International Journal of Advanced Research in Biological Sciences
ISSN: 2348-8069
www.ijarbs.com
(A Peer Reviewed, Referred, Indexed and Open Access Journal)
DOI: 10.22192/ijarbs Coden: IJARQG (USA) Volume 10, Issue 6 -2023

Research Article

DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.06.011

Rainfall Variability Analysis of Saurashtra Region of Gujarat

Pandya P. A.*, Parmar S. H., Prajapari G. V., Gohil G. D. and Vadalia D. D.

Centre of Excellence on Soil and Water Management, Research Training and Testing Centre, Junagadh Agriculture University, Junagadh, India

*E-mail: *papandya@jau.in*

Abstract

Understanding rainfall variability is crucial for effective water management, agricultural planning, and disaster preparedness in the region. Statistical analysis of rainfall data plays a vital role in identifying long-term climate changes, assessing the likelihood of drought or flood events, and developing predictive models. Droughts occur when prolonged periods of below-average rainfall lead to water scarcity and moisture stress. They have severe implications for agriculture, resulting in crop failures, livestock losses, and economic hardships for farmers. Conversely, sporadic floods arise when intense rainfall exceeds the region's capacity to absorb and drain water effectively. The study area for the statistical analysis includes 36 rainfall stations in the Saurashtra region. The analysis covers monthly and seasonal rainfall data from 1980 to 2019, and the aforementioned parameters are calculated to assess rainfall variation.The coefficient of variation (%CV) for monthly rainfall ranges from 65% to over 100%, highlighting significant variability. Months with higher average rainfall, like July and August, exhibit less variability compared to months with lower average rainfall, such as June and September. Coastal districts near the Arabian Sea experience high rainfall variability, making them more susceptible to extreme climatic conditions like droughts and floods. Statistical analysis of rainfall patterns provides valuable insights into the variability of rainfall in the Saurashtra region. It helps identify areas with high variability and assesses the reliability of rainfall as a consistent source for crop production. This information is crucial for water resource management, agricultural planning, and mitigating the impact of droughts and floods in the region.

Keywords: Rainfall Pattern, Rainfall Variability, Drought, Coefficient of Skewness, Coefficient of kurtosis

1. Introduction

Rain is the most important phase of hydrologic cycle. The rainfall is a prime requirement for living organism and most important requirement for agricultural production and social development in country like India (Sojitra *et al.*, 2015) The Saurashtra region of Gujarat experiences significant variability in rainfall patterns, which has a profound impact on the local environment, agriculture, and water resources. Understanding this variability is crucial for effective management of these sectors and for disaster preparedness in the region. Water is a main constraint in arid and semi- arid regions for intensive irrigation (Pandya and Rank, 2014).The region primarily relies on monsoon rainfall for agriculture, with a significant portion of cultivated land being rain-fed. The monsoon season typically occurs from June to September, bringing the majority of the annual precipitation. However, the timing, duration, and intensity of monsoon rains can vary greatly from year to year, leading to considerable variability in the overall rainfall patterns. Saurashtra is prone to drought events due to its arid and semi-arid climate. Droughts occur when there is a prolonged period of below-average rainfall, resulting in water scarcity and moisture stress. The region's annual dry seasons significantly increase the chances of drought development. Pandya and Gontia, (2023) demonstrated the methodology for developing DSDF curves to identify drought proneness in terms of drought severity and duration. The most promising drought index of the semi-arid region, i.e. SPEI, was used to construct the drought severity time series of 1–4 months duration and severities for 2–100 years return periods were estimated by testing various probability distributions. Droughts have severe implications for agriculture, as they can lead to crop failures, livestock losses, and economic hardships for farmers. In contrast to droughts, Saurashtra also experiences sporadic flood events. These events occur when intense rainfall exceeds the region's capacity to absorb and drain water effectively. The variability in rainfall can lead to sudden and unpredictable flood occurrences, causing damage to crops, infrastructure, and human settlements. Flood events pose challenges for disaster management and require appropriate preparedness measures. Vadalia *et al*. (2022) Broad bed furrow (BBF) land configuration observed lower Kc values compared to flat land configuration at all growth stages of wheat.

However, the rainfall patterns in Saurashtra are highly variable and unpredictable due to its geographical location and complex weather systems (Sodha *et al*. 2023). Rainfall is a critical element in shaping the environment and supporting life. In regions like Gujarat, where the monsoon is the principal element, understanding rainfall variability is crucial for managing agriculture and water resources. Parmar and Tiwari, (2020) revealed that remote sensing-based data exhibited comparable performance to point estimations from field studies in accurately estimating ET_0, so it’s very useful method in semi-arid region.The region experiences both droughts and floods at irregular intervals, which can have a significant impact on the local economy and livelihoods. Therefore, understanding the rainfall variability in Saurashtra is crucial for effective water management, agriculture planning, and disaster preparedness in this region (Mandloi *et al*. 1958). Pandya *et al. (*2022) developed the composite drought index using a linear combination with PCA based weights of three parameters including meteorological drought index, vegetation drought index and inverse of maximum consecutive dry days. Annual dry seasons in the tropics significantly increase the chances of development of a drought and subsequent moisture stress. Prajapati and Subbaiah (2018) conducted a study that demonstrated the effectiveness of silver black plastic mulch combined with drip irrigation scheduled at 0.8ETc (evapotranspiration) in improving various aspects of crop growth and productivity and its very suitable in drought prone area. A drought is a period of below-average precipitation of rain in a given region, resulting in prolonged shortages in its water supply. The monsoon rainfall plays a vital role in Indian agriculture as 68% of the total cultivated land in the country is under rain fed condition (Meshram *et al.* 2017). The statistical analysis of rainfall is essential to provide important information for drought related studies (Nyatuame *et al*. 2014; Mahajan and Dodamani 2015). Vadalia and Prajapati (2022) observed a considerable deviation in adjusted FAO and sensor-based Kc.

The agricultural sector in Saurashtra heavily depends on rainfall for irrigation and crop cultivation. Prajapati and Subbaiah, (2019) emphasized the overestimation of seasonal crop evapotranspiration when using adjusted FAO Kc values, highlighting the importance of verification before their blind application. The development of Kc curves for Bt. cotton was pursued due to its simplicity and minimal data requirements, enabling effective irrigation scheduling and water management. Prajapati and Subbaiah, (2015) revealed the drip irrigated silver plastic mulch enhanced the yield by 13.69%, biodegradable plastic mulch 23.94%, wheat straw mulch 28.74%, drip without mulch 52.43% and furrow irrigation at 0.8 ETc, so it is very important factor in water saving. The variability in rainfall patterns can significantly impact agricultural productivity and sustainability. Insufficient rainfall or prolonged drought periods can lead to water shortages and reduced crop yields. On the other hand, excessive rainfall or floods can result in soil erosion, waterlogging, and crop damage. The agricultural sector in Saurashtra heavily depends on rainfall for irrigation and crop cultivation. The variability in rainfall patterns can significantly impact agricultural productivity and sustainability. Insufficient rainfall or prolonged drought periods can lead to water shortages and reduced crop yields. On the other hand, excessive rainfall or floods can result in soil erosion, waterlogging, and crop damage. To better understand and manage rainfall variability, statistical analysis plays a vital role. By analyzing historical rainfall data, trends, and patterns, researchers can identify long-term climate changes, assess the likelihood of drought or flood events, and develop predictive models. Statistical analysis provides valuable information for drought-related studies, water resource planning, and agricultural decision-making. the Saurashtra region of Gujarat experiences significant rainfall variability, ranging from droughts to floods, due to its geographical location and complex weather systems. This variability poses challenges for agriculture, water resource management, and disaster preparedness. A comprehensive analysis of rainfall patterns and trends through statistical methods is crucial for effective planning and sustainable development in the region.

2. Materials and Methods

2.1 Study Area

The present study was carried out in the Saurashtra region of Gujarat State (India). The region is located in the western coastal region of India, which lies between 20°30' to 23° N latitude and 69° to72° E longitude (Fig.1).The peninsula of Saurashtra forms a rocky Tableland (altitude 300-600 meters) fringed by coastal plains with a central part made up of an undulating plain broken by hills and considerably dissected by various rivers that flow in three directions. The eastern fringe of Saurashtra is a low-lying ground marking the site of the former sea connection between the Gulf of Kutch and Khambhat. An elevated strip of ground connecting the highlands of Rajkot and Girnar forms the major water divide of Saurashtra. The climate of the region is subtropical and semi-arid type. After persistent hot weather and dryness during the pre-monsoon months, the southwest monsoon rains arrive over the Indian subcontinent with amazing regularity from June to September every year (Mujumdar *et al.*, 2020).

2.2 Rainfall Variability

The study area usually monsoon commences at the start of June and gets withdrawn by the end of August. The statistical analysis of monthly rainfall (June to September) as well as seasonal rainfall (June to November) for 40 years from 1980 to 2019 using 36 rainfall stations was carried out by evaluating arithmetic mean, standard deviation, coefficient of variation, coefficient of skewness and coefficient of kurtosis to evaluate spatial and temporal variations in rainfall pattern of the region.

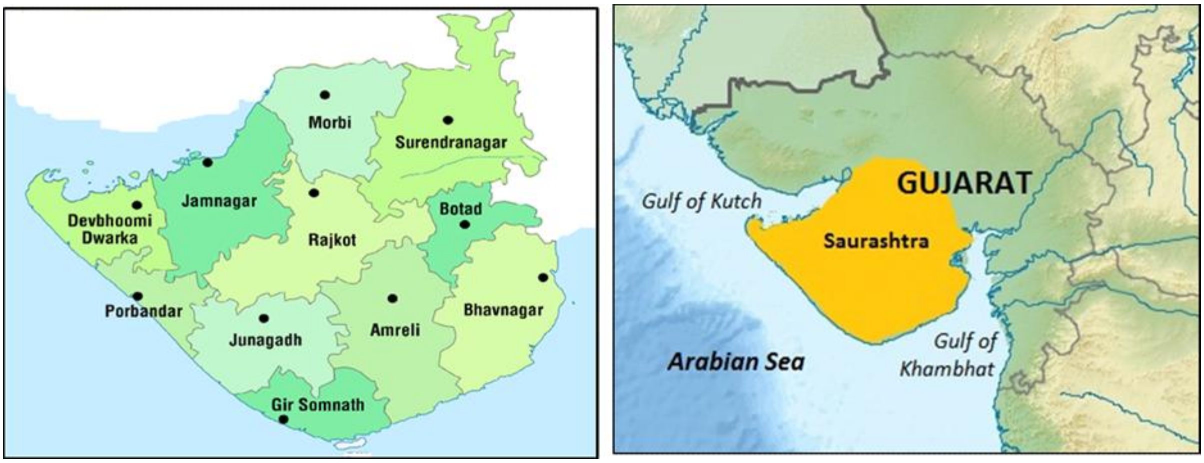

Fig. 1: Location Map of the study area (Saurashtra)

2.2.1 Arithmetic Mean:

Arithmetic mean or simply the mean of a variable is defined as the sum of the observations divided by the number of observations. It is denoted by the symbol $\bar{x}$. If the variable x assume n values X1,X2 ....Xn, then the mean is given by

$$\bar{x} = \frac{x1+x2+x3+\cdots+xn}{n} \text{.........(1)} \frac{1}{n}\sum_{i=1}^{n} x_i$$

2.2.2 Standard Deviation:

Standard Deviation is a no. used to tell how measurements for a group are spread out from the average (mean) or expected value. A low Standard Deviation means that most of the no. are very close to the average.

A high Standard Deviation means that the no. is spread out. It is defined as the positive square-root of the arithmetic mean of the Square of the deviations of the given observation from their arithmetic mean.

The formula 2.2 is used for calculating standard deviation is as follows:

$$s = \sqrt{\frac{\sum x^2 - \frac{(\sum x)^2}{n}}{n-1}} \text{..........(2)}$$

Where,

S=Standard deviation
X=Temperature, ^{0}C
n=Number of years

2.2.3 Coefficient of variation:

The Standard deviation is an absolute measure of dispersion. It is expressed in terms of units in which the original figures are collected and stated. Therefore, the standard deviation must be converted into a relative measure of dispersion for the purpose of comparison. The relative measure is known as the coefficient of variation. The coefficient of variation is obtained by dividing the standard deviation by the mean and expressed in percentage. Symbolically, Coefficient of variation,

$$\text{Coefficent of Variation} = \frac{\text{Standard Deviation X100}}{\text{Arithmatic Mean}} \text{.........(3)}$$

Where,
SD=Standard Deviation,
AM=Arithmetic Mean

To compare the variability of two or more series, we can use C.V. The series or groups of data for which the C.V. is greater indicate that the group is more variable, less stable, less uniform, less consistent or less homogeneous. If the C.V. is less, it indicates that the group is less variable or more stable or more uniform or more consistent or more homogeneous.

2.2.4 Coefficient of Skewness

The coefficient of skewness is a measure of asymmetry in the distribution. A positive skew indicates a longer tail to the right, while a negative skew indicates a longer tail to the left. A perfectly symmetric distribution, like the normal distribution, has a skew equal to zero. For small data sets this measure is unreliable.

$$\gamma_1 = \frac{1}{N\,\sigma^3}\sum_{i=1}^{N}(x_i-\mu)^3 \quad \text{.........(4)}$$

3.2.5 Coefficient of Kurtosis

Coefficient of Kurtosis is a measure of the sharpness of the data peak. Traditionally the value of this coefficient is compared to a value of 0.0, which is the coefficient of kurtosis for a normal distribution, i.e., the bell-shaped curve. A value greater than 0 indicates a peaked distribution and a value less than 0 indicates a flat distribution. Without a very large sample size, the use of this coefficient is of questionable value.

$$\gamma_2 = \left(\frac{1}{N\,\sigma^4}\sum_{i=1}^{N}(x_i-\mu)^4\right) - 3 \quad \text{.........(5)}$$

σ = Population Standard Deviation
μ = Population Mean
N = number of data values for a population
Xi = i^{th} data value

3. Results and Discussion

The statistical analysis of monthly and seasonal rainfall was carried out using data of 36 stations of Saurashtra for the period 1980 to 2019 (40 years). The temporal and spatial variation in rainfall was evaluated using statistical parameters arithmetic mean, standard deviation, coefficient of variation (%), coefficient of skewness and coefficient of kurtosis. The district wise average monthly rainfall (1980-2019) for the Saurashtra is given in Fig. 2.It can be observed from Fig. 1 that average monthly rainfall of June was ranging from 75 mm to 190 mm, July as 173 mm to 360 mm, August as 118 mm to 195 mm and September as 76 mm to 154 mm for various districts. The average seasonal rainfall for various district was between minimum 491 mm for Morbi and maximum of 908 mm for Gir Somnath district. The districts Gir Somnath, Junagadh and Jamnagar were among the districts with high average rainfall than rest of the districts. While, Morbi, Botad and Surendranagar were among the districts with low annual average rainfall. The average annual rainfall of Saurashtra was observed to be 660 mm which was also reported by Nandargi*et al.* (2019). Dave and James (2017) also reported that the average monsoon rainfall over the Saurashtra region varied between 500 mm and 950 mm during 1970-2014 considering rainfall data of 15 IMD observatories. On an average, the July month contributed highest (37%) in seasonal rainfall followed by August (24). The contribution of June and September in total seasonal rainfall was almost identical as 18% and 17% respectively.

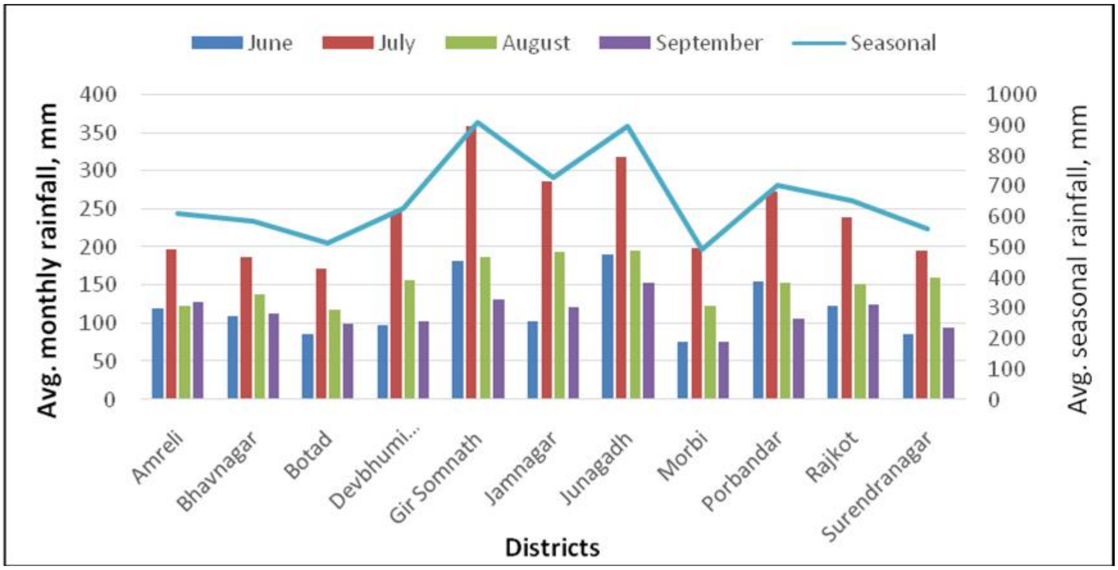

Fig.2: Average monthly rainfall for various districts of Saurashtra, mm

The district wise standard deviation and CV (%) of monthly and seasonal rainfall are given in Table 1 while coefficient of skewness and kurtosis is given in Table 3.2. It is evident from Table 1 that the variation of monthly rainfall was much higher as compared to seasonal rainfall with CV% between 96% to 167% for June, 65% to 97% for July, 73% to 124% for August, 88 to 170% for September and 41% to 75% for Seasonal. For all the months, the CV% of rainfall was more than 65% and goes as more than 100% in many instances which indicates that the temporal distribution of rainfall in Saurashtra region highly irregular and erratic.

Table 1: District wise standard deviation (mm) and CV (%) for monthly and seasonal rainfall

Sr. No.	District	June		July		August		September		Seasonal	
		SD	CV	SD	CV	SD	CV	SD	CV	SD	CV
1	Amreli	115	96	131	66	93	76	121	94	256	42
2	Bhavnagar	114	103	124	67	100	73	115	101	248	43
3	Botad	92	107	112	65	90	77	87	88	211	41
4	Devbhumi Dwarka	121	130	236	97	189	124	175	170	432	71
5	Gir Somnath	178	98	260	72	173	91	135	103	398	44
6	Jamnagar	127	125	253	87	184	95	151	131	406	57
7	Junagadh	256	135	245	77	171	88	163	106	457	51
8	Morbi	93	127	164	82	103	84	100	134	255	52
9	Porbandar	258	167	255	94	167	109	152	143	524	75
10	Rajkot	143	115	169	71	133	87	124	99	311	48
11	Surendranagar	108	127	131	67	134	82	112	119	246	44
Minimum		92	96	112	65	90	73	87	88	211	41
Maximum		258	167	260	97	189	124	175	170	524	75
Average		146	121	189	77	140	90	130	117	340	52

Among the monthly rainfall, months with relatively high average rainfall amount (July and August) showed less variability as compared to months with low average rainfall (June and September). Porbandar, Devbhumi Dwarka, Junagadh and Jamnagar were among the districts with very high variability of monthly as well as seasonal rainfall, while Amreli, Bhavnagar, Botad and Surendranagar were among the districts with comparatively better consistency in rainfall with less CV%.The four districts mentioned above with high variability are the districts near the coastal area of Arabian Sea. Nyatuame *et al.* (2014.) also reported the high rainfall variability of the coastal area in Ghana. The high rainfall variability implies higher deviation from long-term average condition hence more prone to extreme climatic condition of droughts and floods. Pandya *et al.* (2022) carried out trend and seasonalityanalysis of annual one day maximum rainfall for Saurahstra region of Gujarat. They observed that Saurashtra region is characterized by high temporal and spatial rainfall fluctuations.The standard deviation and CV% range in these districts also indicates low reliability of rainfall in terms of its persistence as constant and stable replenishing source for crop production.

Table 2: District wise average coefficient of skewness (Cs) and coefficient of kurtosis (Ck) for monthly and seasonal rainfall

Sr. No.	District	June		July		August		September		Seasonal	
		Cs	Ck	Cs	Ck	Cs	Ck	Cs	Ck	Cs	Ck
1	Amreli	1.4	2.0	0.6	0.4	1.0	1.0	1.2	1.3	0.6	0.6
2	Bhavnagar	1.6	2.8	1.3	3.4	1.1	1.0	1.4	2.3	0.6	0.5
3	Botad	1.9	4.3	0.9	1.4	1.2	1.6	1.0	0.2	0.8	1.1
4	Devbhumi Dwarka	1.8	3.6	1.3	1.4	2.3	6.7	2.4	6.1	1.3	2.6
5	Gir Somnath	1.8	4.7	1.1	1.8	1.7	4.1	1.5	2.6	0.6	0.5
6	Jamnagar	2.0	4.5	1.3	2.4	1.6	3.3	1.8	3.3	0.8	0.1
7	Junagadh	2.8	10.3	1.5	3.2	1.5	2.6	1.6	3.0	1.1	2.1
8	Morbi	2.3	6.4	1.1	1.4	0.8	0.0	1.7	2.5	0.3	-0.8
9	Porbandar	3.2	11.1	1.8	3.6	2.5	8.0	2.4	6.8	2.1	5.9
10	Rajkot	2.1	6.4	1.0	1.9	2.0	7.5	1.2	0.8	1.0	1.9
11	Surendranagar	2.4	7.0	0.8	0.8	1.1	0.8	2.0	5.0	0.3	-0.1
	Minimum	1.4	2.0	0.6	0.4	0.8	0.0	1.0	0.2	0.3	-0.8
	Maximum	3.2	11.1	1.8	3.6	2.5	8.0	2.4	6.8	2.1	5.9
	Average	2.1	5.7	1.2	2.0	1.5	3.3	1.6	3.1	0.9	1.3

To the lack of symmetry of the rainfall data, i.e. how much the data deviate from normal distribution can be tested by computing the skewness and kurtosis were computed. Table 2 presents district wise coefficient of skewness (Cs) and kurtosis (Ck) for monthly and seasonal rainfall. The skewness is a measure of symmetry or, more precisely. The skewness for a normal distribution is zero, and any symmetric data should have skewness near zero. Negative values for the skewness indicate that data are skewed to the left and positive values for the skewness indicate that data are skewed to the right. The coefficient of skewness for all the stations was found positive for all the monthly and seasonal rainfall. In a positively skewed data, the mean exceeds the mode and median.

For monthly rainfall, all districts in June and September showed Cs>1, while for July and August, 7 and 9 districts respectively showed Cs>1. A skewness value greater than 1 or less than -1 indicates a highly skewed distribution.

These results conveysa higher probability of failure of rainfall which is riskier situation regarding monthly rainfall. The maximum coefficient of skewness was found for June followed by September, which reveals that rainfall of these two months has more deviation from normal distribution as compared to July and August. For seasonal rainfall the coefficient of skewness ranged from 0.3 to 2.1 for various districts of Saurashtra. Porbandar district was observed with the highest skewness for all the monthly as well as seasonal rainfall. Apart from this, Cs of Devbhumi Dwarka and Junagadh was higher as compared to rest of the districts for some monthly as well seasonal rainfall, while Amreli, Botad, Bhavnagar and Morbi showed comparatively low Cs. A skewness value greater than 1 or less than -1 indicates a highly skewed distribution. A value between 0.5 and 1 or -0.5 and -1 is moderately skewed. A value between -0.5 and 0.5 indicates that the distribution is fairly symmetrical.

Kurtosis is a measure of whether the distribution is too peaked, *i.e.*a very narrow distribution with most of the responses in the center (Hair *et al.*, 2017). The coefficient of kurtosis is the average of the fourth power of the standardized deviations from the mean. Since 'outlying values' are the most influential to study extreme events like droughts, a more useful way to regard kurtosis is in terms of tail length (if the tails are longer than expected it is platykurtic, if shorter it is leptokurtic). The range coefficient of kurtosis (Ck) examined from Table2 shows that for June month, all the stations except Amreli showed Ck >3, for July only three districts (Bhavnagar, Junagadh and Porbandar), for August five districts and for September four districts showed Ck >3. As far as seasonal rainfall is concerned, districts Porbandar showed Ck >3. For a normal population, the coefficient of kurtosis is expected to equal 3. A value greater than 3 indicates a leptokurtic distribution; a values less than 3 indicates a platykurtic distribution. The curves with greater peakedness than the normal curve are called “Leptokurtic”. The curves, which are more flat than the normal curve, are called “Platykurtic”. The normal curve is called “Mesokurtic”. Hence, Saurashtra region experiences leptokurtic distribution for June for almost all the districts, while platykurtic for majority of districts in case of July and seasonal rainfall. While in case of August and September leptokurtic distribution was observed for 55% and 36% of the districts respectively.

June-September monsoon rainfall is the dominant feature for the water resources in the Gujarat state (Nandargi *et al.,* 2019). The unique climatic regime prevalent in Indian Monsoon was discussed by Rathore *et al.* (2016) and the local vulnerability from the extreme events such as floods, droughts, heavy rainfall, cyclones, hail storm, thunderstorm, heat and cold waves was evaluated (Gangarde, 2022). The variability in monsoon rainfall results in disasters like droughts and floods causing high negative impact on agriculture, livestock and socio-economic condition of human life. The results on various statistical parameters also indicates low reliability of rainfall in terms of its persistence as constant and stable replenishing source for crop production. These facts necessitate to study comprehensive drought analysis of the region along with its impact on agriculture.

4. Conclusion

The region's economy heavily relies on agriculture, which is predominantly rain-fed and depends on the monsoon rainfall. However, the region experiences significant variability in rainfall patterns, including droughts and sporadic flood events, which can have severe implications for agriculture and livelihoods.Analyze rainfall variability, statistical methods are applied to historical rainfall data from 1980 to 2019 obtained from 36 rainfall stations in the Saurashtra region. Statistical parameters such as arithmetic mean, standard deviation, coefficient of variation, coefficient of skewness, and coefficient of kurtosis are calculated to evaluate spatial and temporal variations in rainfall.The results of the analysis show that the monthly and seasonal rainfall in the region exhibits high variability. The coefficient of variation (%CV) for monthly rainfall ranges from 65% to 167%, indicating irregular and erratic temporal distribution. Districts near the coastal areas of the Arabian Sea, such as Porbandar, Devbhumi Dwarka, Junagadh, and Jamnagar, exhibit higher variability in rainfall. On the other hand, districts like Amreli, Bhavnagar, Botad, and Surendranagar show relatively better consistency in rainfall with lower %CV.The coefficient of skewness and coefficient of kurtosis are used to assess the asymmetry and sharpness of the rainfall distribution, respectively. The analysis reveals the presence of skewed distributions and peakedness in certain districts, indicating deviations from the normal distribution. The statistical analysis of rainfall variability in the Saurashtra region provides insights into the spatial and temporal patterns of rainfall. The findings highlight the need for effective water management, agricultural planning, and disaster preparedness in the region to cope with the challenges posed by the variability in rainfall.

References

Dave, H and James, M E. 2017. Characteristics of intense rainfall over Gujarat State (India) based on percentile criteria. *Hydro. Sci. J.*, 62(12):2035-2048.

Gangarde, A.; Dauji S. and Londhe S. 2022. Comparison of long-term and short-term trends of annual rainfall in India: a case study, ISH *J. Hydraul. Eng*.https://doi.org/10.1080/09715010.2022.2084351.

Hair, J. F.; Hult, G. T. M.; Ringle, C. M., and Sarstedt, M. 2017. A Primer on Partial Least Squares Structural Equation Modeling (PLS-SEM). 3rd ed. *Thousand Oaks*, CA: Sage.

Mahajan, D. R. and Dodamani, B. M. 2016. Spatial and temporal drought analysis in theKrishna river basin of Maharashtra, India. *Cogent. Eng.*, 3:*1185926*.

Mandloi, K., Kamani, G. J., &Chinchorkar, S. S. (1958). A Study of Change in Rainfall Pattern in Anand (middle Gujarat) in the last 60 years (1958-2017). *Current World Environment*, *14*(1), 128.

Meshram, S. G.; Singh, V. P. and Meshram, C. 2017. Long-term trend and variability of precipitation in Chhattisgarh State, India. *Theor. Appl. Climatol.*, 129(3–4): 729–744.

Mujumdar, M.; Bhaskar, P.; Ramarao M.V.S.; Uppara, U.; Goswami, M.; Borgaonkar, H.; Chakraborty, S.; Ram, S.; Mishra, V.; Rajeevan, M. and Niyogi, D. 2020. Droughts and Floods. *In:* Krishnan, R., Sanjay, J., Gnanaseelan, C., Mujumdar, M., Kulkarni, A., Chakraborty, S. (eds). Assessment of Climate Change over the Indian Region. Springer, Singapore. pp. 117-142.

Nandargi, S.; Kumar, A.; Warwade, P. 2019. Analysis of rainfall and rainstorms over the Gujarat state, India. *J. Eng. Appl. Sci.*, 4:43-56.

Nyatuame, M.; Owusu-Gyimah, V. and Ampiaw F. 2014. Statistical analysis of rainfall trend for Volta region in Ghana. *Int. J. Atmos. Sci.*, 203245:1-11.

Nyatuame, M.; Owusu-Gyimah, V. and Ampiaw F. 2014. Statistical analysis of rainfall trend for Volta region in Ghana. *Int. J. Atmos. Sci.*, 203245:1-11.

Pandya, P. A., & Rank, H. D. (2014). Summer sesame response to irrigation methods and mulching. *Research on crops*, *15*(4), 810-815. DOI:10.5958/2348-7542.2014.01416.8.

Pandya, P., &Gontia, N. K. (2023). Development of drought severity–duration–frequency curves for identifying drought proneness in semi-arid regions. *Journal of Water and Climate Change*, *14*(3), 824-842.doi: https://doi.org/10.2166/wcc.2023.438.

Pandya, P., Gontia, N., & Parmar, H. (2022). Development of PCA-based composite drought index for agricultural drought assessment using remote-sensing. Journal of Agrometeorology, 24(4), 384-392. https://doi.org/10.54386/jam.v24i4.1738.

Parmar, S. H., & Tiwari, M. K. (2020). Estimation of Reference and Crop Evapotranspiration in Panam Canal Command using Remote Sensing and GIS. *International Journal of Current*

Microbiology and Applied Sciences, *9*(8), 2141-2151.
DOI: 10.20546/ijcmas.2020.908.244.

Prajapati, G. V., &Subbaiah, R. (2015). Response of Bt cotton productivity to conjunctive stimulus of irrigation regimes and mulching. *Research on Crops*, *16*(3), 509-514. **DOI:** 10.29321/MAJ.2017.000055.

Prajapati, G. V., &Subbaiah, R. (2018). Combined response of irrigation system regimes and mulching on productivity of Bt. Cotton. *J. Agrometeorol*, *20*, 47-51.

Prajapati, G. V., &Subbaiah, R. (2019). Crop coefficients of Bt. cotton under variable moisture regimes and mulching. *Journal of Agrometeorology*, 21(2), 166-170. DOI**:** 10.54386/jam.v21i2.227.

Rathore, L.; Pattanaik, D. and Bhan, S. 2016. Weather extremes: A spatio-temporal perspectives. *Mausam*, **67**:27-52.

Sodha, K., Pati, P., Rajput, D., & Solanki, H. (2023). Review of The Study Climate Change Impact Assessment on The Gujarat Coastline: The Role of Artificial Intelligence, Statistical, Mathematical and Geographic Information Systems (GIS). *International Association of Biologicals and Computational Digest*, *2*(1), 241-244.

Sojitra M. A., Purohit R. C. and Pandya P.A., 2015. Comparative Study of Daily Rainfall Forecasting Models Using Adaptive-Neuro Fuzzy Inference System (ANFIS) Current World Environment Vol. 10(2), 529-536.

Vadalia, D. D. and Prajapati G. V. (2022). Determination of crop coefficients for wheat *(Triticum aestivum L.*) under different land configuration and irrigation systems. *The Pharma Innovation Journal.* 11(1), 1245-1249
https://www.thepharmajournal.com/archives/2022/ vol11issue1/PartQ/11-1-108-142.pdf

Vadalia, D. D., Prajapati G. V., Parmar, S. H., & Gohil, G. D. (2022). Determination of Growth-Stage-Specific Crop Coefficients (Kc) for Drip Irrigated Wheat (*Triticum aestivum L.*) under Different Land Configurations. *Research Biotica*. 4(2): 69-73 DOI: 10.54083/ResBio/4.2.2022/69-73.

Access this Article in Online	
	Website: www.ijarbs.com
Quick Response Code	Subject: Environemtal Sciences
DOI:10.22192/ijarbs.2023.10.06.011	

How to cite this article:
Pandya P. A., Parmar S. H., Prajapari G. V., Gohil G. D. and Vadalia D. D. (2023). Rainfall Variability Analysis of Saurashtra Region of Gujarat. Int. J. Adv. Res. Biol. Sci. 10(6): 131-140.
DOI: http://dx.doi.org/10.22192/ijarbs.2023.10.06.011