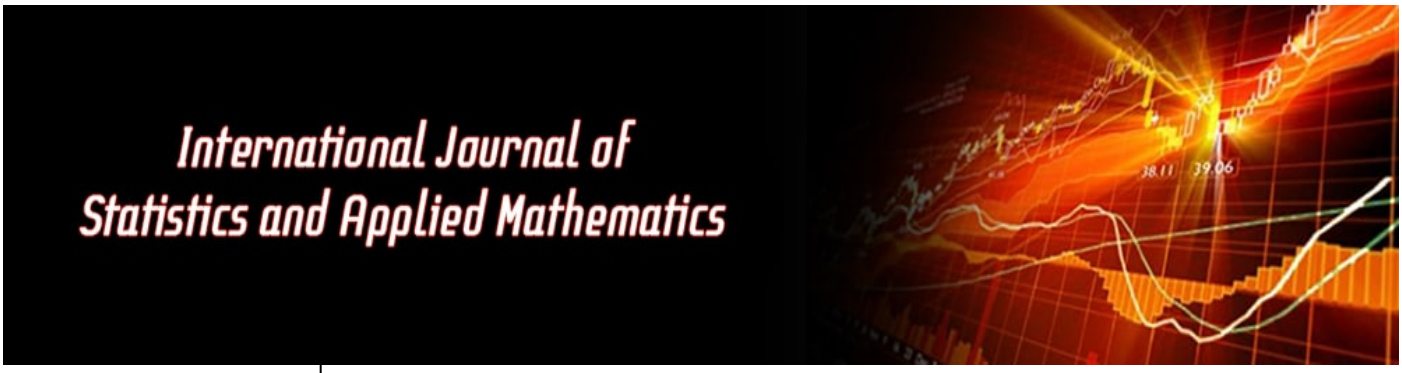
International Journal of Statistics and Applied Mathematics 2023; SP-8(6): 14-18



ISSN: 2456-1452
Maths 2023; SP-8(6): 14-18

https://www.mathsjournal.com
Received: 10-09-2023
Accepted: 17-10-2023

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An analysis of Rainfall distribution pattern in Mandya District of Karnataka

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Abstract
The historical daily rainfall data of 49 years (1973-2022) in Mandya district of Karnataka have been analyzed for establishing the long term averages of weekly, monthly, seasonal and annual rainfall and its variability. Increasing and decreasing mean annual rainfall was recorded in the results which indicated that rainfall was not uniform over the years and variability showed an increasing trend. The overall mean annual rainfall at Mandya district was 716.3 mm with distribution of 8.0 mm, 161.6 mm, 321.2 mm and 225.5 mm in Winter (Jan-Feb), Pre-monsoon (Mar-May), Monsoon (Jun-Sep) and Post monsoon (Oct-Dec) respectively. The month of October received maximum mean rainfall of 161.1mm contributing to 22.5% followed by September month 129.8mm and contribution of 18.1%. Mandya district was frequently affected by periodical drought and the study indicated that for the past 49 years, 3 years were experienced with Slight Drought (>-19 to -25% D from N) and 9 years falls under moderate drought (-26 to -49% D from N). Whereas, year 1982 and 1990 were affected due to severe drought with -49.3% and -58.4% deviation in rainfall than the normal respectively.

Keywords: Rainfall, Karnataka, Mandya, variability, drought

Introduction
Every economy which depends on the agriculture, rainfall is very crucial for the economic development for which India is one such example where in agriculture is said to be gamble with rainfall. In no area the rainfall is uniform over the years. The rainfall received in an area is an important parameter which determines the availability of required quantity of water to meet various types of demand including agricultural, industrial, domestic water supply and power generation as well [1]. Thus, rainfall has profound effect on the agriculture and related industry and power generation of the country like India. In nutshell of the economy, energy and food security of the country is largely being controlled by availability of adequate amount of water or normal rainfall. The amount of rainfall hugely varies over time and space in India. Rainfall generally occurs in monsoon season (June-September) with erratic variation during rest of the months of the year. Hence, proper attention should be given towards the variation of rainfall since it affects the food production and availability of fresh water [2]. Moreover due to changing global meteorological phenomena and climate change the onset and withdrawal of monsoon has also badly affected over the last few decades. Studies have indicated that change in the rainfall pattern has considerably affected the water and agriculture sector of Asia Pacific region [3]. Thus rainfall variation can be considered as indirect indicator of global/regional level climate change. The changed pattern of monsoon rainfall accompanied by population growth, increased urbanization frequently causes extreme events like flood, drought. Therefore, several studies have been carried out worldwide to analyze spatial and temporal variations in rainfall. Rainfall variability is a major factor influencing the agricultural productivity and sustainability in tropics [4]. Rainfall pattern and the quantity decide the cropping system in rainfed agriculture. Rainfall amount, distribution and intensity of rainfall mainly determine the choice of any particular crop and agronomic practices. Scientific study on the quantum and distribution of rainfall if made would enable the farming community to adjust or modify the cropping programme as well as the cultural operations to utilize the actual moisture available in the field for profitable crop production.

In line of the above facts, an attempt is made with the present study to address the following objectives: (a) To analyse the changes in rainfall pattern in Mandya district of Karnataka during 1973-2022 (b) The variation in the rainfall over the years in the study area. The study will help us to develop agricultural adaptation and mitigation strategies in the face of climate change as an integral part of agricultural development and food security policy.

Materials and Methods

Mandya district belongs to Southern Dry Zone (Zone-VI) of Karnataka and lies between North latitude $12^0$13' to $13^0$04'and East longitude From $76^0$19' to $77^0$20' and with an altitude of 706m. Daily rainfall data for the past 49 years (1973-2022) were collected from Indian Meteorological Department (IMD), Bangalore Meteorological Centre for analysis. The data was aggregated to weekly, monthly, seasonal and annual totals. The Mean Rainfall, Standard Deviation and Coefficient of Variation for annual, seasonal, monthly and weekly period were also worked out. The annual rainfall received was classified based on IMD specification as Normal (particular year that received +19 per cent of mean annual rainfall), Excess (year that received more than 19 per cent of mean annual rainfall) and deficit (year that received less than 19 per cent of the mean annual rainfall).

IMD Classification

- E = Excess RF (>19%)
- N = Normal RF (=-19%)
- SLD = Slight Drought (>-19 to -25%)
- MD = Moderate Drought (-26 to -49%)
- SD = Severe Drought (-50% & above)

Results and Discussion

Annual Rainfall

The mean annual rainfall of Mandya district was 716.3 mm spread with coefficient of variation of 33.8%. The highest rainfall was 1561 mm received during 2022 followed by 1192.9 mm in 2005 and 1188.1 mm in 2017 and the lowest rainfall was 298.0 mm received in 1990 followed by 362.8 mm in 1982 and 382.1 in 1976. The normal range i.e. between ± 19 of mean annual rainfall was 616.1 to 844.0 mm. Out of 49 years, twelve years *viz.*, 1987, 1991, 1996, 1997, 2000, 2004, 2005, 2010, 2017, 2020, 2021 and 2022 received excess of rainfall (>19%). Whereas nine years *viz.*, 1976, 1984, 1985, 2002, 2006, 2007, 2012, 2015 and 2016 received less than -26 to -49% rainfall than the normal range and these seven years were declared as moderate drought years. In general, the annual precipitation receipt in this region was not normal and varied significantly and the annual rainfall from 1973 to 2022 ranges from 298.0 mm to 1561 mm (Table.1) An increasing trend of annual rainfall was observed over the period of 1973-2022 (Fig. 1).

The rainfall of 49 years (Table 2) ranged from 1973mm to 2022 mm with a mean of 716.3 mm. The standard deviation (SD) was moderately high (242.0) with a coefficient of variation (CV) of 33.8 per cent, indicating moderately high variability and dependability on rainfall. The decadal analysis indicated that, the mean annual rainfall varied consistently with decade to decade. During the period 1973-1982 mean annual rainfall was 633.5 mm with lower SD 160 and CV 25.3(%). During 1983-1992 this region experienced moderate drought (mean annual rainfall of 619.0mm) with SD 178.4 and CV 28.8%. During better rainfall years, 2013-2022 mean rainfall was 843.24mm with higher SD 349.0 and CV 41.4%.

Monthly rainfall: Rainfall quantum and distribution during different months have been indicated in Fig 2. October month received maximum mean rainfall of 161.1mm which contributed 22.5% followed by September month 129.8mm contributed 18.1%.(Fig 2) It is also observed that there was higher dependability of rainfall from the months of June to September (CV 44.2%) (Table 3)

Seasonal rainfall: South west (SW) monsoon season (June - September) contributed 44.8 per cent of mean annual rainfall. The mean rainfall during this period was 321.2 mm. Total amount of rainfall received during north east (NE) monsoon (October – December) was 31.5 per cent of the mean annual rainfall. The mean rainfall during this period was 225.5 mm. Pre-monsoon season (March - May) contributed 22.6 per cent (161.6 mm) of the mean annual rainfall. The winter rainfall contributed 1.1 per cent (8 mm) to the mean annual rainfall. (Table 3) and (Fig 3)

Annual rainfall: The overall mean annual rainfall for the past 49 years (1973-2022) was 716.3 mm with a standard deviation (SD) of 242 mm and coefficient of variation (CV) 33.8 per cent. The maximum annual rainfall of 1561 mm and the lowest rainfall of 298 mm were recorded. The coefficient of variability (C.V.) indicates the dependability or reliability on rainfall for any period. (Table 3) Lower values of C.V. indicate better reliability (5).

Weekly rainfall

The weekly rainfall analysis was done for mean, standard deviation and coefficient of variation and the relevant data is presented in Table 4. Each standard week from 16th to 46th received rainfall more than 15 mm in between many of the weeks rainfall was not equally distributed and many a times there was a break in monsoon and received less than 20 mm of rainfall especially in the months of June and July.

Table 1: Year wise mean rainfall and% rainfall departure from normal at Mandya District of Karnataka

Year	Mean	% RF departure from Normal	Classification	Year	Mean	% RF departure from Normal	Classification
1973	650.1	-9.2	N	1998	623.1	-13.0	N
1974	685.2	-4.3	N	1999	844.0	17.8	N
1975	758.9	5.9	N	2000	1143.5	59.6	E
1976	382.1	-46.7	MD	2001	807.5	12.7	N
1977	804.8	12.4	N	2002	503.9	-29.7	MD
1978	826.8	15.4	N	2003	748.5	4.5	N
1979	648.2	-9.5	N	2004	929.5	29.8	E
1980	548.9	-23.4	SLD	2005	1192.9	66.5	E
1981	667.4	-6.8	N	2006	466.6	-34.9	MD
1982	362.8	-49.3	SD	2007	517.4	-27.8	MD
1983	616.1	-14.0	N	2008	536.2	-25.1	SLD
1984	480.8	-32.9	MD	2009	621.9	-13.2	N

1985	501.0	-30.1	MD	2010	863.4	20.5	E
1986	702.0	-2.0	N	2011	759.2	6.0	N
1987	856.4	19.6	E	2012	423.5	-40.9	MD
1988	555.3	-22.5	SLD	2013	668.7	-6.6	N
1989	646.7	-9.7	N	2014	633.3	-11.6	N
1990	298.0	-58.4	SD	2015	481.8	-32.7	MD
1991	906.0	26.5	E	2016	378.3	-47.2	MD
1992	628.0	-12.3	N	2017	1188.1	65.9	E
1993	642.8	-10.3	N	2018	793.3	10.8	N
1994	645.0	-10.0	N	2019	787.0	9.9	N
1995	650.0	-9.3	N	2020	931.8	30.1	E
1996	942.2	31.5	E	2021	1009.1	40.9	E
1997	995.3	39.0	E	2022	1561.0	117.9	E

Mean =716.3mm, IMD Classification, E =Excess RF (>19%), N = Normal RF (+-19%), SLD=Slight Drought (>-19 to -25%), MD= Moderate Drought (-26 to -49%) and SD= Severe Drought (-50% & above).

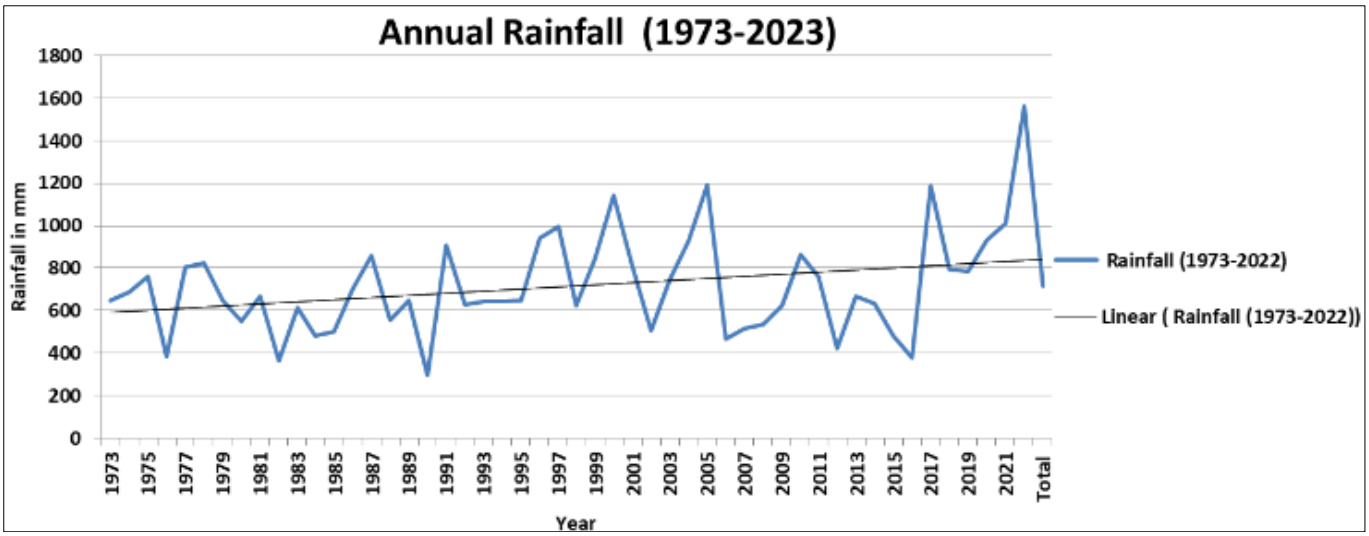

Fig 1: Rainfall trend over the period of 49 years (1973-2022)

Table 2: Annual Rainfall (mm) Variability between 1973 to 2022(49 Years) at Mandya

Decades	1973-1982	1983-1992	1993-2002	2003-2012	2013-2022
Mean	633.5	619.0	779.7	705.9	843.24
SD	160.0	178.4	201.2	241.5	349.0
CV%	25.3	28.8	25.8	34.2	41.4

Table 3: Mean seasonal and annual rainfall of Mandya District of Karnataka

Month	Mean	SD	CV (%)	% of Total
January	2.1	7.2	341.3	0.3
February	5.9	18.0	304.5	0.8
March	14.9	31.7	212.8	2.1
April	50.2	41.2	82.2	7.0
May	96.5	66.5	68.9	13.5
June	58.8	52.5	89.3	8.2
July	51.1	36.2	70.8	7.1
August	81.5	86.3	105.8	11.4
September	129.8	72.2	55.6	18.1
October	161.1	96.8	60.1	22.5
November	49.9	45.0	90.1	7.0
December	15.5	21.5	138.8	2.2
Total	716.3	242.0	33.8	100.0
Winter	8.0	19.5	243.5	1.1
Pre-monsoon	161.6	72.5	44.9	22.6
Monsoon	321.2	142.1	44.2	44.8
Post- monsoon	225.5	115.9	51.4	31.5
Total	716.3	350	384	100

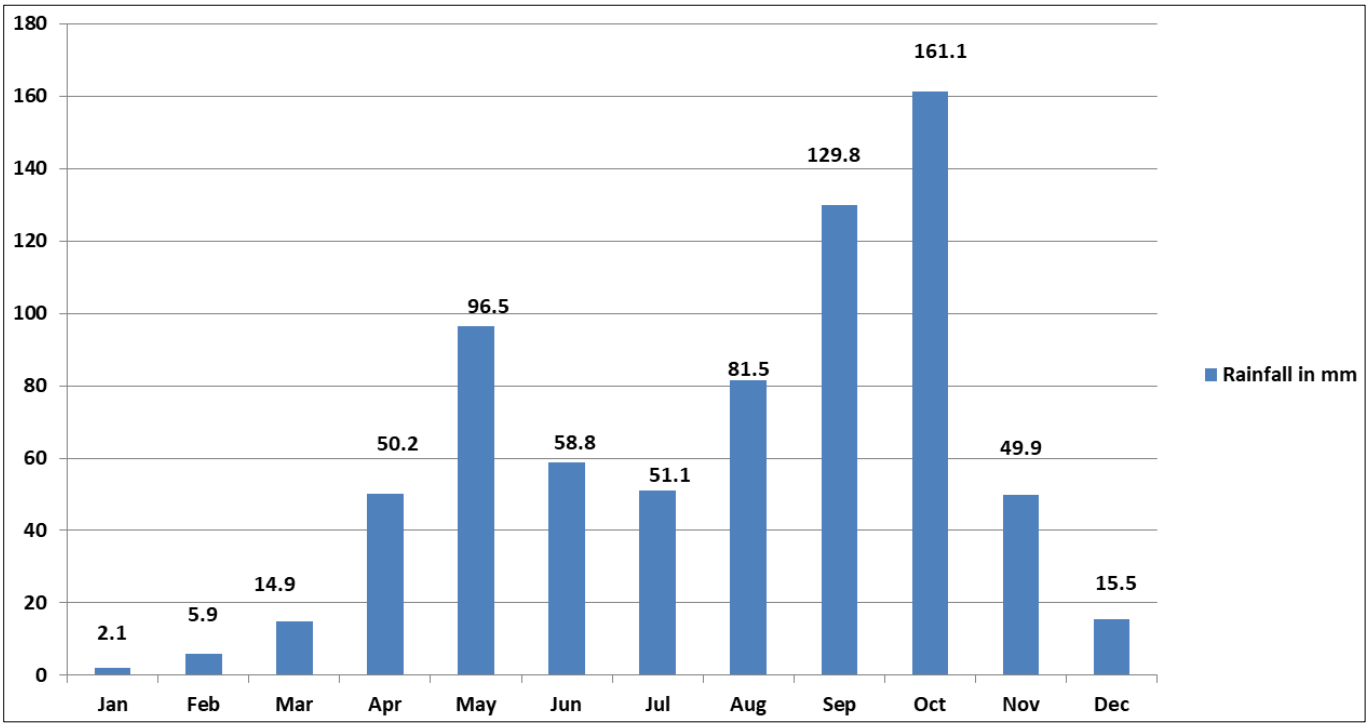

Fig 2: Monthwise rainfall (mm) over the period of 49 years (1973-2022)

Table 4: Weekly rainfall analysis (1973-2022) at Mandya District of Karnataka

SMW	Date & Month	Mean RF(mm)	SD	CV%	% of Total Annual Rainfall
1	01-07 Jan	0.5	2.3	485.2	0.1
2	08-14 Jan	0.1	0.6	469.0	0.0
3	15-21 Jan	0.3	1.8	577.1	0.0
4	22-28 Jan	1.0	6.6	638.6	0.1
5	29 Jan- 04 Feb	0.0	0.1	707.1	0.0
6	05 -11 Feb	0.6	3.6	574.9	0.1
7	12 -18 Feb	0.8	3.5	437.2	0.1
8	19 -25 Feb	2.6	12.1	465.3	0.4
9	26 Feb- 04 Mar	1.3	5.4	433.7	0.2
10	05-11 Mar	4.9	20.6	422.8	0.7
11	12-18 Mar	2.7	8.4	310.1	0.4
12	19-25 Mar	5.2	17.7	342.6	0.7
13	26 Mar- 01 April	3.1	8.2	263.5	0.4
14	02-08 Apr	6.4	11.0	170.9	0.9
15	09-15Apr	8.5	14.9	174.5	1.2
16	16-22 Apr	12.3	20.1	163.3	1.7
17	23-29 Apr	13.7	17.8	129.5	1.9
18	30 Apr- 06 May	17.0	21.0	123.4	2.4
19	07-13 May	20.6	23.9	116.5	2.9
20	14-20 May	24.5	32.0	130.7	3.4
21	21-27 May	24.0	32.4	135.0	3.4
22	28 May-03 Jun	25.0	27.4	109.6	3.5
23	04 -10 Jun	22.4	32.4	144.4	3.1
24	11-17 Jun	18.6	31.8	171.2	2.6
25	18-24 Jun	7.2	10.5	144.4	1.0
26	25 Jun-01 Jul	7.3	12.1	166.0	1.0
27	02-08 Jul	6.4	10.0	156.5	0.9
28	09-15 Jul	15.5	24.8	159.9	2.2
29	16-22 Jul	9.3	10.6	113.7	1.3
30	23-29 Jul	13.8	16.5	120.0	1.9
31	30 Jul-05 Aug	15.8	36.6	232.4	2.2
32	06-12 Aug	14.7	29.8	203.2	2.0
33	13-19 Aug	17.9	33.3	186.2	2.5
34	20-26 Aug	17.0	29.2	171.9	2.4
35	27 Aug- 02 Sep	21.6	30.3	140.5	3.0
36	03-09 Sep	20.1	29.2	145.4	2.8
37	10-16 Sep	26.3	37.8	143.8	3.7
38	17-23 Sep	33.8	44.3	131.0	4.7
39	24-30 Sep	40.7	44.5	109.2	5.7

40	01-07 Oct	36.5	38.7	106.1	5.1
41	08-14 Oct	36.9	41.4	112.2	5.2
42	15-21 Oct	40.8	46.9	115.1	5.7
43	22-28 Oct	32.8	37.4	114.0	4.6
44	29 Oct -04 Nov	30.3	38.9	128.3	4.2
45	05-11 Nov	16.3	21.8	133.5	2.3
46	12-18 Nov	8.9	11.9	134.8	1.2
47	19-25 Nov	7.8	21.7	278.6	1.1
48	26 Nov-02 Dec	8.9	21.0	236.6	1.2
49	03 -09 Dec	3.7	8.6	233.5	0.5
50	10 -16 Dec	5.5	13.5	245.6	0.8
51	17 -23 Dec	1.4	6.3	438.6	0.2
52	24 -31 Dec	3.2	10.5	322.4	0.5

Conclusion

From the above data available, it was concluded that Mandya district received mean annual rainfall of 716.3 mm with less coefficient of variation (33.8). October month received maximum mean rainfall of 161.1mm contributed 22.5% followed by September month 129.8mm contributed 18.1, Whereas, year 1982 and 1990 were affected due to Severe drought with -49.3% and -58.4% deviation in rainfall than normal respectively. The highest rainfall was 1561 mm received during 2022 and the lowest was 298.0 mm received in 1990. In general, the annual precipitation receipt in this region was not normal and varied significantly and the normal rainfall from 1973 to 2022 ranges from 298.0 mm to 1561 mm. An increasing trend of annual rainfall was observed over the period of 1973-2022.

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