

“Runoff Modeling in Ghataprabha Sub basin for Climate Change Scenario”



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Motivation.....

- ▶ Climate change can be sum up to measurable difference in the values of atmospheric variables such as precipitation, temperature, humidity, wind, solar radiation, atmospheric pressure and other meterological variable over a long period of time.
- ▶ Thus, it is important to quantify the impacts of climate change to frame mitigation and adaptation measures.
- ▶ Hydrological modeling of water cycle in areas with extreme events and natural hazards (e.g., flooding, droughts) is imperative for sustainable management of soil and water resources.
- ▶ Understanding water resources availability would help stakeholders and policymakers to plan and develop an area.
- ▶ The distributed hydrological model can also be used for climate change impact on surface runoff and water availability in the basin catchments.
- ▶ The main aim of this study is to predict surface runoff in the Ghataprabha sub basin catchment using hydrological model SWAT.



Objectives

The main aim of the study is to simulate the runoff over a Ghatapraha sub basin. Following are the specific objectives are to be achieved.

- Multi-site calibration and validation of SWAT Model for Ghataprabha sub basin for the monthly discharge.
- Downscaling of climate variables (precipitation, temperature, relative humidity, solar radiation and wind speed) for the Ghataptabha sub basin.
- To simulate the surface runoff for the Ghataprabha sub basin using downscaled data from 2021-2100.
- Simulate of streamflow at the four discharge gauge (Bagalkot, Gokak falls, Gotur and Daddi) stations.



STUDY AREA

Ghataprabha Sub Basin

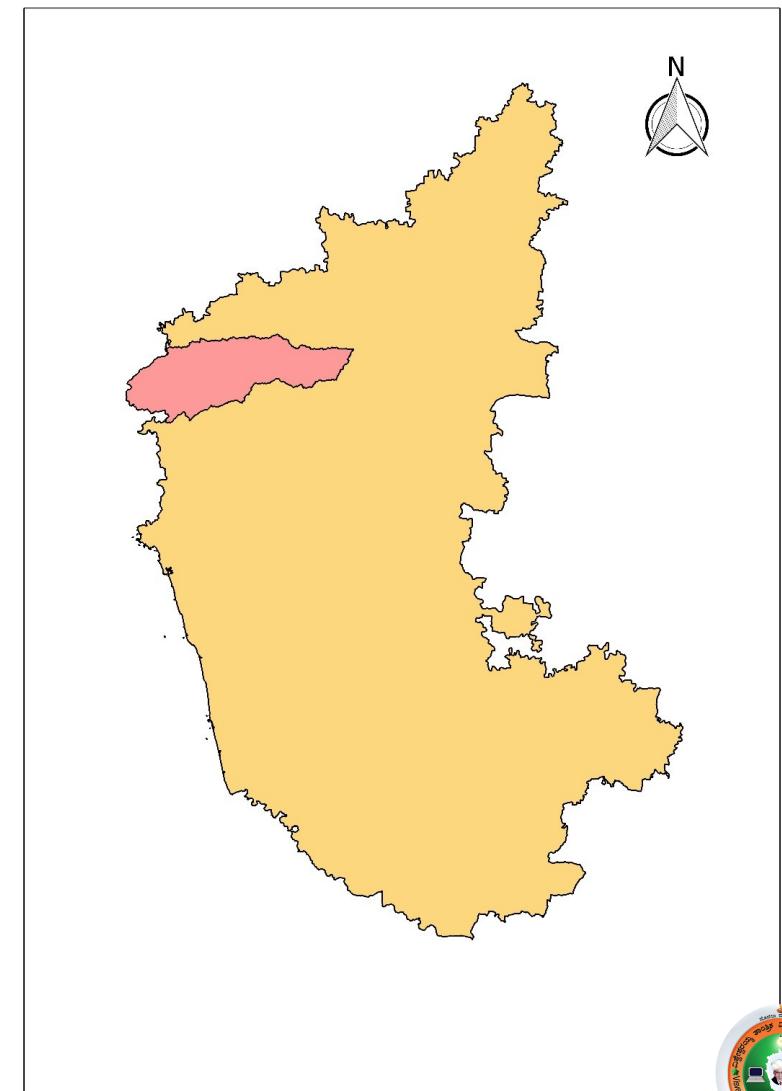
- The **Ghataprabha** river is an important tributary of the Krishna River.
- It flows eastward for a distance of 283 kilometers before joining the River Krishna at Almatti.
- The river basin is 8,829 square kilometers wide and stretches across Karnataka and Maharashtra states.

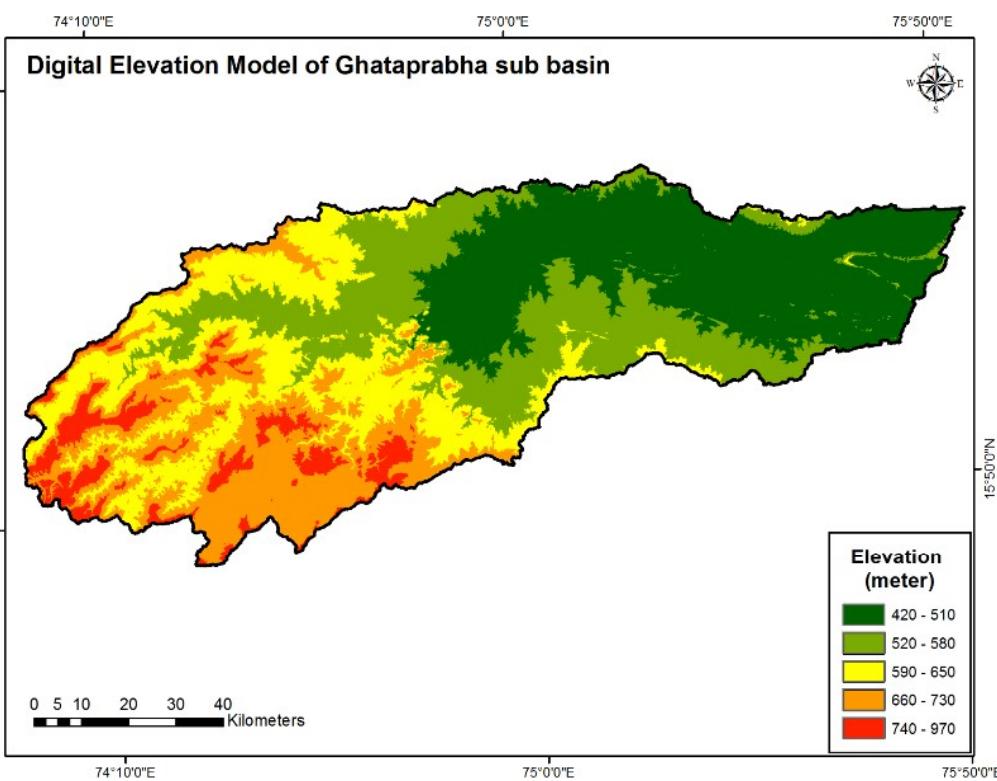


Study area

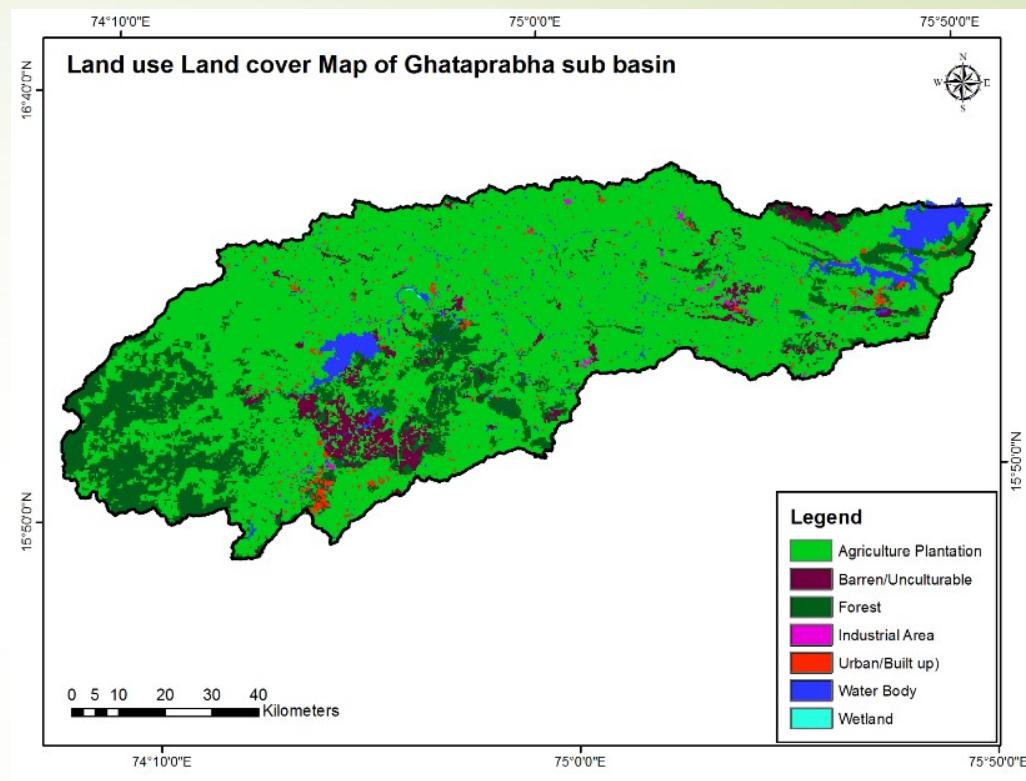


Sub basin	Ghataprabha (K3)
Area	8829 km ²



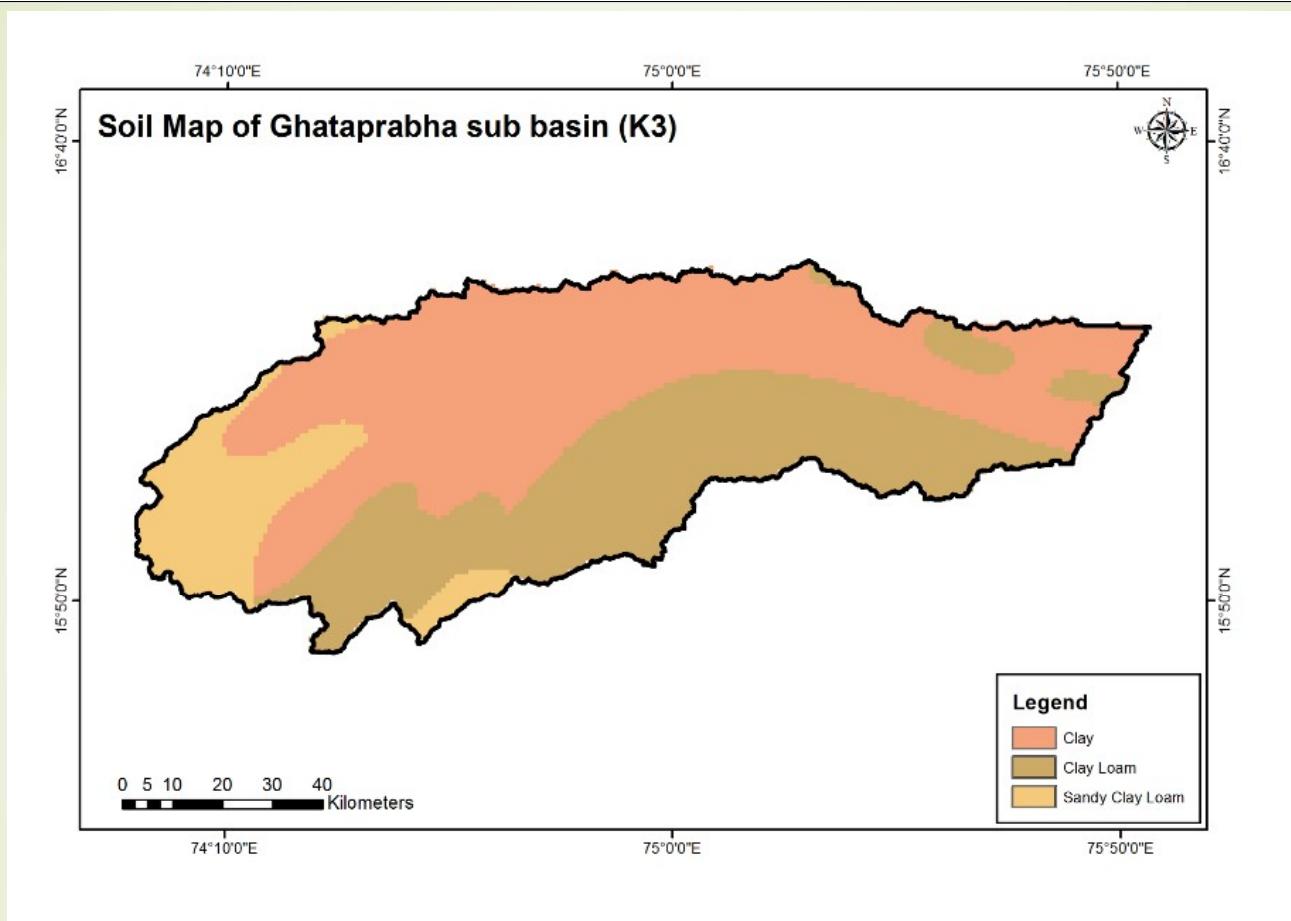


DEM
Source: Cartosat Ver. 3R1



LULC (2011)
Source: KSRAC, Govt. of Karnataka





Soil
Source: FAO



Data and Its Sources

Sl. No .	Data	Source
1	Precipitation 0.25 x 0.25 deg Gridded data	India Meteorological Department (IMD)
2	Temperature 1.00 x 1.00 deg Gridded data	India Meteorological Department (IMD)
3	Digital Elevation Model (32m resolution)	Bhuvan: Cartosat Ver. 3R1
4	LULC 2011	KSRAC GoK
5	Soil	FAO
6	Discharge Data for <ul style="list-style-type: none">• K3 Sub basin (Bagalkot, Gokak falls, Gotur, Daddi)	Water Resource Information System (WRIS)

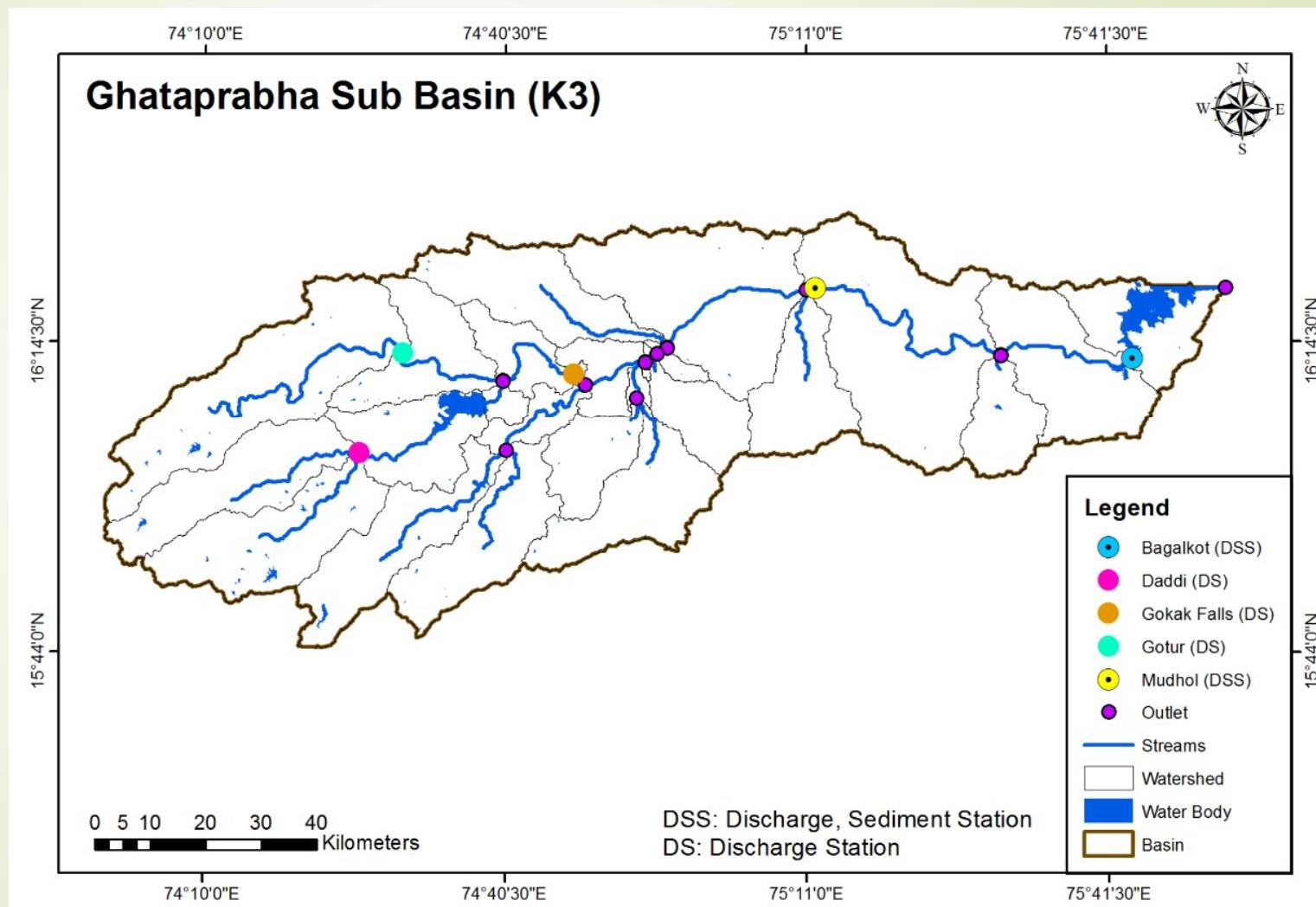


Data	Source
GCM Historical and Future data	World Data Center for Climate (WDCC)
NCEP-NCAR Reanalysis data Relative Humidity Solar Radiation U & V Wind components	NOAA National Center for Environmental Prediction



Multisite Calibration and Validation of SWAT Model

- ▶ The calibration and validation of the model is performed manually.
- ▶ The calibration carried out from 1980-1998 with 3 years warm up period.
- ▶ The model is validated from 1999 to 2005.
- ▶ The calibration of the model performed for the Bagalkot gauge and validated with the remaining gauges in the Ghataprabha sub basin.



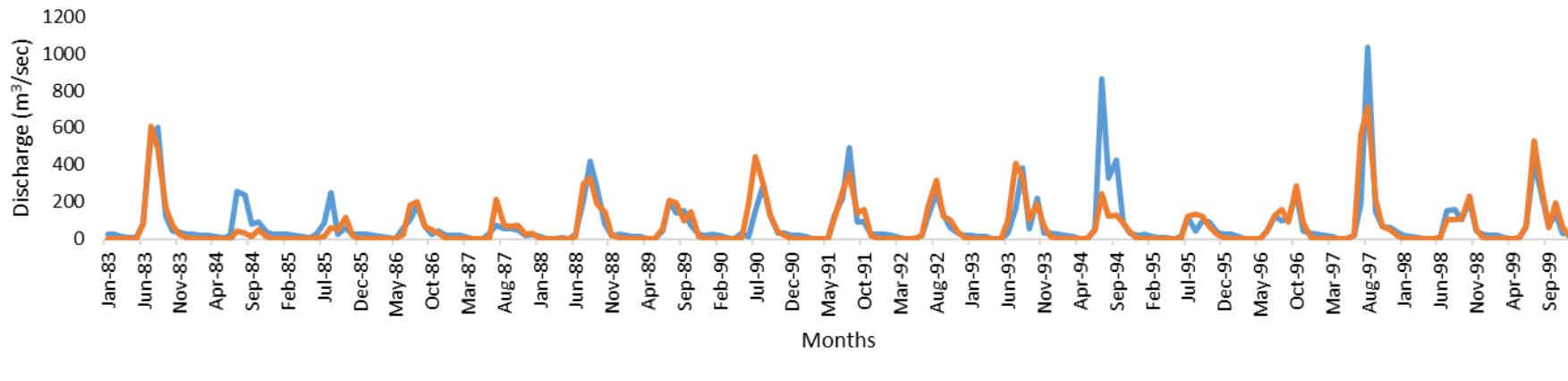
Parameters and their ranges used during calibration

Sl.No	Parameter	Range
1	CN2	80-90
2	ALPHA-BF	0.85-0.95
3	GW_DELAY	0-500
4	GWQMN	1000-2000
5	CH_K2	2-4
6	CH_N2	0.014-0.2
7	EPCO	0.5-1
8	ESCO	0.7-1
9	GW_REVAP	0-0.2
10	RCHRG_DP	0-1
11	REVAPMN	750-1000
12	SOL_AWC	0-1
13	SOL_K	
14	SURLAG	0-4

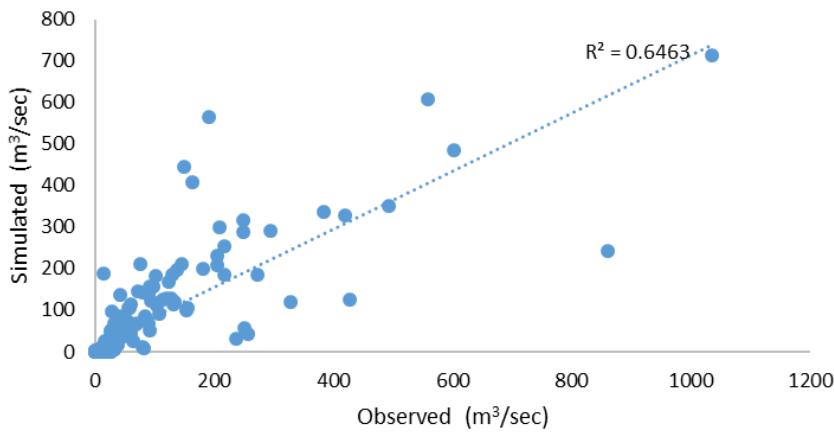


Comparison of Stream Flows

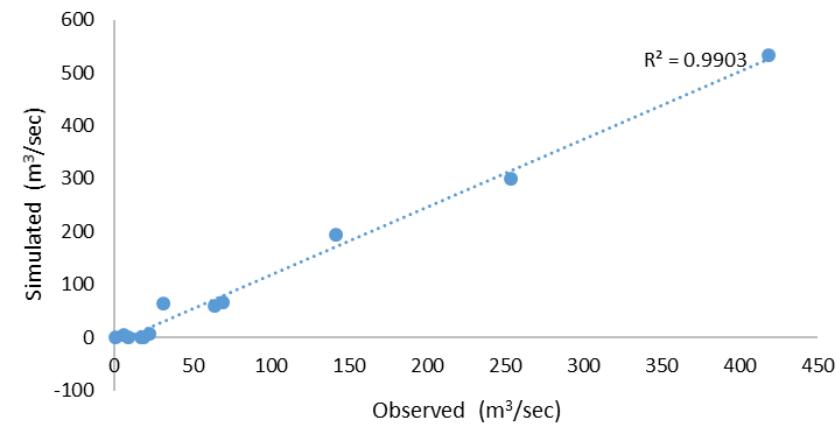
Bagalkot

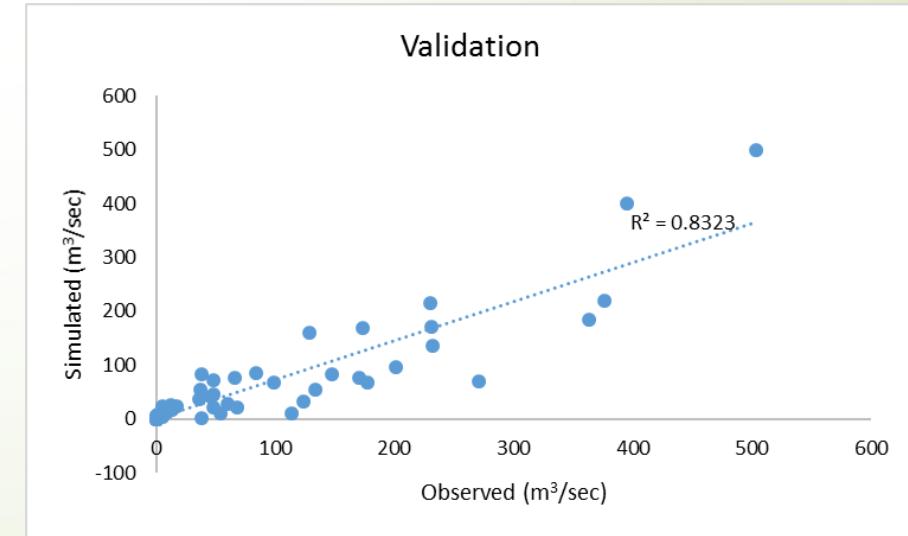
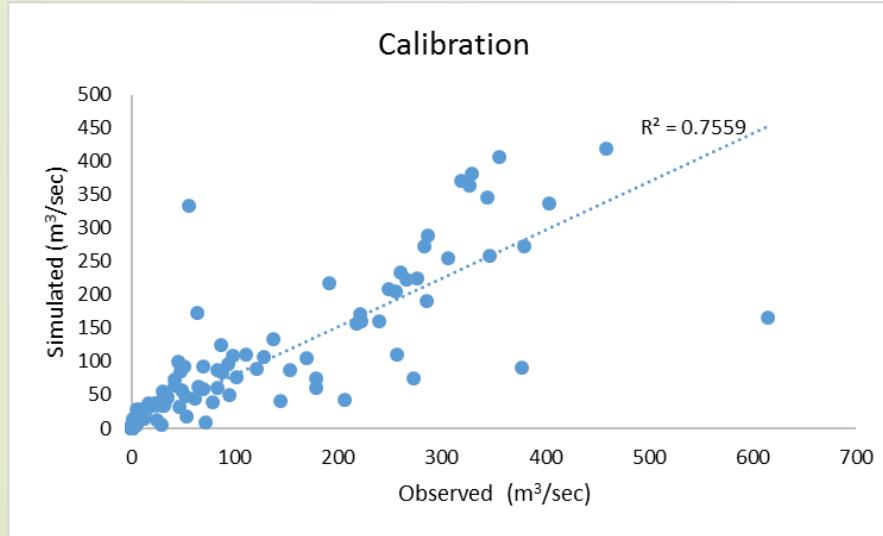
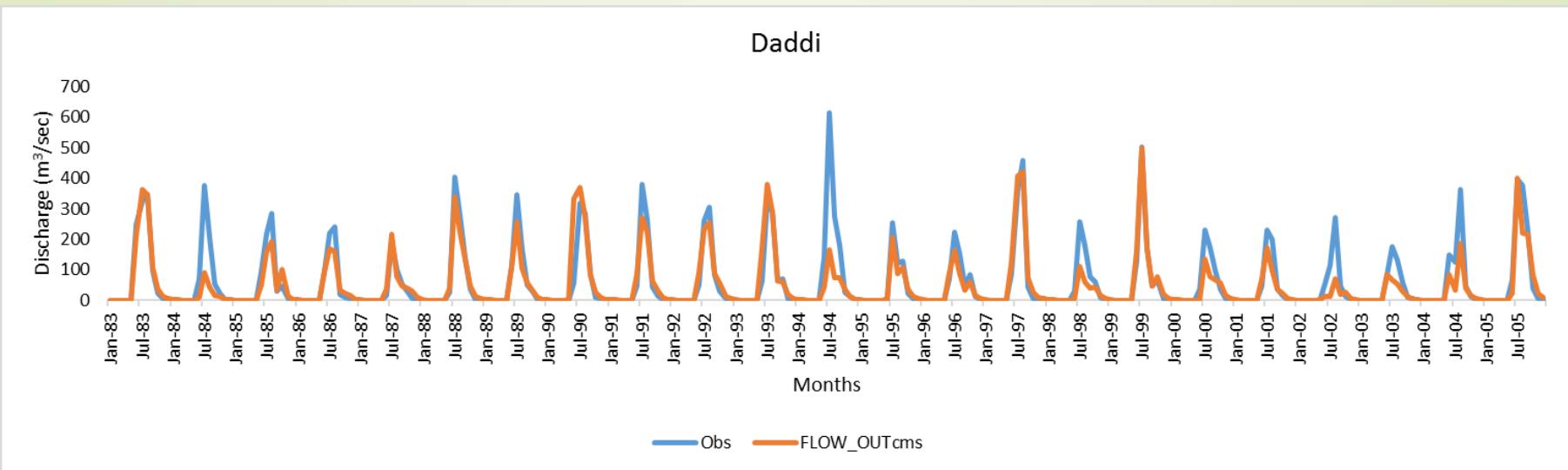


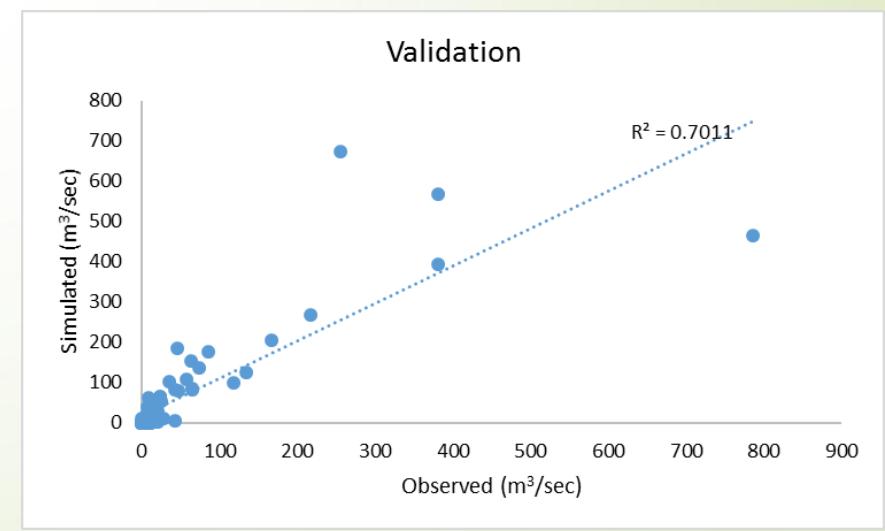
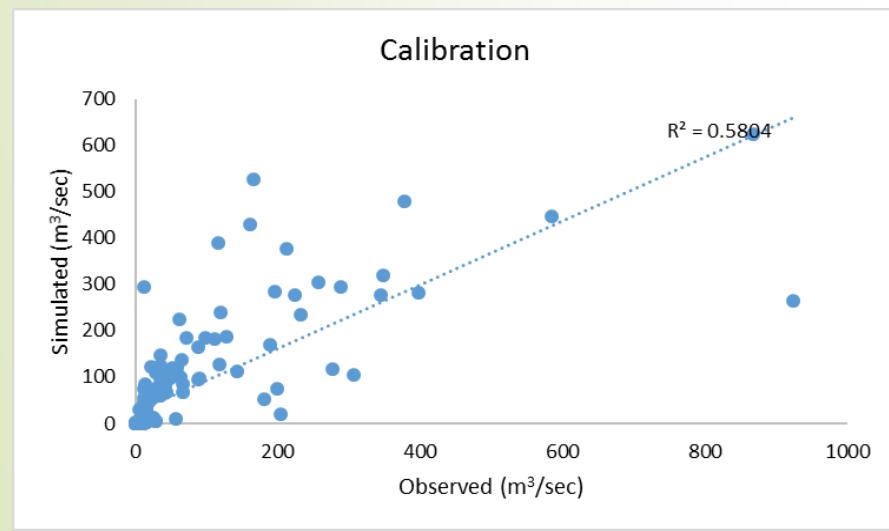
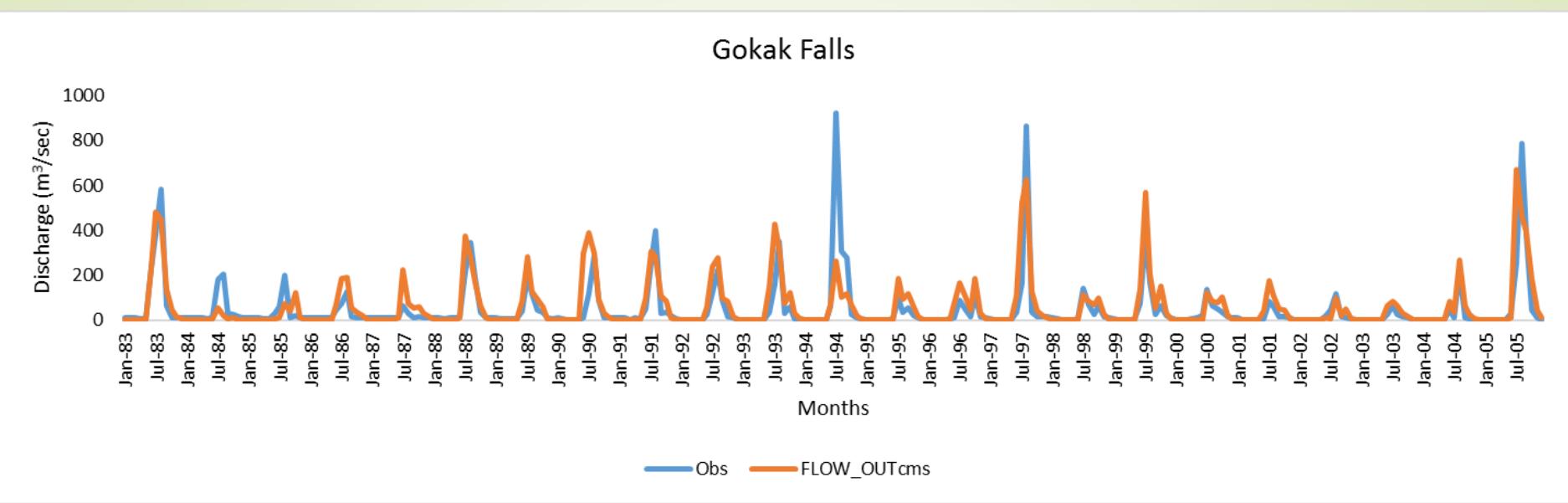
Calibration

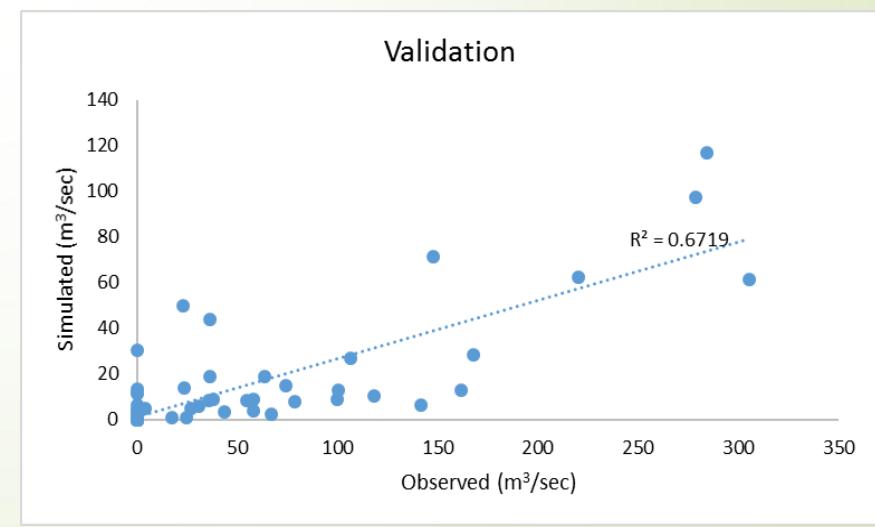
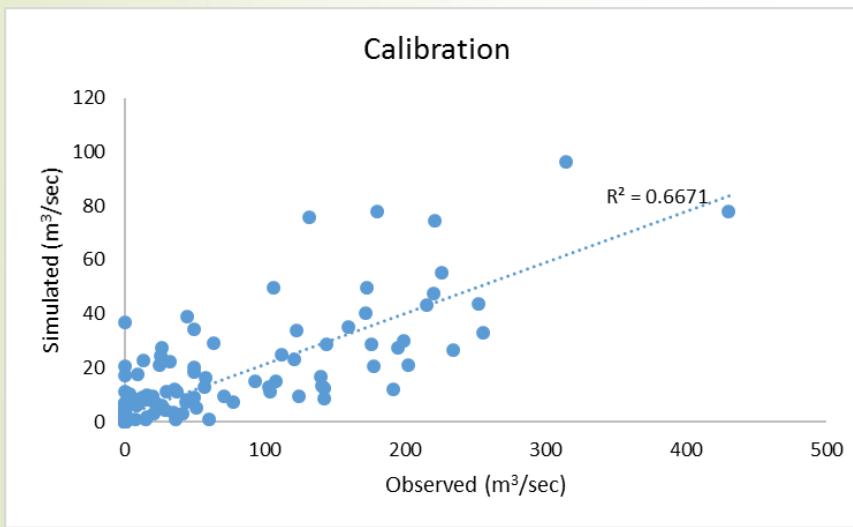
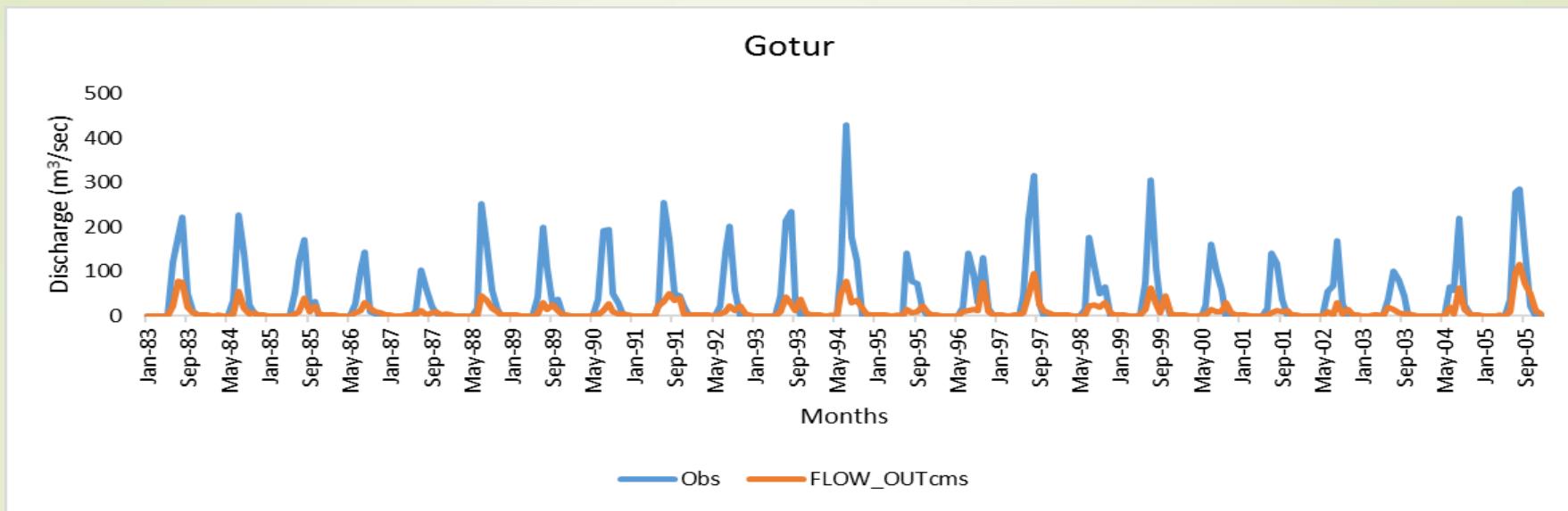


Validation









Statistical Performance Results

Source: D. N. Moriasi et al. 2007

Station	Calibration				Validation			
	R ²	NSE	PBIAS	RSR	R ²	NSE	PBIAS	RSR
Bagalkot	0.65	0.81	10.32	0.104	0.99	0.82	-17.17	0.187
Gokak Falls	0.58	0.78	-14.98	0.15	0.70	0.79	-35.85	0.363
Daddi	0.76	0.83	13.93	0.139	0.83	0.82	27.41	0.277
Gotur	0.67	0.43	74.96	0.75	0.67	0.48	71.21	0.72



METHODOLOGY For Downscaling The Climate Variables

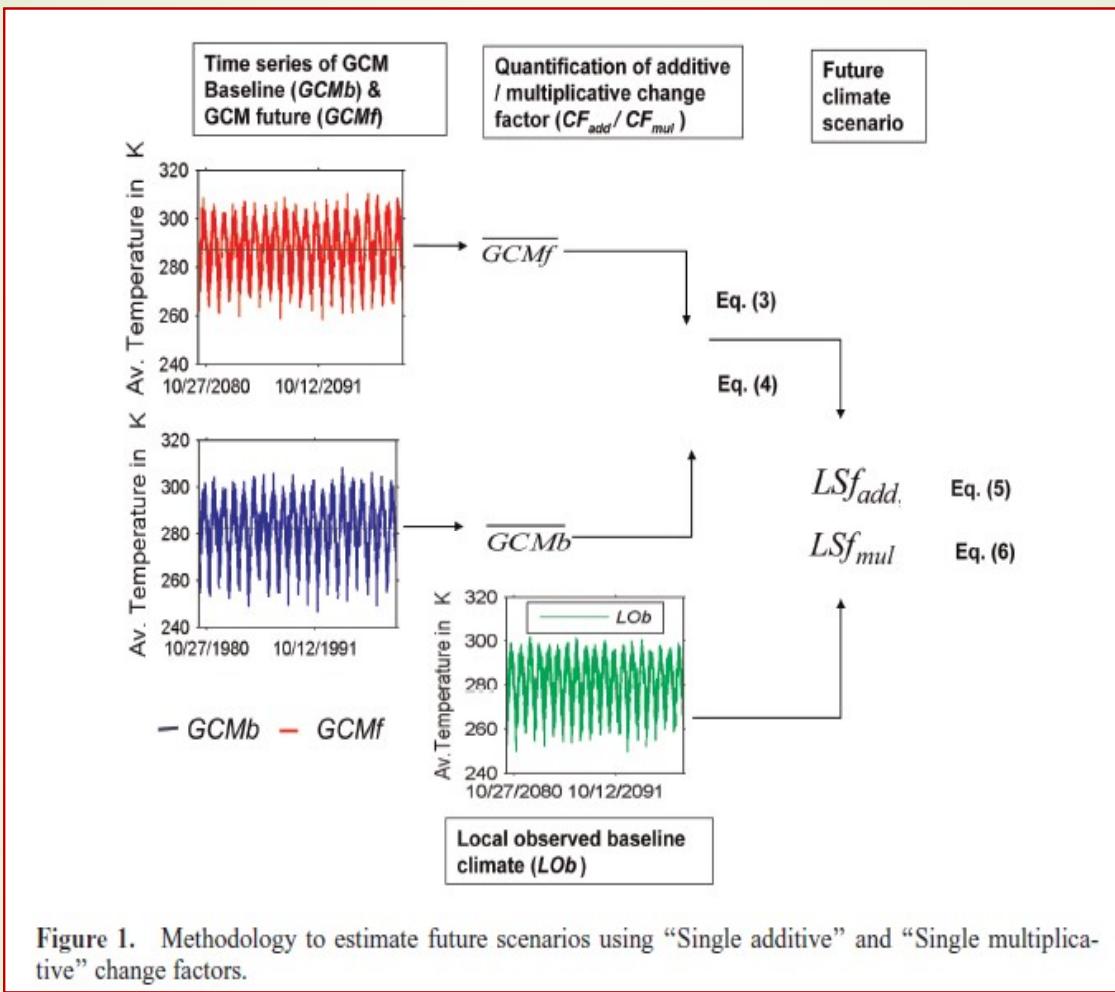


Figure 1. Methodology to estimate future scenarios using “Single additive” and “Single multiplicative” change factors.

Source : Examination of change factor methodologies for climate change impact assessment, Anandhi et al. (2011)



METHODOLOGY: CHANGE FACTOR METHOD

- This method can be used for future projection of climate variable.
- This method involves single change factor method which includes additive and multiplicative change factor method.

Single additive change factor method

$$CF = GCM_{fut} - GCM_{his}$$

$$OBS_{fut} = OBS + CF$$

Single multiplicative change factor method

$$CF = \frac{GCM_{fut}}{GCM_{his}}$$

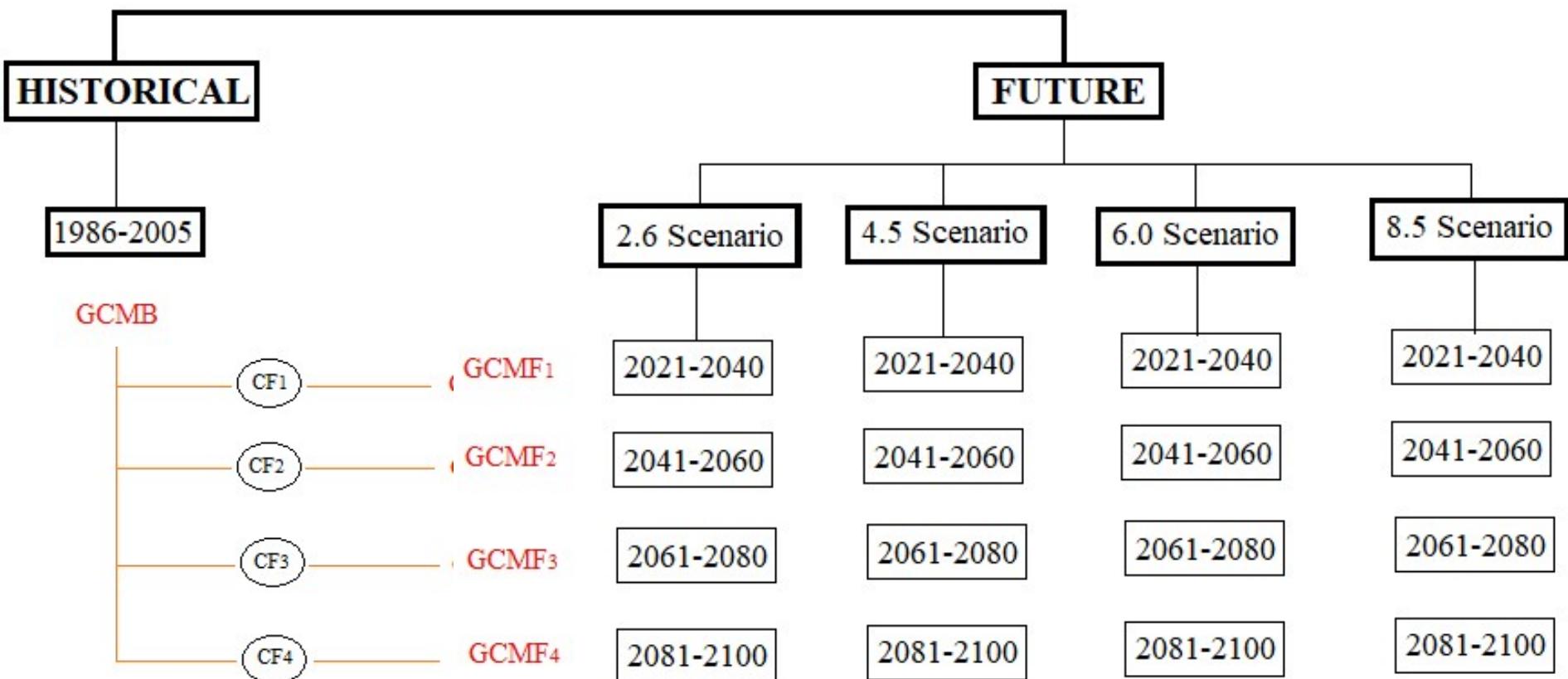
$$OBS_{fut} = OBS \times CF$$

(Source: Anandhi et. al., 2011)



GCM DATA

$$\overline{GCMF} - \overline{GCMB} = CF$$



4. FUTURE PROJECTION

Now the change factor values are added to observed IMD data to obtain future climate data.

ie.,

$$\boxed{LOB} + \boxed{CF_1} = \boxed{LOF_1} \quad 2021-2040$$

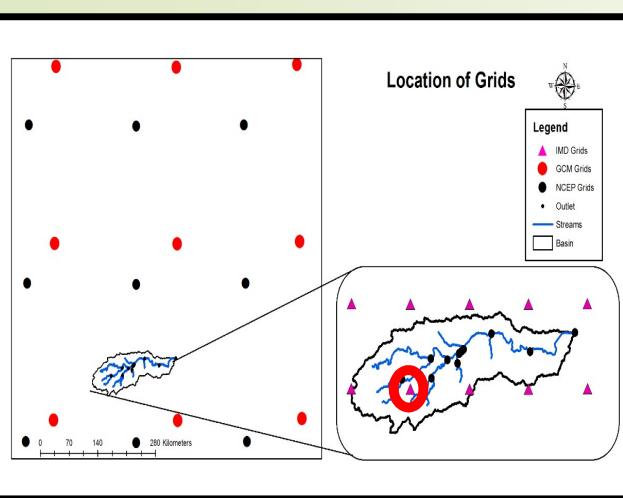
$$\boxed{LOB} + \boxed{CF_2} = \boxed{LOF_2} \quad 2041-2060$$

$$\boxed{LOB} + \boxed{CF_3} = \boxed{LOF_3} \quad 2061-2080$$

$$\boxed{LOB} + \boxed{CF_4} = \boxed{LOF_4} \quad 2081-2100$$

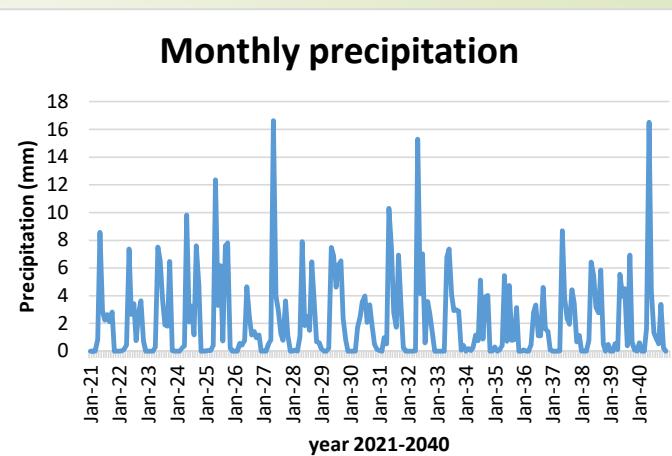
RESULT AND DISCUSSION

Precipitation for 2.6 scenarios

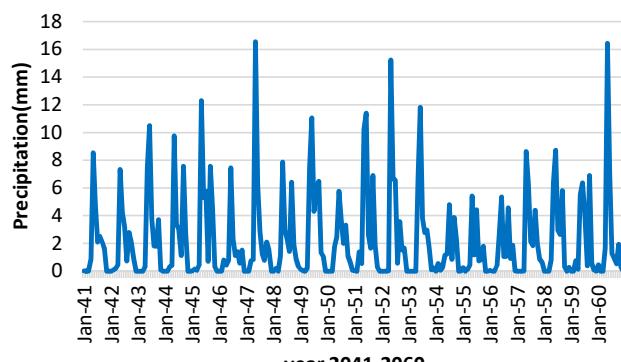


For RCP 2.6 scenarios			
Future projection	Mini	Mean (mm)	Max (mm)
2021-40	0	2.15	16.63
2041-60	0	2.23	16.55
2061-80	0	2.39	25.42
2081-100	0	3.44	49.80

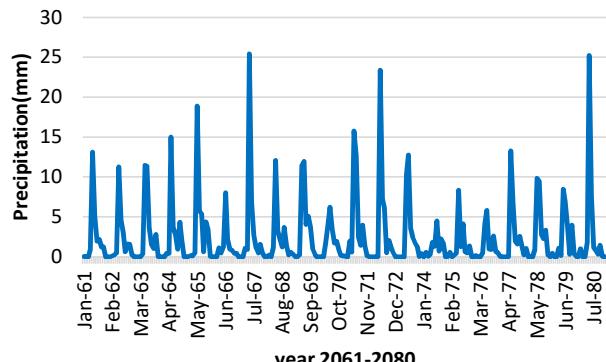
Monthly precipitation



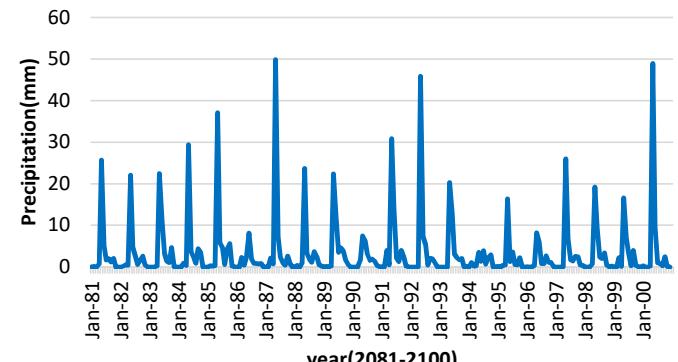
Monthly precipitation



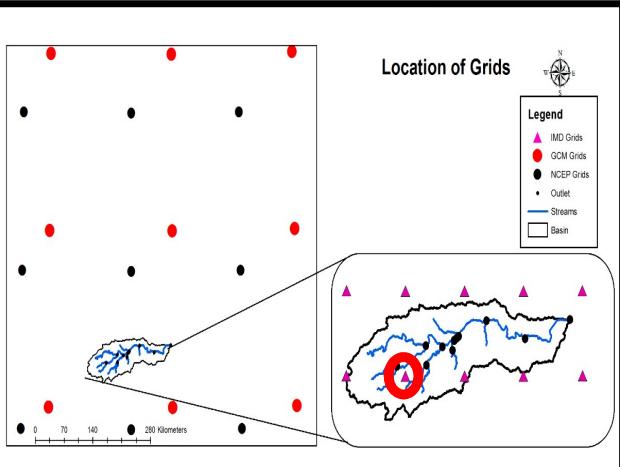
Monthly precipitation



Monthly precipitation

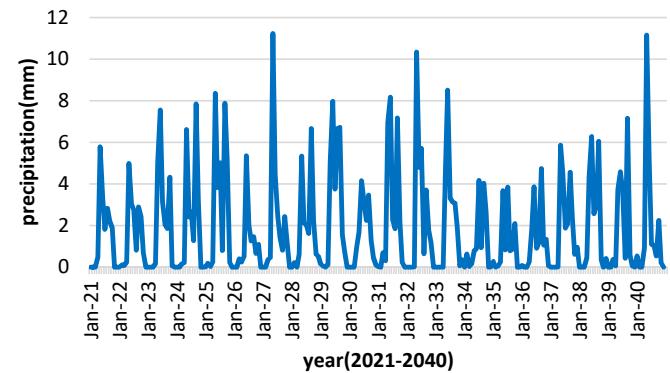


Precipitation for 4.5 scenarios

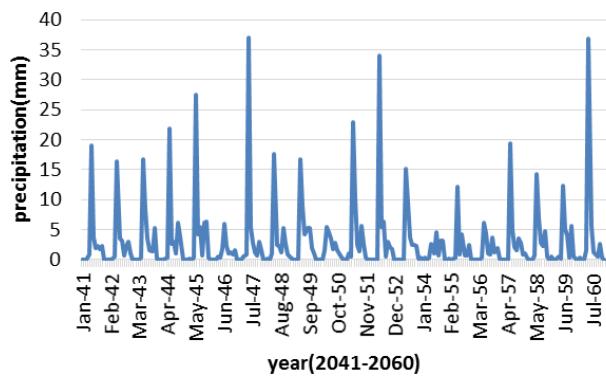


For RCP 4.5 scenarios			
Future projection	Mini	Mean	Max
2021-40	0	1.84	11.24
2041-60	0	2.91	37.06
2061-80	0	2.77	0.00
2081-100	0	3.42	42.85

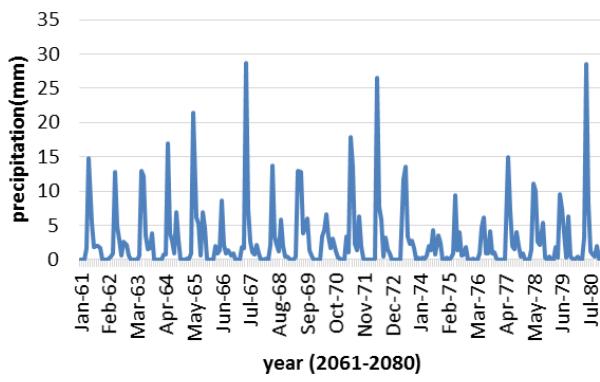
Monthly precipitation



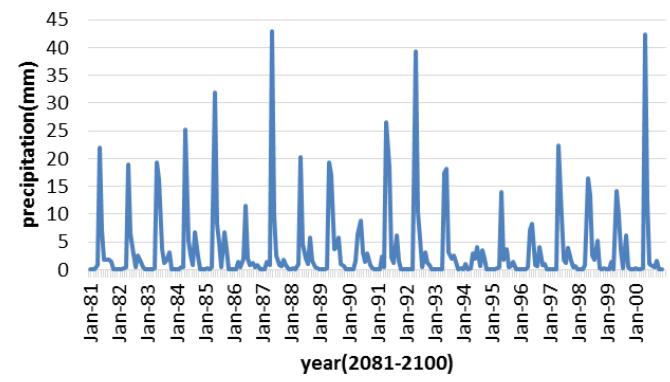
Monthly precipitation



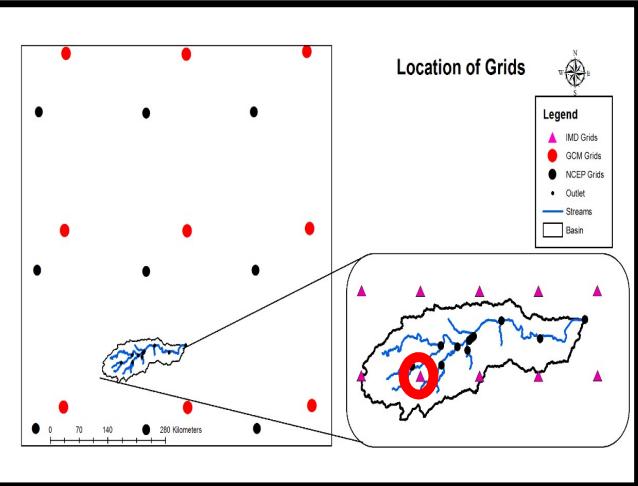
Monthly precipitation



Monthly precipitation

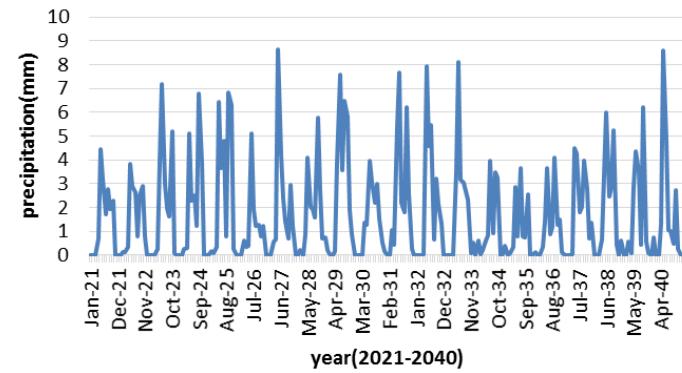


Precipitation for 6.0 scenarios

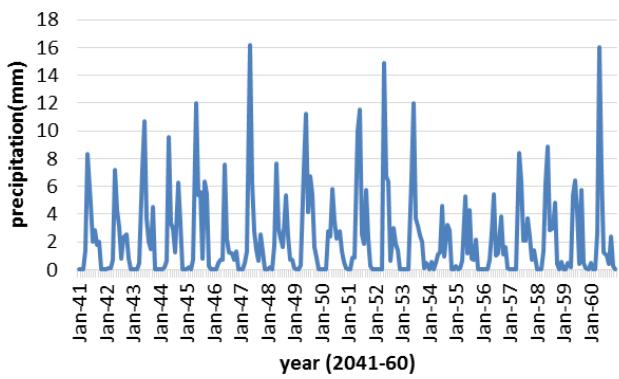


For RCP 6.0 scenarios			
Future projection	Mini	Mean	Max
2021-40	0	1.72	8.65
2041-60	0	2.23	16.15
2061-80	0	2.63	27.89
2081-100	0	3.64	51.65

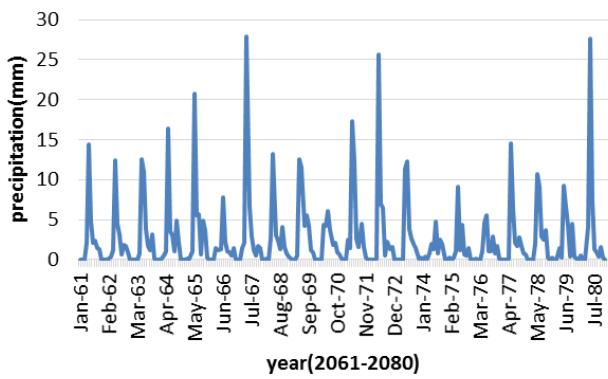
Monthly precipitation



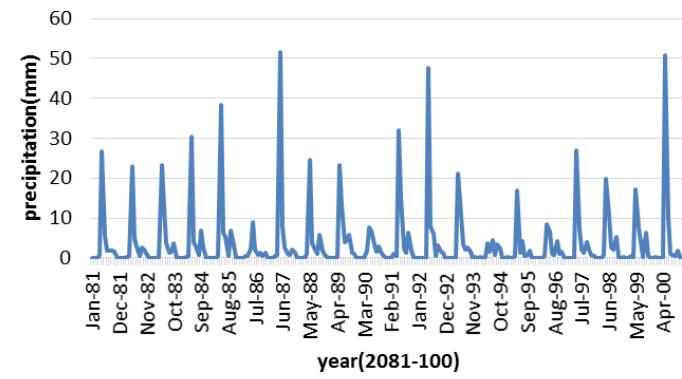
Monthly precipitation



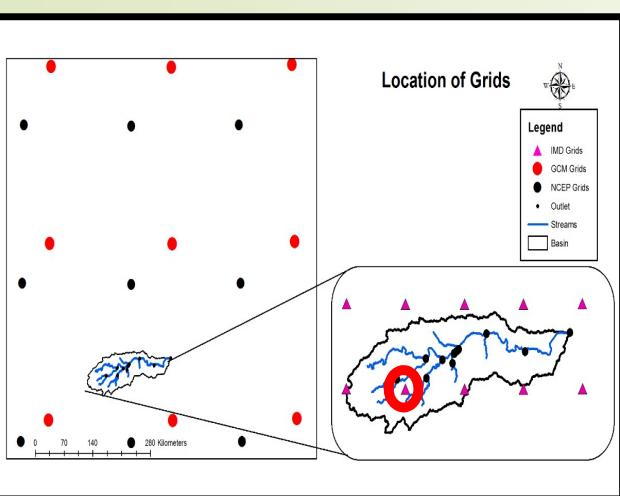
Monthly precipitation



Monthly precipitation

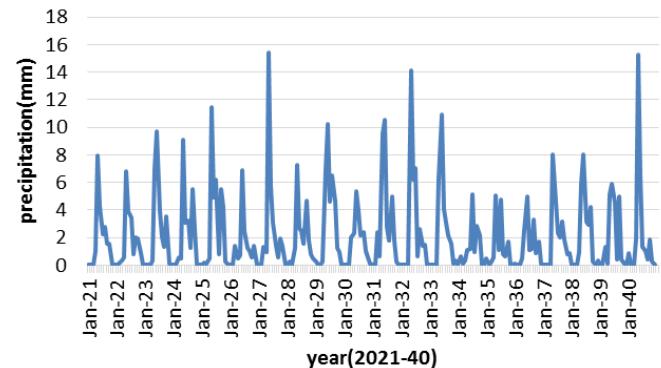


Precipitation for 8.5 scenarios

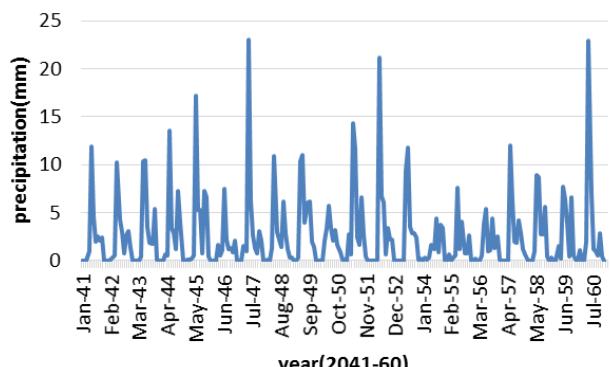


For RCP 8.5 scenarios			
Future projection	Mini mm	M mm	Max mm
2021-40	0	2.10	15.38
2041-60	0	2.57	23.05
2061-80	0	3.08	31.64
2081-100	0	4.2	63.50

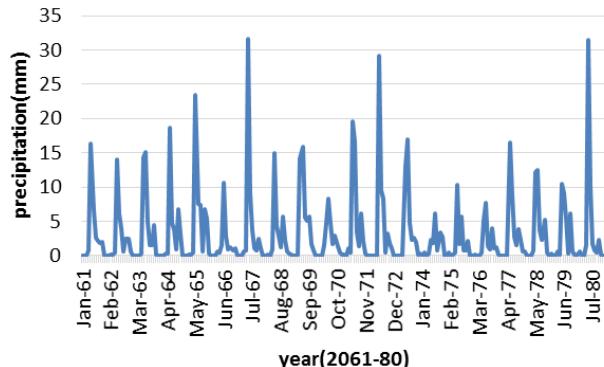
Montly precipitation



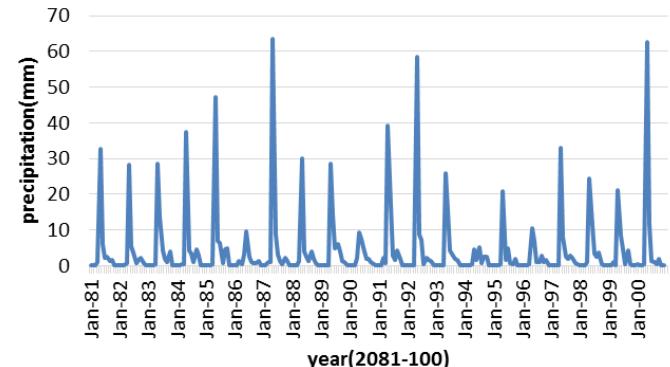
Monthly precipitation



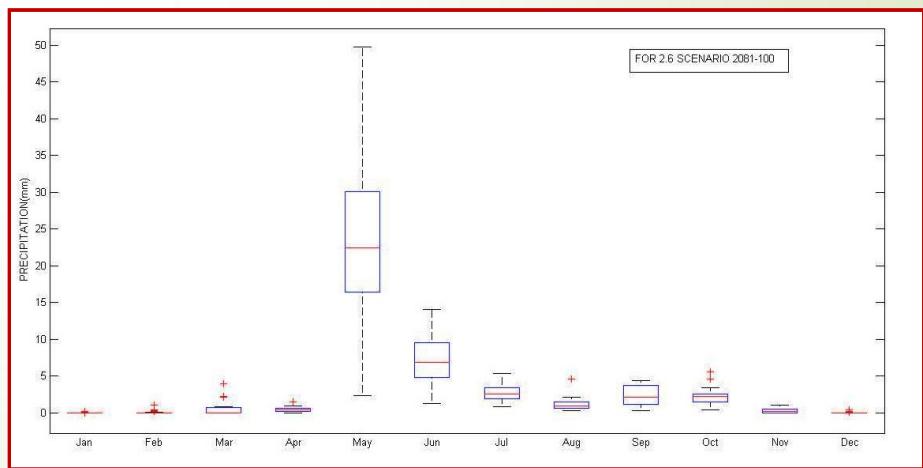
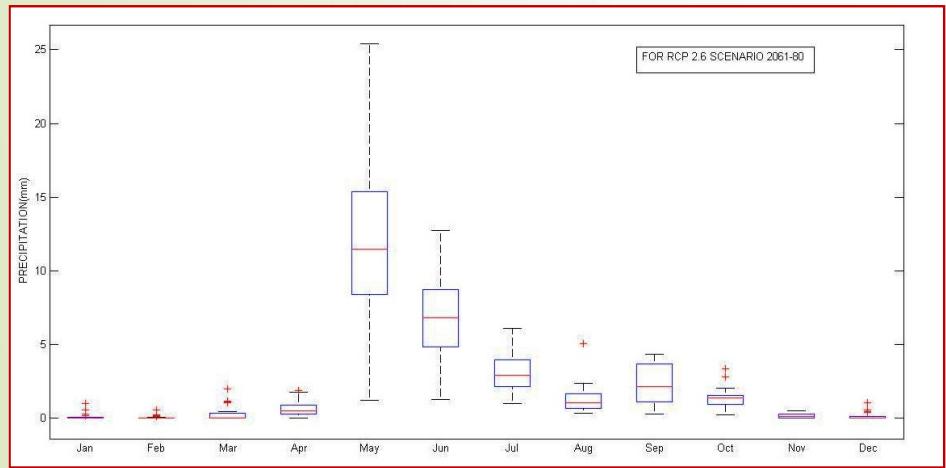
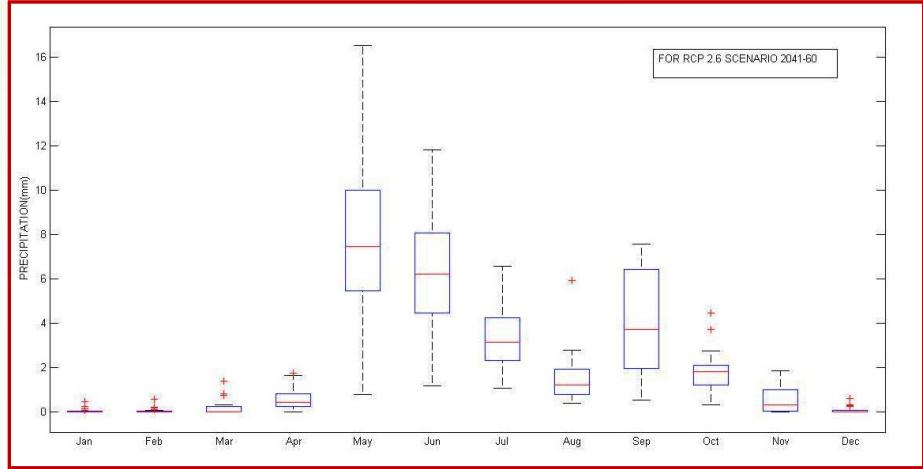
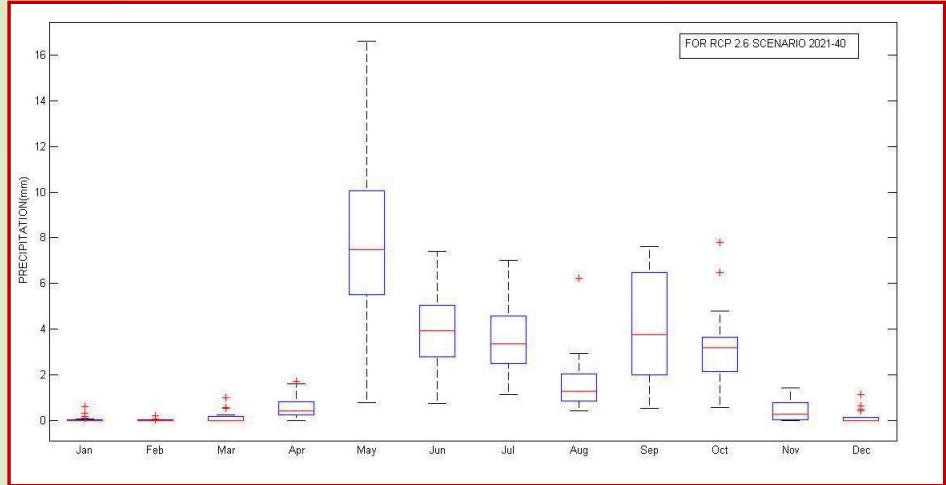
Monthly precipitation



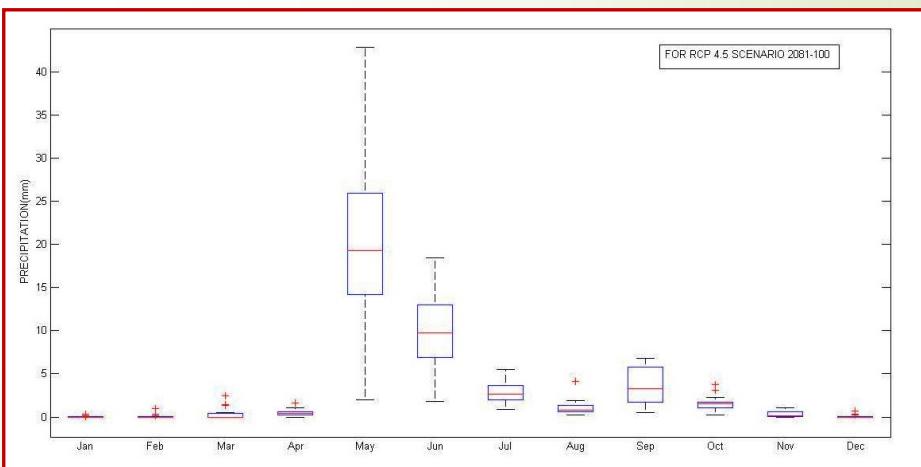
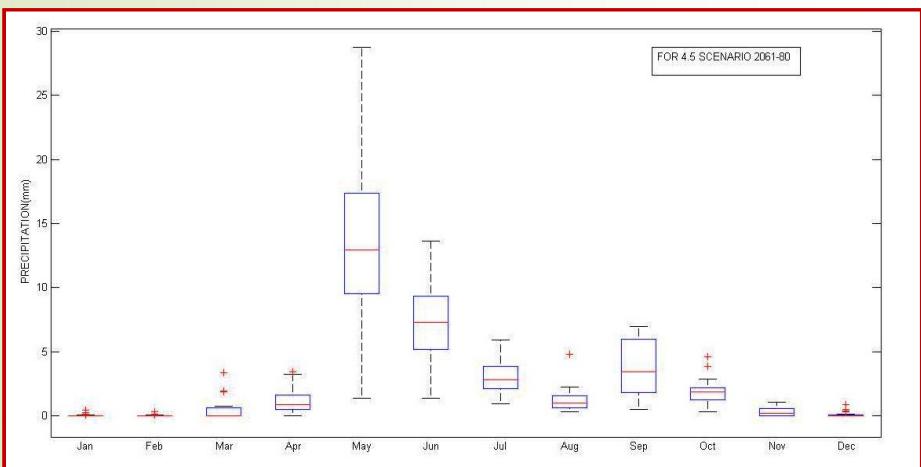
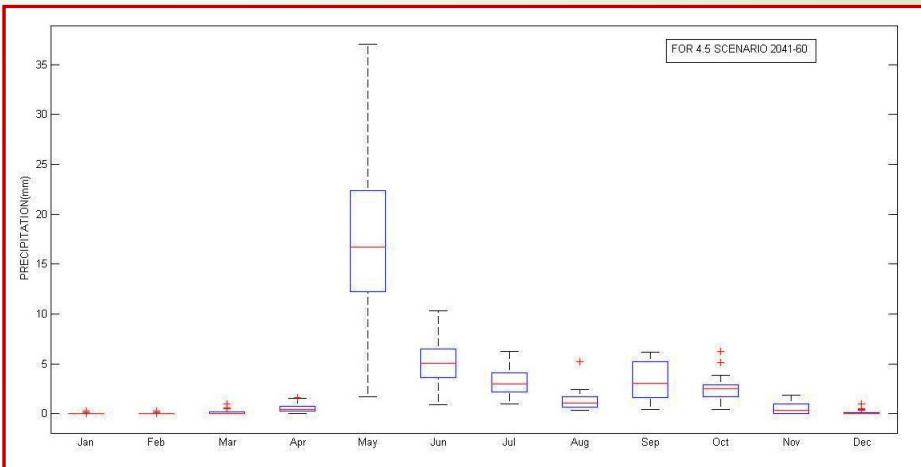
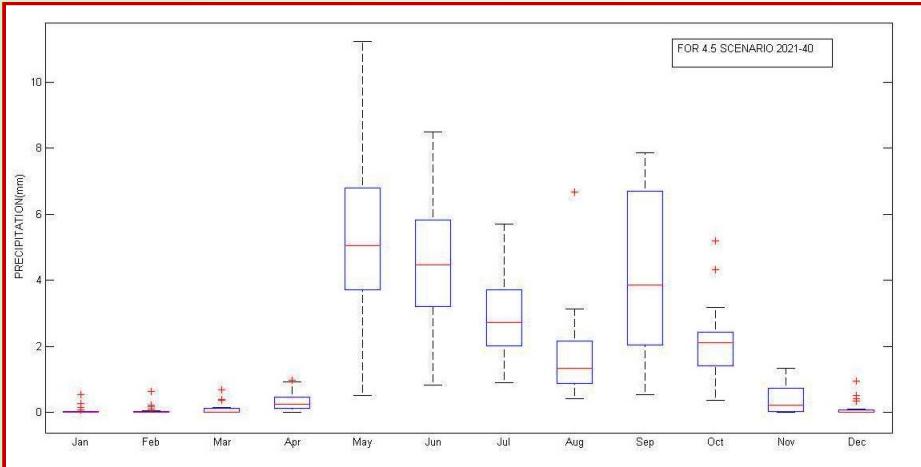
Monthly precipitation



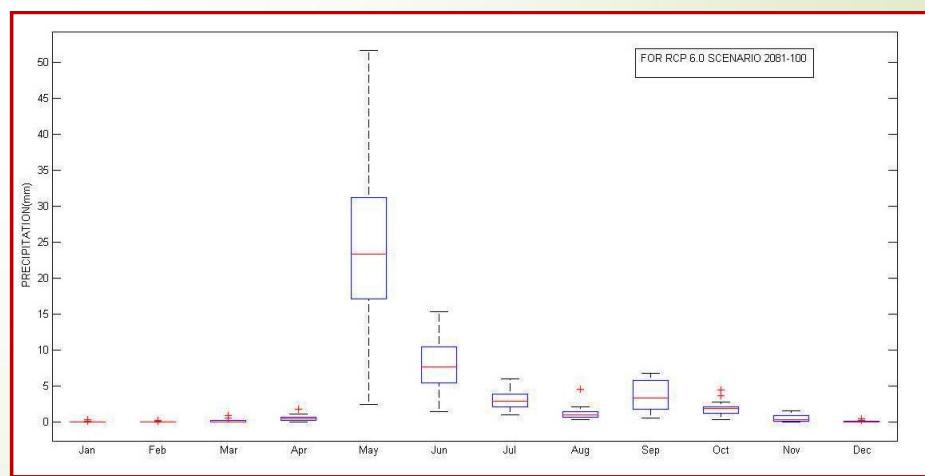
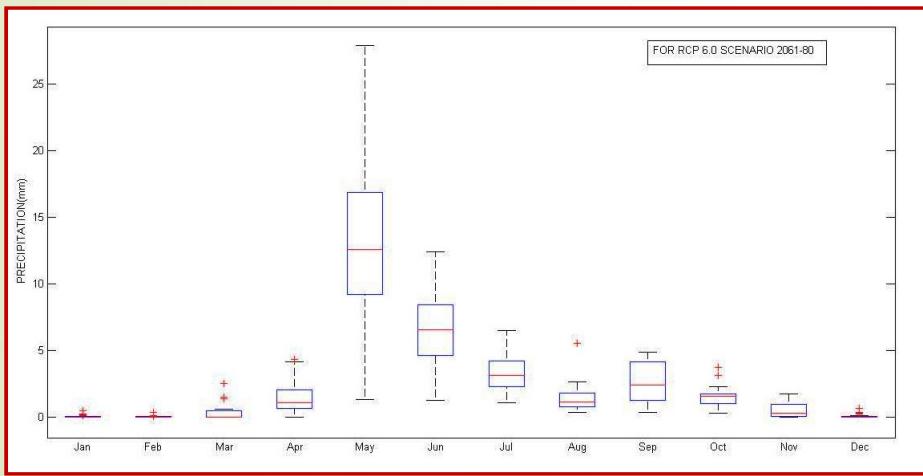
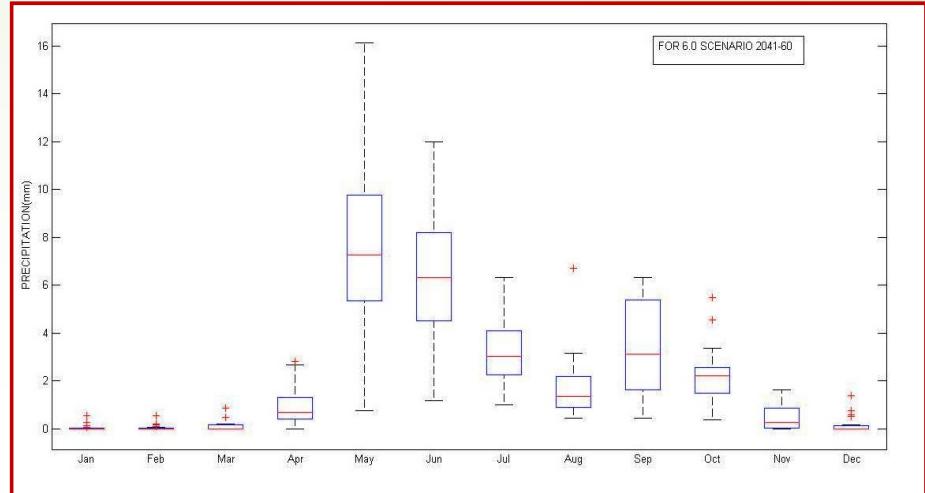
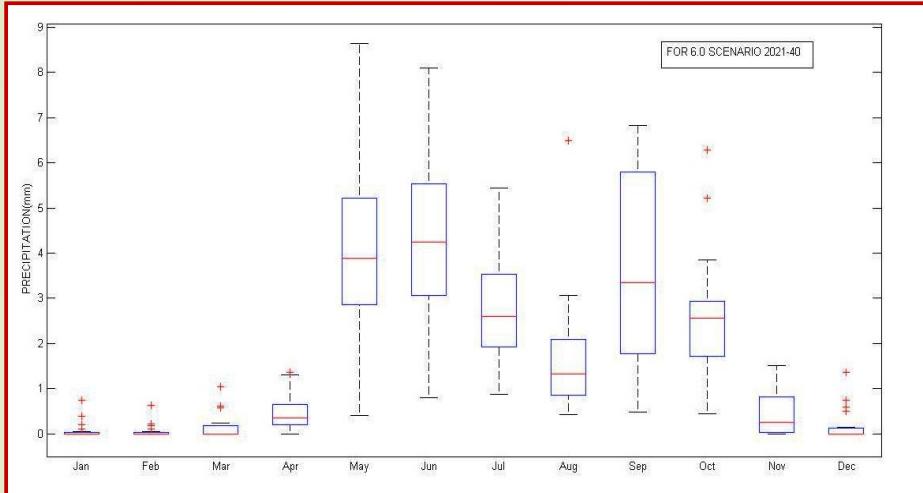
PLOT FOR 2.6 SCENARIO 2021-2100 (Precipitation)



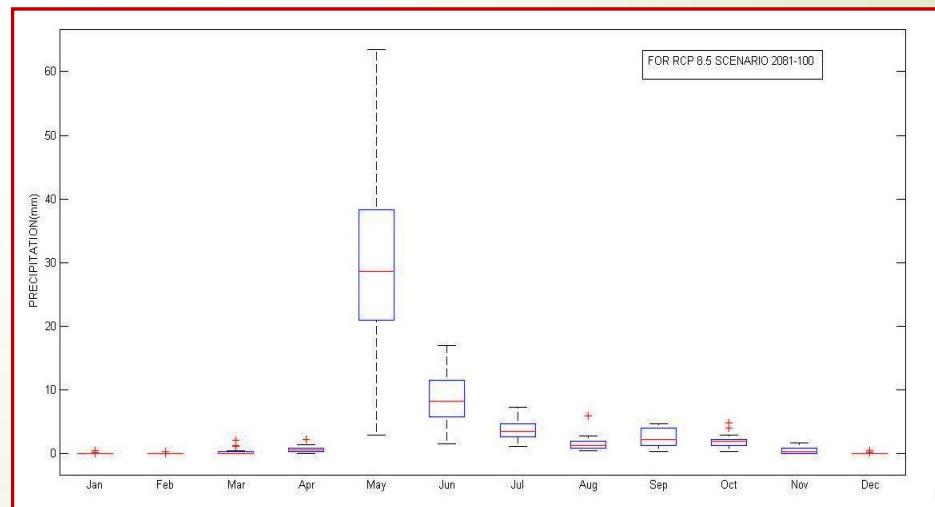
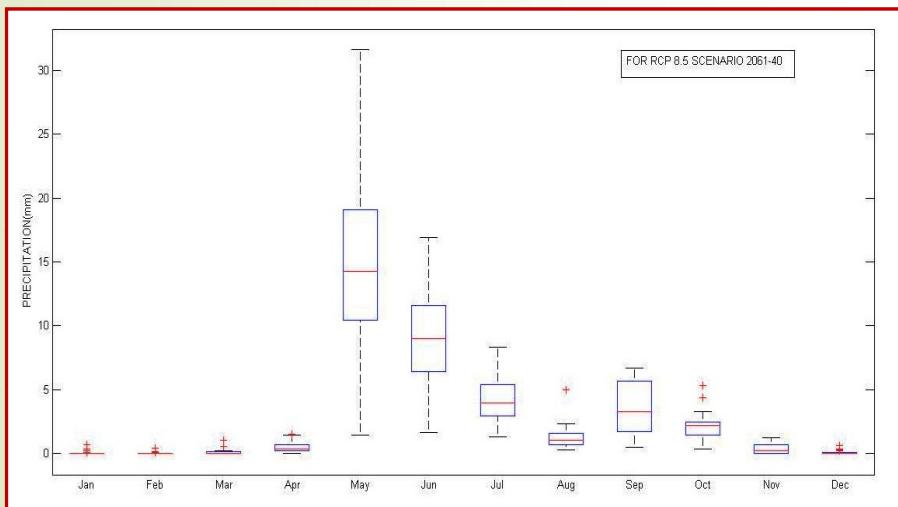
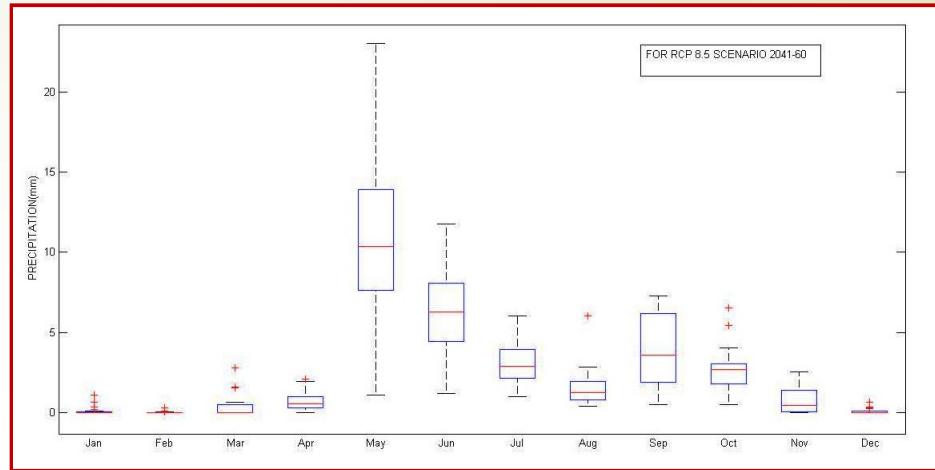
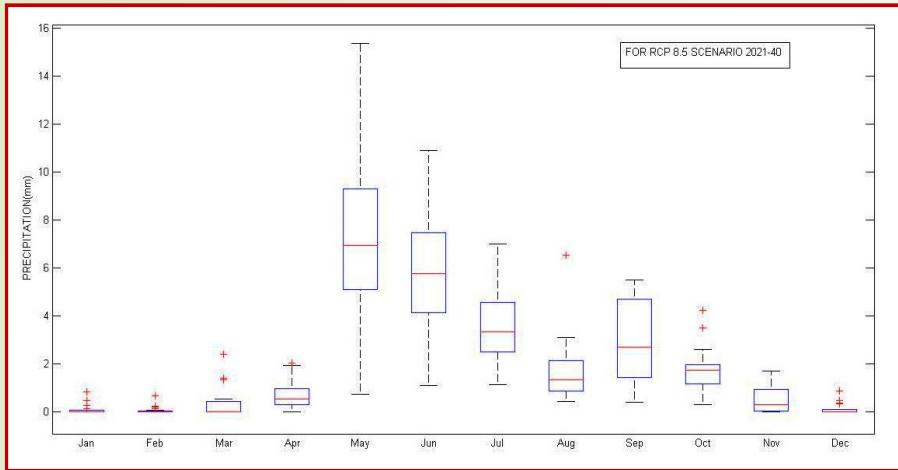
BOXPLOT FOR 4.5 SCENARIO 2021-2100



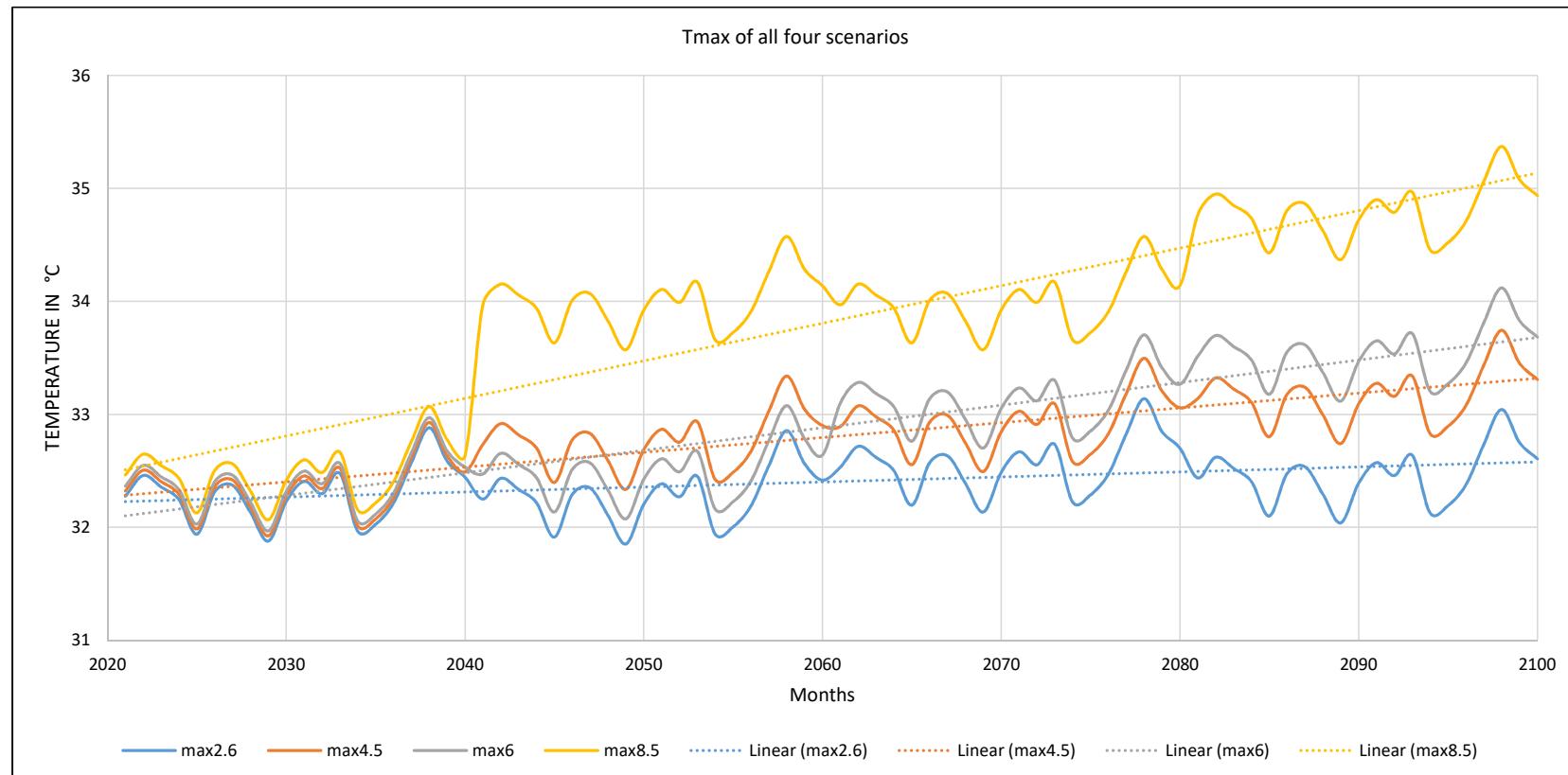
BOXPLOT FOR 6.0 SCENARIO 2021-2100



BOXPLOT FOR 8.5 SCENARIO 2021-2100



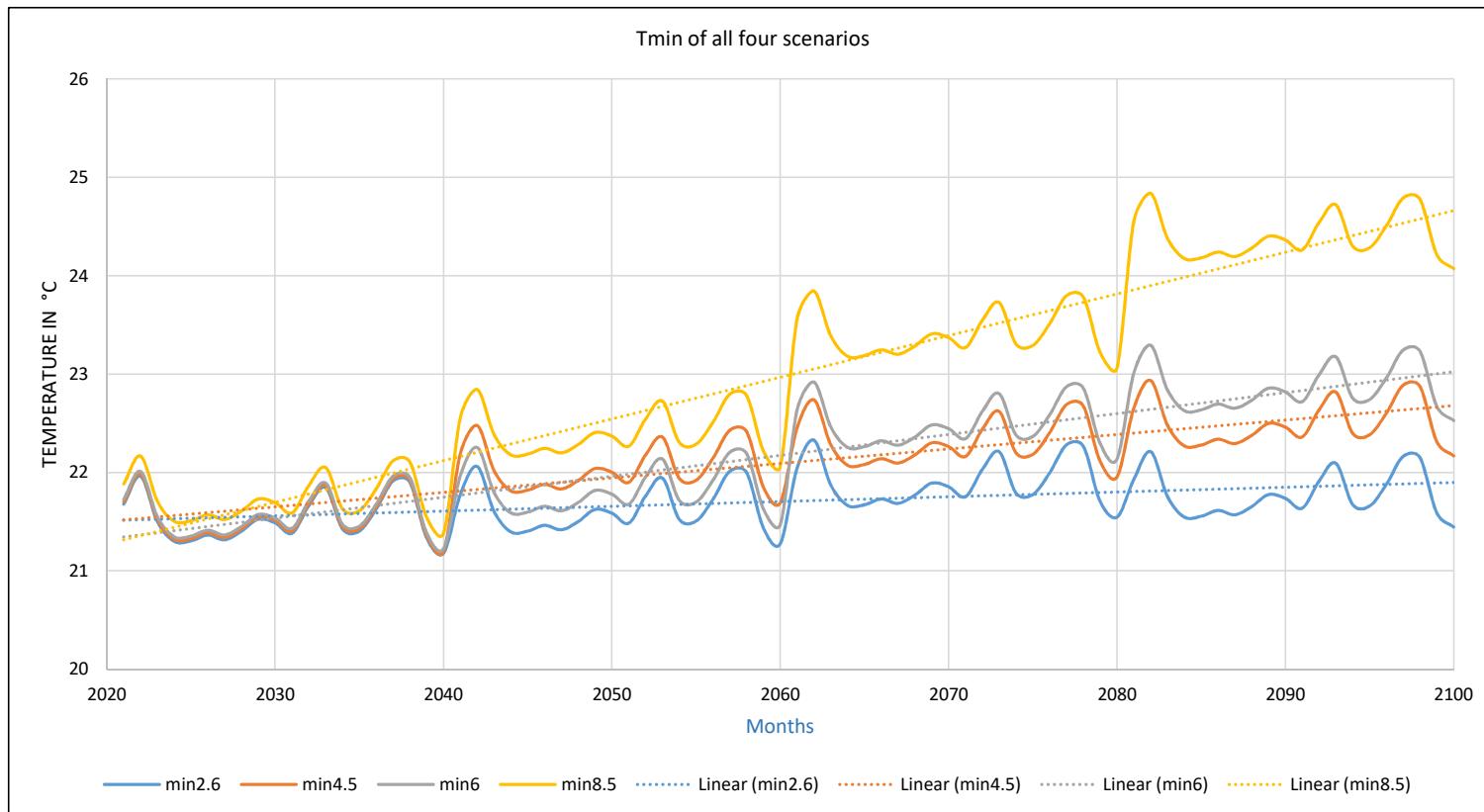
Comparison of Tmax of all four scenarios for time period 2021-2100



The mean temperature of 2.6, 4.5, 6 and 8.5 scenarios are 32.40, 32.80, 32.89, 33.82°C respectively.



Comparison of Tmin of all four scenarios of time period 2021-2100



The mean temperature of 2.6, 4.5, 6 and 7.5 scenarios are 21.70, 22.09, 22.18, 22.99°C respectively.

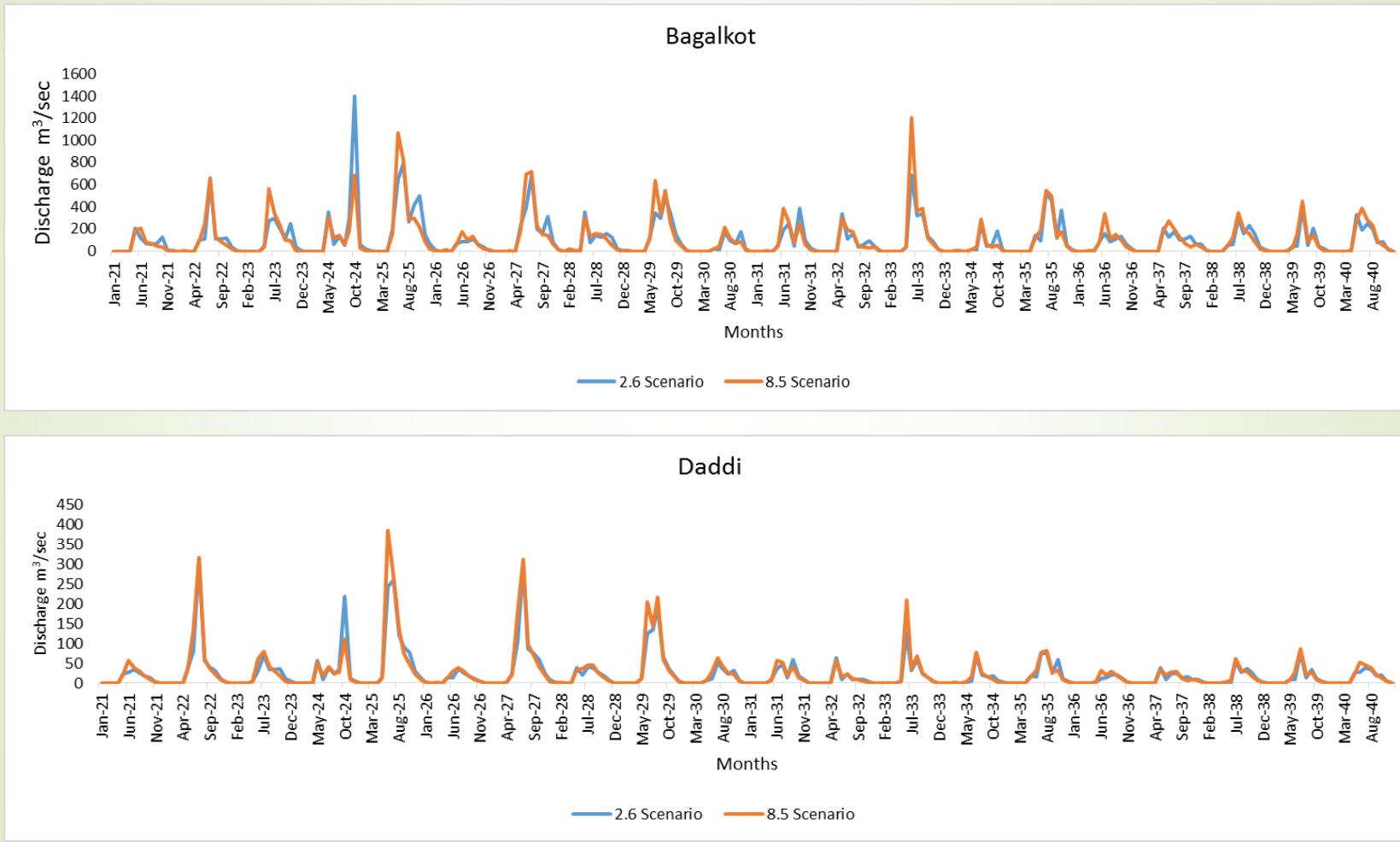


Mean, maximum and minimum temperature values

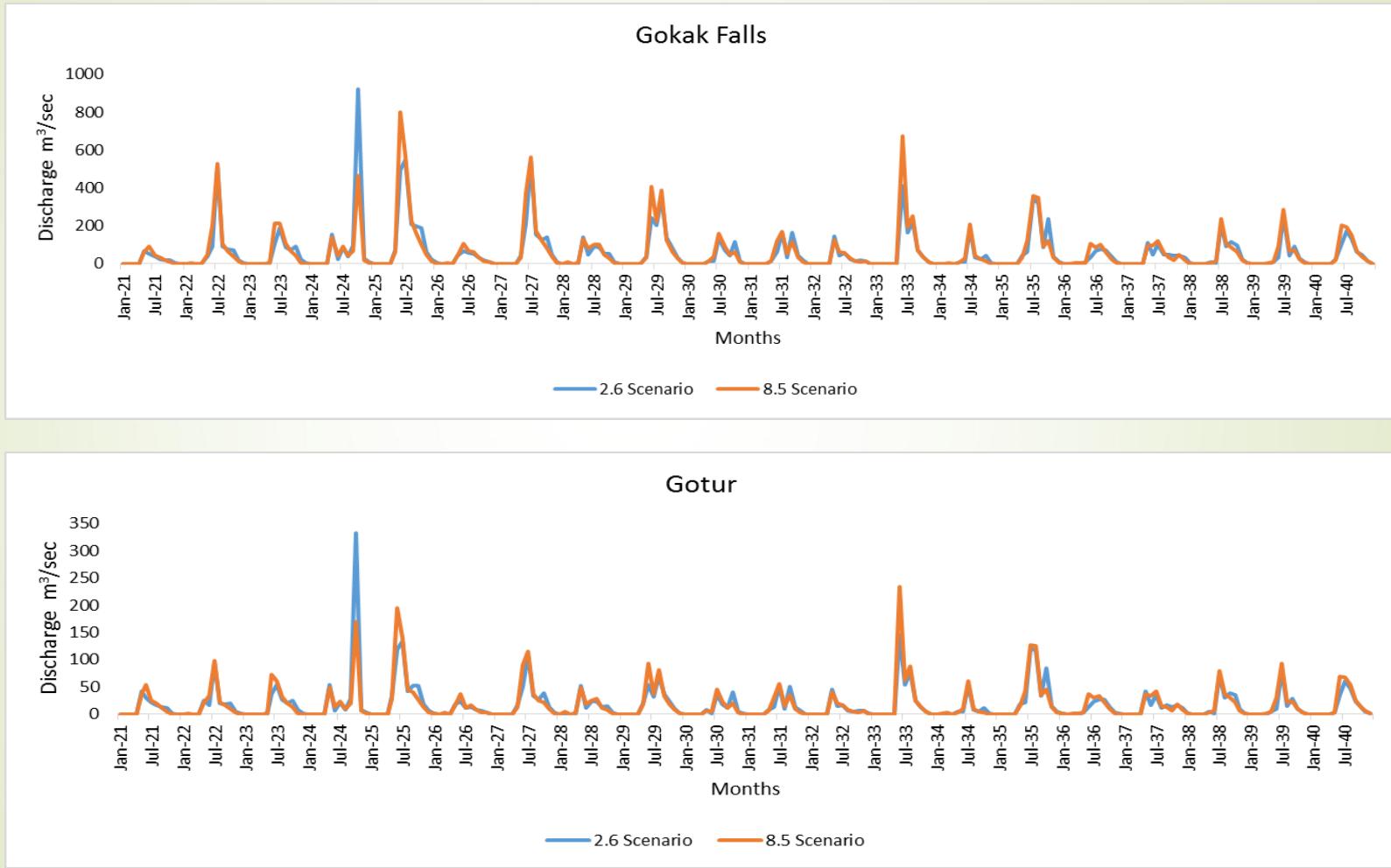
		T-max				T-min			
		2021-40	2041-60	2061-80	2081-100	2021-40	2041-60	2061-80	2081-100
2.6 Scen	Max	39.527	40.017	40.439	40.561	27.4	27.638	27.874	27.948
	Min	24.51	23.786	23.171	22.813	11.22	11.359	11.826	11.885
	Mean	32.305	32.280	32.563	32.467	21.527	21.626	21.895	21.777
4.5 Scen	Max	39.631	40.73	40.824	41.42	27.433	28.154	28.449	28.772
	Min	24.829	24.506	23.568	23.689	11.18	11.591	12.125	12.627
	Mean	32.351	32.763	32.921	33.169	21.549	22.042	22.304	22.501
6.0 Scen	Max	39.453	40.278	41.163	41.845	27.453	27.785	28.745	29.29
	Min	24.602	24.155	23.877	23.863	11.276	11.592	12.548	13.088
	Mean	32.394	32.501	33.128	33.544	21.575	21.819	22.485	22.859
8.5 Scen	Max	39.784	42.069	42.069	43.261	27.62	28.603	29.666	30.586
	Min	24.512	24.964	24.964	24.821	11.439	12.19	13.419	14.667
	Mean	32.493	34.000	34.000	34.796	21.732	22.408	23.410	24.404



Runoff Simulation at Bagalkot and Daddi discharge gauge from 2021-40



Runoff at Gokak Falls and Gotur discharge gauge from 2021-40



Conclusion

- ▶ This study encompass modelling of hydrological cycle for the Ghataprabha sub basin (K3) to know the **streamflow and water availability for the present scenario and to simulate changes** in streamflow in the K3 sub basin over a period of time.
- ▶ In this Study perfomed with **multi-site manual calibration and validation of SWAT model** from year 1980 to 2005. The performance results during calibration and validation of SWAT model checked by statistical metrics R², NSE, PBIAS, RSR.
- ▶ Calibration and Validation results shows that **Bagalkot, Daddi, Gokak falls gauge stations are giving satisfying, good and very good indication and Gotur gauge station is showing unsatisfactory results.**



Contd...

- ▶ Precipitation trend is consistently increasing over a period and Maximum precipitation is observed in the month of July which is measured to be 95% and minimum value is observed during the month of April which is 20%.
- ▶ The mean maximum temperature of 2.6, 4.5, 6 and 8.5 scenarios are 32.403, 32.801, 32.891, 33.822°C respectively.
- ▶ The mean minimum temperature of 2.6, 4.5, 6 and 7.5 scenarios are 21.706, 22.099, 22.185, 22.99°C respectively.
- ▶ Maximum and minimum temperature is showing rising trend with respect to 4 scenarios (RCP 2.6, RCP4.5, RCP 6.0, RCP8.5).



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Thank you!