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RESEARCH ARTICLE

IMPACT OF CLIMATE CHANGE ON RAINFALL IN THE IRRIGATED INDUS BASIN: A CASE STUDY IN THE LOWER CHENAB CANAL SYSTEM

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ABSTRACT

Impact of climate change on the water resources is considerable for the future policy making. Climate change impact on the irrigated Indus basin is also significant as it is in the upper Indus basin. In hydrological cycle, rainfall is the most important component and has significant contribution in the crop water requirement. Recharge in the aquifer is not a hidden phenomenon during the monsoon period in the irrigated Indus basin. Impact of climate change on the rainfall was studied using the Hadley Climate model version 3 (HadCM3). HadCM3 provides the A2 and B2 scenario and its impact on the future climatic parameters. Statistical downscaling model (SDSM) was used for downscaling the rainfall in the selected area of the Faisalabad irrigation zone. NCEP predictors was used for the assessment of the downscaled data using SDSM. Percentage change in the rainfall was observed for the midcentury (2040-2069) as compared to the base period (1981-2010). Results reveled the increase in the rainfall during the Rabi season. While significant decrease in the rainfall was observed during the monsoon season. Maximum percentage decrease in the rainfall was observed 6.42% and 61.9% in the month of November under A2 and B2 scenarios, respectively. Similarly, maximum percentage increase in the rainfall was observed 10.4.6% and 101.4% in the month of November under A2 and B2 scenarios, respectively. Decrease in the rainfall was observed in the months of monsoon and in April. While the increase in the rainfall was observed in the remaining period.

KEYWORDS

Climate Change, HadCM3, SDSM, Rainfall.

1. INTRODUCTION

Proper functioning of the earth system required the global circulation of precipitation, as it help to regulate the earth temperature by carrying heat from tropics to the higher altitude. However, this circulation is more vulnerable to climate change. Climate change is presently discussed as an anthropologically improved sensation. Scientists are working on the impact of climate change on the different environmental factors. The most important is the occurrence of rainfall. Scientists are also working on the impact of climate change on the monsoon (Loo et al., 2015; Reuter et al., 2013; Kumar et al., 2013).

Indus basin is the most vulnerable area under climate change. In Indus basin, irrigation is supplemental to the rainfall to meet the crop water requirement. Climate change impact on rainfall is significant (Mahmood et al., 2015). Rainfall not only provides the discharge in the rivers due to regular occurrence in the watershed it also contributes to meet the crop water requirement and recharge to the aquifer. Monsoon is the major rainfall period in the Indus basin. In study area, 75% rainfall is occurred in the monsoon (Awan and Ismaeel, 2014). The aim of the study was to evaluate the impact of the climate change on the rainfall distribution due to its significant contribution in agro-eco system of the Indus basin. Rainfall contribution in the study area is significant especially during the summer season due to heavy rainfall under monsoon. It reduced the soil temperature and definitely reduced the water demand.

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2. METHODOLOGY

2.1 Study area

Faisalabad is zone falls in the command area of lower Chenab canal system (LCC). LCC is the oldest and considered as the most productive area of the Indus basin. Average annual rainfall of the study areas is almost 400 mm. summer is the longest season and the winter the second big season of the area. Faisalabad zone is considered as the mix cropping zone. Major crops of the study area are wheat, maize, cotton, rice and sugarcane. Average maximum and minimum temperature during the June is 40.5 and 26.5 ^{o}C. While, in January the maximum and minimum temperature is 19.4 and 4.1 ^{o}C.

2.2 Data Source

2.2.1 Global Circulation Model

In this study, Hadley climate model version 3 (HadCM3) was used for the assessment of future data on the course resolution. HadCM3 is widely used and recognized model by the scientific community. The spatial resolution (latitude by longitude) of the model is 2.5 X 3.75 degree. A group researchers used the HadCM3 for the assessment and evaluation of climatic parameter under changing climate in the upper Jhelum basin (Mahmood et al., 2015). In this study, two scenarios of fourth assessment report was downloaded under HadCM3. Data of A2 and B2 scenario was obtained from the Canadian website. A group researchers presented the detailed methodology used for the assessment of the impact of climate change on the water resources of the Kunhar river basin [6].

2.2.2 Downscaling

To overcome the problem of course resolution of the model. Downscaling of data was performed using the Statistical Downscaling Model (SDSM). SDSM required the observed data that is used for the selection of the predictors for downscaling the data. Predictors are selected based on the partial correlation and p values of the data (Salzmann et al., 2007). Based on these predictors' rainfall was predicted for A2 and B2 scenarios.

2.2.3 Bias correction

Bias correction is used after downscaling the data to enhance the accuracy of the predicted scenarios data. A study described that bias correction is used to de biased the daily downscaled data (Salzmaan et al., 2007). Bias correction for the rainfall is mathematically presented in equation 1.

$$RF_{cr} = RF_{df} \times \left(\frac{\overline{RF_o}}{\overline{P_{dp}}}\right) \qquad (1)$$

Where RFcr is future de-biased daily data of rainfall. RFdf is SDSM based downscaled rainfall for the duration of 2011-2069, and RFdp is SDSM based downscaled rainfall for the base line period 1980-2010. $\overline{RF_{dp}}$ is the 30 years SDSM base period mean monthly values of rainfall and $\overline{RF_O}$ is 30 years mean monthly observed values for rainfall.

3. RESULT AND DISCUSSION

During the predictor selection, the super predictor was specific humidity was found as the super predictor. Super predictor is that predictor that has highest partial correlation value. Based on the selected predictors, rainfall was downscaled for the A2 and B2 scenario. A group researchers described that the rainfall accuracy is improved after the application of bias correction on the rainfall data. Average annual rainfall was increased for the midcentury scenario in the study area (Salzmann et al., 2007). The monthly analysis showed the increase in the rainfall, while significant decrease in the rainfall was observed during the Kharif season. Detail description about the percentage change in the rainfall is given in table 1. Most, significant decrease in the rainfall was observed during the monsoon season.

Table 1: Percentage change in rainfall under A2 and B2 scenario for the midcentury

Months	%Change in RF under A2	%Change in RF under B2
January	64	61
February	21	17
March	8	2
April	-21	-24
May	129	156
June	82	76
July	-11	-14
August	-35	-37
September	-62	-62
October	-24	-17
November	105	101
December	31	41

Impact of climate change is significant especially during the monsoon season. It will affect the overall water cycle and crops cultivated in the summer season. During the monsoon season, especially in the month of September, 62% decrease in the rainfall under both scenario is the alarming situation (Mahmood and Babel, 2013). It's the decrease in the rainfall during the highest rainfall occurring period in the study area. Secondly the most notable period is the month of august during the monsoon season. It also shows the 35to 37% decreases under A2 and B2 scenario respectively. Figures 1 and 2 shows the average annual rainfall for the midcentury under A2 and b2 scenario.

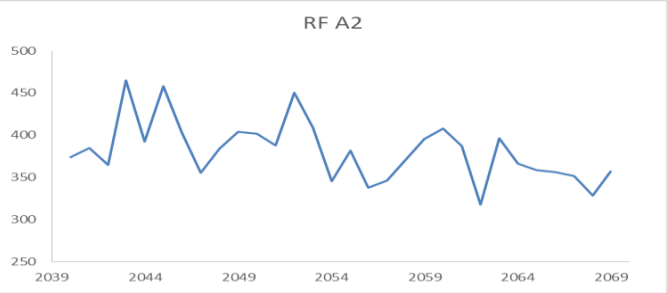

Figure 1: Rainfall under A2 scenario for the midcentury

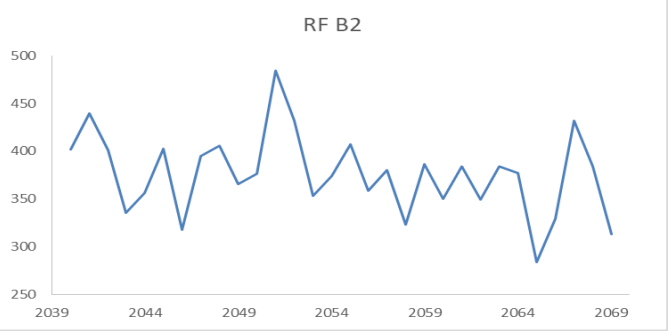

Figure 2: Rainfall under B2 scenario for the midcentury

4. CONCLUSION

It is dire need to study the impact of climate change not only on the catchment of the Indus basin but also on the irrigated area of the Indus basin. It will help to mitigate the climate change. Detailed studies on the climate change will help the policy makers for better water management strategies under changing climate.

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