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Research Article

VARIABILITY AND TREND ANALYSIS OF RAINFALL FOR CROP PLANNING AND MANAGEMENT

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Abstract- The rainfall data of 37 year (1981-2017) of Sardarkrushinagar has been analyzed to find out fluctuations and presence of trend with historical time series. The results revealed that the annual rainfall significantly increased at the rate of 13.9 mm/year. The long term annual mean of rainfall was 704.1 ± 420.1mm with coefficient of variation of 59.7%. Decadal variability showed that the rainfall was found in decreasing trend during the decade of 1991-2000 while upward trend found during the decades of 1981-1990 and 2001-2010. The quantum of total rainfall in monsoon season was found to be increased significantly at the rate of 14.2mm/year. The contribution of winter, pre monsoon, monsoon and post monsoon rainfall to the annual mean was 0.5%, 1.2%, 94.6% and 3.7% respectively. Similarly, the quantum of monthly rainfall was found to be increased significantly in July at the rate of 10.4mm/year. July month contributes highest rainfall (43.2%) followed by August (30.9%) to the S-W monsoon rainfall. The contribution of June and September month was 9.0 and 16.7% respectively.

Key words- Rainfall, Variability, Trend analysis and Crop planning.

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Introduction

Indian agriculture is a gambling with S-W monsoon and majority of food production contributed from rainfed agriculture. Agricultural production is controlled by monsoon rainfall particularly, which is the primary natural source for soil moisture to the plants. In Agricultural Planning, rainfall variability analysis aids to take farm decisions on times of sowing, inter culture operations, fertilizers application etc. The agricultural crop production is largely depending on the rainfall distribution and its intensity during the rainy season. Rainfall could be practically useful in making decisions, risk management and optimum usage of water resources (Chattopadhyay and Chattopadhyay) [3]. Rainfall during south west monsoon is a major factor influencing the agricultural production stability in our country. Rainfall variability, both in time and space influences the agricultural productivity and sustainability of a region (Virmani) [11]. The amount, distribution and intensity of rainfall have a considerable influence on crop production as well as determined the choice of crops, varieties and agronomic practices. The information on rainfall distribution and probability is essential to avoid water stress and subsequently raising of crop successfully. The time series analysis has become a major tool in hydro-meteorological applications to study trends and variations of rainfall [1]. Rainfall may also be in excess or deficit from the optimum and thereby cause reduction in yield which may appear paradoxical to semi-arid climate. Climate change is very likely to have a major impact on hydrological cycle, available water resources, flood and drought frequencies and natural ecosystem. Rainfall variability analysis for crop planning and management in India was carried out by many workers as reported by Sharma *et.al.* [9], Ghedkar and Thakare [4], Chaudhry and Tomar [3], Tupe *et al.,* [10], Halikatti *et al*., [5] and Ravindrababu *et al*., [8]. The information of rainfall distribution and pattern particularly in rainfed region helps to crop planning, management and land preparation. Therefore, the aim of present study is to find out the possible trends and variability pattern in rainfall with historical time series in view of crop planning and management.

Materials and Methods

The rainfall data recorded at Agromet observatory of S.D. Agricultural University, Sardarkrushinagar for 37 years (1981-2017) was analyzed for detection of variability and existing trend. The station is situated at the latitude of 24.19° N, longitude of 72.19° E and an altitude of 154.5 meter above mean sea level. The climate of the location is semi-arid to arid type falls under IV-Agro climatic Zone of Gujarat. The weather condition is quite favourable for normal growth and development of the crops. Generally, monsoons are warm and moderately humid; winters are fairly cold and dry, while summers are largely hot and dry with gusty wind. The soil of the region is deep sandy loam to loam belonging to Inceptisols, Entisols and Aridsols order. The principal major crops of the region are pearl millet, pulses, cotton, castor, tobacco, wheat, sorghum, groundnut, oil seeds, species and condiments, vegetables and horticultural crops. The daily rainfall data of 37 years was converted into annually, seasonally and monthly means then variability and trend analysis were done accordingly. The season was decided as per the IMD classification i.e. monsoon season (June –September), post monsoon season (October-November), winter season (December- February) and summer season (March-April). The non-parametric Mann-Kendall statistical test was employed in the present study to find out fluctuation and presence of trend in time series of rainfall data of this place.

The Mann-Kendall (M-K) statistical test is computed as

$$S = \sum_{k=1}^{n-1} \sum_{j=k+1}^{n} \operatorname{sgn}(x_j - x_k)$$

Where, n is the number of data values in the data series and x_j and x_k are the

annual values in years *j* and *k* respectively, and

$$\text{sgn}(x_j - x_k) = \begin{cases} 1 & \text{if } x_j - x_k > 0 \\ 0 & \text{if } x_j - x_k = 0 \\ -1 & \text{if } x_j - x_k < 0 \end{cases}$$

If n is 9 or less, the absolute value of S is computed directly to the theoretical distribution of S derived by Mann and Kendall (Gilbert. 1987).

If n is 10 or more, the normal distribution test is used. The test statistic Z is computed by using formula with the help of variance of S.

$$Z = \begin{cases} \frac{S-1}{\sqrt{VAR(S)}} & \text{if } S > 0 \\ 0 & \text{if } S = 0 \\ \frac{S+1}{\sqrt{VAR(S)}} & \text{if } S < 0 \end{cases}$$

The statistically significant of the trend is evaluated on the basis of Z value.

Results and Discussion

The rainfall at Sardarkrushinagar for 37 years (1981-2017) has been analyzed to known its variability and presence of trend with historical time series. The results reflected that the annual mean of rainfall was found to be 704.1 ± 420.1mm with a coefficient of variation of 59.7%. The quantum of annual rainfall was found to be increased significantly at the rate of 13.9mm/year [Fig-1]. However, the frequency of occurrence of annual rainfall below normal was found in 60% years in the period of 37 years. The highest rainfall (2083.6mm) was received during the year 2017 while, the lowest (68.4mm) during 1987. It has been observed from the analysis that the year to year variability in quantum of annual rainfall was more pronounced at this location. Kolli *et.al.,* [6] also reported that the monsoon rainfall does not follow any definite trend at all India scale. From the evident of the decadal study of rainfall, the annual rainfall showed that an alternate increasing and decreasing trends in all the three decades *viz*., 1981-1990, 1991-2000 and 2001-2010. The amount of rainfall was found to be decreased during the decade of 1991-2000 at the rate of 66.6mm/year while, it was increased during the decades of 1981-1990 and 2001-2010 at the rate of 10.7 and 48.8mm/year respectively [Fig-2]. A similar study was carried out by Kumar *et.al.,* [7].

The trend analysis of season wise rainfall revealed that the quantum of total rainfall showed upward trend in post monsoon and monsoon season while, downward trend was observed in pre-monsoon and winter season [Fig-5]. The rate of increment of rainfall was negligible in post monsoon season. Since, the rainfall in monsoon was found to be increased significantly at the rate of 14.2mm/year over its normal value 665.9mm. In this context, it may be reported that the rainfall would be helpful for crop planning and management for *kharif* season crops with appropriate utilization of farm resources. Under heavy rainfall events, excess rainwater would be harvested in well framed water harvesting structures like ponds and recharging open wells that could be used during dry spells or critical stages of the crops to minimize the loss. Short and medium duration *kharif* crops like pulses, pearmillet, sorghum, maize, sesame, groundnut and vegetables could be successfully raised with suitable farm mangement practices. So far as seasonal pattern of rainfall is concerned, the monsoon season contributes 665.9mm (94.6%), post monsoon 26.2mm (3.7%), pre-monsoon season 8.7mm (1.2%) and winter season 3.3mm (0.5%) to the annual mean [Fig-3]. The results of monthly distribution of rainfall showed that, the rainfall was found to be increased significantly in July month [Fig-6]. The highest rate of increment was observed in July i.e. 10.4mm/year followed by September (2.6mm/year). The contribution of July month to the S-W monsoon rainfall was highest i.e. 287.9mm (43.2%) followed by August 206.1mm (30.9%). However, June and September month contributes 60.4mm (9.0%) and 111.5mm (16.7%) respectively [Fig-4].

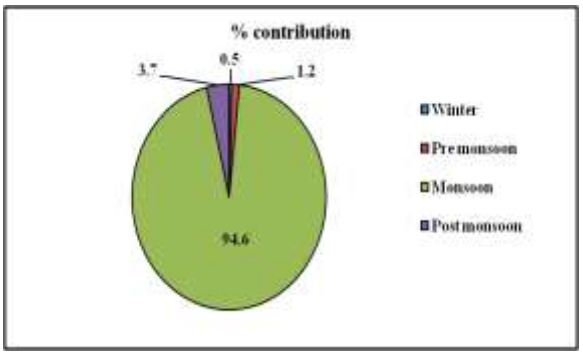


Fig-3 Seasonal partitioning of rainfall (%) at Sardarkrushinagar

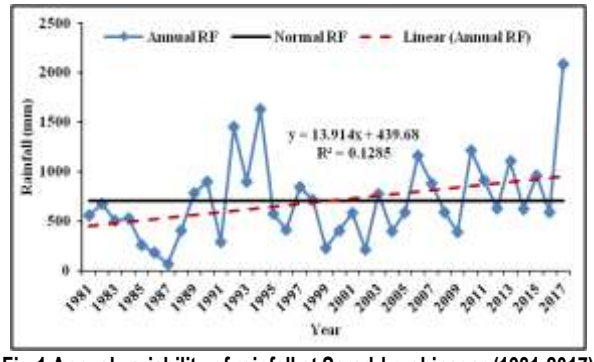


Fig-1 Annual variability of rainfall at Saradrkrushinagar (1981-2017)

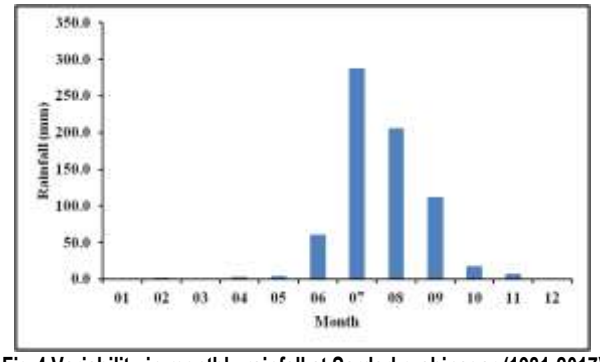


Fig-4 Variability in monthly rainfall at Sardarkrushinagar (1981-2017)

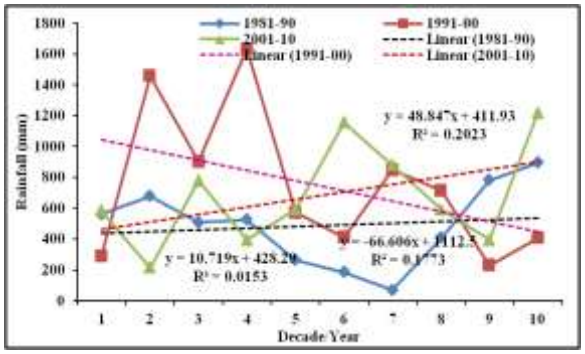
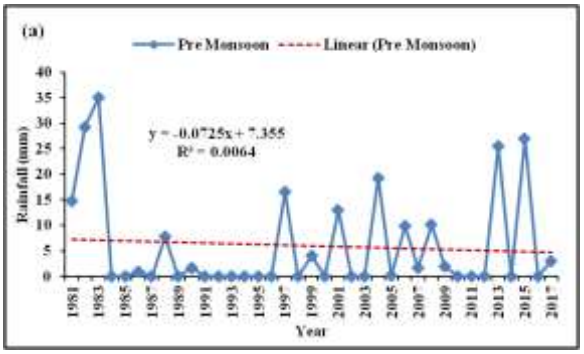


Fig-2 Decadal variability of rainfall at Sardarkrushinagar



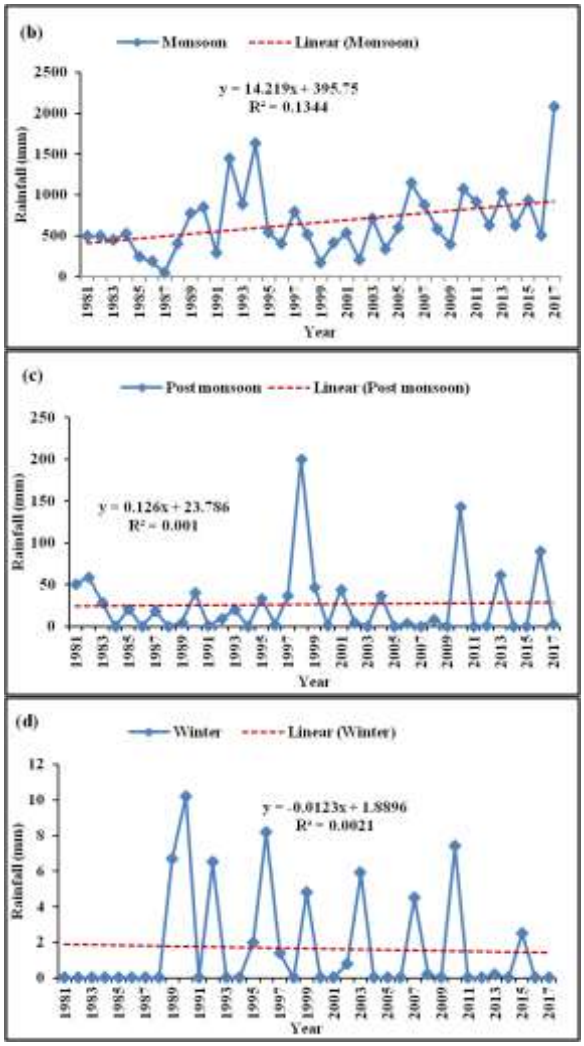
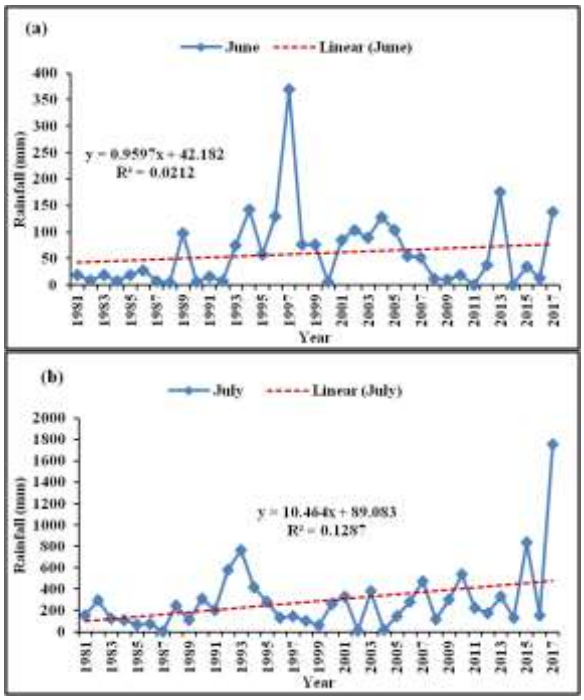


Fig-5(a-d) Seasonal rainfall variability at Sardarkrushinagar (a) Pre monsoon (b) Monsoon (c) Post monsoon and (d) Winter rainfall (mm)



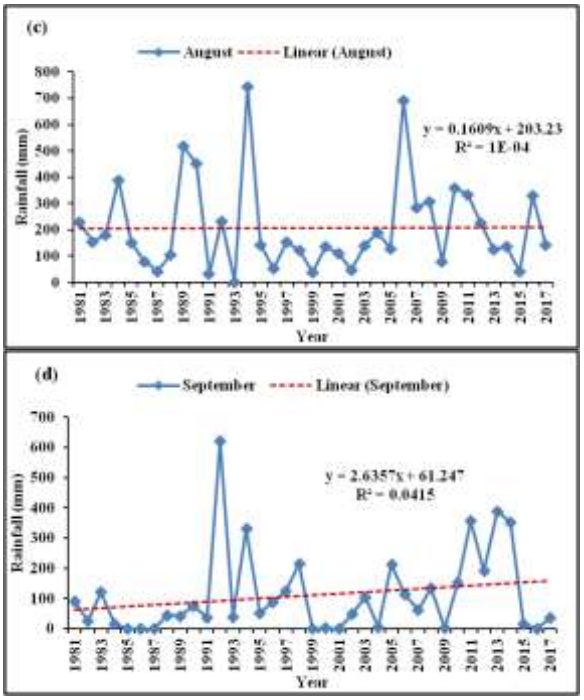


Fig-6(a-d) Monthly rainfall variability at Sardarkrushinagar (a) June (b) July (c) August and (d) September rainfall (mm)

Conclusion

From the long term analysis of rainfall at Sardarkrushinagar (1981-2017), it may be concluded that the annual rainfall had increased significantly at the rate of 13.9 mm/year over its normal value 704.1mm. Decadal variability showed that the alternate increasing and decreasing trend was existed in all the three decades *viz*., 1981-1990, 1991-2000 and 2001-2010. On seasonal basis, the quantum of total rainfall was found in increasing trend in post monsoon and monsoon season. Whereas, decreased in pre-monsoon and winter season. Most of the rainfall in this region received in monsoon season which contributes 94.6% to the annual mean.

Application of research: The present research may be applicable for agricultural planning particularly in Kharif season based on rainfall characteristics in north Gujarat.

Research Category: Crop Planning and Management

Abbreviations:
%: Percentage
mm: Millimeter
IMD: India Meteorological Department

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Research project name or number: Nil

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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