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COMPARISON OF PRECIPITATION PATTERNS (A CASE STUDY OF MANGLA WATERSHED)

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Abstract: *The importance of precise future projections of precipitation trends cannot be over-looked in water resources management and socio-economic development of any country. In this study, the bias-corrected output (future projections of precipitation) of two Regional Climate Models (RCMs), CCAM and RCA4 is plotted against the observed historic precipitation data (1970-2000) for Mangla basin to evaluate the annual precipitation trends in near and far future i.e. (2011-2040, 2041-2070 and 2071-2100) under both RCP 4.5 and 8.5. Comparison of the results indicate that there would be more precipitation (increasing trend) in mid period (2041-2070), and significant decrease is noticed for the last period (2071-2100) of the ongoing century. Consequently, due to the changing trends in climate variables and land use practices the basin may face extreme events in future. To cope with such alarming situation proper pro-active strategies and planning is essential.*

Key-words: *Precipitation Pattern, RCMs, Mangla Basin*

1. INTRODUCTION

Pakistan is an agricultural country, and agriculture of any country acts like a backbone for the economic health of the country, which is linked with precipitation variation. Nature and type of harvesting and many other environmental variations are directly or indirectly affected by the type and trend of precipitation in that region. According to Intergovernmental Panel for Climate Change (IPCC) 2013 report, till the end of the current century Asian countries will undergo noticeable variation in precipitation both in time and space [2]. The main causes of precipitation variation are shift in climate due to global warming [3], Deforestation [4] and alteration in land use practices [5]. It is of utmost importance to assess the change in precipitation trend, variation in Global climate and global monsoon circulation [6]. Nowadays researchers have focused on assessment of precipitation trends. A decrease in average annual precipitation trend is projected in different parts of Pakistan [7]. The surface area of the globe covered under 30°-85°N has undergone increase in precipitation while, a noticeable decrease is observed under 10°S-30°N in last 30-40 years of the 20th century [8]. A decreasing trend is noticed in the annual average precipitation in Russia [9,10], North-China [11,12] and coastal areas of Pakistan [13]. It is also observed to have increased trend in annual average precipitation like western region of China [14], Bangladesh [15] and western belts of Philippines [16]. It is more cumbersome to predict precipitation trend based on time-series data than prediction of temperature trend [1]. The average annual temperature of the globe has been raised by 0.6 °C, it is also projected to have more increase in temperature by the end of the 21st century due to high rate of GHGs emissions and global warming which ultimately affects the frequency, pattern and intensity of precipitation [17]**.** Mangla catchment has very diverse variation in precipitation, two peaks have been noticed, one occurs in the month of March (Snow-fall) and another one occurs in July (Monsoon) [18]. Northern (elevated area) especially Kunhar watershed receives greater amount of precipitation compared to the southern plains, the mean annual precipitation in Northern and southern regions are 1893 mm and 846 mm, respectively. Most of the northern hills are covered by snow and glacier and contributes primarily to the stream flow [18]. The outcome of this research will provide assistance to watershed management and policy makers and also to hydro-climate modelers in real time decision making processes.

2. MATERIALS AND METHODS

2.1. Study Area

Mangla Catchment is situated in North-East region of Pakistan, with total watershed area of 33,466 km^2 as shown in figure (1). It is a transboundary region and almost 58% of the area is located in India and 42% in Pakistan, Azad Kashmir [19]. It comprises of five major tributaries i.e. Jhelum, Neelum, Kunhar, Poonch and Kanshi. The weather conditions of the watershed changes with altitude [18]. Snow and Glacier have very vital contribution to the stream flow in this basin. Precipitation pattern has great diversity in time and space. In general, northern mountainous parts receive more precipitation than southern plain parts of the basin.

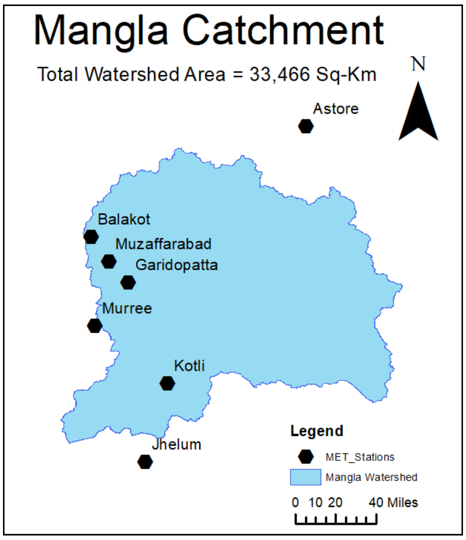

Fig.1 Study Area (Mangla Watershed)

2.2. Data Collection

Thirty years of daily observed precipitation data (1970-2000) was collected seven different metrological stations from Pakistan Meteorological Department details of all the MET-stations are given in table (1). SRTM (90m x 90m) DEM was downloaded from US-GS website. For future precipitation two RCMS data has been used in this study, The Conformal-Cubic Atmospheric Model (CCAM) has been developed at CSIRO, Australia Rossby Centre Regional Climate Model (RCA version 4) is a Swedish Meteorological and Hydrological Institute (SMHI) regional climate model developed at the Rossby Centre for Climate Research.

Table 1: Details of MET-Stations

S.No	Station	Latitude	Longitude	Elevation
1	Jhelum	32.94	73.74	282
2	Kotli	33.5	73.9	614
3	Murree	33.91	73.38	2213
4	Garidopatta	34.22	73.62	814
5	Astore	35.34	74.9	2168
6	Muzaffarabad	34.37	73.48	686
7	Balakot	34.55	73.35	995.4

2.3. Methodology

Delineation of Mangla catchment has been done by using Arc GIS 10.3.1 and then RCMs data were downscaled on each grid point in the basin. There were total 22 and 20 grid points within Mangla Basin under CCAM and RCA4 respectively. The output of RCMs i.e. daily precipitation data for the period of 2011-2100 has been bias-corrected with the historic observed precipitation data (Average of 7 stations daily precipitation data for baseline period 1970-2000 by using encoded excel sheets which are based on Quantile Delta Mapping (QDM) technique. The bias-corrected output was compared with the observed data (1970-2000) on annual scale for three time periods each 30 years slice i.e. 2011-2040, 2041-2070 and 2071-2100 to have an idea of variation in precipitation over the entire basin.

3. RESULTS & DISCUSSION

Results of the following study comprise of the following sections:

(1) Measured Annual Precipitation data (1970-2000)

(2) Comparison of Annual Precipitation values for CCAM

(3) Comparison of Annual Precipitation values for RCA4

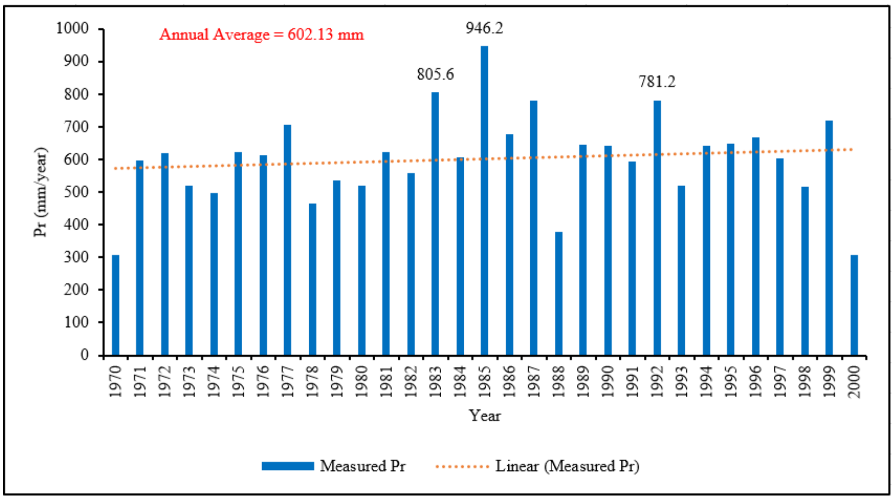

Fig.2 Measured Annual Precipitation data (1970-2000)

Fig.3 Comparison of Annual Precipitation values of CCAM (RCP 4.5)

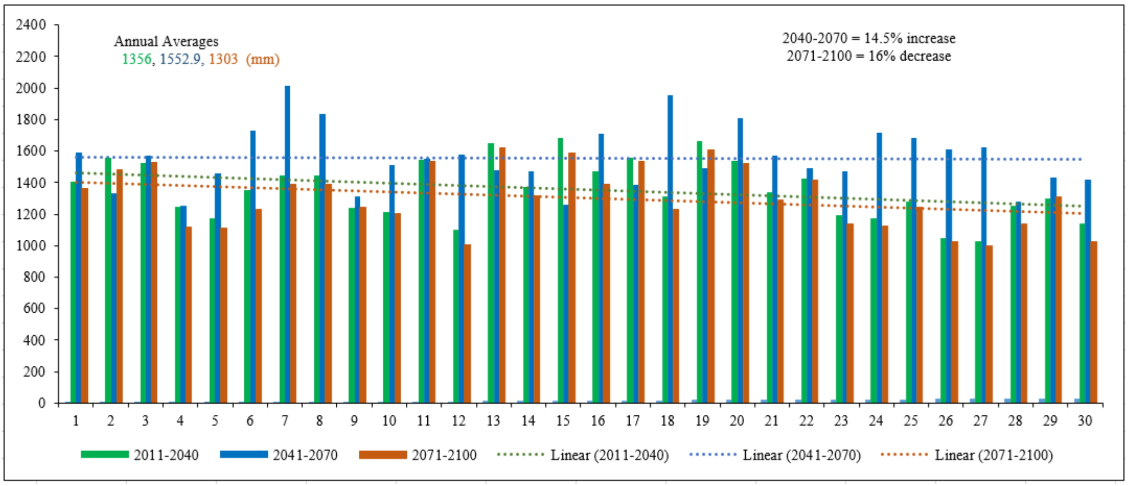

Fig.4 Comparison of Annual Precipitation values of CCAM (RCP 8.5)

The average annual precipitation of the historic observed period (1970-2000) is 603.13 mm with an increasing trend and highest annual precipitation is recorded for the year 1985 as shown in figure 1. The average annual precipitation is 1482 mm for the period 2011-2040 with decreasing trend. For second time period (2040-2070) the annual precipitation has an increase of 7% with an increasing trend and then a very significant decrease of 19.15% is observed for the last period of the century (2071-2100) under RCP 4.5 as shown in figure 2. RCP 8.5 results showed that the annual precipitation has decreasing trend with mean annual value of 1365 mm for the period 2011-2040. For second period (2041-2070) the mean annual value is increased by 14.5% with an ascending pattern. And again a very prominent decline of 16% is noticed for 2071-2100 with decreasing trend in precipitation pattern as shown in figure 3.

Comparison of precipitation results for RCA4 show the same trend however, the variation is less intensive as compared to CCAM results. For RCP 4.5 the average annual precipitation has a decreasing trend both for 2011-2040 and 2041-2070 with annual averages 1304 mm and 1375 mm respectively. An increasing trend is noticed for 2071-2100 although, the average annual precipitation has been declined by 7.3%. For RCP 8.5 all the three time periods have decreasing trend in precipitation with average annual precipitations of 1391 mm, 1441.9 mm and 1304.7 mm respectively.

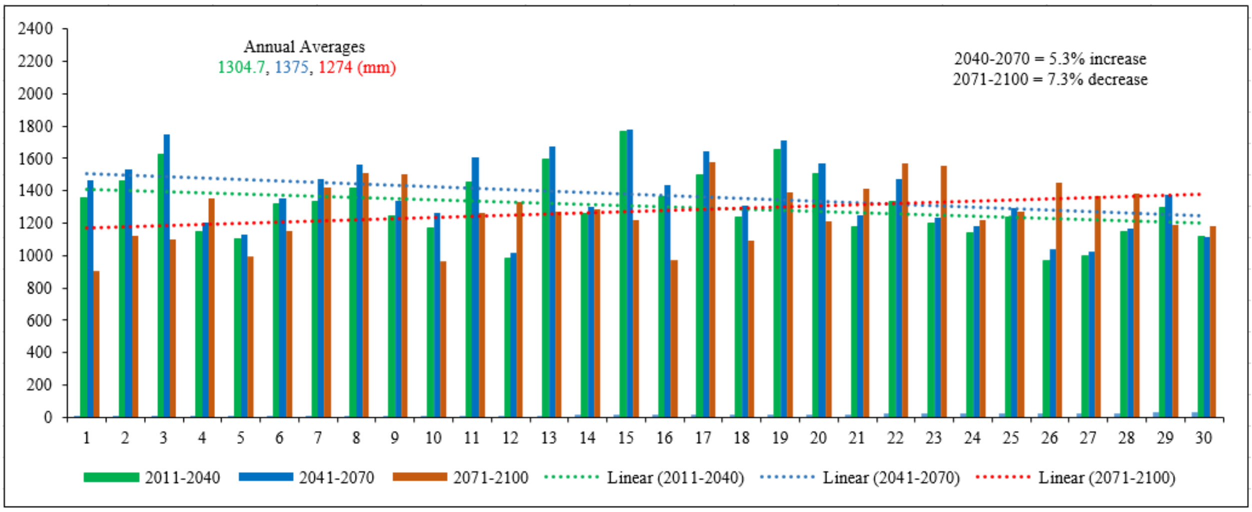

Fig.5 Comparison of Annual Precipitation values of RCA4 (RCP 4.5)

Fig.6 Comparison of Annual Precipitation values of RCA4 (RCP 8.5)

4. CONCLUSIONS

Due to natural and human induced causes the climate of the globe getting worst with a very faster rate. These changes in average temperature causes spatial and temporal variation in precipitation pattern. Greater intensity precipitation for a short period of time is one of the main reasons for flooding. The overall trend of precipitation is following a descending trend till the end of the 21st century. However, CCAM results show some increasing pattern for the middle period (2041-2070) and then followed by significant decline. Because, according to Inter Governmental Panel for Climate Change (IPCC), during this period it is projected that the average annual temperature will increase by 2 to 4 °C and the snow and glacier reservoirs will start receding with a very faster rate, consequently affecting the magnitude and intensity of monsoon precipitation pattern. Keeping in view the above mentioned variation in precipitation pattern in future, it is concluded that the basin will face more extreme events in future (Floods in middle time period and droughts in last time period). The findings of this research study will help watershed management team and policy makers in proper mitigation measures and better management.

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