Trend and variability of rainfall in Jalgaon district of Maharashtra

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ABSTRACT

Rainfall is the most important weather factor that determines the agricultural production in India. The rainfall variability and its pattern are very important for agricultural production. The prevailing drought conditions have led to sharp decline in agricultural production in Maharashtra. The economic survey report indicated that the deficient rainfall in the year 2018 has resulted in sharp fall in the production of kharif crops viz jowar, bajara, tur, groundnut, sesamum and sunflower. Due to large amount of variability in rainfall, the farmers have been facing major problem of getting remunerative yield of crops. The climate of Jalgaon district of Maharashtra is generally dry except monsoon season. The non-parametric Mann-Kendall rank test was applied to detect monotonic trends in series of rainfall in the district. It was observed that the mean annual rainfall in the district showed a long term insignificant declining trend during the study period of last 28 years except pre-monsoon season. The average rainfall and variability were 676.3 mm and 30.40 per cent respectively in the district during the study period.

Keywords: Rainfall; variability, trend, agricultural production

INTRODUCTION

Rainfall is the most important weather factor that determines the agricultural production in India. The rainfall variability and its pattern are very important for agricultural production. The prevailing drought conditions have led to sharp decline in agricultural production in Maharashtra. The economic survey report indicated that the deficient rainfall in the year 2018 has resulted in a sharp fall in the production of kharif crops viz jowar, pearl millet, tur, groundnut, sesamum and sunflower. Due to large amount of variability in rainfall, the farmers have been facing major problem of getting remunerative yield of crops.

Climate change and variability will directly and significantly affect the current and future agriculture (Gregory et al 2010). Changes in farm operational schedules also lead to changes in productivity and therefore contribute to inter-annual changes in crop yield (Adejuwon 2005). Crop growth and development are affected by solar radiation, relative humidity, rainfall, temperature and cloud cover which combine to produce the observed impacts of climate on crop yield (Daubenmire 1974). Ayinde et al (2011) observed the effect of climate change on agricultural productivity in Nigeria.

Jalgaon district is located in western part of Indian peninsula and northern side of Maharashtra state. The climate of the district is generally dry except monsoon season. Normally a year is subdivided into four seasons. The ideal temperature for crop growth is 25 to 30°C. Bright sunshine after light showers is very useful in early stages of crop growth. Here nearly 90 per cent of annual rainfall is received from the southwest monsoon and the rainiest months are July and August. Looking at the adverse climatic situation and persistent changes in the area, production and productivity of different crops in the district, the present investigations were undertaken in order to study the trend and variability.

METHODOLOGY

Mann-Kendall test

The non-parametric Mann-Kendall test is commonly employed to detect monotonic trends in series of environmental or hydrological data. For the time series $x_1, .., x_n$, the Mann-Kendall test uses the following statistic:

$$s = \sum_{i=1}^{n-1} \sum_{j=k+1}^{n} sign\,(x_j - x_i)$$

If $s > 0$ then later observations in the time series tend to be larger than those that appear earlier in the time series, while the reverse is true if $s < 0$.

The variance of S is given by:

$$var = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_t f_t(f_t - 1)(2f_t + 5)\right]$$

where t varies over the set of tied ranks, f_t = Number of times (ie frequency) that the rank t appears

The Mann-Kendall test uses the following test statistic:

$$z = \begin{cases} (S-1)/se, & S > 0 \\ 0, & S = 0 \\ (S+1)/se, & S < 0 \end{cases}$$

where se = Square root of var

If there is no monotonic trend (the null hypothesis), then for time series with more than 10 elements, $z \sim N\,(0, 1)$, ie z has a standard normal distribution

Descriptive statistics

The arithmetic mean, standard deviation and coefficient of variation (Panse and Sukhatme 1985) were applied to monsoon data from June to September for rainfall and weather parameters during the study period from 1991 to 2018.

$$Arithmetic\ mean = \frac{\sum X_i}{n}$$

$$Standard\ deviation\ (\sigma) = \sqrt{\frac{\sum(X_i - \bar{X})^2}{n-1}}$$

$$Coefficient\ of\ variation\ (CV) = \frac{\sigma}{\bar{X}} \times 100$$

RESULTS and DISCUSSION

Behaviour of monthly rainfall was studied for individual months by subjecting them to the Mann-Kendall test (Table 1). The mean annual rainfall in Jalgaon district showed a long term insignificant declining trend. However the declining significant trend was noticed in pre-monsoon rainfall only. Non-significant increasing trend of rainfall was observed during February, July, August and September months. The Mann-Kendall test indicated that seasonal rainfall during the pre-monsoon was showing decreasing trend which was significant at 5 per cent level of significance. The results of Mann-Kendall test showed the non-significant decreasing trend during the period of monsoon, post-monsoon and winter seasons. The decrease in rainfall during the crop season is not beneficial to pearl millet crop. However high variability of rainfall leads to uncertainty and the crops need assured irrigation.

It is interesting to note that rainfall in February, July, August and September months showed an insignificant increasing trend while rainfall during January, March to June and October to December months showed insignificant decreasing trend. The month-wise picture showed that the rainfall in eight months as well as annual rainfall had declined in Jalgaon district while rainfall in June, July and August months had not declined but remained stagnant. However slight increase in rainfall was noticed in February month. The results of variability in monsoon period for rainfall and weather parameters of Jalgaon district are presented in Table 2.

The mean maximum and minimum temperature of monsoon season in the district was 33.4 and 23.8°C respectively. The coefficient of variation for minimum temperature (5.0%) was higher than the maximum temperature (2.4%) during this season. Kaur et al (2006) analysed the annual and seasonal variabilities in maximum and minimum temperature and rainfall from historical daily meteorological data for Ludhiana (1970-2004). The wind velocity in Jalgaon district was 6.6 kmph with coefficient of variation of 43.9 per cent. The bright sunshine hours were 7.7 with a variability of 58.4 per cent. The average evaporation was 5.6 mm with 25 per cent variation.

The annual average rainfall in Jalgaon district was 676.3 mm with 30.4 per cent variability and 205.3 mm standard deviation. The annual average

Table 1. Mann-Kendall rank statistics of monthly and seasonal rainfall in Jalgaon district (1991 to 2018)

Month	Kendall score (S)	Denominator (D)	Mann-Kendall *Tau* statistics	Var (S)	P value
January	-15	301.82	-0.048	1971.67	0.75
February	46	252	0.182	1465.33	0.23
March	-15	265.87	-0.056	1611	0.73
April	-32	290.98	-0.109	1864	0.47
May	-60	302.45	-0.198	1972.67	0.18
June	-60	378	-0.159	2562	0.24
July	10	378	0.026	2562	0.86
August	16	378	0.042	2562	0.77
September	18	376.99	0.048	2560	0.74
October	-20	366.83	-0.054	2516.67	0.70
November	-30	302.45	-0.041	1972.67	0.51
December	-8	196.36	-0.054	936.67	0.82
Annual	-30	378	-0.099	2562	0.57
Pre-monsoon (March-May)	-98	359.55	-0.272[*]	2470	0.04
Monsoon (June-September)	-30	378	-0.079	2562	0.57
Post-monsoon (October-November)	-38	375.99	-0.101	2557.33	0.46
Winter (December-February)	-36	336.75	-0.107	2293.33	0.46

Table 2. Variability in rainfall and weather parameters of Jalgaon district (1991-2018)

Component	AM	SD	CV (%)
Maximum temperature (ºC)	33.4	0.8	2.4
Minimum temperature (ºC)	23.8	1.2	5.0
Relative humidity- morning (%)	80.9	5.0	6.2
Relative humidity- evening (%)	60.8	6.2	10.2
Wind velocity (kmph)	6.6	2.9	43.9
Evaporation (mm)	5.6	1.4	25.0
Bright sunshine (h)	7.7	4.5	58.4
Rainfall (mm)	676.3	205.3	30.4
Number of rainy days	40.0	9.0	22.5

number of rainy days was 40 with a standard deviation of 9 days during the period of last 28 years. Thus among the weather parameters, high variability was observed in case of bright sunshine hours and wind velocity.

CONCLUSION

The mean annual rainfall in Jalgaon district showed a long term insignificant declining trend during the study period of last 28 years except pre-monsoon season. The average rainfall was 676.3 mm with rainfall variability 30.4 per cent during the study period.

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