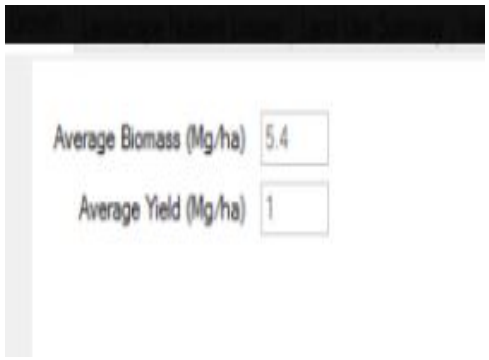
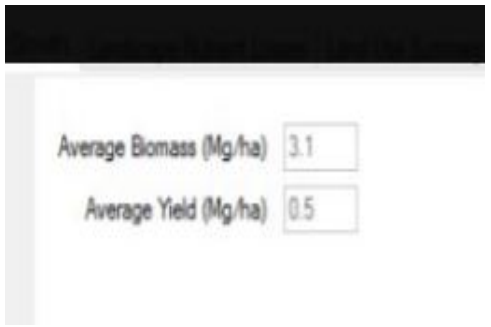
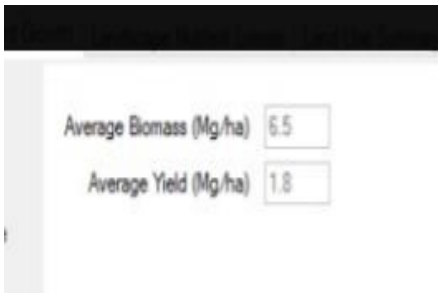
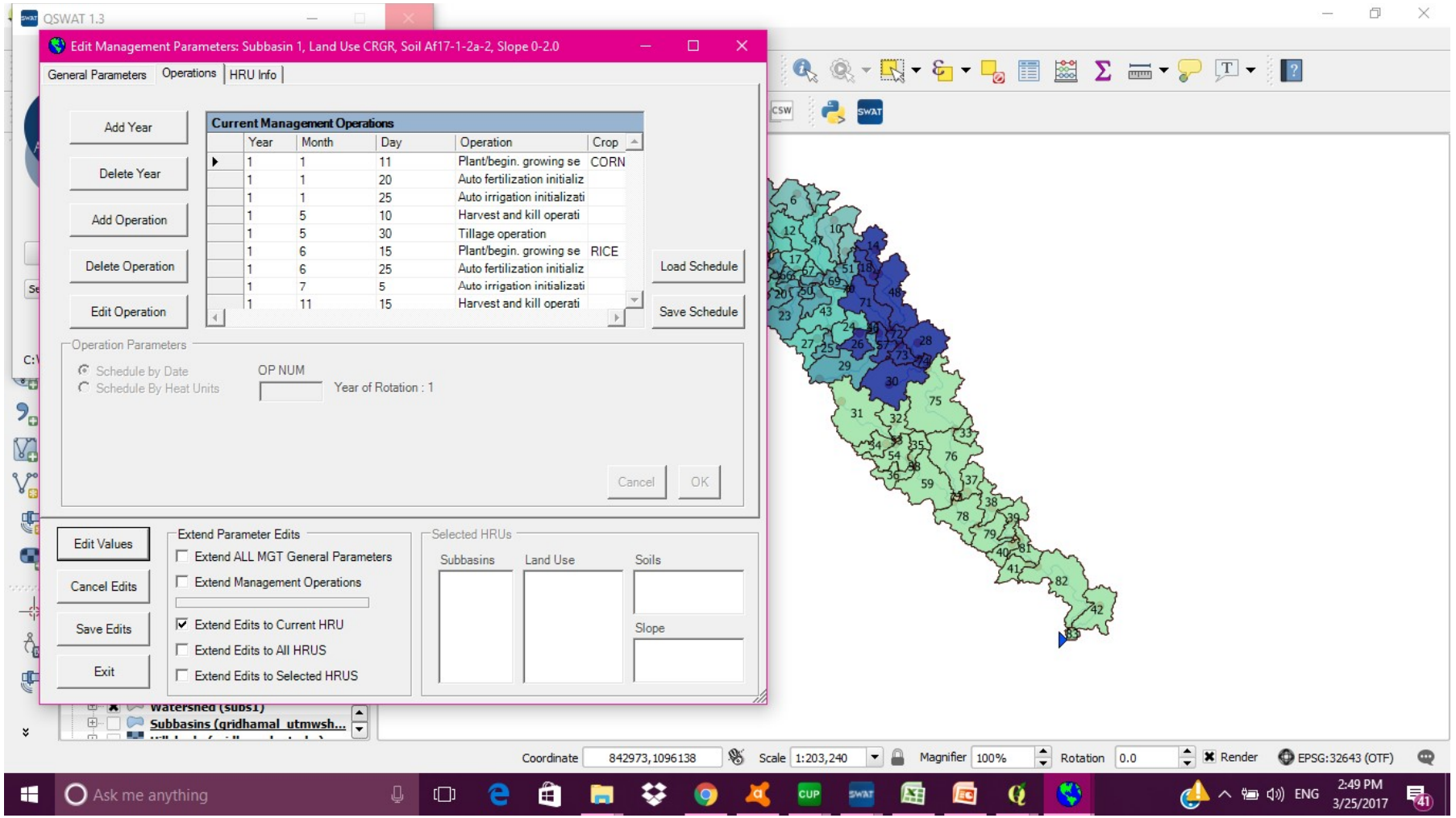

Average Biomass (Mg/ha) 5.4
Average Yield (Mg/ha) 1


Average Biomass (Mg/ha) 3.1
Average Yield (Mg/ha) 0.5


Average Biomass (Mg/ha) 6.5
Average Yield (Mg/ha) 1.8

Management File – Schedule

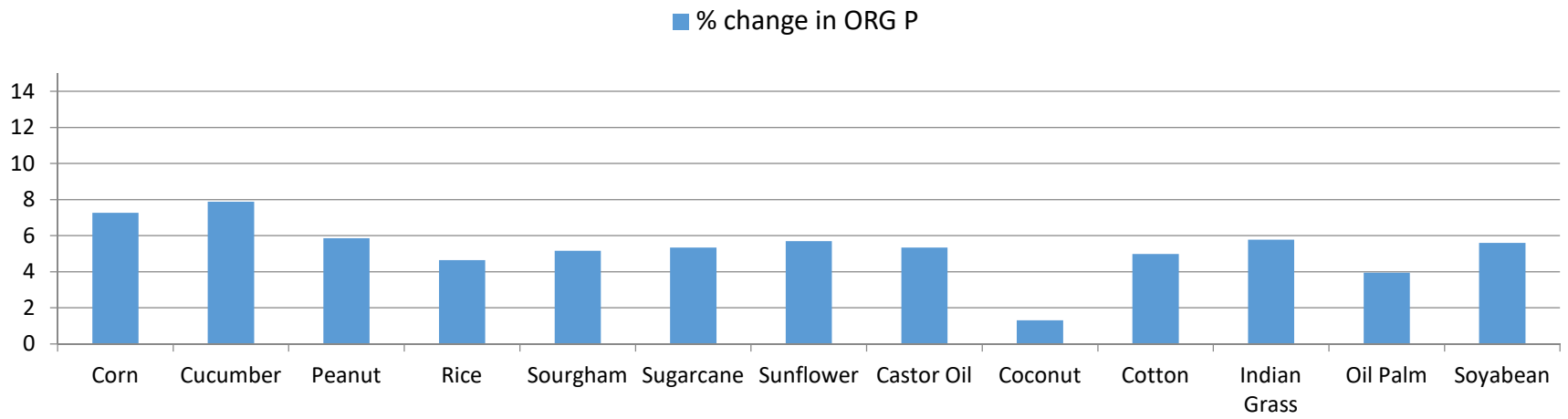


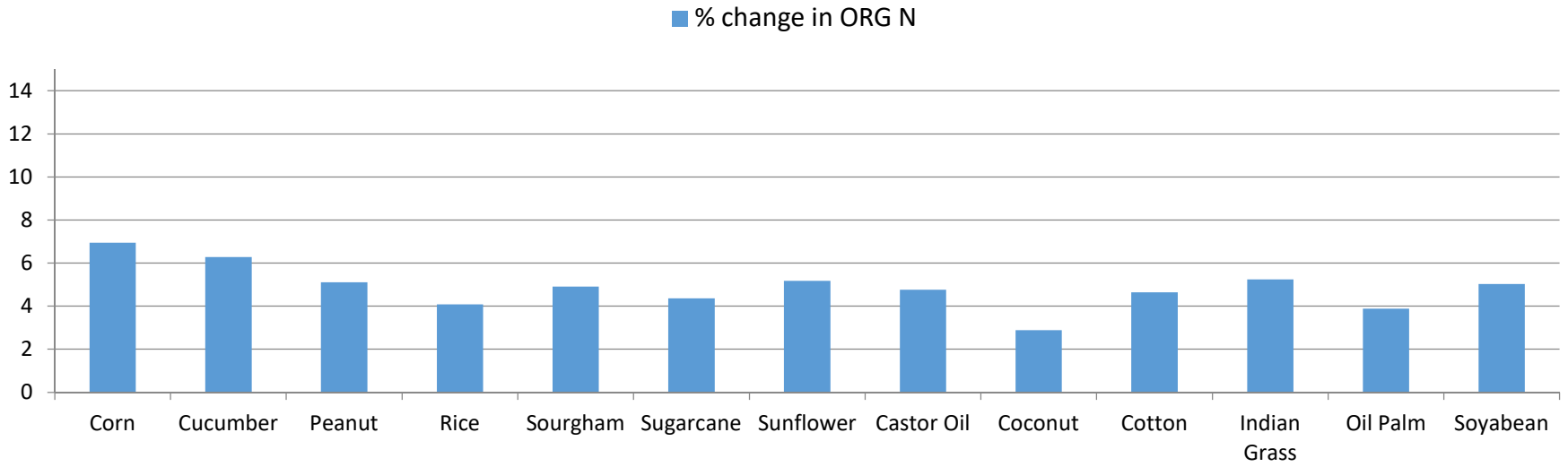
Comparison of Simulated yield with average by TNAU

Crop_Growth						
Sl.No	Crop Name	Model Simulated Yield Kg/Hec	Avg. Range by TNAU	Average Yield by TNAU	Deviation	Suitability
1	Rice	3200	3000-3500	3200	0	Highly Suitable (A)
2	Corn	4900	4000-5000	4800	-2.083	Highly Suitable (A)
3	Cucumber	6200	6000-8000	7000	11.42	Highly Suitable (A)
4	Peanut	1600	1800-2200	2000	20	Highly Suitable (A)
5	Sunflower	1000	1100-1400	1200	16.67	Highly Suitable
6	Sugarcane	110	100-120	110	0	Highly Suitable (A)
7	Sourgham	1800	1600-1900	1800	0	Highly Suitable (A)
8	Coconut	9500	12000-15000	13500	29.6	Suitable
9	Oil Palm	500	300-400	350	-42.8	Suitable
10	Castor Oil	180	200-300	250	28	Suitable
11	Soyabean	550	600-900	700	21.42	Suitable
12	Spinach	5100	6000-8000	7000	27.2	Suitable (A)
13	Cotton	400	500-700	600	33.33	Suitable
14	Indian Grass	8100	10000-16000	13500	40	Suitable
15	Banana	6000	35000-40000	36000	83.3	Not Suitable
16	Papaya	3600	30000-36000	32000	88.75	Not Suitable
17	Cabbage	1000	45000-55000	55000	98.18	Not Suitable
18	Orange	600	1600-2100	1800	66.67	Not Suitable
19	Pine Apple	5000	30000-36000	32000	84.3	Not Suitable
20	Potato	3000	12000-16000	14000	78.5	Not Suitable
21	Tomato	1600	11500-14000	12500	87.2	Not Suitable
22	Sweet Potato	500	11000-15000	12000	95.83	Not Suitable
23	Tobacco	100	300-500	350	71.42	Not Suitable
24	Onion	3200	7000-8000	7200	55.55	Not Suitable
25	Water Melon	4400	25000-30000	27000	83.7	Not Suitable
26	Green Beans	2600	8000-10000	8700	70.1	Not Suitable

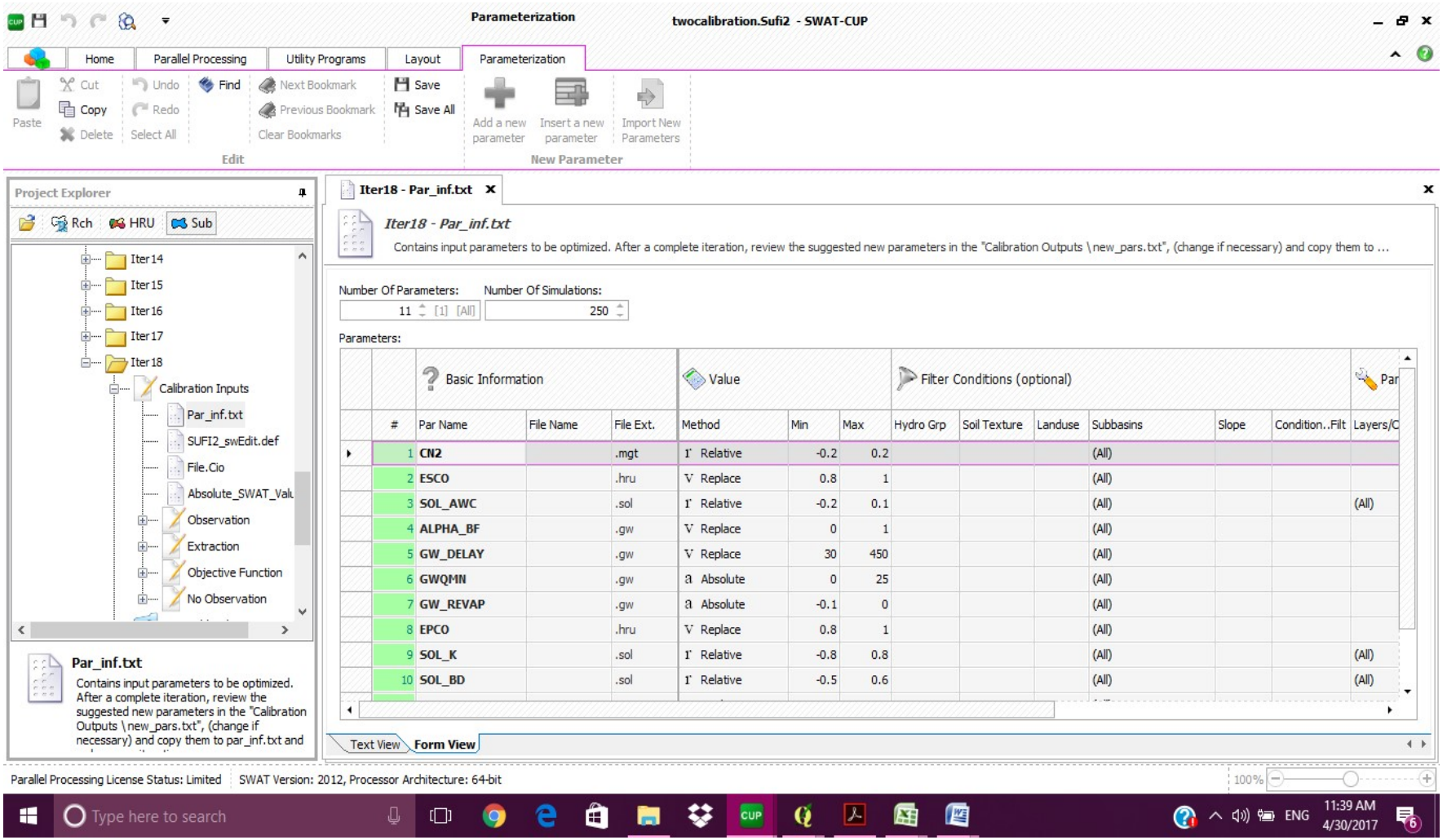
A – Crops having this mark are already an usual crop in our study area

NUTRIENT CHANGES

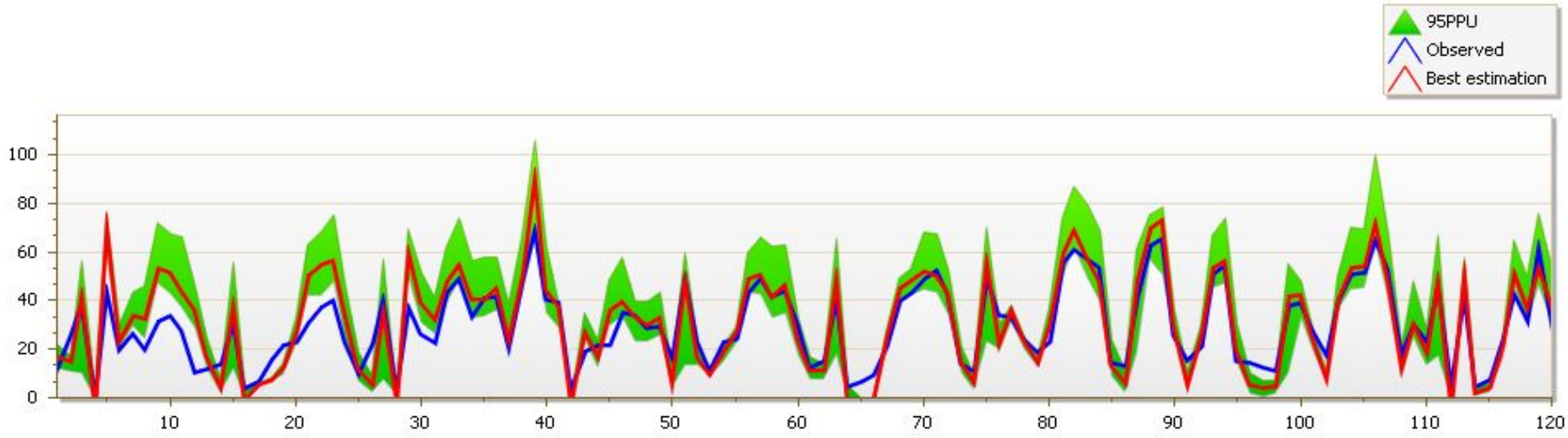




Calibration



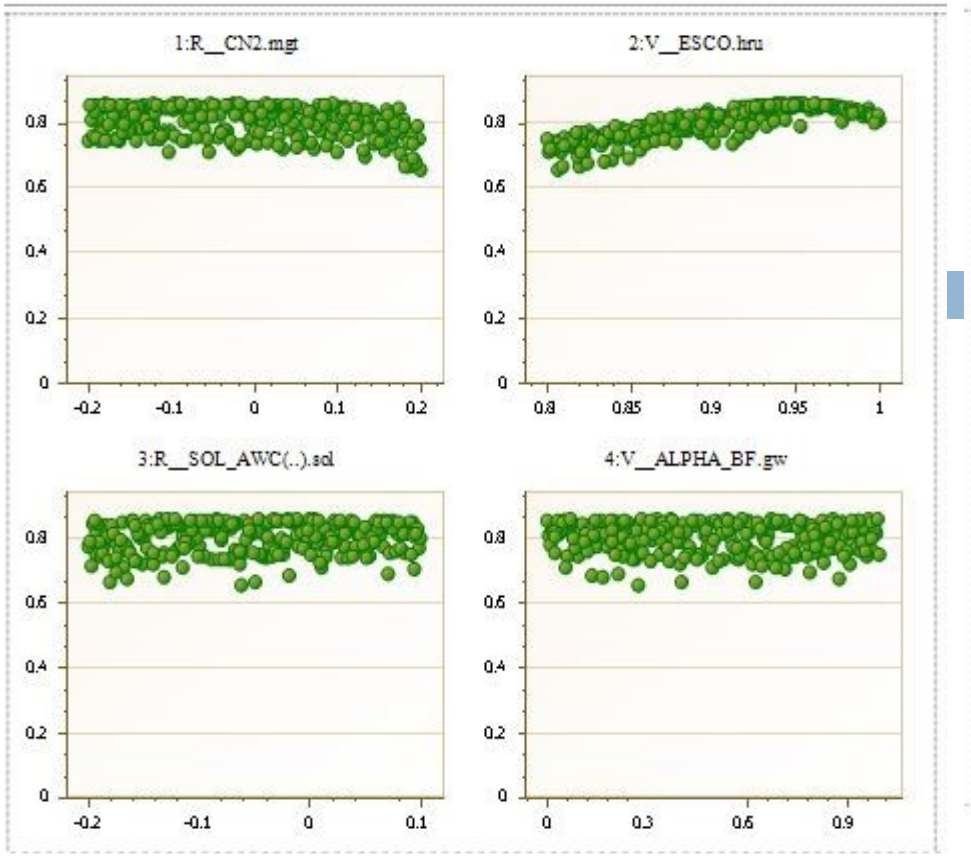
ET_10

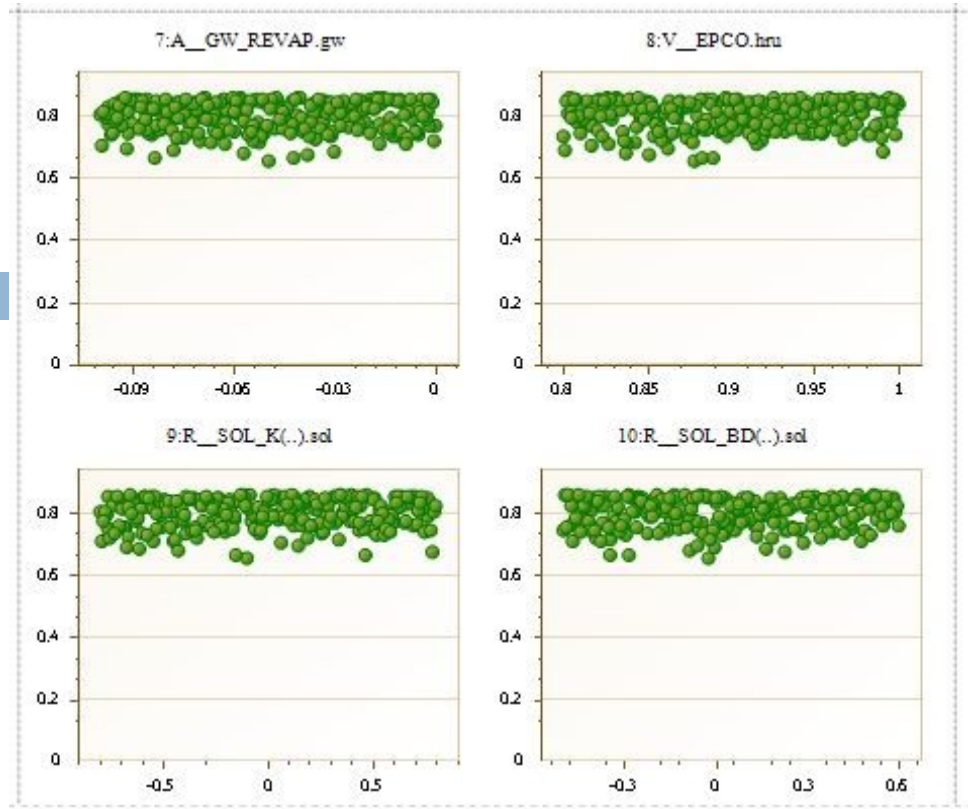


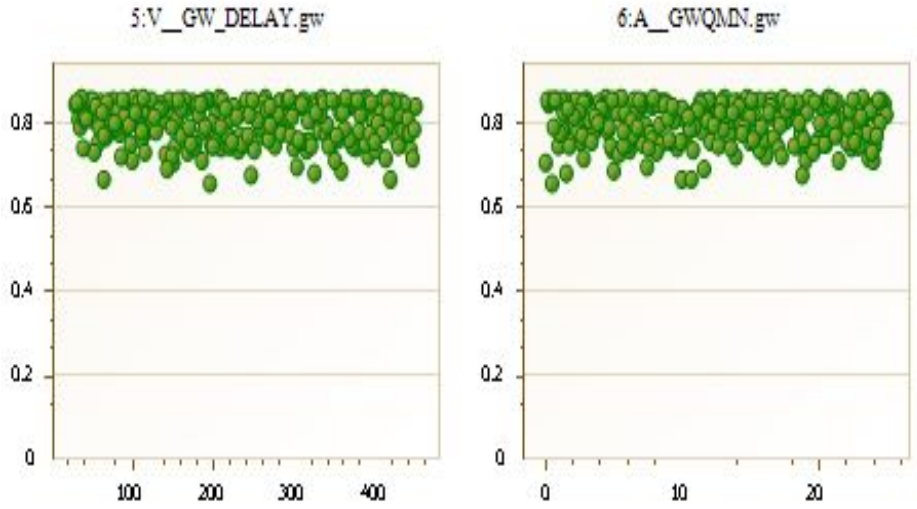
Iter18 - Summary_Stat.txt

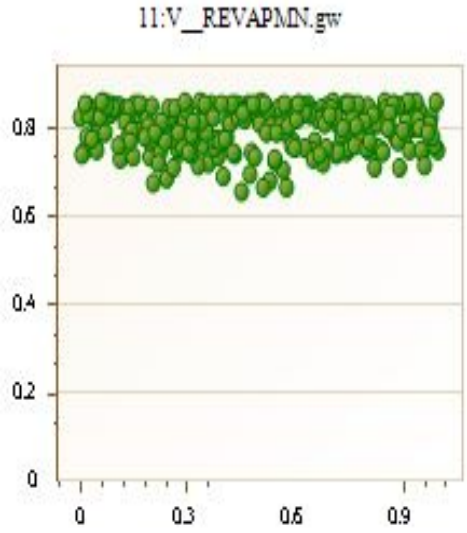
This file has the statistics comparing observed data with the simulation band through p-factor and r-factor and the best simulation of the current iteration by using R2, NS, bR2, MSE, and SSQR

```
Goal_type= R2    No_sims= 250    Best_sim_no= 54    Best_goal = 8.577751e-001

Variable          p-factor  r-factor  R2    NS    bR2     MSE       SSQR      PBIAS  KGE   RSR   MNS   VOL_FR  ---
ET_10             0.68      1.06      0.86  0.72  0.7307  7.4e+001  3.0e+001  -7.2   0.71  0.53  0.53  0.93

---- Results for behavioral parameters ---
Behavioral threshold= 0.600000
Number of behavioral simulations = 250

Variable          p-factor  r-factor  R2    NS    bR2     MSE       SSQR      PBIAS  KGE   RSR   MNS   VOL_FR  ---
ET_10             0.68      1.06      0.86  0.72  0.7307  7.4e+001  3.0e+001  -7.2   0.71  0.53  0.00  0.93
```

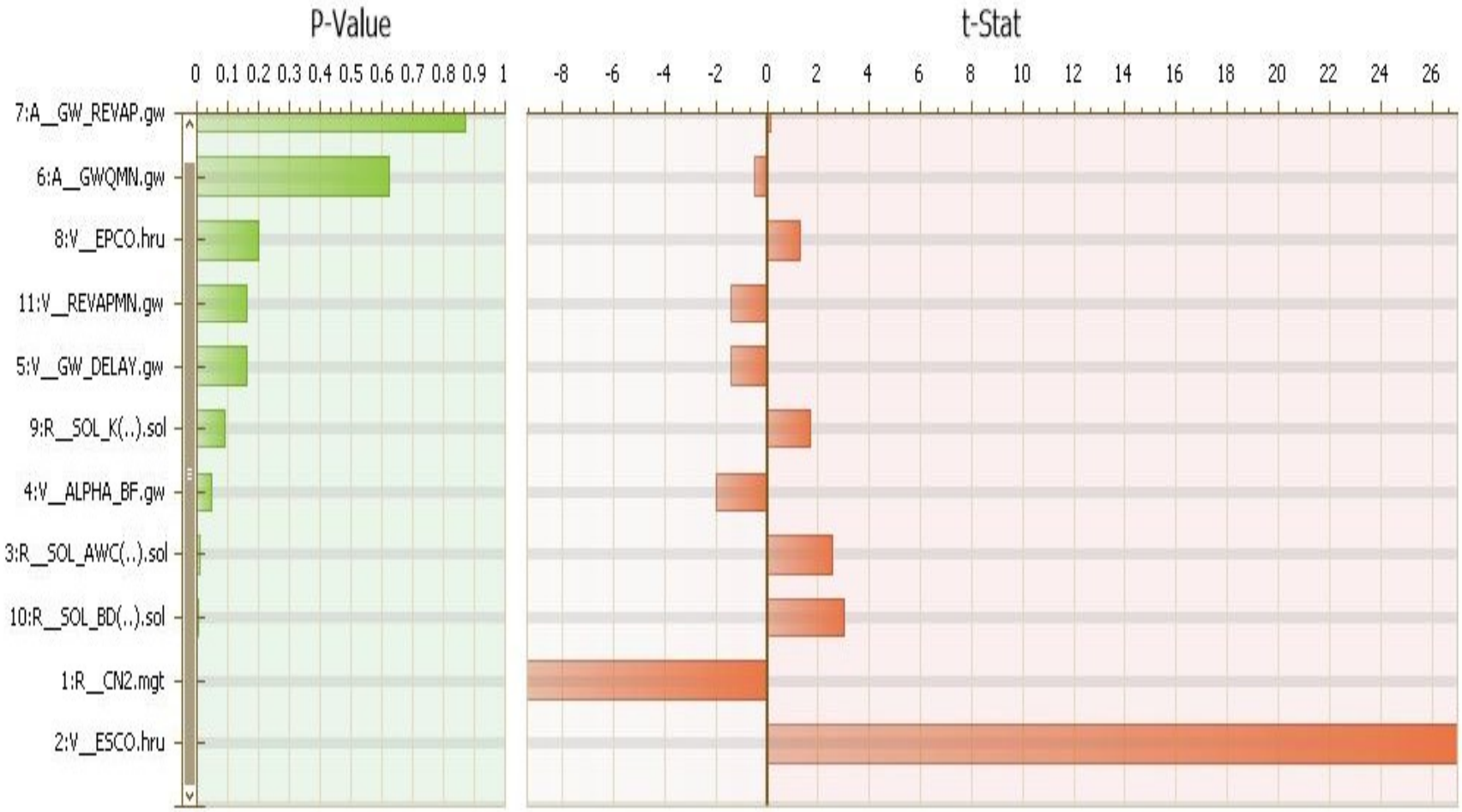

1:R__CN2.mgt
2:V__ESCO.hru
3:R__SOL_AWC(..).sol
4:V__ALPHA_BF.gw


7:A__GW_REVAP.gw
8:V__EPCO.hru
9:R__SOL_K(..).sol
10:R__SOL_BD(..).sol


5:V__GW_DELAY.gw
6:A__GWQMN.gw


11:V__REVAPMN.gw

Sensitivity Analysis



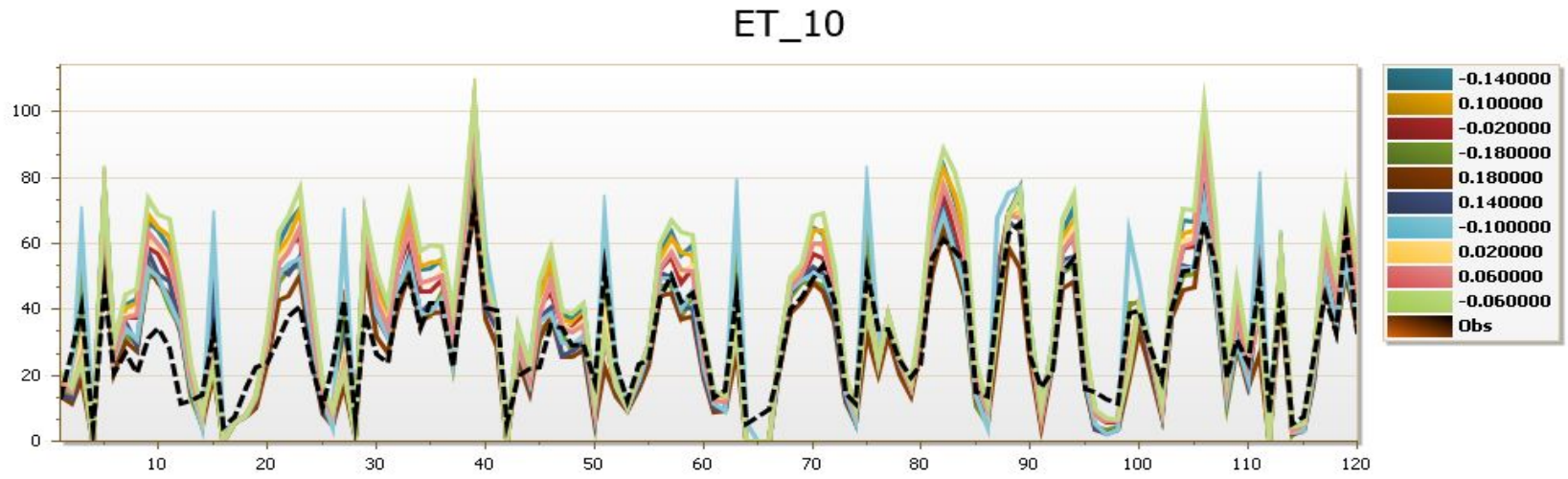
New set of values

Par_No	Par_Name	Rank	t-Stat	p-value	Description
1	CN2.mgt	11	-9.3825295	0.0000000	curve number
2	ESCO.hru	1	26.9988940	0.0000000	Soil evaporation compensation factor
3	SOL_AWC().sol	3	2.5714094	0.0107371	Available water capacity of soil layer
4	ALPHA_BF.gw	10	-1.9755991	0.0493554	Baseflow factor
5	GW_DELAY.gw	9	-1.4008556	0.1625597	Groundwater delay
6	GWQMN.gw	7	-0.4943307	0.6215285	Treshold water in shallow aquifer required for return flow to occur (mm)
7	GW_REVAP.gw	6	0.1646679	0.8693451	GW "revap" coefficient
8	EPCO.hru	5	1.2904292	0.1981538	Plant uptake compensation factor
9	SOL_K().sol	4	1.7003348	0.0903742	Saturated hydraulic conductivity.
10	SOL_BD().sol	2	3.0291082	0.0027232	Moist bulk density
11	REVAPMN.gw	8	-1.397088	0.1636881	Threshold water in shallow aquifer for "revap" to occur (mm)

par_no	par_name	new_min	new_max
1	r__CN2.mgt	-0.240519	0.053319
2	v__ESCO.hru	0.876490	1.029910
3	r__SOL_AWC().sol	-0.253785	-0.017815
4	v__ALPHA_BF.gw	0.482727	1.449273
5	v__GW_DELAY.gw	147.063324	381.656647
6	a__GWQMN.gw	-5.831972	14.731972
7	a__GW_REVAP.gw	-0.087327	-0.029073
8	v__EPCO.hru	0.886143	1.058657
9	r__SOL_K().sol	-0.200442	1.000442
10	r__SOL_BD().sol	-1.040403	0.053602
11	v__REVAPMN.gw	0.252721	0.759279

Validation

```
Goal_type= R2    No_sims= 10    Best_sim_no= 3    Best_goal = 8.534294e-001

Variable          p-factor  r-factor  R2    NS    bR2     MSE      SSQR      PBIAS  KGE   RSR   MNS   VOL_FR  ---
ET_10             0.63      0.89      0.85  0.61  0.6932  1.0e+002 5.7e+001  -14.6  0.63  0.63  0.42  0.87


---- Results for behavioral parameters ---
Behavioral threshold= 0.600000
Number of behavioral simulations = 10

Variable          p-factor  r-factor  R2    NS    bR2     MSE      SSQR      PBIAS  KGE   RSR   MNS   VOL_FR  ---
ET_10             0.63      0.89      0.85  0.61  0.6932  1.0e+002 5.7e+001  -14.6  0.63  0.63  0.00  0.87
```



Summary

- Model is first simulated with Scenario 1 and for this calibration and validation was done with ET values
- Then the corrected model was used for future predictions.
- Outputs are focused on CROP GROWTH, GW RECHARGE, SOIL NUTRIENT CHANGES and ECONOMICAL ASPECTS.

Conclusion and Recommendations

- The results of Calibration and Validation for ET value with objective functions of **R^2 and NS** were **0.86 & 0.72** and **0.85 & 0.61**
- As an average of more than **300 mm** will be percolated every year in these 22 sub-basins. These sub-basins has an area of 6500 hectares and approximately **19.5 Mm^3** of water will gets percolated.
- If we properly utilize the treated wastewater as per this study, the Peri Urban will get lot of benefits in the form of CROP PRODUCTION, GW RECHARGE.


Thank
You