RECENT TREND ANALYSIS FOR ANNUAL PEAK FLOW IN TAPI BASIN

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ABSTRACT

Intergovernmental Panel on Climate Change (IPCC) suggested recent trends in hydro-meteorological condition over the past 30 years. Mann-Kendall (MK) and Spearman's rho (SR) tests are non-parametric tests to detect the trend in time series, depending upon pre-assigned significance level, magnitude of trend, sample size and the amount of variation within time series. Also, analysing the hydro-meteorological time series without checking the serial correlation in the time series is a misuse of statistical analysis. Şen (2012)[1] presented innovative trend analysis methodology on basis of sub-section time series plots derived from a given time-series on cartesian coordinate system, which is independent of the trend in time series, depends upon pre-assigned significance level, magnitude of trend, sample size and the amount of variation within the time series. In such plot, increasing and decreasing trends occupy upper and lower triangular area respectively, of the square area defined by the domain of concern variable while trend free time series appears along 45° straight-line. Aforesaid trend analysis has been used to check the trends in annual peak flow at three streamflow gauging stations (Burhanpur, Gopalkheda and Sarangkheda) in the Tapi basin. Annual peak flow time series of about 30 years have been used in the analysis of above stream gauging stations. Statistical parameters like mean, median, standard deviation, coefficient of kurtosis and coefficient of skewness have also been worked out for above annual peak flow time series for all the stations. High values of annual peak flow at all aforesaid gauging station have shown increasing trend. In other words, floods are bound to increase in the Tapi basin in future, which is inline with the study of Gosain et al. (2011)[2].

KEYWORDS: *Intergovernmental Panel on Climate Change (IPCC), Innovative trend analysis methodology, annual peak flows, time series, Tapi basin.*

INTRODUCTION

Time series analysis has become a major tool in hydrology to detect the trends and its shifts of hydrometerological variables under changing climate conditions, (Salas 1992)[3]. Parametric and non-parametric tests are widely used to detect or extrapolate trends in time series data. Non-parametric test like Mann-Kendall (MK) and Spearman's Rho (SR) tests are normally used and suitable when time series data are non-normally distributed (Yue et al., 2002)[4]. Strength of such non-parametric test depends upon pre-assigned significance level, magnitude of trend, sample size and the amount of variation within time series. The checking of serial correlation of hydrological time series data is a pre-requisite for their frequency analysis. The statistical analysis, without checking serial correlation, could be misuse of statistical analysis as reported by von Storch (1998)[5] and Clarke (2010)[6]. Pre-whitening on the time series is required to be carried out before using non-parametric test on such serially co-related time series. Şen (2012)[1] presented innovative trend analysis methodology on basis of sub-section time series plots derived from a given time-series on cartesian coordinate system which is independent of the trend in time series, pre-assigned significance level, magnitude of trend, sample size and the amount of variation within time series. Intergovernmental Panel on Climate Change (IPCC) suggested recent trends in hydro-meteorological condition over the past 30 years through out the world. In this paper, aforesaid trend analysis has been used to check the trends in annual peak flow at three streamflow gauging stations (Gopalkheda, Burhanpur and Sarangkheda) in the Tapi basin. Such studies, on detection of recent trends in annual peak streamflow, not only important for future planning of the water resources in the basin but also a

need of the hour for developing countries like India to create resilience in the country man against the variation in the climate.

METHODOLOGY

The innovative trend analysis methodology has recently been presented by Şen (2012)[1]. The basis of this methodology is the scatter plot of sub-series in the ascending order from the original time series on a cartesian coordinate system. The 45° straight line implies no trend but any plot appearance above (below) this line implies increasing (decreasing) trends. Increasing or decreasing trends occupy upper or lower triangular areas of the square plots respectively. In interpretation, it is better to think of the annual flow in three clusters as low, medium and high peak annual flows and scatter diagram of 1:1 line (45˚ straight-line) divided into three clusters. Trend in the high, medium and low magnitude can be detected using this simple but still powerful innovative trend analysis methodology.

STUDY AREA AND TREND OF OBSERVED DATA

The Tapi basin spreads an area of 65145 km^2 which is nearly 2% of the total geographic area of the country. The basin lies between east longitudes of 72°38' to 78°17' and north latitudes of 20°5' to 22°3'. The basin has elongated shape with a maximum length of 587 km from east to west and the maximum width of 210 km from north to south. The entire Tapi basin area further divided in three sub-basins: Upper Tapi Basin up to Hathnur (29430 km^2), Middle Tapi Basin form Hathnur up to the Gidhade (25320 km^2) and Lower Tapi Basin from Gidhade gauging site up to the sea (10395 km^2). The annual rainfall for the upper, middle and lower Tapi basins for an average year has been reported to be 935 mm, 631 mm and 1042 mm respectively (Jain at al., 2007)[8]. Apart from the Tapi River, The Purna River and the Girna River together account for nearly 45% of the Tapi basin area as shown in Fig.1. Burhanpur and Sarangkheda gauging station are situated on the Tapi River having catchment area of 8700 km^2 and 58400 km^2 whereas Gopalkheda gauging station situated on the Purna River having catchment area of 9500 km^2. The Ukai reservoir project system is a multipurpose major irrigation project which mainly serves the purposes like irrigation, power generation, water supplies to industries and drinking, partial flood control and fisheries in state of Gujarat, India with 21˚15' N latitude and 73˚35' E longitude. The Ukai reservoir project has gross storage capacity of 7414.29 Mm^3 with 684.39 Mm^3 as dead storage and catchment area 62225 km^2.

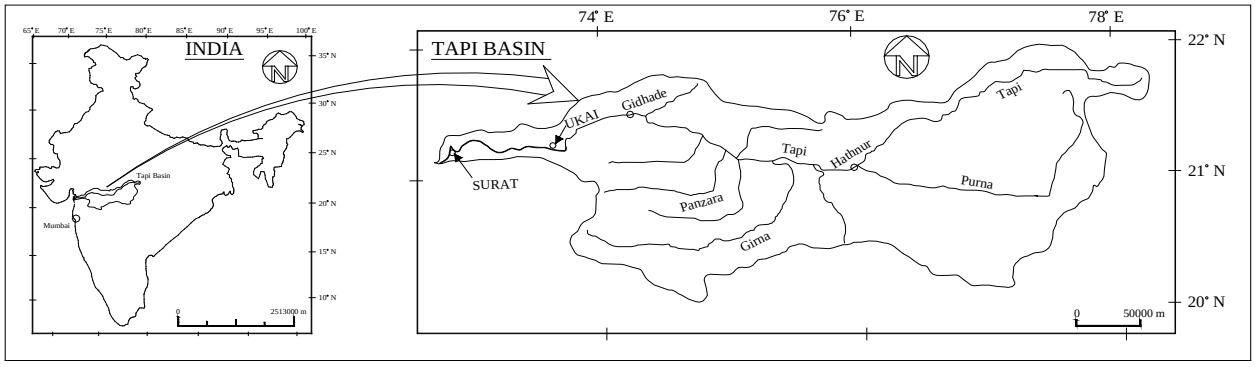

Fig.1. Map of Tapi River basin (Timbadiya et al. 2011)[7]

Annual peak flow time series of about 30 years at Burhanpur, Sarangkheda and Gopalkheda gauging station has been collected from Central Water Commission for the present study. The time series of annual peak flow at Burhanpur from 1972 to 2007 is shown in Fig. 2, while Figs. 3 & 4 show corresponding parameter for stations Gopalkheda and Sarangkheda for period 1980 to 2007 and 1978 to 2007 respectively. From these figures, it can be seen that trend of extreme flood is aggravating on the Tapi river with passage of time.

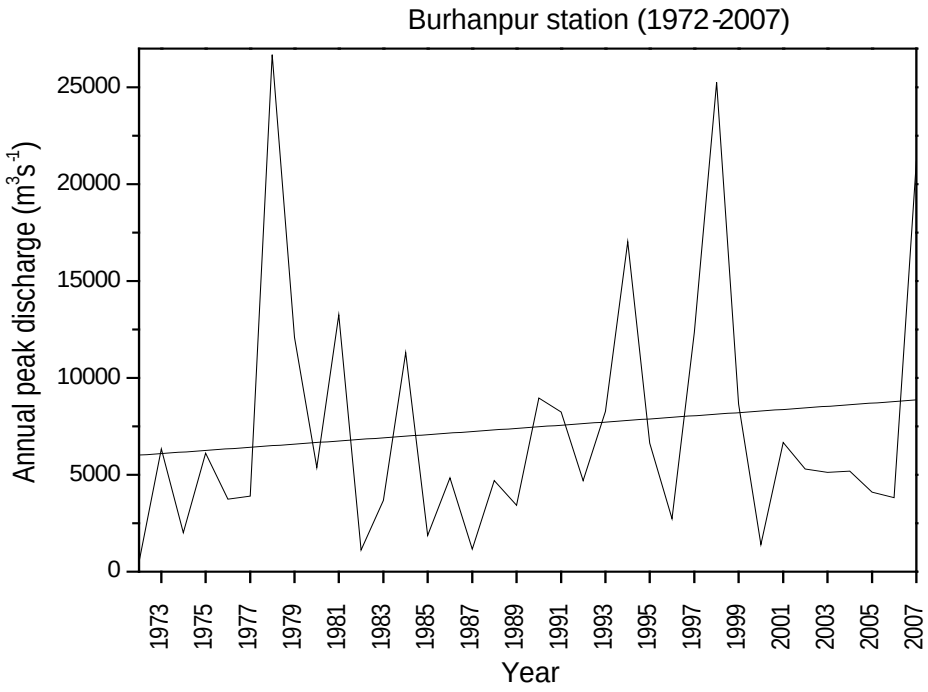

Fig. 2 Time series of annual peak flow at Burhanpur gauging station

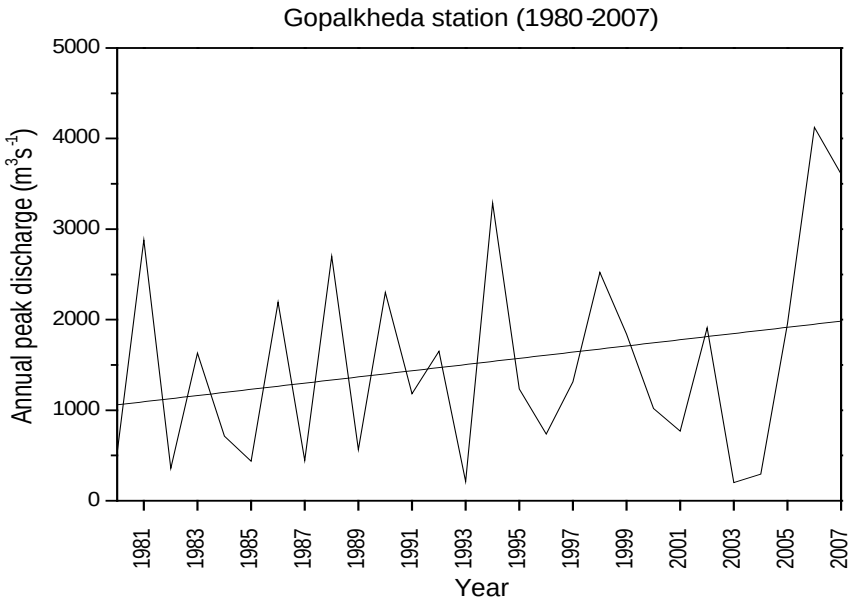

Fig. 3 Time series of annual peak flow at Gopalkheda gauging station

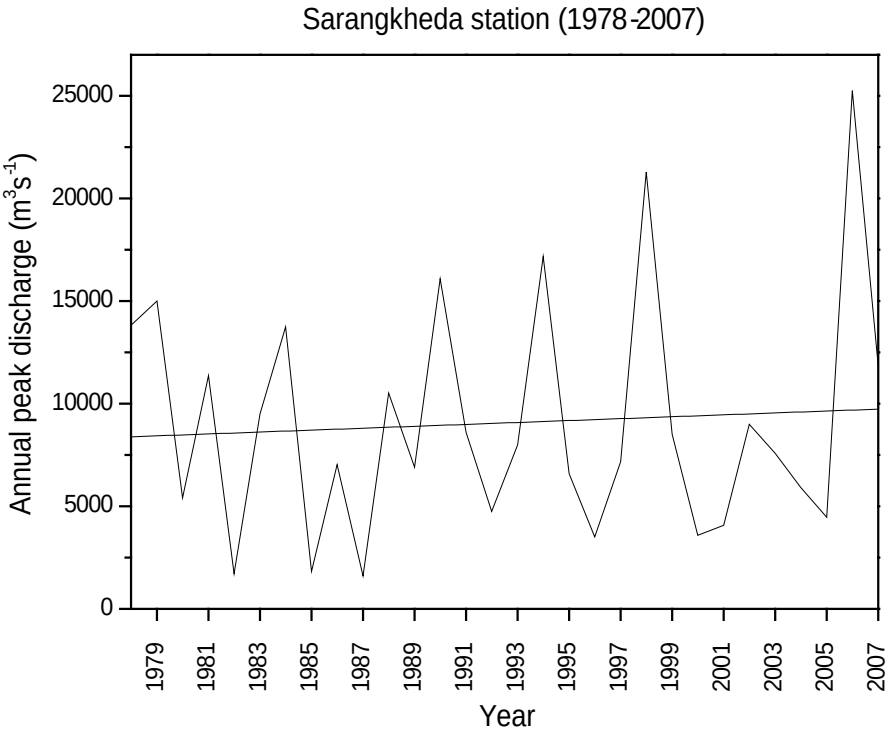

Fig. 4 Time series of annual peak flow at Sarangkheda gauging station

The highest annual peak flow of magnitude 26683 m^3s^{-1}, 4124 m^3s^{-1} and 25259 m^3s^{-1} were observed at Burhanpur, Gopalkheda and Sarangkheda stations respectively in the Tapi basin. Statistical parameters like mean, median, standard deviation, coefficient of kurtosis and coefficient of skewness have also been worked out for above annual peak flow time series for all the stations and tabulated in Table 1.

Table 1 Statistical parameters of annual peak flows

Stations / Statistical parameters	Burhanpur	Gopalkheda	Sarangkheda
No. of data	36	28	30
Mean (m^3s^{-1})	7438.45	1521.57	9059.74
Median (m^3s^{-1})	5248.59	1273.5	7782.84
Standard deviation (m^3s^{-1})	6416.43	1103.78	5739.17
Coefficient of Kurtosis	2.63	-0.32	1.069
Coefficient of Skewness	1.70	0.72	1.068

TREND ANALYSIS

Annual peak flow series were sub divided in two portion with respect to time and arranged in the ascending order. Taking the first half as ordinate and second half as abscissa, scatter plot of the annual peak flows have been drawn, see Figs.5,6 and 7, with 45° (1:1 line) for Burhanpur, Gopalkheda and Sarangkheda gauging stations respectively. From Fig. 5 and 6, it is clearly depicted that low, medium and high values of annual peak flow has increasing trend at Burhanpur and Gopalkheda gauging station while Fig.7 indicates the increasing trend in the low and high annual peak flow and decreasing trend in medium peak annual flow at Sarangkheda gauging stations.

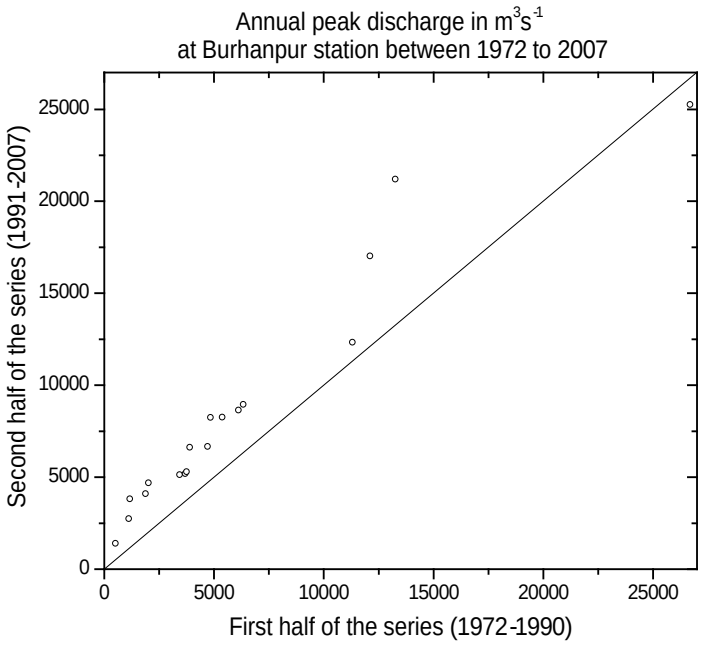

Fig. 5 Trend analysis of annual peak flow at Burhanpur gauging station

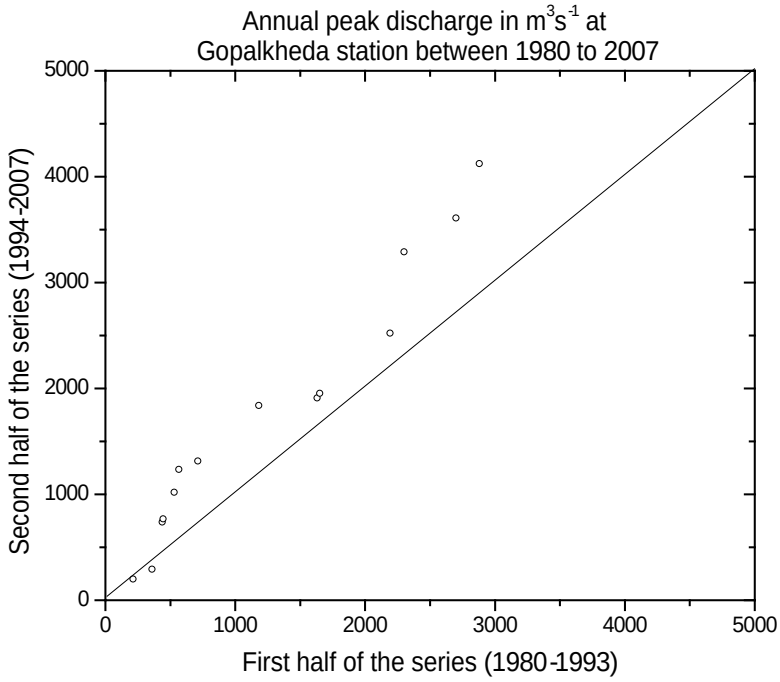

Fig. 6 Trend analysis of annual peak flow at Gopalkheda gauging station

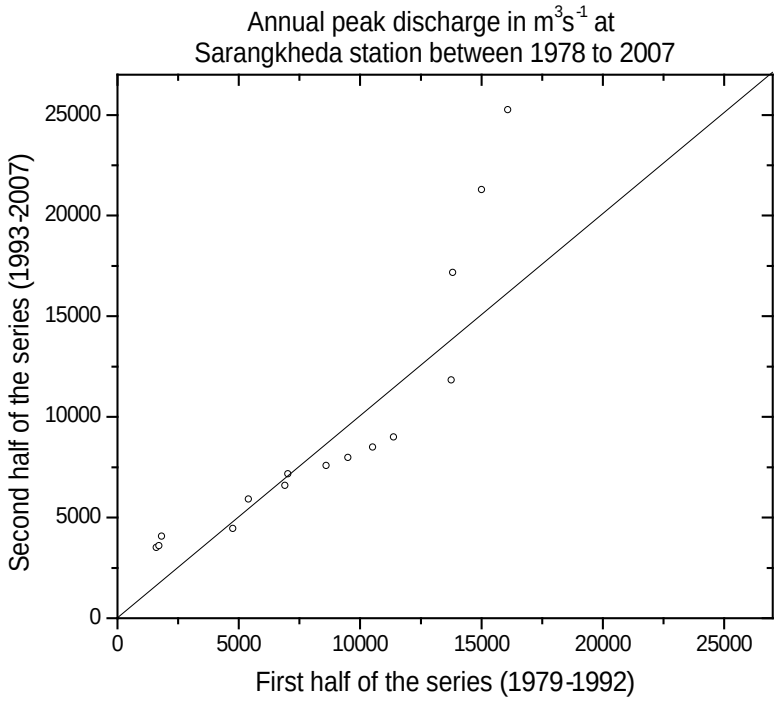

Fig. 7 Trend analysis of annual peak flow at Sarangkheda gauging station

CONCLUSION

From the present study, it can be concluded that low, medium and high values of annual peak flow has increasing trend at Burhanpur and Gopalkheda gauging station of Tapi basin. Increasing trend in the low and high annual peak flow and decreasing trend in medium peak annual flow has been observed at Sarangkheda gauging station. The results demonstrated in the present study, are in line with the study of Gosain et al. (2011)[2] wherein they have predicted an increase in precipitation of 17.5 % and 5.7 % in near term (2021-2050) and long-term (2071-2098) respectively with respect to PRECIS RCM output between 1961 to 1990. It can be concluded that floods are bound to increase in the Tapi basin in future.

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