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Spatial and temporal variability of rainfall pattern in the Mahasamund districts of Chhattisgarh Plain Agro climatic zone

Harshana Chandrakar and Shivam Mishra

Abstract
The present paper is titled Spatial and temporal variability of rainfall pattern in the Mahasamund districts of Chhattisgarh state. The district-wise long term weather data (1981-2018) was collected from Department of Agrometeorology, IGKV, and Raipur. Rainfall pattern are generally described in two parts, with respect to time called as temporal rainfall pattern and other with respect to space and region know as spatial rainfall pattern. It is very important to know the historical changes in the mean annual rainfall and seasonal rainfall. Different indexes have been introduced like Walsh and Lawler introduced the "Rainfall Seasonality Index" which helps in evaluating the precipitation seasonality based on vector analysis which helps in understanding the seasonality pattern of precipitation. The method aims to characterize the distribution of precipitation throughout the year and to classify the climate of an area. Based on this view trend analysis, seasonality index and Precipitation Concentration Index was evaluated for Chhattisgarh plain agro climatic zone district Mahasamund. Based on those Mahasamund districts recorded significant increasing trend of rainfall at the rate of 8.9mm per year. The Seasonality Index was worked out on annual basis indicates that the districts falls in the range of 1.0-1.19 in which Mahasamund districts reported maximum value of Seasonality Index 1.25. It indicates that in these districts rainfall occur during 1 to 2 months. The outcome of Seasonality Index carried out on south-west monsoon basis indicates that the value was in the range of 0.33 to 0.39 in this districts means that the rainfall spread throughout the season. The result of Precipitation Concentration Index reported that entire districts falls under extreme seasonality category that is in the range of 28 to 31.2 it means they received rainfall within 1 to 2 months in the year.

Keywords: temporal, rainfall, Mahasamund, pattern, generally

1. Introduction
Rainfall is one of the important natural phenomena through which we receive water which sustains life in the earth. According to the one estimation the amount of world's total water is about 1.386 billion km³.The maximum contribution of water is in the form of precipitation and it is the principal source of water for all living organisms. The yearly rainfall average over the world is about 1000mm, but the distribution is unevenly across the world. The regions of highest rainfall are found in the equatorial zone and the monsoon area of Southeast Asia. Middle latitudes receive moderate amounts of precipitation, but little falls in the desert regions of the subtropics and around the poles. In the subtropics, the trade winds bring plentiful rain to the east coasts of the continents, but the west coasts tend to be dry. In high latitudes the west coasts are generally wetter than the east coasts. The equatorial belt, the trade winds from both hemispheres converge and give rise to a general upward motion of air, which becomes intense in locally the tropical storms that produces very heavy rains in the Caribean, the Indian and southwest Pacific oceans

Rainfall pattern are generally described in two parts, with respect to time called as temporal rainfall pattern and other with respect to space and region know as spatial rainfall pattern. In India the temporal rainfall pattern are divided into summer monsoon (march-may), south-west monsoon (June - September) post-monsoon (October - December), and winter season monsoon (January - February). Out of hundred percentages approximately 80% of India region shows seasonal distribution of temporal pattern and covers the entire India except at coromandal coast of Tamil Naidu and north of Himalaya region, where as in Chhattisgarh the maximum rainfall occurs during south-west monsoon period. The left over 20% are occurs during pre and post monsoon period, due to the reason of western disturbance, tropical cyclone and conventional rainfall by intense heating.

The spatial pattern of rainfall is divided into five different classes those are very heavy rainfall region or pre-humid region (more 2000mm per year), heavy rainfall or humid region (1500-2000mm per year), sub-humid or moderate rainfall (between 75-150cm per year), semi-arid region (370.5-750mm per year) and very low rainfall region (less than 370.5cm per year). The largest track of India from the foot hills of Himalayas up to the point comrin belongs to the region of sub-humid rainfall pattern and some part of heavy rainfall that covers the west of Western Ghats and coastal plain, north-east India and the island group of our country. Chhattisgarh region comes under in some part of humid region basically the upper hilly region and rest of the part comes under sub-humid region.

It is very important to know the historical changes in the mean annual rainfall and seasonal rainfall. Different indexes have been introduced to know the relative variation of rainfall throughout the particular location with respect to the time period. Walsh and Lawler introduced the “Rainfall Seasonality Index” which helps in evaluating the precipitation seasonality based on vector analysis which helps in understanding the seasonality pattern of precipitation. The method aims to characterize the distribution of precipitation throughout the year and to classify the climate of an area. For example the climate of an area can be characterized as rather seasonal with a short dry season or marked seasonal with a long dry season. The seasonality index classifies the type of climate in relation to water availability. The higher the seasonality index of a region the greater the water resources variability and scarcity in time, the more vulnerable the area to desertification. Whereas another scientist named as Oliver introduces the” Precipitation Concentration Index” with different formula on a scale that ranges from less than 10 for evenly distributed rainfall to 100 for extreme monthly rainfall distribution and this also helped to estimate the distribution of rainfall on the basis of temporal and spatial variation of annual and seasonal rainfall distribution.

2. Material and Methods

2.1 Study Area

Chhattisgarh is located in the central part of India, between the latitude of 17º 46´N - 24º 5´ N and the longitudes of 80º 15´ E - 84º 20´ E. Its proximate position with the Tropic of Cancer has a major influence on its climate. Chhattisgarh has substantial plain area in the middle. The plains are enclosed by forested hills and plateaus. The state is divided into three agro-climatic zones. The Baster plateau agroclimatic zone, Northern Hilly Region and Plains of Chhattisgarh under this Mahasamund comes.

2.2 Data

The present work carried out in Mahasamund district of Chhattisgarh. The district-wise monthly rainfall data from 1981-2000 has been collected from India Meteorological Department (hhttps://mausam.imd.gov.in) and 2000-2018 collected from weather database of Agrometeorology department of Indira Gandhi Krishi Viswavidalaya, Raipur Chhattisgarh.

2.3 Description of software used

The two software that are used in the current study are Weather cock software and Trend V1.0.2 software

2.3.1 Weather cock software

Weather cock is software developed by I Ramamohan, on AICRP of Agrometeorology CRIDA Hyderabad, India which is used for different purposes for analysing weather data for example check of data quality, data management and conversion of daily data. Weather Cock contains 26 modules which are related to agro-climatic parameter. Here in this study, it was used for conversion of daily rainfall data for different districts to convert in monthly rainfall.

2.3.2 TREND V1.0.2 software

In the present study, trend was calculated by using TREND software. This software calculates trend based on Mann-Kendall test. TREND is designed to facilitate statistical testing for trend, change and randomness in hydrological and other time series data.

In the output file of trend analysis the first column lists the statistical tests, the second column gives the test statistics for each test, the next three columns gives the critical values of the statistics for significance levels of α = 0.1 or 10%, α = 0.05 or 5%, and α = 0.01 or 1% (from standard statistical table), and the last column gives the test result (NS means not significant at α =0.1; S means statistical significant, with the significance level shown in brackets).

2.4 Seasonality Index

A seasonality index **(SI)** permits a quantification of the variability of precipitation through the year using a single figure. Such an index does not provide a month-by-month detailed look at seasonal variation, but rather it should be complemented by a detailed analysis of monthly precipitation across an area, as in the current study. A commonly used SI *is* that derived by Walsh and Lawler (1981):

$$\overline{SI} = \frac{1}{R}\sum_{n=1}^{12}\left|Xn - \frac{\bar{R}}{12}\right|$$

Where R is the total annual precipitation for the particular year under study and Xn is the actual monthly precipitation for month *n*. In this study of spatial and temporal variation in seasonality, provided that complementary information on precipitation amount is also considered Higher index values indicate a greater overall departure from an equal distribution of Precipitation through the year, with near zero values indicating that there is little or no seasonal variation in precipitation.

2.5 Precipitation Concentration Index

The P.C.I refers to Precipitation Concentration Index proposed by Oliver (1980) and developed by De Luis *et al*. (1997) was used for the calculation of the annual P.C.I. Here the P.C.I was used to estimate the heterogeneity of rainfall. Through P.C.I the data related to the long term variability in the amount of rainfall received is obtained and was calculated using the formula given below eq.

$$\frac{\sum_{i=1}^{12} Pi^2}{\sum_{i=1}^{12} Pi} * 100$$

Where pi is monthly precipitation in month i. The precipitation concentration index was also calculated on a seasonal scale for southwest monsoon (jun-sep), post monsoon (oct-dec), summer season (mar-may), and winter season (jan-feb) in Eqs. (2), (3), (4) and (5):

2.6 On seasonal scale for southwest monsoon (June-September)

$$\frac{\sum_{i=1}^{4} Pi^2}{\sum_{i=1}^{4} Pi} * 33.3$$

3. Result and Discussion

3.1 Trend analysis of annual rainfall for Mahasamund district: The outcome of trend analysis of rainfall workout for Mahasamund district is presented in table 1 and depicted in figure no. 1 Indicates that district received a maximum rainfall of 1582.1mm in the year 1985 and the lowest rainfall of 640.1mm in the year 1996, with the average annual rainfall of 1105.2 mm during the last 38 years. The district rainfall data is subjected to trend analysis and outcome indicates increasing significant trend at 5% level for annual rainfall in linear trend.

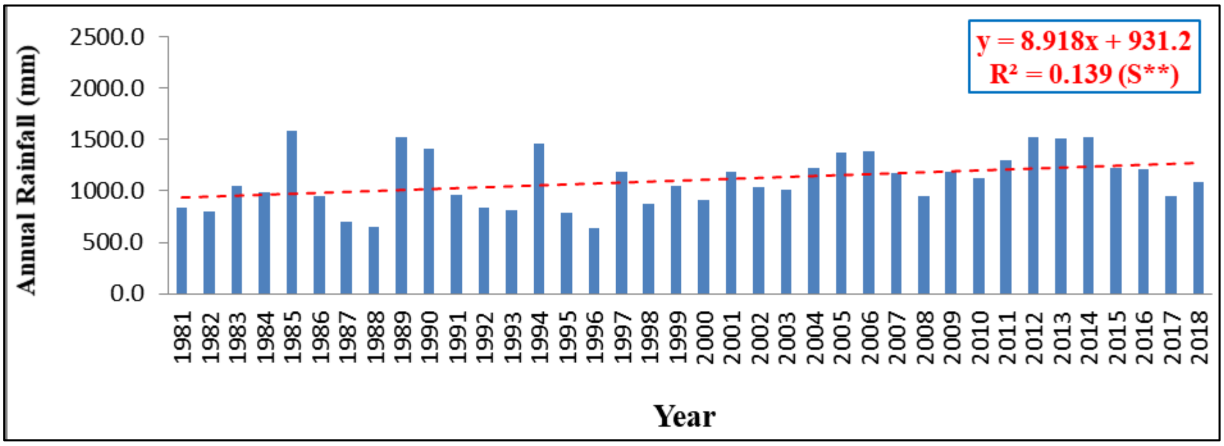

Fig 1: Trend analysis of annual rainfall for Mahasamund district

3.2 Annual Seasonality Index of Mahasamund district

The result of annual rainfall Seasonality Index of Mahasamund district was carried out with the help of last 38 year monthly rainfall data, and the values are given in the Table 1 and in figure no 2. It is quite clear from the table that the highest value is 1.5 which was observed in 2009 years which indicates that during these years the distribution of rainfall pattern is less than in 3 months while in the year 2005 realized lowest value with 0.9 which indicates that in this year the distribution of rainfall is notably seasonal with a period of long dry in the season. The average Seasonality index value of the district denotes than the Mahasamund district showed the distribution of rainfall pattern in less than 3 months.

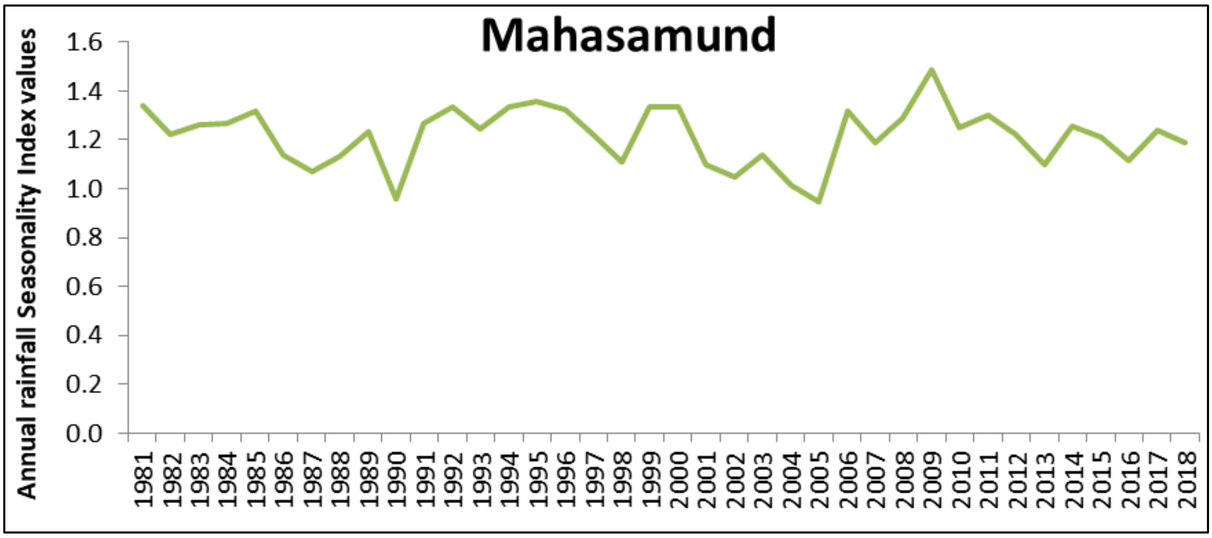

Fig 2: The Annual Rainfall Seasonality Index for Mahasamund from 1981-2018

3.3 Annual Precipitation Concentration Index of Mahasamund district

Annual Precipitation Concentration Index value with the help of long term rainfall data (1981-2018) work on Mahasamund district are given in the Table 1 and depicted in the fig 3. The values are obtained in between 18.1 and 59.5 in which the lowest value was 18.1 was observed in 1990 year. On the basis of Precipitation Concentration Index this year indicates the rainfall distribution is irregular in the Mahasamund district. The highest value was obtained in 2009 (59.5) which denoted that the rainfall distribution is strong irregular with high precipitation concentration. On average values from 1981-2018 years the value was observed is 27.6 denotes that Mahasamund district reported strong irregular rainfall distribution with high precipitation during the last 38years.

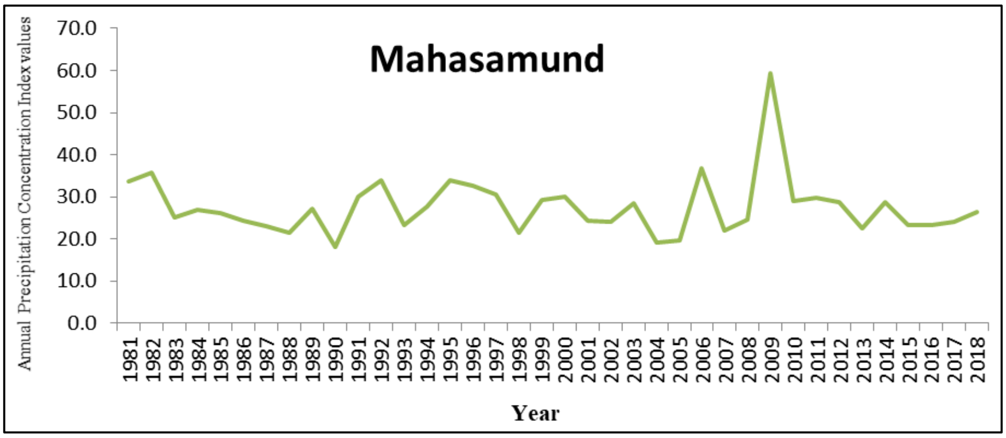

Fig 3: The annual Precipitation Concentration Index for Mahasamund from 1981-201

3.4 South-West Monsoon Precipitation Concentration Index of Mahasamund district

District-wise precipitation concentration index values are presented in the table 1 from 1981-2018. District showed irregular precipitation concentration in the past 38 years. The minimum value is observed in the years 2007 i.e. (8.42) in the range of less than 10, which denotes low concentration. The maximum value was observed in the year 2009 i.e. 20.35 which is in the range >20 that indicates a strong irregular precipitation concentration in the season.

Table 1: Annual rainfall, annual rainfall seasonality index, annual precipitation concentration index and south-west monsoon precipitation concentration index from (1981-2018) of Mahasamund districts of Chhattisgarh

District name - Mahasamund				
Year	**RF(mm)**	**SI**	**APCI**	**SWPCI**
1981	843.7	1.3	33.7	11.59
1982	795.9	1.2	35.8	15.5
1983	1054.9	1.3	25.2	9.02
1984	984.3	1.3	26.9	10.42
1985	1582.1	1.3	26	8.82
1986	950.9	1.1	24.4	10.55
1987	704.3	1.1	23.1	10.5
1988	650.4	1.1	21.4	8.72
1989	1520.6	1.2	27.3	10.01
1990	1409.8	1	18.1	8.75
1991	959	1.3	30.1	10.72
1992	837.4	1.3	34.1	11.34
1993	814	1.2	23.3	8.45
1994	1460.8	1.3	27.8	9.27
1995	785.9	1.4	34	11.33
1996	640.1	1.3	32.7	10.98
1997	1183.1	1.2	30.6	11.36
1998	872.3	1.1	21.6	9.08
1999	1048.5	1.3	29.1	9.7
2000	906.5	1.3	30	9.98
2001	1187.9	1.1	24.4	10.51
2002	1032.5	1	24	10.67
2003	1016.5	1.1	28.6	11.77
2004	1222.8	1	19.1	8.76
2005	1379	0.9	19.6	9.45
2006	1383.9	1.3	36.7	12.99
2007	1174.6	1.2	21.9	8.42
2008	944.9	1.3	24.6	8.53
2009	1190.1	1.5	59.5	20.35
2010	1130	1.2	29.1	10.56
2011	1298.6	1.3	29.9	10.27
2012	1518.3	1.2	28.8	10.7
2013	1511.2	1.1	22.6	9.36
2014	1519.8	1.3	28.8	10.35
2015	1228.3	1.2	23.2	8.71
2016	1212.6	1.1	23.4	9.64
2017	951.1	1.2	24.1	8.76
2018	1091.3	1.2	26.4	10.13
Average	1105.2	1.2	27.63	27.6

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