

Scour and Deposition around Causeways and Bed Bars

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Abstract

The Una is in Agro climatic zone VI (South Saurashtra) in Gujarat. The monthly, seasonal, dry and wet seasonal and annual trends for rainfall were analyzed for the period of 1974 to 2017 (44 year). A powerful indicator of the temporal distribution of rainfall is Precipitation Concentration Index (PCI) used for analysis of monthly, seasonal and annual rainfall data. Precipitation Concentration Index is a statistically derived index used in quantifying the relative distribution of the rainfall patterns. Rainfall seasonality is related to the temporal distribution of rainfall on a monthly basis. The normal precipitation near the study area in the basin is highest going up to 2034 mm in 2005 and lowest going up to 239 mm in 1987, with an inter annual variation of 11%. The normal annual rainfall in the study area is 935 mm. About 90%, 50%, 5.2% rainfall is received during the monsoon months of July, August and September respectively. The rainfall analysis over Una (1974 to 2017) implies a decreasing trend in southwest monsoon, while the post and pre monsoon rainfall have increasing trends. This study indicates that the annual rainfall over Una is concentrated roughly in one third of the year or in other words total rainfall occurred in four months and shows strongly irregular rainfall distribution.

Keyword- Climate, Precipitation Concentration Index, Seasonality Index

I. INTRODUCTION

A. General

The increase in temperature and consequently the changes in precipitation are having an impact on the ecosystems across the world and thereby on the human population. The IPCC-2007 study for the period of 1900–2005 identified that an increase in precipitation has occurred in the region of north of 30° latitude (valli et al. 2013). A study carried out in the tropical and subtropical areas has shown a decrease in rainfall from 1970s which has led to subsequent drought in the region. There are indications of changes in rainfall taking place both on the global and regional scales. Changes in the patterns of rainfall and its impact on vegetation and animal life including humans, is an important climatic problem which need to be address on priority. The trends reported by the IPCC on India's climate have been in conformity with the observations of the Indian Meteorology Department and the Indian Institute of Tropical Meteorology. In India, there has always been an erratic trend to the monsoon rainfall during the last century, although there have been some regional patterns emerging. The optimum time and space scales for rainfall are not well studied in the local domain and therefore it becomes important for one to understand the dynamics of the rainfall seasonally and annually. The IPCC-2007 suggests the there is a need for detailed analyses of the sub-regional variability in precipitation. Detailed spatial datasets having multiple decades of information are required to carry out this kind of a study (Luis et al. 2011). This paper aims to study the distribution of rainfall across various agro-climatic zones in Una city of Gir Somnath district, India. Decadal analyses of the rainfall patterns in the study area were attempted. Analysis of the Precipitation Concentration Index (PCI) and Seasonality Index trends was carried out in Una city.

II. STUDY AREA AND DATA COLLECTION

A. Study Area

Una is a city in district of Gir Somnath, Gujarat, India. Una has a population of 56456 making it the 45th biggest city in Gujarat. It lies between 20° 82'N and 71° 03'E. Una is located on the bank of Machchundri river, which originates from Gir forest and falls in Arabian Sea. Based on agro climate Gujarat has been divided in eight zones. The city is in agro climatic zone VI (south Saurashtra). Una has a dry sub humid climate throughout the year except in winter. Almost all precipitation falls during the summer monsoon season from June to September. Figure 1 shows the Study Area.

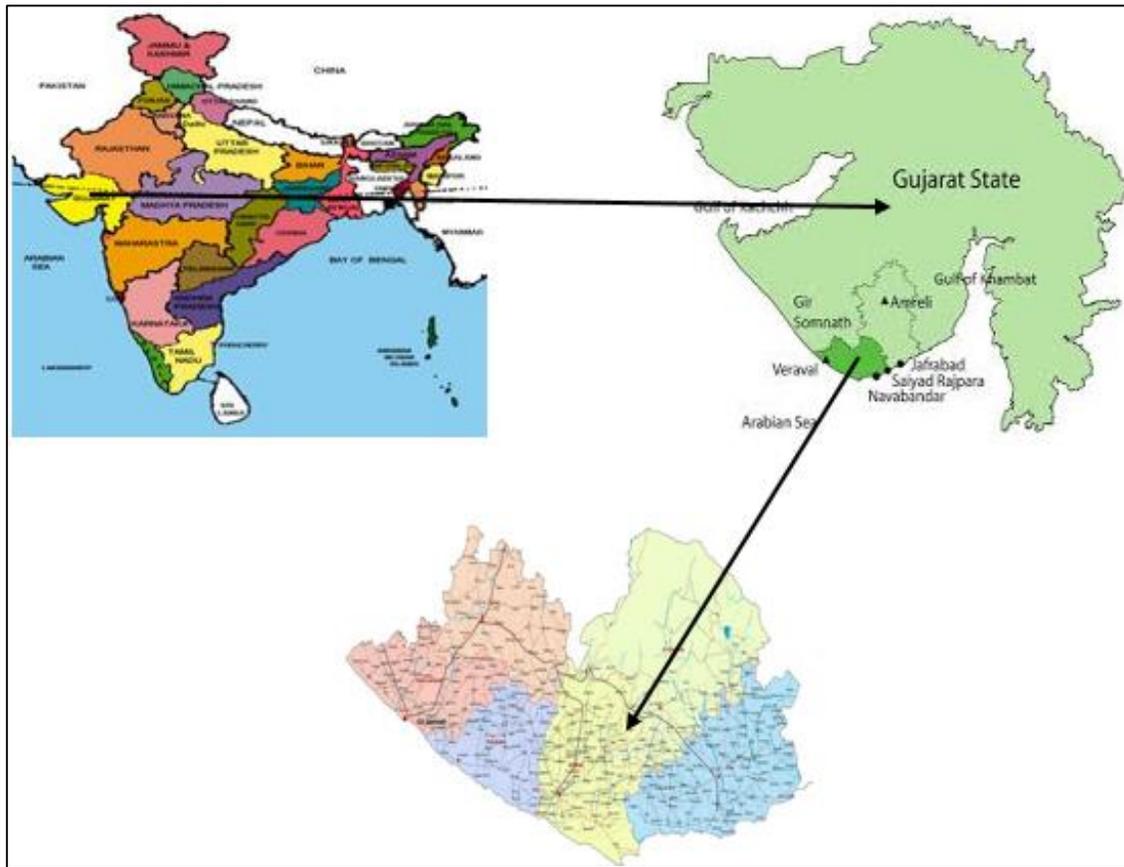


Fig. 1: Study Area

B. Data Collection

The geographic area under study is 37.4 km². IMD (Indian Meteorological Department) classified the seasons of India in four parts as: 1) Southwest Monsoon (June-September), 2) Post monsoon (October- December), 3) Winter (January- February) and 4) Pre-monsoon (March-May). But, in Gujarat monsoon is only phenomenon which contribute climate seasonality. The daily rainfall data was collected from Narmada, Water Resources, Water Supply and Kalpsar Department (WRD), Irrigation Sub division Department – UNA and SDWS, Gandhinagar for year 1974 to 2017.

III. METHODOLOGY

A. The Precipitation Concentration Index (PCI)

Precipitation Concentration Index is used in quantifying the relative distribution of the rainfall patterns and for evaluating the degree of seasonal concentration of precipitation. It is also useful for comparing different climates in terms of seasonality of precipitation regime. It provides information on water availability within an environment and this information can be used for variety of hydrological, environmental management program and agricultural planning.

Oliver (1980) suggested equations (1-4) to find out rainfall concentration for annual and seasonal scales (wet and dry seasons). In this study we examined 44-years rainfall data for Una Area. The equations are used for the purpose are written as follows.

$$PCI_{\text{annual}} = \frac{\sum_{i=1}^{12} p_i^2}{(\sum_{i=1}^{12} p_i)^2} \times 100 \quad (1)$$

$$PCI_{\text{dry}} = \frac{\sum_{i=1}^5 p_i^2}{(\sum_{i=1}^5 p_i)^2} \times 42 \quad (2)$$

$$PCI_{\text{wet}} = \frac{\sum_{i=7}^{12} p_i^2}{(\sum_{i=7}^{12} p_i)^2} \times 58 \quad (3)$$

$$PCI_{\text{seasonal}} = \frac{\sum_{i=1}^{12} p_i^2}{(\sum_{i=1}^{12} p_i)^2} \times 25 \quad (4)$$

Where, P_i is monthly precipitation of i^{th} month.

The eq. 4 is a combination of eq. 2 and 3, which is used for seasonal PCI. The classification of PCI values by Oliver (1998) (Thomas et al. 2016) is given in Table 1. Minimum value of PCI is 8.3 which indicate perfectly uniform distribution of rainfall, while 16.7 indicates that rainfall occurred in half of the period and 25 indicates that rainfall occurred in 1/3rd of the period.

PCI Value	Significance (Temporal Distribution)
$PCI \leq 10$	Uniform Precipitation Distribution (low precipitation concentration)
$10 < PCI \leq 15$	Moderate Precipitation Distribution
$16 < PCI \leq 20$	Irregular Precipitation Distribution
$PCI > 20$	Strong Irregularity of Precipitation Distribution

Table 1: PCI classification by Oliver (1980)

B. Rainfall Seasonality (SI)

Seasonality Index (Walsh and Lawler, 1981) aims to characterize the distribution of precipitation throughout the year and to classify the climate of an area. The higher the SI of a region, greater is the water resources variability and scarcity in time and the area is more vulnerable to desertification. The SI is defined as the sum of the absolute deviation of mean monthly rainfall from the overall monthly mean divided by the mean annual rainfall. Following equation is suggested for SI:

$$SI = \frac{1}{R} \sum_{i=1}^{12} \left| X_n - \frac{R}{12} \right|$$

Where, X_n is the mean monthly rainfall of n month and R is the mean annual rainfall. The value of SI varies from 0 (rainfall occur every month) to 1.83 (rainfall occurs in one month). The SI can be classified according to different ranges seasonality and rainfall regimes (Kanellopoulou, 2002) (Thomas et al. 2016) as given in Table 2.

SI value	Rainfall Regime
≤ 0.19	Very equable
0.2-0.39	Equable but with a definite wetter season
0.4-0.59	Rather seasonal with a short drier season
0.6-0.79	Seasonal
0.8-0.99	Markedly seasonal with a long drier season
1.00-1.19	Most rain in 3 months or less
≥ 1.20	Extreme, almost all rain in 1-2 months

Table 2: SI and characteristic of Rainfall Regime

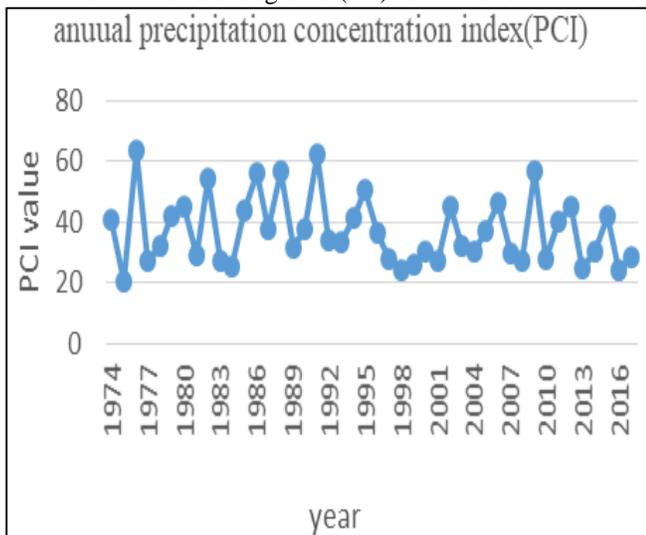
IV. RESULTS AND ANALYSIS

A. Annual Precipitation Concentration Index

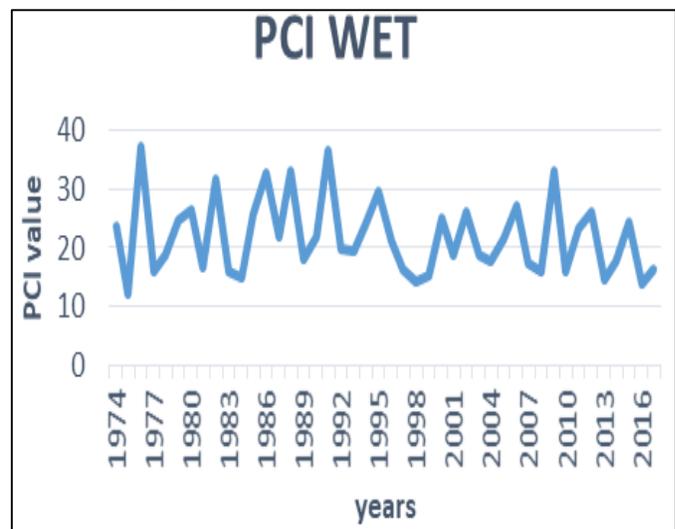
On annual scale, values of PCI on annual scale varies from 20.7537 to 60.8341. As minimum and maximum PCI values are 20.7537 (1974) and 63.8341 (1976). Average annual precipitation concentration index (PCI) 37.19301 which is more than 20, It clearly indicate that rainfall has strong irregularity of precipitation distribution and occurred in one third of the period.

B. Wet-Dry Season Precipitation Concentration Index

On seasonal scale, the mean annual PCI for the wet season was calculated and found to be 21.809 (strong irregularity of precipitation distribution). 12 % of the 44 year period had moderate precipitation concentration. 42 % of the years yielded PCI values between 16 to 20 indexing irregular precipitation distribution, and 46% of the years showed PCI value greater than 20 indicating strong irregularity of precipitation distribution. For the dry season, rainfall was strong irregular and all the rainfall was received in one month. Figure 2 (a-c) shows the PCI values for different time steps.



(a)



(b)

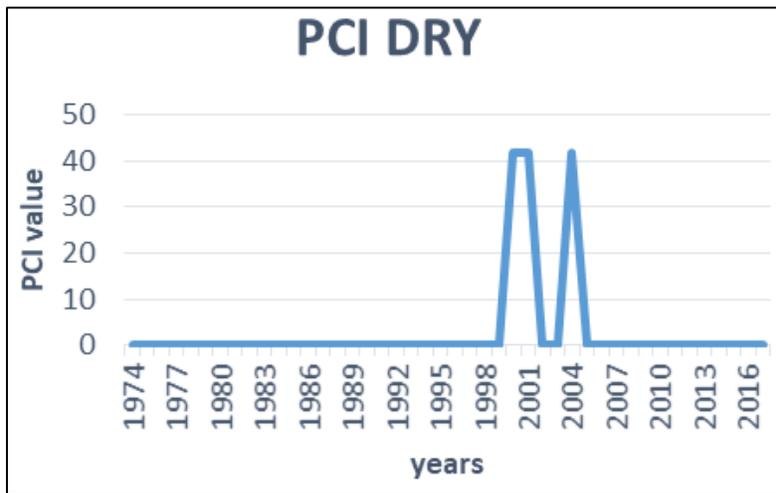


Fig. 2: PCI from 1974 to 2017 (a) annual rainfall (b) wet period (c) dry period

C. Seasonal Precipitation Concentration Index

PCI values were also calculated on seasonal scales which show the temporal patterns of rainfall over UNA. PCI of southwest monsoon shows relatively lower value of PCI ranging from 0.427407 to 15.6286 with average value of 7.9883, which shows lesser variability of southwest monsoon as compared to other seasons (Figure 3a). It means uniform precipitation distribution (low precipitation concentration) within these four months (June-September).

Ranges of PCI values of post monsoon and pre monsoon (Figure 3b and 3c) is 23.6587 to 25 which clearly indicates the larger variability or strong irregular rainfall distribution or all rainfall occurred in one month during the season.

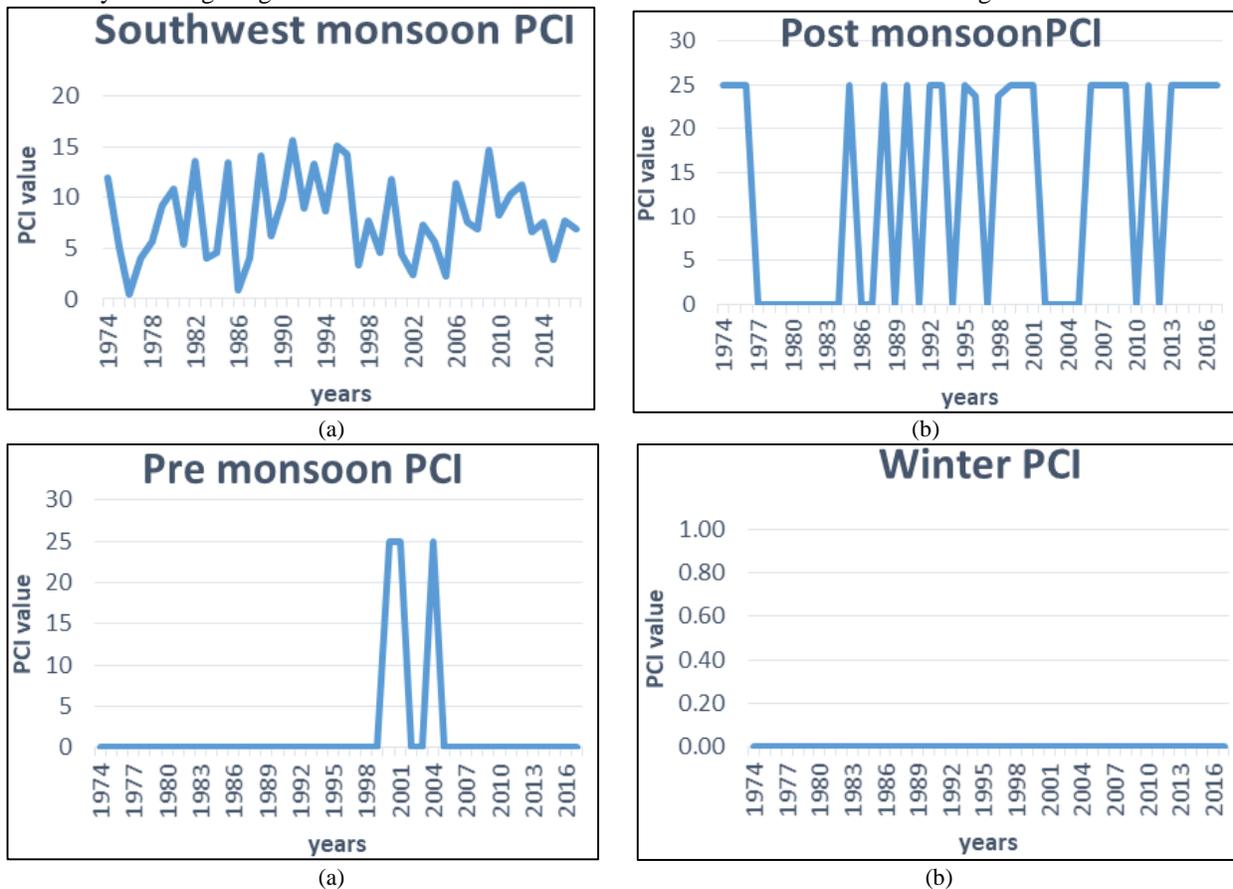


Fig. 3: PCI over Una (a) southwest monsoon rainfall (b) post-monsoon rainfall (c) pre-monsoon rainfall (b) winter rainfall

The rainfall during all wet season considers around 99% of total pre monsoon and pre monsoon rainfall. In winter PCI value is zero which indicated no rainfall occurred in the season (January and February) (Figure 3d). For southwest monsoon season all 44 years 30 years shows value less than 10 which indicate that low precipitation concentration in this season (June to September)

while remaining 14 years have more than 10 PCI value (moderate precipitation distribution). The decade of study period (i.e. 1984 to 1993) has relatively higher values of PCI; whereas in early decade (1974 to 1983) and recent decade (1994-2017) values are lower as compared to middle decade.

D. Analysis of Seasonality Index (SI)

Rainfall seasonality is related to the temporal distribution of rainfall on a monthly basis. There for rainfall distribution can also find by using seasonality index (SI). As given in Table 2, lesser value of SI indicates equal distribution of monthly rainfall and higher value of SI indicates the more irregularity of rainfall concentration in the year. In present study the SI value varies from 0.6625 to 1.06576. Figure 4 shows the Seasonality Index for 44 (1974 to 2017) year time period. Only 13 % of the 44- year period has most rainfall in 3 month and seasonal rainfall respectively. Remaining 74 % of the 44-year period has markedly seasonal rainfall with a long drier season.



Fig. 4: Seasonality index (SI) for 44 years rainfall over Una

V. CONCLUSION

In the present study the rainfall pattern of Una is determined using PCI and SI as an index of rainfall concentration and variability. The rainfall analysis over Una (1974 to 2017) showed a decreasing trend in southwest monsoon, while the post and pre monsoon rainfall have increasing trends. The annual rainfall over Una is concentrated roughly in one third of the year, i.e., total rainfall occurred in four months and showed strongly irregular rainfall distribution. SI values from 1974 to 2017 indicate higher value of seasonality during all periods, implying extreme rainfall regime which shows that most of rainfall occurs within one to two months. Trends in PCI value and value of SI suggest decline in degree of irregularity in annual and seasonal rainfall. The results could be useful for water resource planning and management, disaster preparedness, and the other relevant government agencies.

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