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Analysis of Rainfall Pattern -A study in Agro-climatic Zones in Dry region in Karnataka state

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ABSTRACT

The rainfall pattern showing dry and wet years are computed for each agro- climatic zone in the dry region in Karnataka state based on annual scales from 1979 to 2019. The occurrence of drought was recorded under the categories of extreme, severe and medium drought at different agro-climatic zones level. Visual interpretation of RAI of all zones reveals same pattern but the magnitude varied over the time. An extreme drought of more than -3 and -2 magnitude was recorded in all zones. Extreme drought condition was experienced during the year 2018 in the North eastern dry zone, 2003 in the northern dry zone, 1995 in the central dry zone, 2002 in the eastern dry zone and 2003 in the southern dry zone. Further, the study revealed that, at least 3 to 5 drought events under the extreme drought category. The occurrence of at least 4 to 6 drought events under the severe drought category was observed across all five zones in dry region in the state. Assessment of dry years help in studying the exposure component of vulnerability in the area to drought and necessary adaptative strategies to be followed by farmers in the zone.

Keywords: *Dry agro-climatic zones, Karnataka, Rainfall Anomaly index, Drought severity*

INTRODUCTION

The emission of green house gases disturbs the established energy balance of the atmosphere which result in rising temperature and increased erraticity of climatic parameters. The global annual mean surface temperature has increased by more than 1.5°C above the pre -industrial level [1]. This increase in temperature has caused unprecedented changes across the human and natural systems. In the process of gradual warming, the mean temperature shifted upward which amounts to climate change. In India, the last five decades experienced an increase in the frequency and magnitude of extreme rain events over central India, western India, north-eastern India, and southern India whereas, an increase in the frequency of severe droughts have been observed over south India, central Maharashtra, the Indo-Gangetic plains, north and northwest India [2]. The vulnerability of a system is determined by concepts of exposure, sensitivity and adaptive capacity towards climate change. Semi-arid regions of peninsular India are vulnerable to drought and water stress due to the uneven distribution of monsoon rainfall. The delay in monsoon or dry spells adds pressure on available water resources. Even in such situations farmers in semi-arid India continue to grow water intensive crops. Karnataka ranks second among drought affected states after Rajasthan with frequent occurrence of droughts once in five years. The impact of climate shock creates unequal access to resources, food insecurity and incidence of poverty in the country. The risk associated with climate change calls for a broad spectrum of policy responses and strategies at the local, regional, national and global level to mitigate the effect of the same. Karnataka has a Dry zone, Transition zone and Hilly zone which further divided into 10 agro climatic zones. The dry zone has five agro climatic zones which covers a large area in the state namely North Eastern Dry Zone, Northern Dry Zone, Central Dry Zone, Eastern Dry Zone and Southern Dry Zone. The rainfall dispersion has more effect on crop productivity especially the crops which required more irrigation. The analysis of rainfall pattern will help the policy makers and researchers to develop new varieties which withhold the drought severity. Therefore, the study attempted to examine the magnitude of drought in dry agro climatic zone of Karnataka.

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2. Methodology

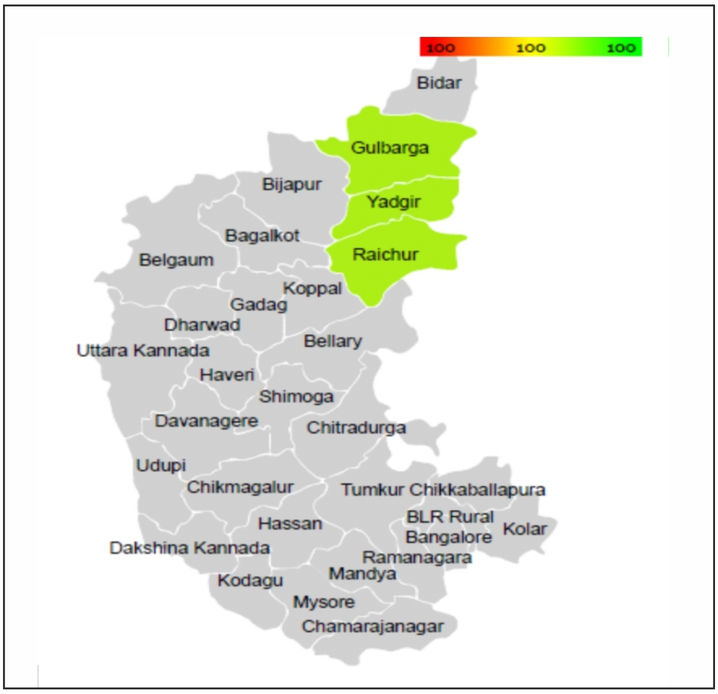
Karnataka is located between 11° 40' N and 18° 27' N latitudes and between 74° 5' E and 78° 33' E longitudes, at the center of the western Peninsular India covering an area of 19.1 million hectares, accounting for 5.8 % of the country's total geographical area .The northern dry zone has 5.04 Million ha which is large in area and also receives an average rainfall of 500 to 625 mm among other zones as shown in Table 1.

Table 1: Physiographic of Agro climatic zones in Dry region in Karnataka

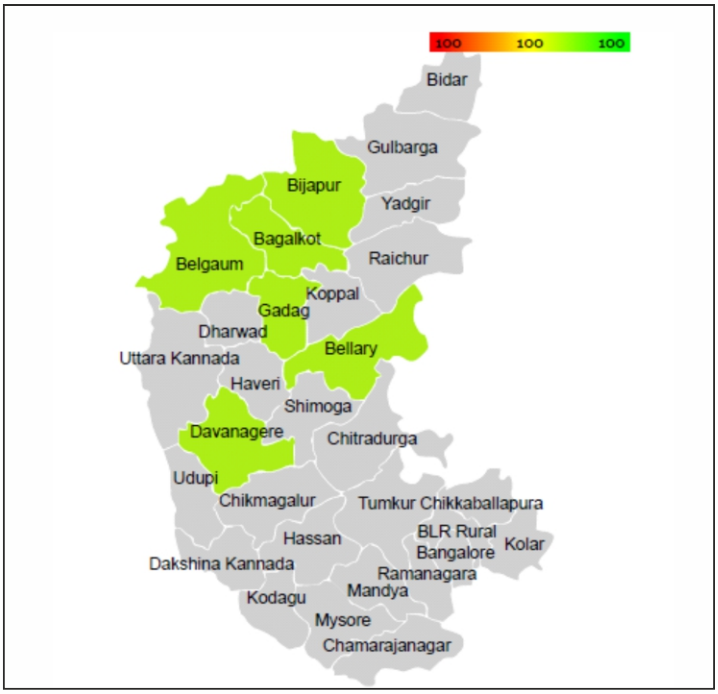
Agro Climatic Zones	Area (M ha)	Annual Rainfall(mm)	Districts	Agromet Field Unit Location
North Eastern Dry Zone	1.76	633 to 780	Gulbarga,Yadgiri,Raichur	Raichur
Northern Dry Zone	5.04	500 to 625	Koppal,Bagalkot,Bijapur,Davangere, Bellary,Belagum,Gadag	Bijapur
Central Dry Zone	1.98	400 to 620	Chitradurga,Davangere,Tumkur	Hiriyur
Eastern Dry Zone	1.80	750 to 810	Bengulur,Tumkur,Ramanagar,Kolar, Chikballapur	Benguluru
Southern Dry Zone	1.56	650 to 760	Mysore,Mandya,Chamrajanagar,Hassan	Naganahalli

Source: Department of Mines and Geology, Government of Karnataka Annual Report 2013

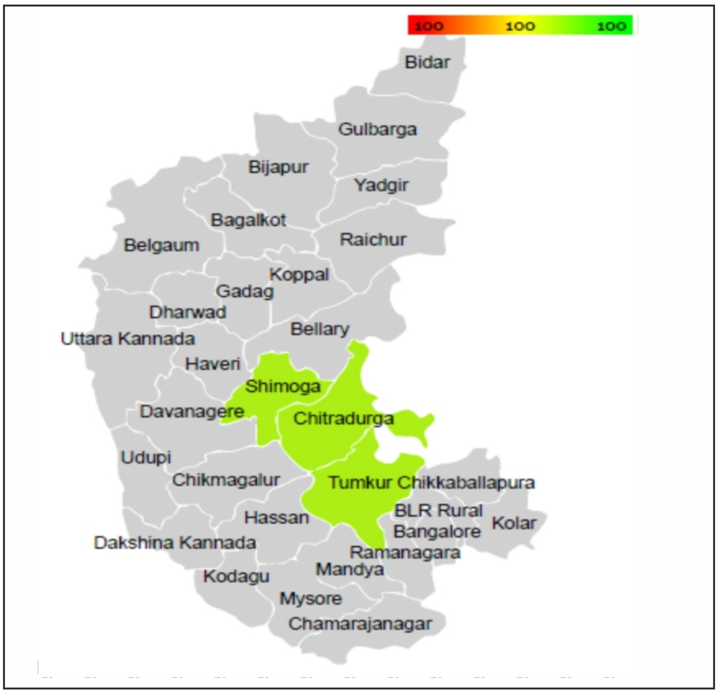
The lowest rainfall was received by CDZ with 400 to 620 mm. The highest rainfall was received by EDZ with 750 to 810 mm. Rainfall measure is used in drought index calculations as it is the most vital hydrological variable generally the only meteorological measurement made in semi arid areas[3]. Climatic variables like daily rainfall, temperature from 1979 to 2019 across Karnataka state was collected from AICRPAM CRIDA, Hyderabad.



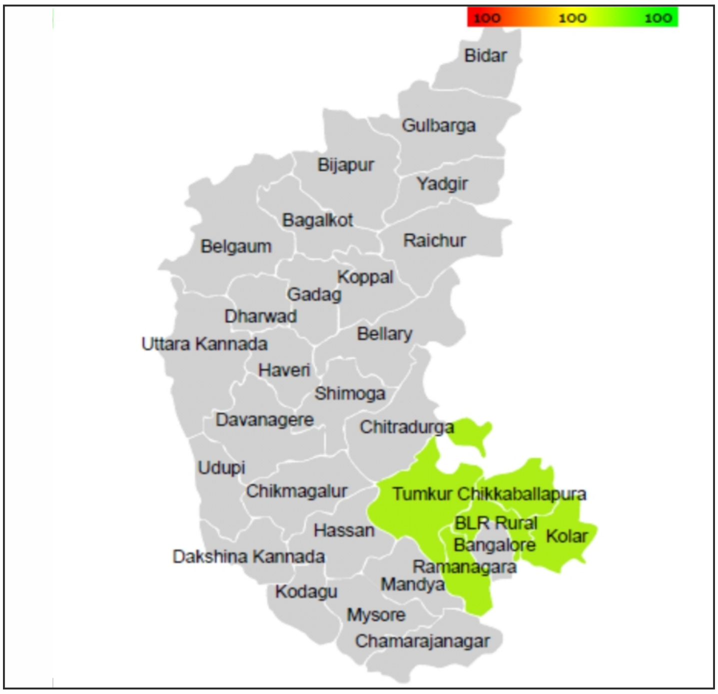
North Eastern Dry Zone



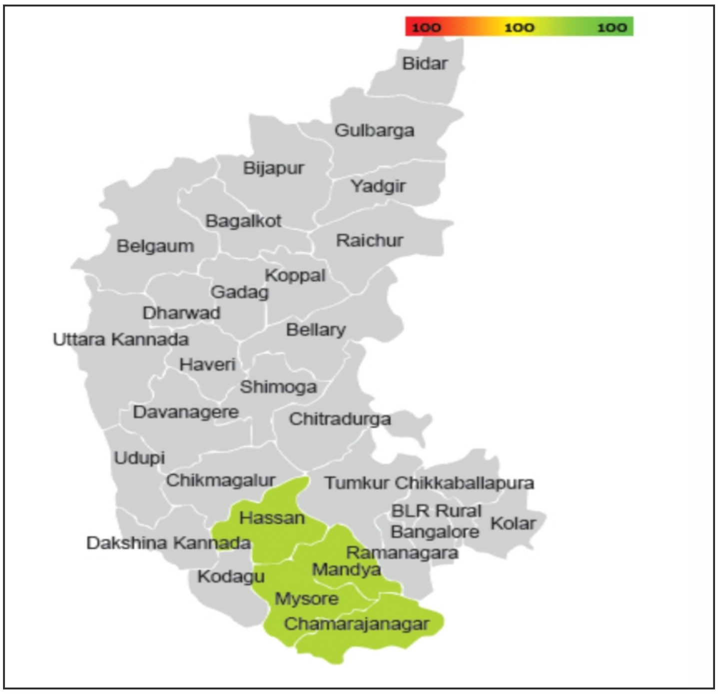
Northern Dry Zone



Central Dry Zone



Eastern Dry Zone



Southern Dry Zone

Map 1: Different Agro-Climatic Zones of Dry Region in Karnataka State

i) Rainfall Anomaly Index (RAI)

In this study, RAI is modified to account for non-normality like Standard precipitation Index (SPI) is used for the assessment of both temporal and spatial droughts as it is independent of time and space. Hence it is more useful in semi-arid regions particularly like India, as at many meteorological stations the recorded rainfall data available is less than 30 years, while most of the metrological drought assessment indices require more than 30 years of data [4]. RAI is used to assess and identify droughts, drought severity and variability by comparing with some established arbitrary value. It is described as rainfall variability over a time and is estimated as below:

For positive anomalities

$$RAI = 3\left(\frac{RNF - RNF_m}{X - RNF_m}\right) \ldots\ldots\ldots\ldots (1)$$

For negative anomalities

$$RAI = -3\left(\frac{RNF - RNF_m}{Y - RNF_m}\right) \ldots\ldots\ldots\ldots (2)$$

Where, RNF = Actual rainfall for a given year (mm)
RNFm =Mean rainfall of the total length of record (mm)
X= Mean of the ten highest values of rainfall (mm)
Y= Mean of the ten lowest values of rainfall (mm)

Table 2: Classification of Rainfall Anomaly Index

S. No	RAI Range	Drought Classification	Percent deficit from mean rainfall
1	>3	Extreme wet	
2	2.1 to 3	Severe wet	
3	1.2 to 2.1	Medium wet	
4	0.3 to 1.2	Weak wet	
5	+0.3 to -0.3	Normal	
6	-0.3 to -1.2	Weak drought	0 to 10
7	-1.2 to -2.1	Medium drought	10 to 15
8	-2.1 to -3	Severe drought	15 to 20
9	< -3	Extreme drought	>20

(Source: Keyantash and Dracup, 2002)

A ranking of nine classes of rainfall abnormality ranging from extremely wet to extremely dry and range of each class[5] is shown in Table 2 . If the purpose of the study is to investigate dry periods the negative prefixed RAI is used, while positive RAI is used to study wet periods[6].

ii) Percentage of Deficit rainfall (DR) or Rainfall Surplus (RS)

The percentage annual rainfall departure from the long term mean annual rainfall was used for drought assessment [7] for all the stations. Percent of deviation for each year was further categorized into four percentage ranges namely 0 to 10, 10 to 15, 15 to 20 and greater than 20.

Percentage of Deviation= $(P_{act}-P)/P*100$
P_{act} –Precipitation of the region
P-Mean precipitation of the region

* AR –Annual Rainfall; MD-Mean deviation ;RAI-Rainfall Anomaly Index; DR- Deficit Rainfall; SR-surplus Rainfall

3. RESULTS AND DISCUSSION

3.1 Analysis of Dry and Wet years in North Eastern Dry Zone

In North Eastern Dry Zone, the dry years occurred for 21 years. Extreme drought occurred in 2018 and 2015 (RAI < -3). The severe drought condition occurred for eight years i.e. 2019, 2003, 2006, 1994, 2016, 2004, 2002 and 1980 as the RAI values ranges from -2.1 to -3 as shown in Table 3. For seven years the zone recorded an RAI between -1.192 to -1.11 which imply medium drought situation experienced by the zone. The majority of the year falls in the normal and weak wet category. The extreme wet year with RAI > 3 occurred between during 1998 and 2005. NEDZ has maximum mean deviation (MD) in the year 2018 with MD value –249.23mm with -50.52 % DR. The minimum MD occurred in the year 1984 with value -18.57 mm which also recorded -3.69 % deficit rainfall (DR).The maximum wet year was observed in the year 1998 with a positive deviation of 246.29 mm with 48.90 % SR. The minimum wet year was observed in the year 1993 with positive deviation of 3.90 mm with 0.77% SR.

Table 3: Rainfall Pattern in North Eastern Dry Zone

S.No	Dry years of North Eastern Dry Zone					S.No	Wet years of North Eastern Dry Zone				
	Year	AR(mm)	MD(mm)	RAI	DR(%)		Year	AR(mm)	MD(mm)	RAI	SR(%)
1	1980	404.82	-98.88	-2.08	-19.63	1	1979	575.84	72.13	1.27	14.32
2	**1984**	**485.13**	**-18.57**	**-0.39**	**-3.69**	2	1981	656.78	153.08	2.7	30.39
3	1985	425.82	-77.89	-1.64	-15.46	3	1982	519.68	15.97	0.28	3.17
4	1986	440.05	-63.65	-1.34	-12.64	4	1983	719.00	215.29	3.80	42.74
5	1991	450.85	-52.86	-1.11	-10.49	5	1987	635.32	131.61	2.32	26.13

6	1992	480.98	-22.72	-0.48	-4.51	6	1988	623.38	119.67	2.11	23.76
7	1994	383.66	-120.04	-2.52	-23.83	7	1989	510.5	6.80	0.12	1.35
8	1997	412.31	-91.39	-1.92	-18.14	8	1990	635.74	132.03	2.33	26.21
9	1999	420.59	-83.11	-1.75	-16.5	9	**1993**	**507.6**	**3.90**	**0.07**	**0.77**
10	2002	397.91	-105.8	-2.22	-21	10	1995	555.84	52.14	0.92	10.35
11	2003	368.98	-134.72	-2.83	-26.75	11	1996	639.26	135.56	2.39	26.91
12	2004	395.63	-108.08	-2.27	-21.46	12	**1998**	**749.99**	**246.29**	**4.35**	**48.9**
13	2006	374.85	-128.85	-2.71	-25.58	13	2000	542.08	38.37	0.68	7.62
14	2008	475.17	-28.54	-0.6	-5.67	14	2001	515.67	11.97	0.21	2.38
15	2011	430.61	-73.09	-1.54	-14.51	15	2005	747.27	243.57	4.3	48.35
16	2012	456.16	-47.55	-1	-9.44	16	2007	552.27	48.56	0.86	9.64
17	2015	279.5	-224.21	-4.71	-44.51	17	2009	671.55	167.85	2.96	33.32
18	2016	390.39	-113.32	-2.38	-22.5	18	2010	658.58	154.88	2.73	30.75
19	2017	417.07	-86.64	-1.82	-17.2	19	2013	609.7	105.99	1.87	21.04
20	**2018**	**249.23**	**-254.47**	**-5.35**	**-50.52**	20	2014	520.74	17.04	0.3	3.38
21	2019	365.45	-138.26	-2.91	-27.45						
Mean Rainfall		**503.70**									

3.2 Analysis of Dry and wet years in Northern Dry zone

In Northern Dry Zone, the dry years occurred for 23 years (57.5 %) out of the 40 years of study period. Extreme drought conditions were observed during the years 2003, 1983, 1984, 2001 and 1985 and recorded the Rainfall anomaly index value of less than minus three (< -3 RAI). The severe drought condition occurred for six years i.e. 1997, 2002, 2016, 1996, 1994 and 2000 and recorded the rainfall anomaly index in the range -2.1 to -3 (Table 4). The normal drought condition prevailed in nine years and recorded the RAI value from -1.87 to -1.00. The Majority of the study period falls in the normal and moderate wet categories. The extreme wet years was observed in the years 2014, 2008, 2010 and 2009 with an estimated rainfall anomaly index value of more than three (RAI> 3). NDZ has experienced maximum mean deviation in rainfall (-137.14 mm) in the year 2003 recording deficit rainfall of -38.82%. The year 1981 recoded the least amount of mean deviation in rainfall (-11.57 mm) and experienced deficit rainfall of just -3.28 %. The year 2014 was the topmost in the category of maximum wet year experiencing a positive deviation of 204. 27 mm and with surplus rainfall of 57.81 %. The year 1988 ranks lowest among the category of wet years with an estimated positive deviation of 1.68 mm and with surplus rainfall of 0.48 %.

Table 4: Rainfall Pattern in Northern Dry Zone

S.No	Dry years of Northern Dry zone					S.No	Wet years of Northern Dry zone				
	Year	AR(mm)	MD(mm)	RAI	DR(%)		Year	AR(mm)	MD(mm)	RAI	SR(%)
1	1979	318.63	-34.60	-1.11	-9.80	1	**1988**	**354.91**	**1.68**	**0.04**	**0.48**
2	1980	340.97	-12.26	-0.39	-3.47	2	1990	452.92	99.69	2.40	28.22
3	**1981**	**341.66**	**-11.57**	**-0.37**	**-3.28**	3	1991	414.56	61.33	1.47	17.36
4	1982	311.39	-41.84	-1.35	-11.84	4	1999	364.36	11.13	0.27	3.15
5	1983	226.54	-126.69	-4.08	-35.86	5	2004	447.73	94.50	2.27	26.75
6	1984	231.86	-121.37	-3.91	-34.36	6	2005	482.98	129.75	3.12	36.73
7	1985	258.27	-94.96	-3.06	-26.88	7	2006	386.01	32.78	0.79	9.28

8	1986	321.99	-31.24	-1.01	-8.84	8	2007	432.96	79.73	1.92	22.57
9	1987	311.67	-41.56	-1.34	-11.76	9	2008	538.66	185.43	4.46	52.49
10	1989	297.05	-56.18	-1.81	-15.90	10	2009	500.13	146.90	3.53	41.59
11	1992	316.50	-36.74	-1.18	-10.40	11	2010	509.40	156.17	3.75	44.21
12	1993	313.09	-40.14	-1.29	-11.36	12	2012	384.56	31.33	0.75	8.87
13	1994	288.20	-65.03	-2.09	-18.41	13	2013	422.75	69.52	1.67	19.68
14	1995	302.74	-50.49	-1.63	-14.29	14	2014	**557.45**	**204.22**	**4.91**	**57.81**
15	1996	287.45	-65.78	-2.12	-18.62	15	2015	392.82	39.59	0.95	11.21
16	1997	272.91	-80.32	-2.59	-22.74	16	2017	359.99	6.76	0.16	1.91
17	1998	295.01	-58.22	-1.87	-16.48	17	2018	433.43	80.20	1.93	22.70
18	2000	288.88	-64.35	-2.07	-18.22	18	2019	359.61	6.38	0.15	1.81
19	2001	247.19	-106.04	-3.41	-30.02						
20	2002	282.17	-71.07	-2.29	-20.12						
21	**2003**	**216.09**	**-137.14**	**-4.41**	**-38.82**						
22	2011	330.03	-23.20	-0.75	-6.57						
23	2016	287.13	-66.10	-2.13	-18.71						
Mean Rainfall		**353.23**									

3.3 Analysis of Dry and wet years in Central Dry zone

In Central Dry Zone, the dry years occurred for 23 years accounting for 57.5 per cent of the study period of 1979-2019. Extreme drought was experienced in four years i.e., 1985, 2003, 1995 and 2016 and the estimated rainfall anomaly index was less than minus three (RAI < -3). Severe drought conditions were observed to prevail in four years i.e., 2002, 1990 ,1984, and 1989 recording the RAI values ranging between -2.1 to -3 (Table 5). The zone suffered from medium drought for seven years which is revealed from the estimated RAI value ranging from -1.84 to -1.00. The majority of the years falls in the medium and severe wet category. The extreme wet year with an estimated rainfall anomaly index value of more than three (RAI > 3) was in years, 2010, 2015, 2019, 2005 and 2014. In CDZ the maximum mean deviation in rainfall was observed to have happened in the year 1985 (MD value –230.50.mm) and the deficit rainfall was -43.05%. The minimum mean deviation in rainfall occurred in the year 1993 with a value -3.90 mm, and was associated with deficit rainfall of -0.73 percent .The wet year was observed to have occurred in 2010 with mean maximum deviation in rainfall of 305.20 mm and with surplus rainfall of 57.00 %. The minimum wet year was in the year 1979 with the minimum deviation in rainfall being 17.30 mm which was associated with surplus rainfall of 3.23 %.

Table 5: Rainfall Pattern in Central Dry zone

S.No	Dry years of Central Dry zone					S.No	Wet years of Central Dry zone				
	Year	AR(mm)	MD(mm)	RAI	DR(%)		Year	AR(mm)	MD(mm)	RAI	SR(%)
1	1980	531.28	-4.15	-0.09	-0.78	1	**1979**	**552.73**	**17.3**	**0.34**	**3.23**
2	1981	526.65	-8.79	-0.18	-1.64	2	1987	576.84	41.4	0.83	7.73
3	1982	447.8	-87.64	-1.84	-16.37	3	1988	603.77	68.33	1.36	12.76
4	1983	452.83	-82.61	-1.73	-15.43	4	1991	583.8	48.37	0.96	9.03
5	1984	423.39	-112.05	-2.35	-20.93	5	1992	590.15	54.72	1.09	10.22
6	**1985**	**304.93**	**-230.5**	**-4.84**	**-43.05**	6	1999	581.86	46.42	0.93	8.67
7	1986	489.49	-45.94	-0.96	-8.58	7	2000	610.28	74.85	1.49	13.98
8	1989	437.27	-98.16	-2.06	-18.33	8	2004	602.06	66.62	1.33	12.44
9	1990	403.16	-132.28	-2.78	-24.7	9	2005	706.04	170.61	3.4	31.86
10	**1993**	**531.54**	**-3.9**	**-0.08**	**-0.73**	10	2007	607.65	72.21	1.44	13.49
11	1994	452.2	-83.23	-1.75	-15.55	11	2008	620.44	85	1.69	15.88

12	1995	357.45	-177.99	-3.74	-33.24	12	2009	659.79	124.35	2.48	23.22
13	1996	500.48	-34.95	-0.73	-6.53	13	**2010**	**840.64**	**305.2**	**6.08**	**57**
14	1997	501.86	-33.57	-0.7	-6.27	14	2013	555.3	19.86	0.4	3.71
15	1998	513.86	-21.58	-0.45	-4.03	15	2014	700.79	165.36	3.3	30.88
16	2001	459.86	-75.58	-1.59	-14.11	16	2015	734.14	198.71	3.96	37.11
17	2002	400.71	-134.72	-2.83	-25.16	17	2017	659.8	124.36	2.48	23.23
18	2003	342.26	-193.18	-4.06	-36.08	18	2019	720.19	184.75	3.68	34.51
19	2006	483.4	-52.03	-1.09	-9.72						
20	2011	487.71	-47.72	-1	-8.91						
21	2012	519.95	-15.49	-0.33	-2.89						
22	2016	364.41	-171.03	-3.59	-31.94						
23	2018	514.14	-21.3	-0.45	-3.98						
Mean Rainfall		**535.43**									

3.4 Analysis of Dry and wet years in Eastern Dry Zone

In Eastern Dry Zone, the dry years occurred for 23 years (Table 6). Extreme drought (RAI <-3) occurred in 2002, 2003, 1985, 1982 and 2018. The severe drought condition occurred for four years i.e. 1990, 2006, 1980 and 2016 as the RAI values ranges -2.1 to -3 as shown in Table 4.40. In six years the RAI value was recorded to be between -1.19 to -1.05 implying occurrence of medium drought in the zone. The majority of the years falls in the normal and weak wet category. The extreme wet year with RAI > 3 occurred in 2005, 2015, 2017 and 1991. EDZ has maximum mean rainfall deviation (MD) in the year 2002 with MD value -413.00 mm with deficit rainfall (DR) of -42.41 % . The minimum MD occurred in the year 1997 with value -7.8 mm recording a deficit rainfall of -0.80 %.The maximum wet year is 2005 with a positive deviation of 577.55 mm with 59.31 % SR. The minimum wet year is 2004 with a positive deviation of 4.98 mm with 0.51% SR.

Table 6: Rainfall Pattern in Eastern Dry Zone

S.No	Dry years of Eastern Dry zone					S.No	Wet years of Eastern Dry zone				
	Year	AR(mm)	MD(mm)	RAI	DR(%)		Year	AR(mm)	MD(mm)	RAI	SR(%)
1	1980	750.43	-223.31	-2.52	-22.93	1	1979	1080.87	107.13	1.1	11
2	1982	690.01	-283.73	-3.21	-29.14	2	1981	1089.36	115.62	1.19	11.87
3	1983	940.51	-33.23	-0.38	-3.41	3	1988	1034.16	60.42	0.62	6.21
4	1984	834.72	-139.02	-1.57	-14.28	4	1991	1381.08	407.33	4.18	41.83
5	1985	682.3	-291.44	-3.29	-29.93	5	1993	1093.55	119.8	1.23	12.3
6	1986	962.95	-10.79	-0.12	-1.11	6	1996	1095.7	121.96	1.25	12.53
7	1987	936.89	-36.85	-0.42	-3.78	7	1998	1162.28	188.54	1.94	19.36
8	1989	804.15	-169.6	-1.92	-17.42	8	1999	1007.87	34.13	0.35	3.51
9	1990	717.05	-256.7	-2.9	-26.36	9	2000	1137.61	163.87	1.68	16.83
10	1992	880.3	-93.45	-1.06	-9.6	10	**2004**	**978.72**	**4.98**	**0.05**	**0.51**
11	1994	850.8	-122.94	-1.39	-12.63	11	**2005**	**1551.3**	**577.55**	**5.93**	**59.31**
12	1995	840.18	-133.56	-1.51	-13.72	12	2007	1022.33	48.59	0.5	4.99
13	**1997**	**965.94**	**-7.8**	**-0.09**	**-0.8**	13	2008	1095.35	121.61	1.25	12.49
14	2001	941.94	-31.81	-0.36	-3.27	14	2010	1158.87	185.13	1.9	19.01
15	**2002**	**560.74**	**-413**	**-4.67**	**-42.41**	15	2011	1113.52	139.78	1.43	14.35
16	2003	674.91	-298.83	-3.38	-30.69	16	2015	1515.37	541.63	5.56	55.62
17	2006	730	-243.74	-2.75	-25.03	17	2017	1448.83	475.09	4.88	48.79

18	2009	952.11	-21.63	-0.24	-2.22	18	2019	1072.96	99.22	1.02	10.19
19	2012	852.21	-121.53	-1.37	-12.48						
20	2013	938.27	-35.47	-0.4	-3.64						
21	2014	904.85	-68.89	-0.78	-7.07						
22	2016	766.96	-206.78	-2.34	-21.24						
23	2018	705.47	-268.27	-3.03	-27.55						
Mean Rainfall		**973.74**									

3.5 Analysis of Dry and Wet years in Southern Dry zone

In Southern dry Zone, the dry years occurred for 20 years as shown in Table 7. Extreme drought occurred in 2003, 2002, 1985, 2001, 2016 and 1990 (< -3 RAI) . The severe drought condition occurred in 1982 and 2012. About five years were recorded with RAI from -1.88 to -1.38 which implies as normal drought in the zone. The majority of the years falls in weak and moderate wet categories. The extreme wet years with RAI > 3 occurred in 2005, 2008, 2017 and 1981. SDZ has maximum mean deviation in the year 2003 with MD value -348.40 .mm with -38.07% DR. The minimum MD occurred in the year 1993 with value -0.42 mm which also recorded with -0.05 % DR .The maximum wet year is 2005 with a positive deviation of 503.79 mm with 55.06 % SR. The minimum wet year is 1987 with a positive deviation of 1.31 mm with 0.14 % SR.

Table 7: Rainfall Pattern in Southern Dry zone

S.No	Dry years of Southern Dry zone					S.No	Wet years of Southern Dry zone				
	Year	AR(mm)	MD(mm)	RAI	DR(%)		Year	AR(mm)	MD(mm)	RAI	SR(%)
1	1982	743.07	-172.7	-2.4	-18.87	1	1979	939.8	24.06	0.34	2.63
2	1983	901.24	-14.5	-0.2	-1.59	2	1980	929.55	13.8	0.19	1.51
3	1984	804.08	-111.7	-1.55	-12.2	3	1981	1137.8	222.01	3.1	24.26
4	1985	685.52	-230.2	-3.2	-25.16	4	**1987**	**917.06**	**1.31**	**0.02**	**0.14**
5	1986	862.04	-53.7	-0.75	-5.87	5	1991	1051	135.25	1.89	14.78
6	1988	874.57	-41.18	-0.57	-4.5	6	1994	1049.9	134.18	1.87	14.66
7	1989	786.81	-128.9	-1.79	-14.09	7	1997	1067	151.2	2.11	16.52
8	1990	699.65	-216.1	-3	-23.62	8	1999	1100.8	185.09	2.58	20.23
9	1992	855.85	-59.9	-0.83	-6.55	9	2000	1030.7	114.96	1.6	12.56
10	**1993**	**915.33**	**-0.42**	**-0.01**	**-0.05**	10	2004	1014.6	98.89	1.38	10.81
11	1995	782.14	-133.6	-1.86	-14.6	11	**2005**	**1419.5**	**503.79**	**7.03**	**55.06**
12	1996	859.58	-56.16	-0.78	-6.14	12	2007	962.36	46.61	0.65	5.09
13	1998	861.82	-53.92	-0.75	-5.89	13	2008	953.54	37.8	0.53	4.13
14	2001	692.33	-223.4	-3.1	-24.42	14	2009	947.93	32.18	0.45	3.52
15	2002	583.8	-332	-4.61	-36.28	15	2010	1116.3	200.54	2.8	21.92
16	**2003**	**567.36**	**-348.4**	**-4.84**	**-38.07**	16	2011	1035.3	119.57	1.67	13.07
17	2006	779.87	-135.9	-1.89	-14.85	17	2014	994.65	78.9	1.1	8.62
18	2012	751.99	-163.8	-2.27	-17.9	18	2015	1068.4	152.67	2.13	16.69
19	2013	816.09	-99.66	-1.38	-10.89	19	2017	1211.5	295.72	4.13	32.32
20	2016	697.33	-218.4	-3.03	-23.87	20	2018	989.91	74.17	1.03	8.11
						21	2019	1087.5	171.78	2.4	18.77
Mean Rainfall		**915.75**									

Conclusion and policy implication

The assessment of rainfall occurrence and dispersion is essential to estimate the irrigation supply to farm & nonfarm population for domestic and farm use respectively. The study revealed that, there is difference in drought occurrence and its intensity across the agro-climatic zones in dry regions. Out of five dry zones, three are recorded with 23 years of drought which effects the Kharif crop production . Therefore, Investment should be made in the creation of micro irrigation methods, water harvesting structures like check dams and farm ponds which helps the farmers to increase crop production despite of existing drought condition in state.

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Competing Interests

The Author has declared that no competing interests exists.

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