Impact of Climate Change on Watershed Response: Representative Concentration Pathways over Delhi Regions

Niyati Naik[1,] Bitishree Patel[2]

Assistant Professor, Gandhi Institute of Excellent Technocrats, Bhubaneswar, Odisha, India

Assistant Professor, Gandhi Institute of Excellent Technocrats, Bhubaneswar, Odisha, India

Abstract

The significance of climate change impact on watershed response for Delhi has been made by determining the watershed response corresponding to the meteorological parameters for different future climate scenarios i.e. RCP scenarios around different periods. Impact of climate change was quantified by determining the change in runoff response or change in water balance of the area from base year to the future time periods corresponding to different climate change scenarios. First of all, future climate for the area has been obtained by downscaling of future climatic series generated from CMIP5 data for different climate change scenarios. Climatic data of Delhi for year 2006 has been used as the base period and used for the downscaling of CMIP data. The rainfall statistical downscaling become executed considering SDSM framework along with the freshly established RCP settings against Delhi regime.

Keywords: CMIP, Watershed, Climate change, SDSM, SWMM.

1. Introduction

Watersheds primarily unite terrestrial landscapes as well as join fine-scale practices (e.g., microbial metabolism) to overall ecological executions (e.g. universal biogeochemical cycles). Practices happening during watersheds likewise produce results which become instant appropriate to human civilization, like prompting water standard duration and amount of water distribution into downstream expanses. Changes in water quality and hydrological regions become major effects aimed at sustainable drive, cultivation, ecological well-being, and social community. Moreover, the vital part of watersheds inside the Earth coordination was accentuated in the most current testimony from the Biological and Environmental Research Advisory Committee (BERAC), calling out the want to appreciate essential methods in watersheds to attain BERAC's 20-year idea for strong energy schemes (BERAC 2017). Usually, watersheds suggest tangibly definable, however intricate, schemes which assumed merely by mixing knowledge and competences through domains.

Watersheds function via unite as well as feedbacks amid physical, chemical, and biotic courses. These procedures happen all over the watershed range, from headwaters to the coast and from bedrock to the uppermost of the vegetative covering. These practices also effect watershed arrangement (e.g., topography and subsurface geology) over erosion and chemical weathering which themselves subjective by biological courses like vegetation instituting and progression. Combined physical, chemical, as well as biotic courses too motivate watershed purpose.

Currently, water resources at global measure become substantial strain as of changed hydrological as well as dispersed pollution circumstances consequential to climate change. Variations in streamflow, water hotness, and water class on behalf of climate change will add to reservations in water resource and ecology well-being. Dispersed pollution from the upstream catchment through environment forcing like rainfall and temperature, counting soil erosion, nutrient discharges from lands, unexpected wastewater releases, and pollution splashed out by rainfall and runoff, is the chief hazard to the water assets. Water-supply scarcities and steady drop in water excellence. Rivers of all magnitudes support form the world's watersheds, and collectively produce a "circulatory system" that pumps life into each bend of the globe. The underneath figure-2 taken by geographer Szűcs Róbert, split the earth's watersheds into imaginative catchment regions, as well as deliver an instructive appearance at the way water surges through continents.

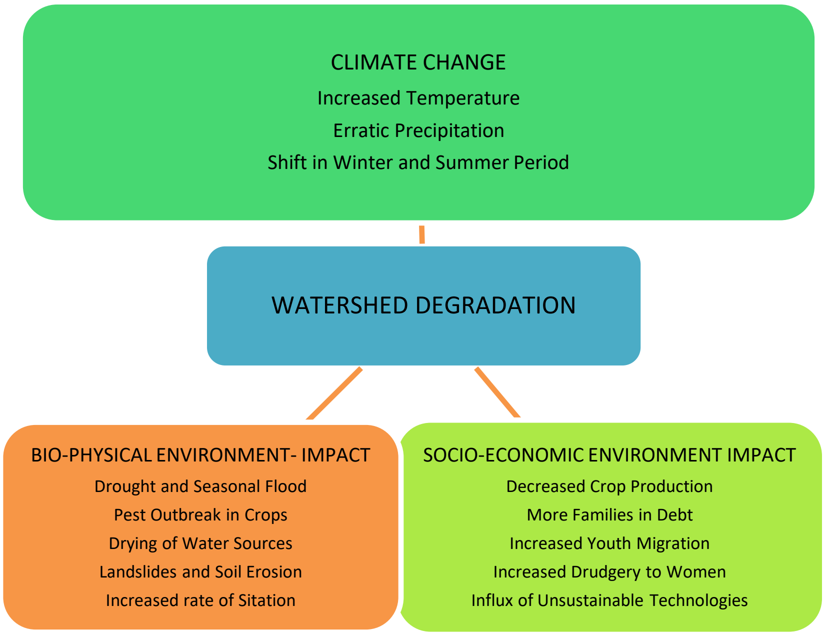


Fig.-1 Aspect of Watershed Degradation

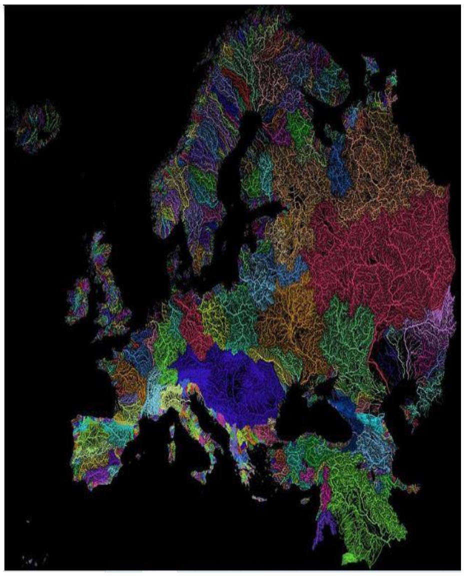


Fig.-2 Earth Catchment areas

2. Rainfall-runoff Modelling in Changing Climate Scenario

The surroundings become subjective by human beings for eras. Still, it is merely then the commencement of the manufacturing insurrection which influence of human executions has started to spread to one universal gage. Nowadays, ecological concern develops the principal distress of mankind as a value of methodical indication around the cumulative application of greenhouse gases in the air and the altering climate of the Globe. Calibrated rainfall-runoff model for the study area (SWMM) has been used to simulate the runoff supposed to be generated corresponding to the climatic characteristics for different year corresponding to different climate change scenarios and catchment characteristics of base year i.e., 2006.

Calibrated SWMM model has been parameterised corresponding to the catchment characteristics i.e., slope, land use land cover, drainage parameters etc. of base year 2006. Further model was run to simulate the runoff to be generated from the catchment for different years using projected climate of that particular year for different scenarios. During simulation of runoff for different future years, catchment characteristics kept same as of base year i.e. 2006. Further, change in runoff response for any future year simulated from the SWMM model with respect to the runoff generated in the base year (2006) will be the impact of only climate change, as catchment characteristics remains constant at base year level.

3. Precipitation forecast vide with diverse RCPs against various temporal scales

The average dispersals for everyday precipitation rate and quantity against varying time scale kinds resulting since interpretations of year 2006 data and GCM model simulations for the current climate (2006-2079) and the forthcoming (2080-2099) vide with scenarios RCP2.6, RCP4.5 and RCP8.5. The study specifies the rainfall occurrences in the Delhi area will be noticeably additional thrilling in the global warming scenarios. It is stated that the number of days of intense rainfall are lower in some months and higher in other months than today and that its contribution to the annual change in rainfall will obviously also be mixed one. This amount of alteration is appropriate for the emission scenarios, with increase in RCP8.5 amount and also in RCP4.5 at both Palam and Safdarjung stations. This modification proposes an increase in the risk of flood in the Delhi area due to the increase in intense rainfall levels in RCP emission scenarios. Comparable consequences can be established in the CMIP5 models.

4. Observations and Discussions

In order to inspect the upcoming influence of climate change, the results concern to CanESM2 standard was implemented to downscale the forthcoming climate and also used to simulate the runoff-rainfall modelling to predict the future outcomes of surface runoff and its factors. The assessment among the intra-annual unevenness of once-a-month measurements of average precipitation were considered. On behalf of the stations i.e. Safdarjung along with Palam, there has been one precipitation downscaling made out. The forthcoming climate status were estimated considering diverse RCPs scenarios (RCP2.6, RCP4.5, and RCP8.5) and NCEP for Canadian (CanESM2) model at a monthly temporal scale.

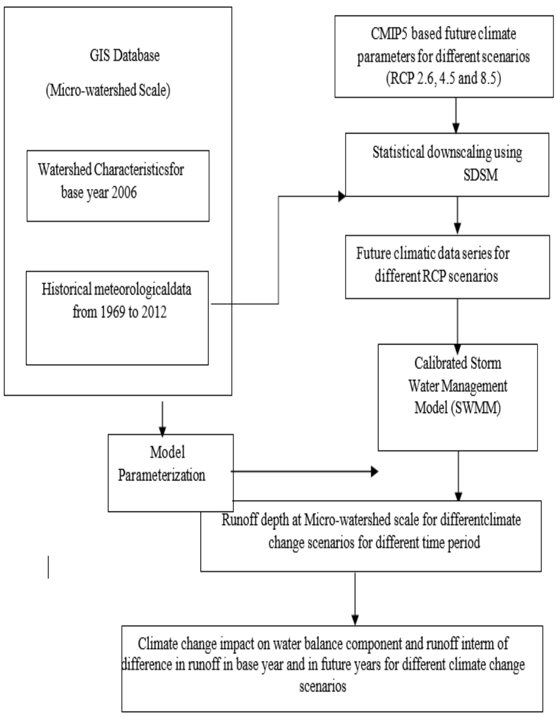


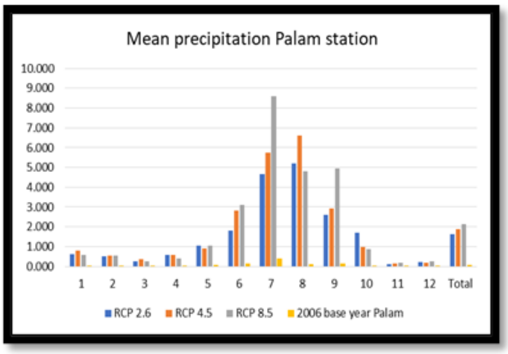
Fig.3 Methodology used for assessment of climate change impact on watershed response

Outcomes indicate that the dispersal of proportion variations in yearly precipitation at the end of the

21st century in RCP4.5 and RCP8.5 compared to the base period. Relative to the rain pattern for whole year in the Delhi area is taken into account (IMD, 2005). The increase in precipitation by taking average of whole future data scenario at monthly temporal scale the total average value of precipitation is 1.6, 1.8 and 2.1 is increased for year 2006 are 0.23, 0.20, and 0.22 respectively.

Palam station for RCP 2.6, 4.5 and 8.5 compared to base year 2006 and the % increase in value 0.19, 0.22 and 0.26 for RCP 2.6, 4.5 and 8.5 respectively. Again for Safdarjung station the average value of precipitation for future scenario 1.9, 1.6 and 1.8 for RCP's 2.6, 4.5 and 8.5 and there percentage change with respect to base

Fig.-4 Compared results of rainfall in different RCP scenarios at monthly temporalscales at Palam station



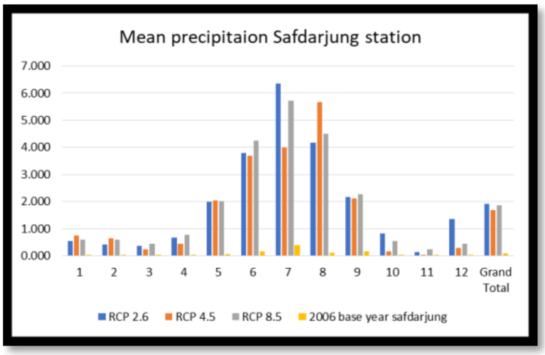


Fig.-5 Compared results of rainfall in different RCP scenarios at monthly temporalscales at Safdarjung Station.

The outcomes are expressed in Table- and Table-2 as well as in Figure-4 and 5 for Palam and Safdarjung, respectively. Frequency of extreme events of rainfall have beenfound to

e rising in some months and reducing for remaining months. Annual change in percentage (%) mean precipitation in three scenarios RCPs (2.6, 4.5, and 8.5) as compared to the base year 2006 has found increasing trend with increase in % change 0.19, 0.22, and 0.26 for RCP 2.6, 4.5 and 8.5 for Palam station, respectively. In Safdarjung station the value of RCP 4.5 is less as compared with 2.6 shows less rainfall and in RCP 8.5 scenario its value is more than RCP 4.5 but it's less than compared with RCP 2.6 which is shown in table-1. Calibrated SWMM model has been used to simulate the runoff in future years corresponding to the future climate data and catchment characteristics of base year 2006. Methodology adopted has been explained in figure-3. Future catchment response i.e., runoff and other water balance components have been simulated for future years for different RCP scenarios. Figure-4 is showing the changes in total runoff over the period of 2006 to 2099 for the study area. It can be observed that the total runoff volume in representative concentration pathways (RCP) of 2.6 is much greater than the base year 2006 runoff which is shown in figure (6.4). The % increase in runoff is up to 23.98% for the RCP 2.6 and for RCP

4.5 & 8.5 the total runoff volume may increase by 29.54 % and 50.54% as shown in figure-5

Table-1 Projection of results in different RCP scenarios for mean precipitation indifferent temporal scales at Palam Station

Sl. no.	RCP	2006* base year runoff	Runoff avg. value	% Change in Runoff
1	2.6	164.54	204.01	23.98
2	4.5	164.54	213.15	29.54
3	8.5	164.54	247.67	50.52

Sl. no.	RCP	2006* base year evaporation	Evaporation avg. value	% Change in Evaporation value
1	2.6	135.61	163.1	20.26
2	4.5	135.61	173.26	27.75
3	8.5	135.61	194.32	43.29
Sl. no.	**RCP**	**2006* base year evaporation**	**Evaporation avg. value**	**% Change in Evaporation value**
1	2.6	135.61	163.1	20.26
2	4.5	135.61	173.26	27.75
3	8.5	135.61	194.32	43.29

Table-2 Projection of results in diverse RCP scenarios against mean precipitation in different temporal scales measured at Safdarjung Station

The summary of possible changes in catchment response in different climate change scenarios have been shown in table-3. The result indicates significant change in catchment response in future in different climate change scenarios.

Table-3 Summary of average runoff volume over different RCP scenario

Temporal scale	RCP 2.6	RCP 4.5	RCP 8.5	Observed Palam	% Change RCP 2.6	% Change RCP 4.5	% Change RCP 8.5
January	0.606	0.799	0.593	0.001	4.998	6.593	4.891
February	0.495	0.557	0.541	0.035	0.131	0.148	0.144
March	0.251	0.377	0.27	0.034	0.064	0.101	0.069
April	0.58	0.574	0.396	0.003	2.078	2.056	1.415
May	1.042	0.92	1.041	0.074	0.131	0.115	0.131
June	1.797	2.822	3.102	0.155	0.106	0.172	0.19
July	4.671	5.748	8.616	0.404	0.106	0.132	0.203
August	5.216	6.599	4.821	0.105	0.487	0.619	0.449
September	2.587	2.928	4.957	0.161	0.15	0.171	0.297
October	1.696	0.966	0.852	0.004	4.196	2.386	2.103
November	0.118	0.13	0.168	0.008	0.132	0.146	0.192
December	0.2	0.173	0.257	0.004	0.455	0.392	0.588

Total	1.618	1.897	2.148	0.079	0.194	0.229	0.261

As in figure-5, the average runoff coefficient over the period from 2006 to 2099 is getting increased as compared with the base year 2006 which is taken as a reference to predict the climate change scenario over a period from 2006 to 2099. The runoff coefficient depends on the runoff as well as rainfall also. It is directly proportional to runoff and rainfall. In table-4 it is observed that the runoff coefficient over the period is increasing for different RCP values. As in RCP 2.6 the runoff coefficient is increased to 0.60%, and in RCP 4.5 it decreased by 0.86% as compared to 2006 runoff coefficient value, the decrease in runoff coefficient as compared to year 2006 base value is there is less rainfall in the RCP 4.5 as compared to RCP 2.6 which is shown in table 6.2, so the value of average runoff coefficient is less compared to RCP 4.5 and 8.5, and in RCP 8.5 it increased to 2.20% as compared to the base year value. Result indicate that with even decrease in mean rainfall in different climate change scenarios runoff coefficient is increasing due to increase in intensity of few rainfall events

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Table-4 Summary of average runoff coefficient over different RCP scenario

Sl. no.	RCP	2006* base year runoff coefficient	Average Runoff coefficient	% Change in Runoff coefficient
1	**2.6**	**0.23**	**0.23**	**0.60**
2	**4.5**	**0.23**	**0.228**	**-0.86**
3	**8.5**	**0.23**	**0.23**	**2.20**

Possible change in average evaporation rate over the period of 2006 to 2099 in different climate change scenarios has been shown in figure 6.8 which shows the increasing trend of evaporation rate in RCP 2.6 followed by 4.5 and 8.5. Table-5 shows the % change in evaporation value as compared to the base year 2006 in RCP 2.6, 4.5 and 8.5. In RCP 2.6 the % change in evaporation value may increase to 20.26% and it may also increase in 4.5 and 8.5 scenarios by 27.75% and 43.29% respectively. The evaporation value depends on many factor i.e. surface area, humidity, wind, and temperature. As the effect of climate change, the temperature is increased year by year. And in the urbanized area, the temperature is more compared to a rural area which increases the rate of evaporation

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Table-5 Summary of Evaporation over different RCP scenario

Sl.no.	**RCP**	**2006* base year infiltration**	**Infiltration avg. value**	**% Change in Infiltration**
1	2.6	144.84	206.70	42.70
2	4.5	144.84	214.43	48.03
3	8.5	144.84	240.66	66.14

The same increasing trend have been observed in infiltration process as shown in figure-5 for RCP 2.6, RCP 4.5, and RCP 8.5. Table-6 shows the summarized report of the average value of infiltration and percent changes in infiltration compared with the base year 2006. The result is shown in RCP 2.6 there is a 42.7 % increase in infiltration followed by 48% and 66.14% in RCP 4.5 and RCP 8.5 respectively.

Sl. no.	RCP	2006* base year evaporation	Evaporation avg. value	% Change in Evaporation value
1	2.6	135.61	163.10	20.26
2	4.5	135.61	173.26	27.75
3	8.5	135.61	194.32	43.29

Sl. no.	RCP	2006* base year evaporation	Evaporation avg. value	% Change in Evaporation value
1	2.6	135.61	163.10	20.26
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Table-6 Summary of Evaporation over different RCP scenario

5. Conclusion

Climate change, linked with variations in aspects like temperature and patterns of precipitation, has major influence on water assets along with the watershed ecosystems. Adjusting to climate change, considered a pivotal plan against watershed administration. The introduction of climate change has unnatural precipitation forms on behalf of aspects like frequency, power, spatial span, and extent, which will have considerable possessions upon hydrology as well as water quality, comprising surface runoff, soil erosion, and pollutant passage and admission practices. Hence, it concluded that catchment response will significantly change in different climate change scenarios.

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