Projecting climate change scenarios on surface hydrology of a small agriculture-dominated watershed

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Flow of Presentation

1. Introduction
2. Knowledge Gap
3. Objectives
4. Materials and Methods
5. Results
6. Conclusions
7. Acknowledgements
8. References

Introduction

- For all IPCC scenarios, temperatures in 2100 are expected to be between 1.1 and 6.4 ° C higher than 1900 (IPCC 2007)

- Even a conservative projection of 2 ° C warmer climate may cause heavy but erratic precipitation , frequent and intense droughts, floods, tornados, heat waves and many more adversities (IPCC 2011)

- Average temperature for May 2012 marked the second warmest May since recordkeeping began in 1880 at a global scale (Kang and Banga 2013)

- The rainiest year on record was 2010 and it tied for the hottest year ever (NOAA 2011)

Knowledge Gap

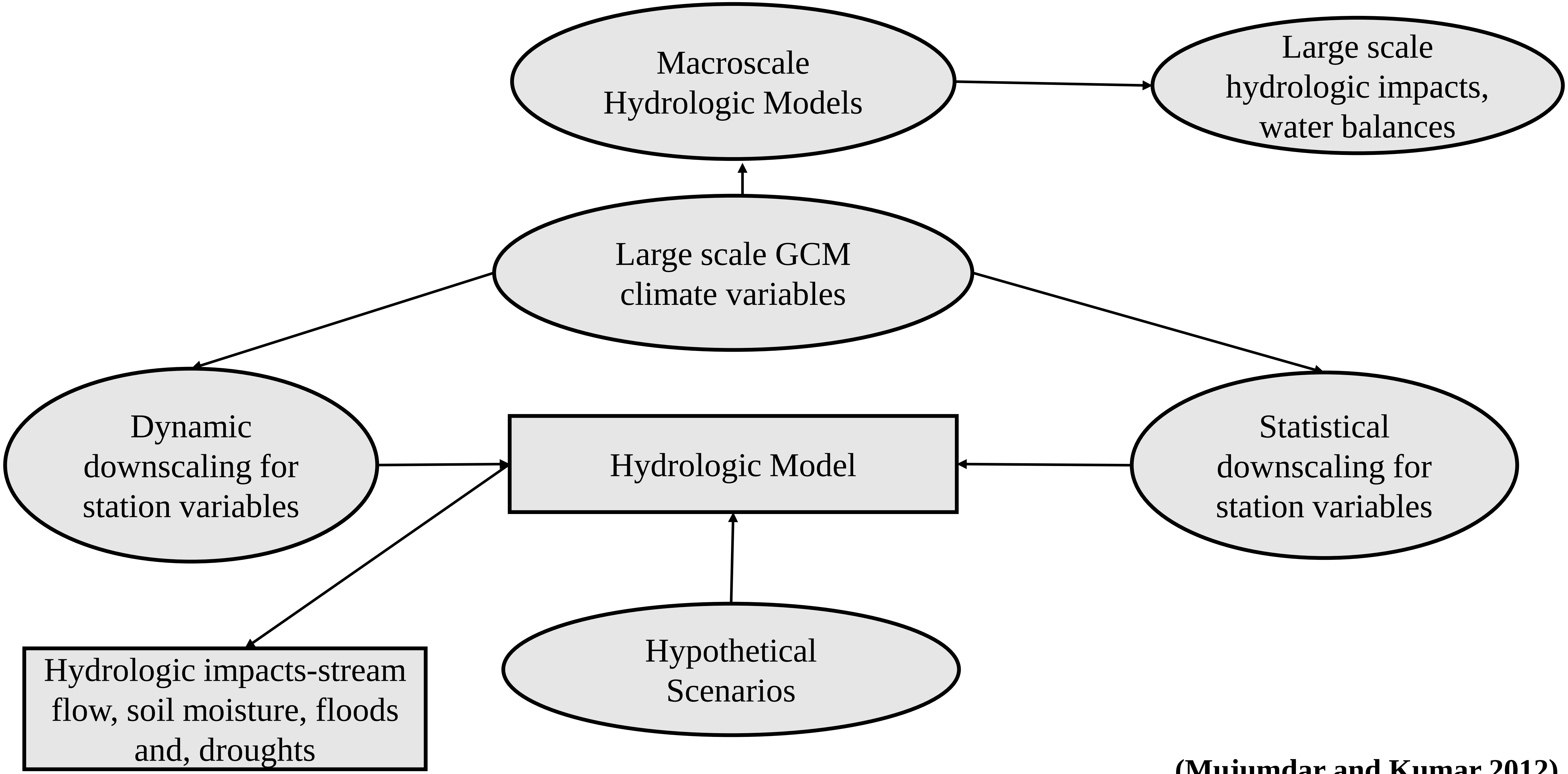
- Possible changes in rainfall intensity and seasonal patterns of temperature and precipitation and their implications for the hydrologic cycle are poorly understood (Ficklin et al. 2009)

http://research.uarctic.org/news/2015/8/our-common-future-under-climate-change-outcome-statement/

Objectives

- ❖ Assessing the sensitivity of hydrologic processes to SRES climate change scenarios for mid- 21^{st} century at monthly time step.
- ❖ The hydrologic processes studied are:
  - Percent change in stream discharge generation with respect to baseline scenarios.
  - Monthly precipitation change
  - Monthly stream discharge
  - Monthly soil water storage
  - Monthly ET change
  - Monthly percolation
  - Monthly Runoff
  - Monthly ground water contribution to streamdischarge
  - Monthly water yield

Projecting hydrologic impacts of climate change

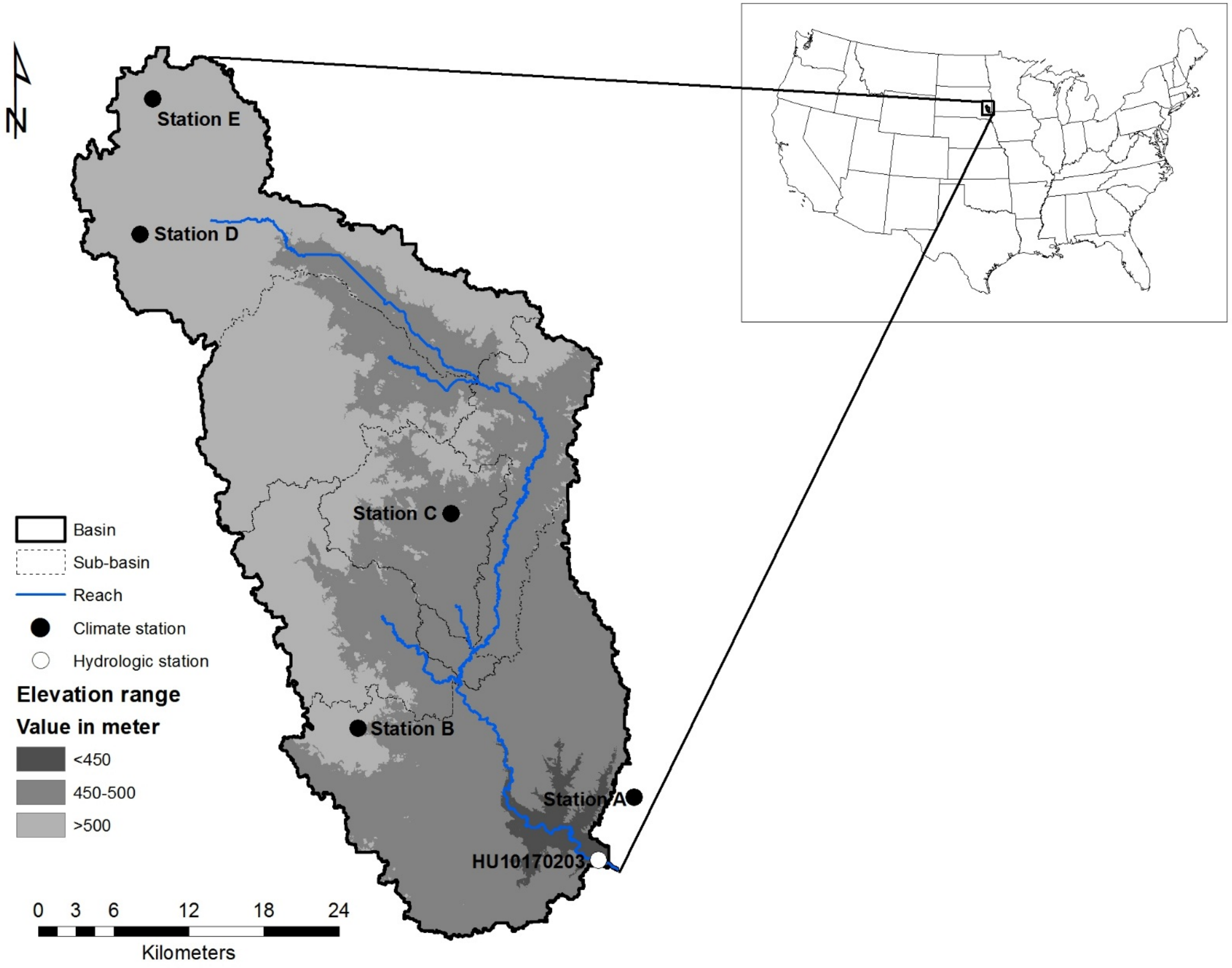


(Mujumdar and Kumar 2012)

Materials and Methods

Study Area

- ❖Skunk Creek Watershed
- ❖Watershed Characteristics
- ❖Geographical Extent of watershed
- ❖Topography



Data Collection and Analysis

S. No.	Data type	Source and Description
1	Digital Elevation Model (DEM)	10 m × 10 m resolution derived from Geospatial Data Gateway (GDG) to use as topographic data of the study basin.(https://gdg.sc.egov.usda.gov/)
2	Land Use Map	Obtained in the form of Cropland Data Layer (CDL), a raster dataset with moderate resolution (30 m and 56 m), created by USDA, National Agricultural Statistics Service (NASS) (http://nassgeodata.gmu.edu/cropscape/)
3	Soil Map	Obtained from Soil Survey Geographic Data (SSURGO) collected by National Cooperative Soil Survey (NCSS),USDA and National Resources Conservation Services (NRCS) with scales ranging from 1:12,000 to 1: 63,360 (Staff 2011). (http://websoilsurvey.sc.egov.usda.gov/App/WebSoilSurvey.aspx)
4	Weather Data	Daily Temperature and precipitation data were extracted from Daily Surface Weather and Climatological Summaries (DAYMET) Single point Data Extraction (SPDE) (Thornton et al 1997; Thornton et al 2012) (http://daymet.ornl.gov/dataaccess). The dataset is available on daily time scale with resolution of 1km × 1 km
5	Stream discharge	Stream discharge taken from USGS site no. 06481500 located at Sioux Falls, SD for the study period. (http://waterdata.usgs.gov/nwis/)

Time periods for Model Development and Future Scenarios

- ❖Baseline time period: 1980-2000
- ❖Baseline warm up period:1980-1986
- ❖Baseline calibration period: 1987-1994
- ❖Baseline validation period: 1995-2000
- ❖Future scenarios time period: 2046-2065

Bias Corrected Constructed Analog (BCCA) Coupled Model Intercomparison Project Phase-3 (CMIP-3) Climate change attributes

Variables:

precipitation; minimum surface air temperature; maximum surface air temperature

Time:

1961-2000; 2046-65; 2081-2100 (daily)

Space:

Coverage: North American Land Data Assimilation System

Resolution: 1/8 degree latitude-longitude (~12 km by 12 km)

Maurer, E. P., L. Brekke, T. Pruitt, and P. B. Duffy (2007), 'Fine-resolution climate projections enhance regional climate change impact studies', *Eos Trans. AGU, 88*(47), 504.

Model Calibration and Validation

Step 1: Objective function is defined and absolute range of parameters is set

Step 2: Absolute Sensitive analysis is carried, using Latin Hypercube sampling; Objective function is computed

Step 3: Sensitivity Matrix of objective function is calculated. Equivalent of Hessian Matrix is formulated

Step 4: High order derivatives are neglected. Based on Cramer Rao Theorem, an estimate of lower bound of parameter covariance is computed

Step 5: Parameter sensitivity is analyzed using multiple regression

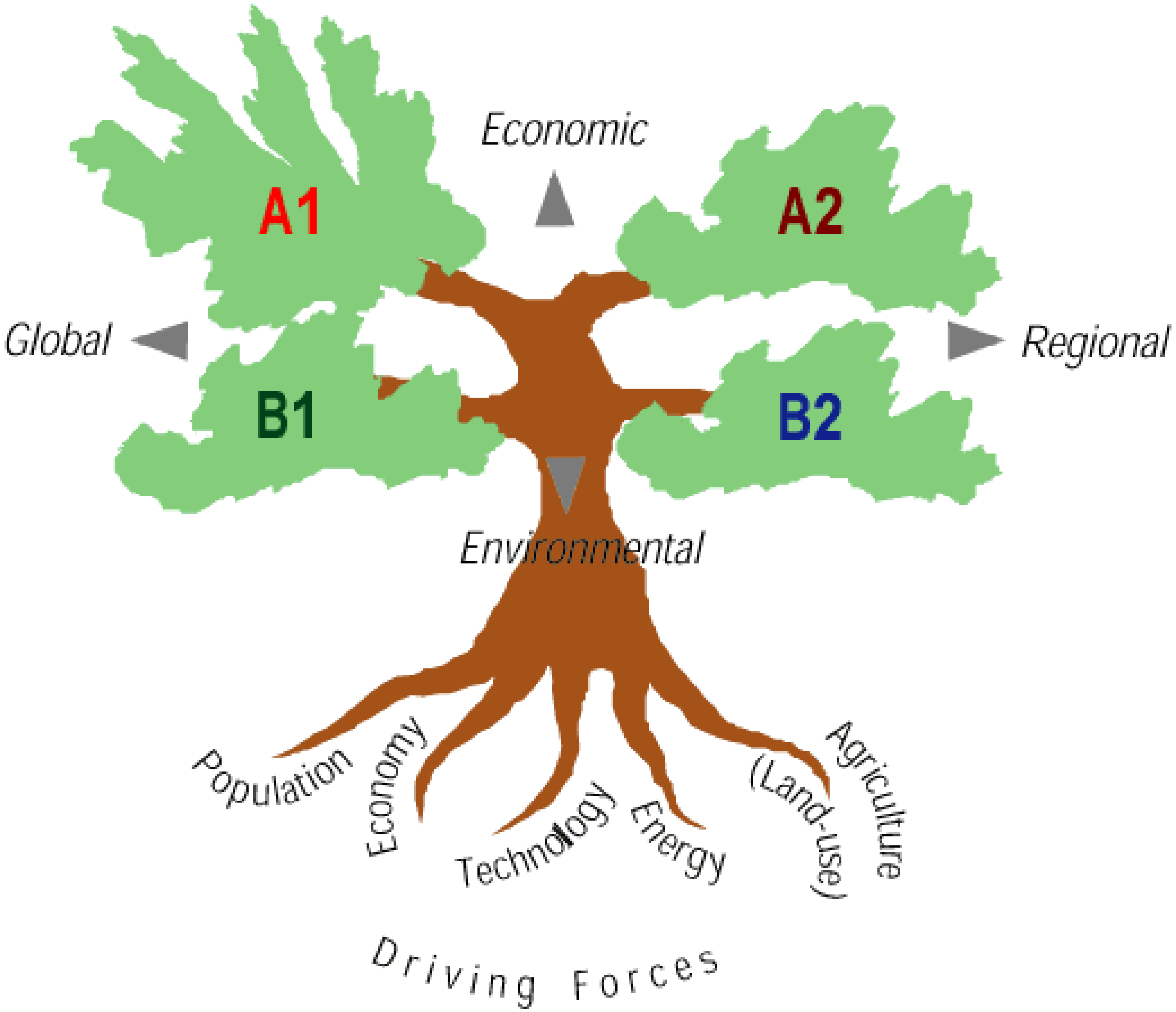
Step 6: Uncertainty measures (p-factor and r-factor) are computed

Algorithm Outputs

- 95ppu Plots
- Dotty plots
- Best_Par.txt
- Best_Sim.txt
- Goal.txt
- New_pars.txt
- Summary_Stat.txt

(Abbaspour et al. 2007)

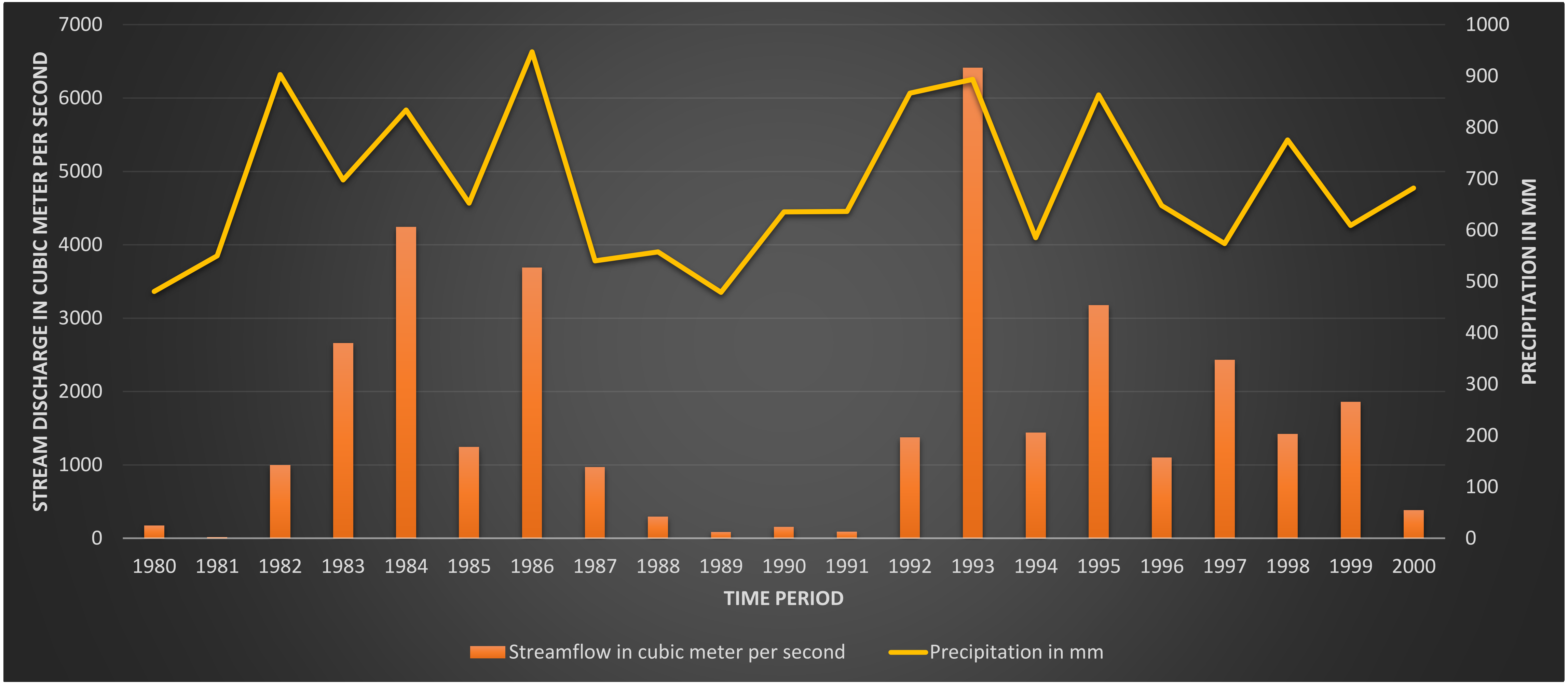
SRES Scenarios



(Nakicenovic et al. 2000)

Results

Hydrographs of Precipitation and Stream discharge on annual basis



Model Calibration and Validation

Statistics	Pre-calibrated Period		Calibration Period		Validation Period	
	Daily	Monthly	Daily	Monthly	Daily	Monthly
NSE†	-1.40	0.59	0.56	0.84	0.55	0.76
PBIAS	-4.22	-4.64	-9.70	-9.53	-16.30	-5.18
RMSE	1178.38	71.44	411.39	38.67	292.75	22.28
R^2	0.18	0.59	0.70	0.84	0.44	0.77

Impact of climate change scenario A1B on stream discharge in comparison to baseline in percentage

	January	February	March	April	May	June	July	August	September	October	November	December
2053	171.86	170.28	840.39	90.12	732.16	568.63	23.18	221.19	233.79	353.09	350.08	289.39
2054	426.06	390.98	704.71	762.46	973.71	880.01	708.23	295.20	385.88	1018.85	1613.36	1186.22
2055	987.32	1465.90	826.57	1730.08	2961.48	1817.46	1090.83	998.27	786.41	2127.74	1429.33	3306.92
2056	3165.19	3665.83	5691.41	3442.96	399.12	124.57	199.79	724.26	2471.81	1144.95	2468.16	2583.74
2057	3207.30	995.12	13117.98	1881.71	1202.79	293.38	756.84	1491.60	796.81	1711.32	238.50	2132.77
2058	1082.74	1034.44	461.99	941.41	4273.99	1480.94	-4.41	-64.95	-18.37	299.33	721.64	865.67
2059	841.96	870.87	24.84	-0.87	-38.57	-83.79	-90.55	2.87	79.12	150.48	152.89	177.53
2060	153.42	106.37	211.22	283.00	384.47	56.08	180.38	244.80	213.98	262.42	412.03	474.85

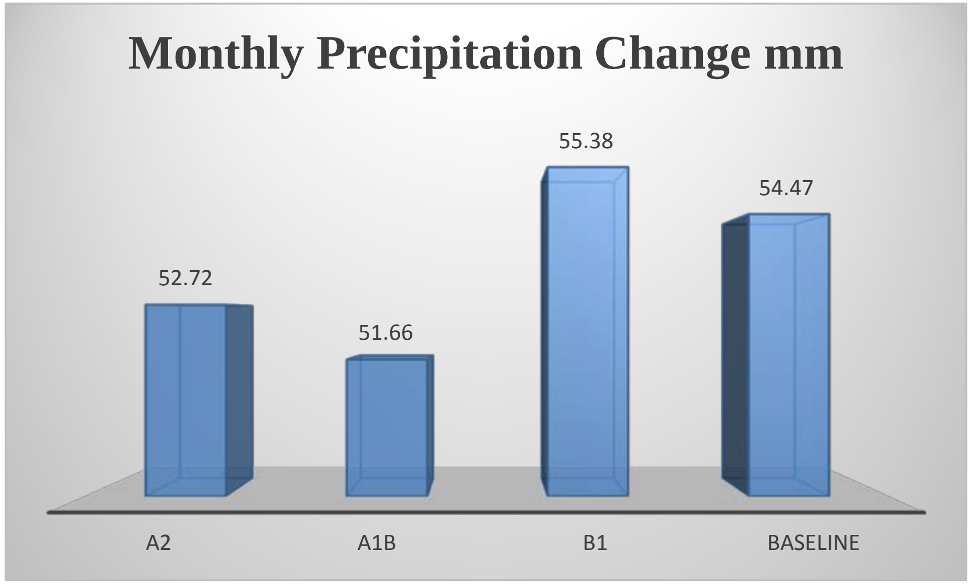
Impact of climate change scenario A2 on stream discharge in comparison to baseline in percentage

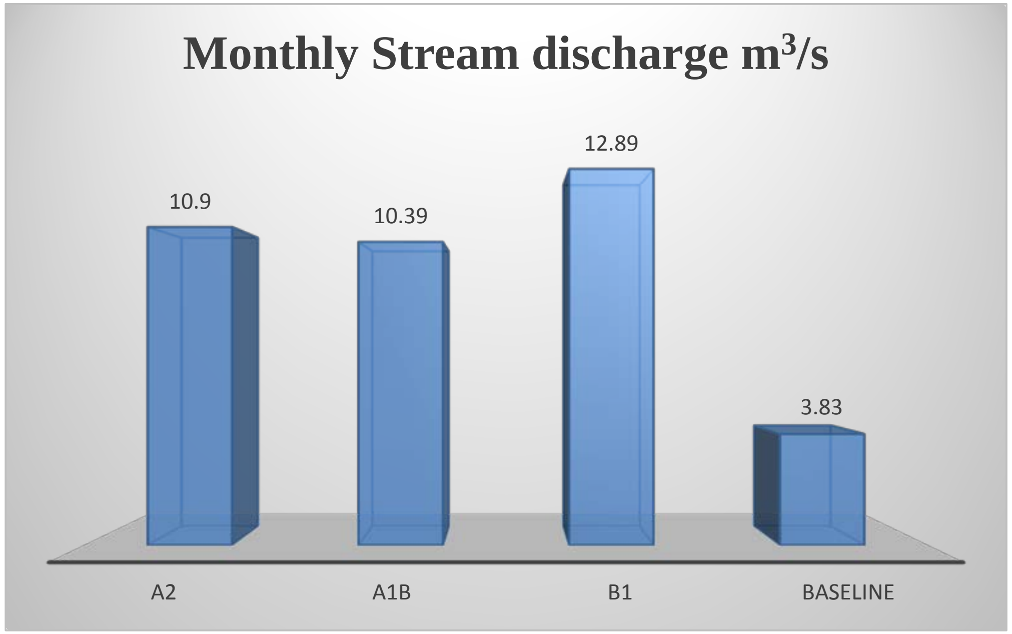
	January	February	March	April	May	June	July	August	September	October	November	December
2053	180.24	288.82	1014.76	140.65	413.66	1416.22	87.66	288.86	268.76	389.41	398.56	292.61
2054	463.31	731.70	276.11	717.42	637.63	1702.87	826.94	237.21	400.15	1056.50	1030.78	1065.33
2055	937.23	1592.02	630.67	1946.62	4871.48	1740.61	936.47	860.53	814.34	2255.88	1465.66	3345.73
2056	3344.80	2788.38	8356.68	6063.20	899.12	104.44	172.76	908.30	2716.65	1129.20	2457.32	2798.92
2057	3408.21	991.05	10286.52	1676.90	814.96	123.02	928.73	1428.29	850.15	1628.71	225.80	2186.86
2058	1099.64	702.32	1245.94	1783.63	4354.94	1232.83	-18.18	-63.78	-15.07	328.50	556.24	997.58
2059	824.61	881.68	-12.90	-36.01	-13.00	-62.27	-87.26	7.95	95.94	299.00	180.88	267.05
2060	213.45	162.52	161.90	420.33	543.58	53.16	194.62	285.34	267.06	355.33	476.94	548.21

Impact of climate change scenario B1 on stream discharge in comparison to baseline in percentage

	January	February	March	April	May	June	July	August	September	October	November	December
2053	156.90	157.86	690.53	122.57	880.18	1140.90	120.04	277.33	246.47	673.53	479.51	312.57
2054	510.82	641.33	540.03	1178.68	979.90	2840.25	2157.34	327.80	562.28	1676.98	1107.71	1269.54
2055	1141.33	1648.70	856.06	1442.86	4516.52	1956.93	1351.16	985.60	783.71	2232.30	1484.61	3359.88
2056	3247.60	2804.33	8972.95	4705.81	948.77	170.91	310.39	855.18	2747.98	1247.29	3788.46	3069.36
2057	3942.44	1192.61	17891.01	3366.64	1361.88	326.85	1020.40	1734.18	936.24	2030.98	286.79	2539.82
2058	1324.97	416.93	1508.02	2428.39	5803.94	1473.37	-15.30	-59.91	-15.18	275.27	521.25	1249.49
2059	807.57	956.54	-6.57	-28.75	-9.29	-64.71	-80.22	6.44	120.77	178.88	186.06	178.72
2060	188.65	135.24	245.74	356.75	447.44	205.21	735.80	298.01	330.30	513.25	705.01	579.72

Impact of climate change scenarios on various hydrologic processes





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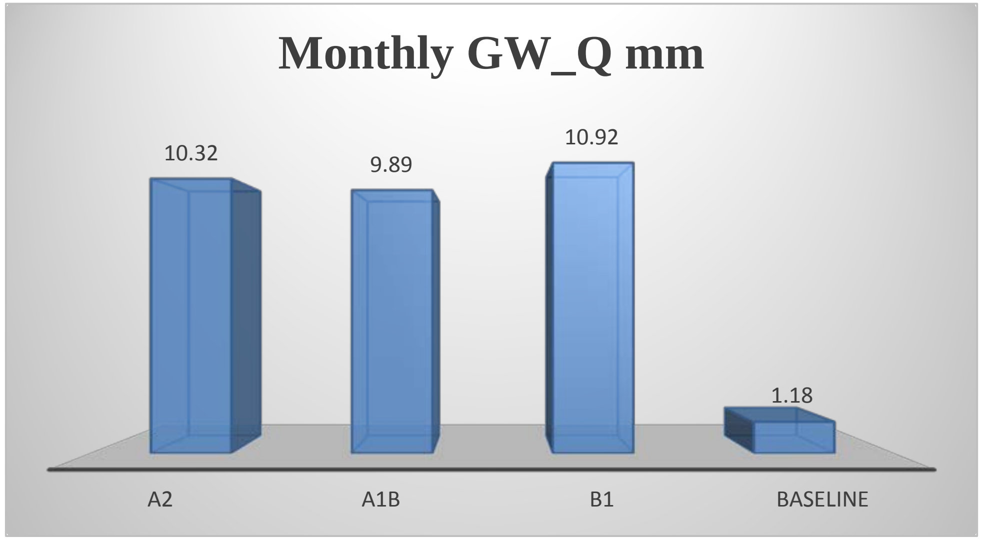
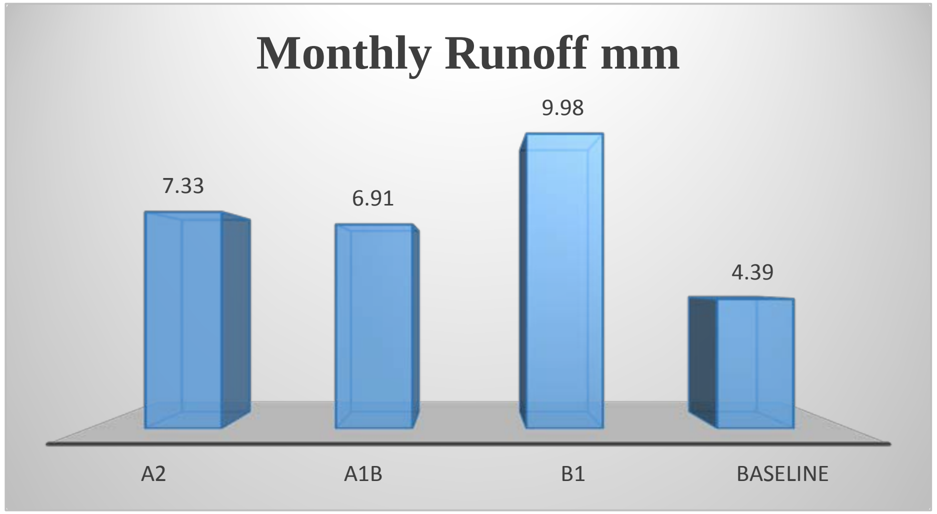
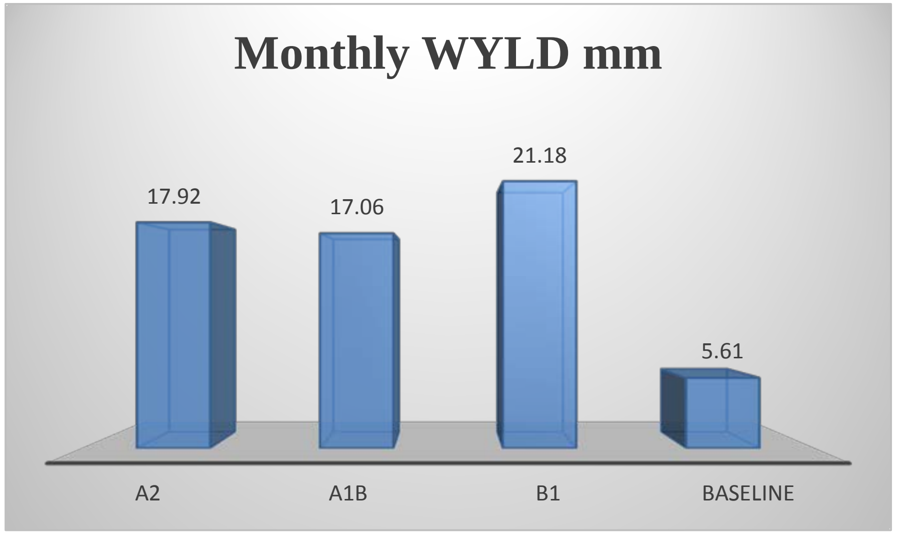
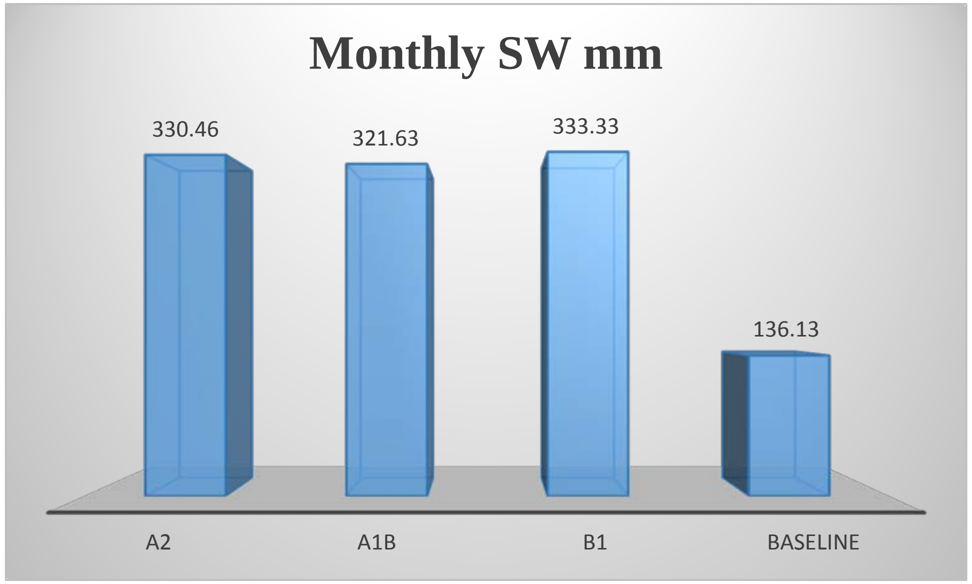
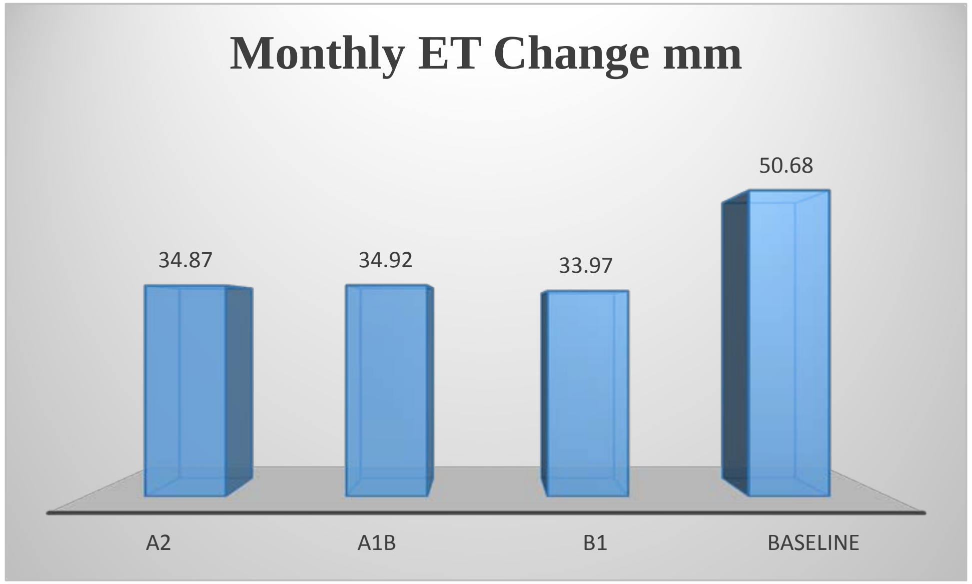


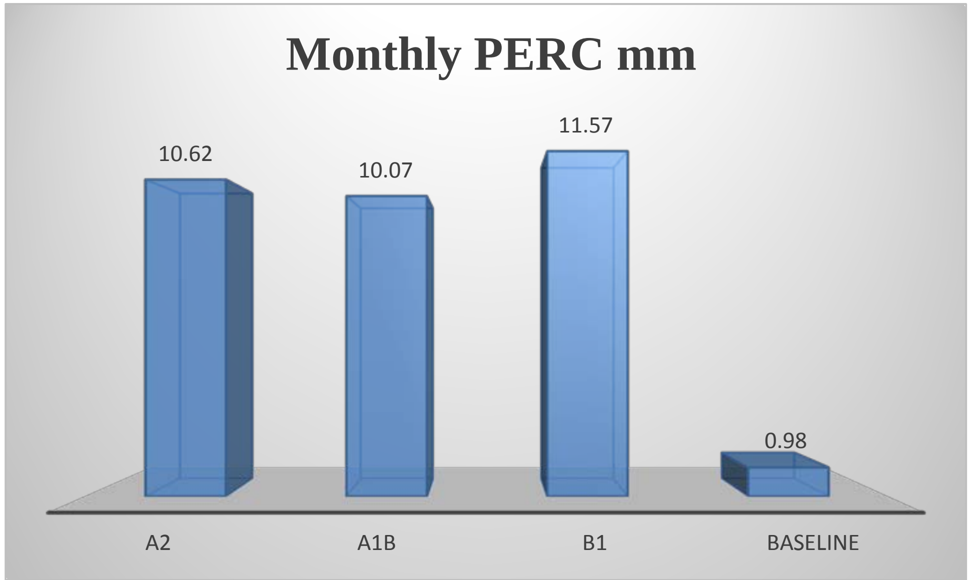




Impact of climate change scenarios on various hydrologic processes







Conclusions

- The study illustrated changes in water resources in relation to SRES climate change scenarios for an agricultural watershed
- The climate change impacts can be witnessed with alternative water surplus and deficit seasons.
- Water deficit conditions in terms of negative increase in stream discharge during crop growth season can adversely affect agricultural productivity in rainfed regions and may progress to agricultural drought.
- Impact of climate change scenarios on hydrologic cycle over the study area may be accompanied with a shift in crop growth cycle (stomatal conductance) due to change in aerothermal regime in producing areas .
- There is a need of more extensive assessment of potential climate change impacts on the hydrology and agricultural production in agriculturally dominated watersheds.

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THANK YOU !!!

http://www.cnn.com/2009/TECH/science/06/16/climate.change.report/index.html?eref=rss_us