International Journal of Advanced Biochemistry Research

ISSN Print: 2617-4693
ISSN Online: 2617-4707
NAAS Rating: 5.29
IJABR 2025; 9(4): 775-782
www.biochemjournal.com
Received: 06-02-2025
Accepted: 09-03-2025

Dr. AM Kamble
Associate Professor (CAS) in Agril. Engg., Department of Agricultural Engineering, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani-Maharashtra, India

UR Sonawane
Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani-Maharashtra, India

SD Joshi
Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani-Maharashtra, India

PP Kottawar
Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani-Maharashtra, India

Corresponding Author:
Dr. AM Kamble
Associate Professor (CAS) in Agril. Engg., Department of Agricultural Engineering, Vasantrao Naik Marathwada Krishi Vidhyapeeth, Parbhani-Maharashtra, India

Drought analysis under climatic variability of Latur zone of Marathwada region

AM Kamble, UR Sonawane, SD Joshi and PP Kottawar

DOI: https://www.doi.org/10.33545/26174693.2025.v9.i4i.4187

Abstract
The erratic nature of rainfall has been the primary reason of droughts in India. Drought causes significant yield reductions both for rainfed and irrigated crops. Sequence of dry and wet periods along with onset and withdrawal of rainy season is necessary for successful agricultural crop planning and soil and water conservation measures. In the present study, dry spell analysis along with onset and withdrawal of rainy season was estimated for Latur zone of Marathwada region. Results indicated that, the average number of rainy days and onset of monsoon were varied from 42.06 to 45.43 days and 23 June to 09 June for the study area. Data on mean dates on first, second and third critical dry spell(CDS) were also estimated and is indicated that, mean CDS for first CDS were less observed for Hingoli station in month of July 09 with mean duration of 17 days and more for Latur station in month of July 04 with mean duration of 20 days were as, mean CDS for second CDS was less observed for Nanded station in August 11 with mean duration of 18 days and more observed for Latur and Hingoli stations with 20 days similarly mean CDS for third CDS were less observed for Hingoli station with 21 days and more for Latur and Nanded with 26 days respectively. These findings are helpful to Latur zone of Marathwada region for understanding the events of occurrence of dry spell and wet spell to decrease the adverse effects of dry spell at sensitive crop development stages.

Keywords: Rainfall, critical dry spell (CDS), onset of effective monsoon (OEM)

Introduction
The major source of water available either for agriculture or for human consumption is obtained from the rain. Rainfall is one of the most important natural inputs in many hydrologic processes. South-West monsoon, North-East monsoon, cyclonic depressions and local storms contribute to rainfall in different degrees in various rainfall regions of the country. Due to high temperature of summer, the moisture-laden south-west monsoon originates from the vast expanse of the Indian Ocean and enters the Indian sub-continent from the south-west. These south-west monsoonal winds increases from June to July and begins to weaken in September, especially in north India. By the first week of July, the monsoon is established all over the country, withdrawal of the monsoon starts in September in north India and there is rapid decrease of rainfall towards the end of month. Rainfed agricultural practices significantly impact the economy of developing countries; however, these practices are highly vulnerable to the effects of weather and climate (Rockstrom, 2002) [7].

The dates of onset of monsoon and withdrawal are different at different parts of the country. The crucial month for agriculture is July and August and the fate space of rain fed kharif crops largely depends upon the amount and distribution of rain specially during these two months.The variation of onset explains the significant variation in season duration since the onset date is more variable than the end date of the rains. Early onset of rains, relative to the mean date of onset for a given location, results in a longer growing season (Sivakumar, 1988) [9] in most of the state the percentage of irrigation is very low. In Maharashtra percentage of total irrigated area to total cropped area is 12.82. In Marathwada region this percentage of total irrigated to total cropped area is only 10.13 leaving about 90 percent area at the whim of monsoon. Marathwada is generally known to be drought prone area in Maharashtra. Precipitation is very uncertain in this region and sometimes suffers from severe droughts.

In such conditions only the knowledge of average annual rainfall is not useful in deciding cropping pattern. With growing emphasis on profitable crop production in such rainfed areas, knowledge of distribution of dry spells during monsoon season assumes an important role, it is important to know the chance of occurrence of dry spell during the critical period of lifecycle of the crops for planning the sowing periods and deciding the varieties of different crops. This helps the farmer in judicious utilization of soil moisture by way of crop planning. The rainfall during the monsoon is very uncertain and its distribution within growing season is not uniform. Delayed onset of monsoon, limiting magnitude at onset, breaks in rainfall and early cessation of rainfall are common phenomena. A break in rainfall continues from a few days to several weeks.

The important characteristics of rainfall influencing production from rainfed farming are the date of onset of monsoon, the duration of rainy spells, the dates of occurrence and duration of intervening dry spells and distribution of weekly minimum rainfall and the number of rainy days. The occurrence of certain amount of rainfall at crucial times can determine the success or failure of a crop. Drying of crops, germination of seeds, disease during its growing period applying irrigation, fertilizer pesticides are some important agricultural activities for which probability of various sequences of wet and dry days may be used to determine the possible economic gains and losses. Rainfall during the monsoon period is not uniform. Breaks in monsoon are common phenomena during the monsoon period. A break continues from a few days to several weeks. Knowledge of the distribution of dry spells during the monsoon period is very much essential for successful management of agriculture. Short period rainfall probability analysis brings out the numbers of years of crops success and duration of crop growing period so that suitable crops may be chosen to get optimum yield. Runs of wet and dry spell helps to identify the duration of stress period. (Biswas, 1981) [2]. Variation in rainfall distribution patterns is the major reason for increasing the probability of occurrence of drought like situation in the country. India stands first among the countries that practice rain fed agriculture both in terms of extent (86 M ha) and value of production (Srinivasa, 2015) [8].

Wet and dry spell helps to identify the duration of surplus water and water stress period. Information on dry spell analysis plays an important role in proper utilization of available rainwater resources. Marathwada region of Maharashtra state, comprises districts Hingoli, Nanded, Latur, Parbhani, Jalna, Beed, Aurangabad and Osmanabad. The area in the region mostly falls under assured rainfall zone, though 15 to 20% falls under low and moderately high rainfall zone each. Under such climate change and aberrant weather situation, crop planning and management should be based on probability of rainfall occurrence, dryspell and available soil moisture analysis. Understanding the events of occurrence of dry spell and wet spell is crucial to decrease the adverse effects of dry spell at sensitive crop development stages. The probable behavior of rainfall was studied by many researchers (Kumar, 2007; Chakravorthy and Mandal, 2008; Chand, 2011; Jakhar, 2011) [6, 3, 4, 5].

Materials and Methods

Location

The present study is confined to Marathwada region. Marathwada is one of the four political regions in the state of Maharashtra. Jawar, Sunflower, are the most important crops grown on large scale all over Latur zone of Marathwada region.

There are 56 rain gauge station in Marathwada. Amongst them, 4 stations of Latur zone are Parbhani, Nanded, Latur and Hingoli, were selected for detailed analysis. The names and locations of the rain guage stations selected for analysis are given in table 1.

Data collection and processing

The daily rainfall data for the 4 rainguage stations of Latur zone of Marathwada region were obtained for the period 1981 to 2011 from the Indian Meterological Department, pune. The data collected for 31 years.

Concise Rainfall data

For making the daily rainfall data obtained for various stations to be concise. The number of rainy days for each month for every year were also obtained.

Onset of Effective Monsoon

There is a need for identifying “Effective Monsoon” as ‘commencement of sowing rains’ distinct from premonsoon showers. Because premonsoon rains cannot be considered as effective monsoon for agriculture operations, particularly because these rains are followed by long dry spells which may affect the germination of seeds resulting in crop failure if sowings are under taken immediately after these showers.

Determination of dates of OEM

The concept developed by Ashok Raj (1979) [1] on onset of effective monsoon and dry spells was adopted in the present study. Effective monsoon is that monsoon which leaves enough moisture to supports agricultural operations. If the average daily evaporation is e mm and after a prolonged dry spell, if it rains on a particular day an amount of r mmof rain, it is assumed that only (r-e) mm of rain will be available for the soil that day. If it rains on the subsequent days, the evaporation loss will be less than e mm. In the light of this, the rainfall of seven-day evaporational demand, is designated as the effective monsoon.

Accordingly, the date of commencement of a 7 days spell satisfying the following criteria can be defined as the date of onset of effective monsoon.

1. The first day’s rain in the seven days spell should be more than the average daily evaporation (e) of the place.
2. The total rain during the seven days spell should not be less than (5e+10) mm.
3. At least four out of these seven days should be rainy days with not less than 2.5 mm of rain each day. A day is called a rainy day if the rainfall of that day is more than or equal to 2.5mm.

The dates of onset of effective monsoon for every year for each station were determined by applying the above three criteria. After identifying the date of onset of effective monsoon xi(i=1,2,3……n) in the Ith year for a particular rain guage station, the mean date m is computed as follows :

$m = \sum xi/n$ (from i=1 to n)

where, n is the number of years.

Determination of Dry spell and Wet spell

The dry spells were found out by applying the criteria stated by Ashok Raj (1979) [1]. The interval between the end of the 7-days spell, beginning with the onset of effective monsoon and another rainy day with 5e mm or more of rain or the commencement of another 7-day rainy spell satisfying the third criteria stated in above paragraph with a total rainfall of 5e mm or more during this spell is called as the first dry spell similarly other dry spells are found.

The interval between the OEM and the beginning of first critical dry spell is called the first wet spell. The subsequent wet spells are defined as the interval between two critical dry spells. thus, the wet spells are spells of prolonged rain with possible intervening dry spells of duration less than the value depending on crop-soil complex of the region, which makes the dry spell critical.

Critical dry spell (CDS)

If the duration the dry spell occurred during the monsoon season exceeds a certain period depending on the crop-soil complex of the region, the dry spell is called the first critical dry spell. Duration of 10 days was considered to classify the dry spell as critical during this study. There occurs more than one critical dry spell during every year. The critical dry spells were obtained for every year for each station.

The mean dates of starting of critical dry spells were obtained by the same procedure adopted for obtaining the mean dates of OEM. The isohyets were drawn for the dates of commencement of CDS and its durations.

Results and Discussion

Record of daily rainfall data for 31 years for Latur zone of Marathwada region that includes Parbhani, Latur, Hingoli, Nanded districts were obtained from the Deptt. of Agricultural Meteorology, M.A.U., Parbhani and Indian Meteorological Department Pune. Data were analyzed to determine rainfall characteristics influencing agricultural operations and irrigation management. The characteristics includes mean monthly rainfall, average weekly rainfall (AWR) and average annual rainfall. Daily rainfall and evaporation data of 31 years were used for determining the dates of onset of effective monsoon, critical dry spells and wet spells. The data were also analyzed for probability of occurrence of dry spell during crop developmental stages.

Analysis for Parbhani station

Analysis of Rainfall data

The variations in annual rainfall and number of rainy days of Parbhani for 31 years (1981-2011) are presented in table 2.

Data from table 3.1 shows that annual rainfall averaged over 31 years for Parbhani station 872.53 mm. The minimum rainfall of 575.7 mm was recorded during 1997 and maximum rainfall of 1408.3mm was recorded during 2005. The number of rainy days varied from minimum of 22 days during 1991 to maximum of 56 days during 1983 and 1990.

Onset and end of effective monsoon

The rainfall data of 31 years (1981-2011) was taken in account. Daily rainfall and evaporation data of 31 years for Parbhani station from 1981-2011 were analyzed to find out the dates of onset of effective monsoon (OEM) and dates of withdrawal of monsoon during individual years. From the table 3, it is seen that effective monsoon starts from first week of June to third week of July. It is also observed that effective monsoon ends in between last week of September and third week of October.

Critical dry spells (CDS)

When the duration of dry spell exceeds a certain value depending on crop-soil complex of the region, it is called as critical dry spell. The critical value of duration of dry spell for Parbhani station was considered as 10 days. As shown in table 4. The mean dates of critical dry spell were July 06 with mean duration of 19 days for first CDS, August 11 with mean duration of 19 days for second CDS, and September 07 with mean duration of 25 days for third CDS for Parbhani station.

Analysis for Latur station

Analysis of Rainfall data

The variation in annual rainfall and number of rainy days of Latur for 31 years (1981-2011) are presented in table 5.

Data from table 5 shows that annual rainfall averaged over 31 years for Latur station 804.90 mm. The minimum rainfall of 311.9 mm was recorded during 1986 and maximum rainfall of 1302.8 mm was recorded during 1983. The number of rainy days varied from minimum of 30 days during 1994 to maximum of 65 days during 2010.

Onset and end of effective monsoon

The rainfall data of 31 years (1981-2011) was taken in account. Daily rainfall and evaporation data of 31 years for Latur station from 1981-2011 were analyzed to find out the dates of onset of effective monsoon (OEM) and dates of withdrawal of monsoon during individual years. From the table 6, it is seen that effective monsoon starts from first week of June to third week of July. It is also observed that effective monsoon ends in between last week of September and third week of October.

Critical dry spells (CDS)

When the duration of dry spell exceeds a certain value depending on crop-soil complex of the region, it is called as critical dry spell. The critical value of duration of dry spell for Latur station was considered as 10 days. As shown in table 7. The mean dates of critical dry spell were July 04 with mean duration of 20 days for first CDS, August 13 with mean duration of 20 days for Second CDS, and September 05 with mean duration of 26 days for third CDS for Latur station.

Analysis for Nanded station

Analysis of Rainfall data

The variation in annual rainfall and number of rainy days of Nanded for 31 years (1981-2011) are presented in table 8.

Data from table 3.7 shows that annual rainfall averaged over 30 years for Nanded station 806.30mm. The minimum rainfall of 351.0 mm was recorded during 2001 and maximum rainfall of 1739.0 mm was recorded during 1989. The number of rainy days varied from minimum of 28 days during 2000 and 2008 to maximum of 63 days during 1984 and 1991.

Onset and end of effective monsoon

The rainfall data of 31 years (1981-2011) was taken in account. Daily rainfall and evaporation data of 31 years for Nanded station from 1981-2011 were analyzed to find out the dates of onset of effective monsoon (OEM) and dates of withdrawal of monsoon during individual years. From the table 9, it is seen that effective monsoon starts from first week of June to third week of July. It is also observed that effective monsoon ends in between last week of September and third week of October.

Critical dry spells (CDS)

When the duration of dry spell exceeds a certain value depending on crop-soil complex of the region, it is called as critical dry spell. The critical value of duration of dry spell for Nanded station was considered as 10 days. As shown in table 10. The mean dates of critical dry spell were July 07 with mean duration of 18 days for first CDS, August 11 with mean duration of 18 days for Second CDS and September 18 with mean duration of 26 days for third CDS for Nanded station.

Analysis for Hingoli station

Analysis of rainfall data

The variation in annual rainfall and number of rainy days of Hingoli for 31 years (1981-2011) are presented in table 11.

Data from table 3.11. shows that annual rainfall averaged over 31 years for Hingoli station 987.06mm. The minimum rainfall of 462.0 mm was recorded during 2008 and maximum rainfall of 1568.1 mm was recorded during 2002. The number of rainy days varied from minimum of 32 days during 1991 to maximum of 62 days during 1983.

Onset and end of effective monsoon

The rainfall data of 31 years (1981-2011) was taken in account. Daily rainfall and evaporation data of 31 years for Hingoli station from 1981-2010 were analyzed to find out the dates of onset of effective monsoon (OEM) and dates of withdrawal of monsoon during individual years. From the table 12, it is seen that effective monsoon starts from first week of June to third week of July. It is also observed that effective monsoon ends in between last week of September and third week of October.

Critical dry spells (CDS)

When the duration of dry spell exceeds a certain value depending on crop-soil complex of the region, it is called as critical dry spell. The critical value of duration of dry spell for Hingoli station was considered as 10 days. As shown in table 13. The mean dates of critical dry spell were July 09 with mean duration of 17 days for first CDS, August 23 with mean duration of 20 days for Second CDS and September 14 with mean duration of 21 days for third CDS for Hingoli station.

Table 1: Location of the rain gauge stations in Latur Zone of Marathwada region selected for analysis.

Sr. No.	Rain gauge station	Location	
		Latitude North	Longitude East
1	Parbhani	19	76
2	Nanded	19	77
3	Latur	19	75
4	Hingoli	18	76

Table 2: Annual Rainfall and rainy days at Parbhani

Years	Rainfall (mm)	Rainy days
1981	825.3	47
1982	679.1	40
1983	1353.5	56
1984	651.3	29
1985	663.8	33
1986	604.8	43
1987	775.2	40
1988	1260.5	50
1989	905.8	35
1990	1254.6	56
1991	637.8	22
1992	727.6	36
1993	660.7	40
1994	668.7	33
1995	730.6	51
1996	846.6	50
1997	575.7	41
1998	1100.2	55
1999	876.8	41
2000	853.9	35
2001	1333.0	44
2002	1142.3	42
2003	872.5	47
2004	678.4	40
2005	1408.3	49
2006	994.6	44
2007	853.8	41
2008	648.1	38
2009	675.6	40
2010	1294.7	44
2011	495.3	30
Mean	872.53	Avg. 41.6

Table 3: Dates of onset and end of effective monsoon for Parbhani station

Year	Effective monsoon		
	Onset on	End on	Duration (days)
1981	June 11	Oct 4	115
1982	July 9	Sept 27	81
1983	July 11	Oct 7	89
1984	June 13	Oct 23	133
1985	June 25	Oct 07	105
1986	June 2	Sept 18	108
1987	July 6	Oct 05	91
1988	June 18	Oct 01	105
1989	June 23	Sept 25	95
1990	May 24	Oct 25	154
1991	June 7	Sept 03	88
1992	June 12	Oct 10	120
1993	June 30	Sept 25	88
1994	June 28	Sept 12	77
1995	June 17	Oct 17	122
1996	June 4	Oct 29	117
1997	June 30	Dec 1	153
1998	June 15	Oct 16	123
1999	June 11	Oct 13	121
2000	May 30	Oct 10	133
2001	June 11	Oct 11	128
2002	June 24	Oct 17	115
2003	July 2	Aug 30	62
2004	June 25	Sept 25	92
2005	July 9	Oct 17	98
2006	June 23	Oct 1	100
2007	June 21	Sept 26	95
2008	June 07	Sept 23	108
2009	June 18	Oct 07	111
2010	June 11	Nov 25	166
2011	July 02	Sept 23	82
31 years	June 22	Oct 07	Avg. 108

Table 4: Critical dry spell during the years for Parbhani

Year	First		Second		Third		total
	Date	Days	Date	Days	Date	Days	CDS
1981	June 18	15	July 9	14	Aug 11	35	3
1982	July 25	20	Aug 21	18	-	-	2
1983	Aug 15	17	-	-	-	-	1
1984	June 17	27	July 20	14	Aug 09	32	3
1985	July 02	19	July 28	16	Aug 16	29	3
1986	June 19	25	July 24	13	-	-	2
1987	July 14	23	Aug 29	36	-	-	2
1988	June 25	14	Aug 01	15	-	-	2
1989	July 02	14	July 29	19	-	-	2
1990	June 23	25	July 26	12	Sept 09	16	3
1991	June 14	17	July 31	16			2
1992	June 25	16	July 2	12	Sept 04	36	3
1993	Aug 4	24	Sept 4	16	-	-	2
1994	July 5	13	July 25	16	-	-	2
1995	Aug 5	23	Sept 19	24	-	-	2
1996	July 20	27	Oct 06	15	-	-	2
1997	July 07	15	Aug 01	20	Sept 27	23	4
1998	July 01	23	Aug 28	10	-	-	2
1999	June 25	10	July 20	12	Aug 10	18	3
2000	June 12	17	July 14	24	-	-	2
2001	June 16	34	Aug 26	32	-	-	2
2002	June 28	21	Aug 09	14	Sept 07	39	3
2003	July 29	10	Aug 12	11	-	-	2
2004	June 30	26	July 31	36	-	-	2
2005	Aug 08	12	Aug 24	11	Sept 14	30	3
2006	July 06	22	Aug 08	41			2
2007	July 03	24	Aug 01	20	Sept 03	10	3
2008	June 14	10	June 28	21	-	-	2
2009	July 22	15	Sept 07	17	Oct 08	20	3
2010	July 09	14	Oct 01	14	Nov 09	10	3
2011	July 13	12	Aug 04	11	-	-	2
31 years	July 06	19	Aug 11	19	Sept 07	25	Avg 3

Table 5: Annual rainfall and rainy days at Latur.

Years	Rainfall (mm)	Rainy days
1981	806.2	44
1982	599.5	38
1983	1302.8	55
1984	488.7	30
1985	539.4	36
1986	311.9	31
1987	709.0	45
1988	1102.1	52
1989	981.9	51
1990	1077.1	44
1991	551.5	34
1992	849.2	36
1993	749.9	49
1994	345.7	33
1995	758.0	39
1996	981.8	45
1997	577.7	46
1998	1223.3	59
1999	697.4	42
2000	929.0	44
2001	553.1	44
2002	442.0	36
2003	840.4	46
2004	829	40
2005	1120	52
2006	921	41
2007	1284	47
2008	785.5	42
2009	720.2	40
2010	1054.4	65
2011	726	42
Mean	804.90	43.48

Table 6: Dates of onset and end of effective monsoon for Latur station

Year	Effective monsoon		
	Onset on	End on	Duration (days)
1981	June 09	Sept 27	111
1982	July 25	Nov 29	128
1983	June 23	Oct 09	109
1984	June 5	Oct 12	130
1985	June 10	Oct 5	118
1986	June 11	Aug 30	81
1987	June 07	Nov 11	158
1988	June 05	Sept 30	118
1989	June 06	Sept 26	113
1990	June 02	Oct 24	145
1991	June 06	Sept 09	96
1992	June 13	Oct 14	124
1993	June 8	Oct 23	138
1994	July 1	Oct 7	99
1995	June 24	Oct 22	121
1996	June 10	Oct 28	141
1997	June 14	Nov 19	159
1998	June 15	Oct 16	124
1999	June 13	Oct 04	114
2000	June 2	Sept 30	101
2001	June 8	Oct 01	116
2002	June 24	Sept 06	75
2003	June 22	Sept 27	98
2004	June 06	Sept 24	91
2005	June 24	Oct 18	117
2006	June 18	Oct 05	110
2007	June 02	Sept 30	121
2008	July 17	Oct 11	25
2009	June 07	Oct 04	120
2010	June 11	Oct 22	134
2011	July 05	Oct 13	100
31 years	June 17	Oct 10	127.70

Table 7: Critical dry spells During the years for Latur

Year	First		Second		Third		total
	Date	Days	Date	Days	Date	Days	CDS
1981	July 02	27	Sept 4	15	-	-	2
1982	July 29	11	Sept 5	29	Oct 29	30	3
1983	July 11	11	Aug 17	10	-	-	
1984	June 11	33	Aug	39	-	-	2
1985	June 13	12	June 30	16	July 29	37	3
1986	June 17	33	July 25	12	-	-	2
1987	July 07	10	Sept 17	39	Oct 30	11	3
1988	June 27	13	Aug 2	14	-	-	2
1989	June 30	14	-	-	-	-	1
1990	June 18	20	July 21	13	Sept 2	19	4
1991	June 13	12	July 14	25	-	-	2
1992	July 05	10	Aug 25	11	Sept 15	29	3
1993	July 04	11	Sept 5	11	-	-	2
1994	July 07	36	Sept 9	27	-	-	2
1995	Aug 06	24	Sept 5	11	Sept 19	24	3
1996	June 16	20	July 26	25	Sept 19	12	3
1997	June 17	13	July 7	18	Aug 2	14	3
1998	-	-	-	-	-	-	0
1999	June 21	18	July 13	11	Aug 11	26	4
2000	June 13	17	July 16	24	Sept 2	26	3
2001	June 16	14	July 17	22	Aug 25	37	3
2002	June 28	17	-	-	-	-	1
2003	Aug 25	26	-	-	-	-	1
2004	June 18	14	July 15	11	Aug 01	35	3
2005	Aug 06	13	Sept 25	18	-	-	2
2006	July 06	23	Aug 18	20	-	-	2
2007	June 30	23	Aug 03	21	-	-	2
2008	Aug 12	13	Sept 24	13	-	-	2
2009	June 04	24	Sept 18	31	Sept 12	27	3
2010	Sept 27	21	-	-	-	-	1
2011	Aug 05	44	Sept 22	20	-	-	2
31 years	July 04	20	Aug 13	20	Sept 05	26	3

Table 8: Annual rainfall and rainy days at Nanded

Years	Rainfall (mm)	Rainy days
1981	970.9	48
1982	1201.1	58
1983	992.6	47
1984	1597.3	63
1985	489.7	32
1986	437.5	33
1987	678.3	35
1988	793.2	45
1989	1739.0	62
1990	954.2	41
1991	1403.3	63
1992	654.6	33
1993	1014.9	43
1994	695.3	37
1995	438.3	42
1996	1146.9	52
1997	896.9	49
1998	705.0	41
1999	670.0	37
2000	539.3	44
2001	351.0	28
2002	511.16	35
2003	608.5	45
2004	387	31
2005	820	42
2006	644	33
2007	582	31
2008	384	28
2009	458	34
2010	1271	57
2011	881	47
31 years	806.30	42.45

Table 9: Dates of onset and end of effective monsoon for Nanded station

Year	Effective monsoon		
	Onset on	End on	Duration (days)
1981	June 26	Nov 1	129
1982	June 24	Oct 29	128
1983	June 25	Oct 08	106
1984	July 5	Oct 11	99
1985	July 6	Oct 8	95
1986	June 2	Sep 20	111
1987	June 3	Nov 19	170
1988	June 9	Oct 3	117
1989	June 7	Oct 1	117
1990	June 5	Oct 27	145
1991	June 5	Oct 4	122
1992	June 9	Oct 12	126
1993	June 13	Oct 19	129
1994	June 10	Oct 7	120
1995	June 27	Oct 30	126
1996	NA	NA	NA
1997	NA	NA	NA
1998	NA	NA	NA
1999	June 12	Oct 13	124
2000	June 4	Aug 28	86
2001	June 12	Sept 3	91
2002	June 24	Sept 6	75
2003	June 13	Oct 8	118
2004	July 22	Nov 9	111
2005	July 9	Oct 18	102
2006	June 29	Oct 01	95
2007	June 15	Sept 29	107
2008	July 25	Sept 14	52
2009	June 26	Oct 04	101
2010	June 28	Oct 22	97
2011	July 06	Sept 17	74
31 years	June 21	Oct 13	99.12

Table 10: Critical dry spells during the years for Nanded

Year	First		Second		Third		total
	Date	Days	Date	Days	Date	Days	CDS
1981	Oct 3	26	-	-	-	-	1
1982	July 27	18	Aug 26	15	Oct 20	21	3
1983	July 1	11	Aug 24	10	-	-	2
1984	Aug 3	39	Sep 21	17	-	-	2
1985	June 12	13	June 30	17	Aug 11	33	4
1986	June 19	24	July 25	11	Aug 15	23	3
1987	June 4	12	July 10	16	Aug 29	35	4
1988	June 25	11	Aug 5	11	-	-	2
1989	June 30	14	Sept 12	15	-	-	2
1990	June 22	26	July 27	11	Sept 9	15	3
1991	June 13	17	July 16	47	-	-	2
1992	June 26	17	Sept 5	31	-	-	2
1993	June 20	21	July 17	11	Sept 2	18	3
1994	June 17	11	July 27	14	Sept 10	21	3
1995	Aug 11	25	Sept 14	10	Sept 29	29	3
1996	NA	NA	NA	NA	NA	NA	-
1997	NA	NA	NA	NA	NA	NA	-
1998	NA	NA	NA	NA	NA	NA	-
1999	June 26	17	Aug 10	18	-	-	2
2000	June 11	17	July 15	22	-	-	2
2001	June 17	34	July 25	31	-	-	2
2002	July 1	23	Aug 9	13	-	-	2
2003	July 26	13	Aug 31	24	-	-	2
2004	July 31	16	Aug 23	14	Sept 13	45	3
2005	Aug 24	27	Sept 25	19	-	-	2
2006	July 5	15	Aug 8	28	-	-	2
2007	June 27	17	Aug 2	18	Sept 7	22	3
2008	Aug 12	13	-	-	-	-	1
2009	July 12	37	Sept 9	8	-	-	2
2010	July 9	15	Aug 1	12	Sept 22	25	3
2011	July 16	10	Aug 5	12	Aug 31	15	4
31 years	July 07	18	Aug 11	18	Sept 18	26	Avg 3

Table 11: Annual Rainfall and rainy days at Hingoli

Years	Rainfall (mm)	Rainy days
1981	781.3	48
1982	807.0	46
1983	1399.2	62
1984	706.2	36
1985	716.9	38
1986	858.9	41
1987	1122.0	44
1988	1178.7	50
1989	778.2	46
1990	1500.6	58
1991	585.1	32
1992	1092.0	37
1993	891.1	34
1994	707.7	47
1995	979.8	58
1996	952.8	57
1997	1063.8	52
1998	1060.7	50
1999	995.4	46
2000	823.0	44
2001	1378.0	50
2002	1568.1	45
2003	1008.1	46
2004	662.5	43
2005	1087.5	44
2006	1320.9	37
2007	950.4	39
2008	462	41
2009	771	42
2010	1400.2	50
2011	989.6	45
31 years	987.06	45.41

Table 12: Dates of onset and end of effective monsoon for Hingoli station

Year	Effective monsoon		
	Onset on	End on	Duration (days)
1981	June 4	Nov 1	151
1982	June 11	Oct 27	139
1983	June 25	Oct 7	105
1984	June 7	Oct 10	106
1985	June 2	Oct 4	125
1986	June 11	Oct 17	129
1987	June 9	Oct 17	131
1988	June 17	Oct 3	109
1989	June 03	Sept 24	114
1990	June 01	Oct 27	149
1991	June 18	Aug 31	75
1992	June 12	Nov 20	162
1993	June 19	Oct 18	122
1994	June 9	Oct 6	120
1995	June 18	Oct 19	124
1996	June 12	Oct 28	129
1997	June 9	Oct 30	144
1998	June 15	Nov 11	150
1999	June 13	Oct 15	125
2000	June 1	Aug 30	91
2001	June 7	Oct 11	127
2002	June 4	Oct 18	137
2003	June 23	Sept 29	99
2004	June 6	Oct 14	131
2005	June 22	Oct 16	117
2006	June 20	Oct 09	112
2007	June 5	Sept 25	113
2008	June 19	Sept 21	63
2009	June 22	Nov 18	151
2010	June 16	Nov 19	157

Table 13: Critical dry spell during the year for Hingoli

Year	First		Second		Third		Total
	Date	Days	Date	Days	Date	Days	CDS
1981	July 15	11	Aug 22	11	Oct 9	22	3
1982	June 27	13	July 26	13	Aug 25	15	4
1983	June 30	10	Oct 8	30	-	-	2
1984	June 18	12	July 21	10	Aug 2	27	3
1985	June 30	16	Aug 18	34	-	-	4
1986	July 5	18	Aug 26	23	Oct 30	25	3
1987	July 20	13	July 10	14	Aug 30	28	3
1988	Aug 4	14	Sep 16	16	-	-	2
1989	June 10	13	July 26	10	Aug 23	27	3
1990	June 22	11	Aug 24	32	Oct 13	12	3
1991	June 23	10	July 22	13	Aug 10	16	3
1992	June 25	32	Sep 7	34	Oct 13	36	3
1993	Aug 6	26	Sep 8	15	Sep 28	15	3
1994	June 16	11	Sep 6	27	-	-	2
1995	Aug 6	31	Sep 17	27	-	-	2
1996	June 19	15	Oct 6	18	-	-	2
1997	June 15	15	July 11	16	Aug 3	12	4
1998	July 11	18	Sep 23	22	Oct 17	23	3
1999	June 22	1	Aug 12	20	Sep 18	26	3
2000	June 10	20	July 20	19	-	-	2
2001	June 20	15	Aug 21	28	Sep 19	12	3
2002	June 5	14	July 1	13	Sep 7	14	3
2003	Aug 10	11	Aug 31	25	-	-	2
2004	June 17	11	Aug 17	18	Sept 30	13	2
2005	Aug 9	42	Sept 24	20	-	-	2
2006	July 6	16	Aug 12	30	Sept 23	26	3
2007	Aug 10	15	Sept 07	11	-	-	2
2008	Aug 12	19	-	-	-	-	1
2009	July 24	19	Sept 06	21	Oct 07	32	3
2010	Sept 17	30	Oct 24	24	-	-	2
2011	July 16	16	Aug 9	11	Sept 5	11	3
31 years	July 09	17	Aug 23	20	Sept 14	21	Avg 3

4. Summary and Conclusion

The daily rainfall and evaporation data of the four rainguage station namely Parbhani, Nanded, Hingoli and Latur were obtained for the analysis from the Department of Agricultural Meterology, VNMKV, Parbhani and Indian Meterology Department, Pune.

The dates of onset and end of effective monsoon were determined for individual years by applying the criteria started by Ashok Raj (1979) [1]. Also mean dates of OEM and end of monsoon with standared deviation were determined for each station. Dry spell analysis was done by applying criteria stated by Ashok Raj (1979) [1]. Also mean dates of OEM and end of monsoon with were determined for each station, the critical dry spells were found during every year. Mean dates of critical dry spell along with their mean durations were also determined. The average dates of starting and ending of wet spell were also determined for each station.

Following are the specific conclusions of the study.

The average annual rainfall at Parbhani, Latur, Nanded and Hingoli stations was recorded as 872.53mm, 804.90mm, 806.30mm and 987.06 mm.

1. The average numbers of rainy days were found to be 41.6, 43.48, 42.55, 45.43 days for Parbhani, Latur, Nanded and Hingoli respectively.
2. The mean dates of OEM were found to be 23 June, 15 June, 17 June, 09 June, for Parbhani, Latur, Nanded and Hingoli respectively.
3. Rainfall Analysis for Latur Zone:
   a) In latur zone the average annual rainfall is Maximum at Hingoli station and Minimum at Latur station.
   Order Hingoli>Parbhani>Nanded>Latur.
   b) In Latur Zone average number of rainy days are Maximum ar Hingoli station and Minimum at Parbhani station.
   Order Hingoli>Latur>Nanded>Parbhani.
   c) In Latur Zone the earliest Onset of rainfall at Hingoli station and latest Onset of rainfall at Parbhani station.
   d) In latur Zone the earliest end of rainfall at Parbhani station and latest end of rainfall at Hingoli station.
   e) The duration of rainfall is greater at Latur station and lower at Nanded station.
   Order Latur>Hingoli>Parbhani>Nanded.

Acknowledgements

The daily rainfall and evaporation data of the four rainguage station namely Parbhani, Nanded, Hingoli and Latur were obtained for the analysis from the Department of Agricultural Meterology, M.A.U. Parbhani and Indian Meterology Department, Pune.

References

1. Raj A. Onset of effective monsoon and critical dry spells. A computer-based forecasting technique. IARI Bulletin No. 2, WTC, IARI, New Delhi; 1979.
2. Biswas BG, Maske SD. Rainfall analysis for use in dryland agriculture. Indian Journal of Soil Conservation. 1981;9(2):8-19.
3. Chakraborty PB, Mandal AP. Rainfall characteristics of Sagar Island in Sunderban, West Bengal. Indian Journal of Soil Conservation. 2008;36(3):125-128.

4. Chand M, Kumar D, Singh D, Roy N, Singh D. Analysis for rainfall for crop planning in Jhansi district of Bundelkhand zone of Uttar Pradesh. Indian Journal of Soil Conservation. 2011;39(1):20-26.
5. Jakhar P, Barman D, Gowda H, Naik B. Probability analysis of rainfall characteristics of Semiliguda in Koraput, Orissa. Indian Journal of Soil Conservation. 2011;39(1):9-13.
6. Kumar A, Pal R, Sharma HC. Probability analysis of monsoon rainfall data of Saharanpur for agricultural planning. Indian Journal of Soil Conservation. 2007;35(2):122-124.
7. Rockström J, Barron J. Rainwater management for increased productivity among small-holder farmers in drought prone environments. Journal of Physics and Chemistry of the Earth. 2002;27:949-959.
8. Srinivasa R, Lal R, Singh R, Jakkula V, Sahrawat K, Venkateshwarlu B, Sikka A, Virmani S. Advances in agronomy. 2015;113-181.
9. Sivakumar MVK. Predicting rainy season potential from the onset of rains in southern Sahelian and Sudanian climatic zones of West Africa. Agriculture and Forest Meteorology. 1988;42:295-305.