

Original Research Article

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Taluka Wise Study of Rainfall Pattern in Nanded District of Marthwada Region (Maharashtra) Using Rainfall Data

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ABSTRACT

About 60 per cent of the total cultivable area of the country is rainfed. However, prolonged dry periods affect the final crop production. Monsoon is an important season for water supplies, from surface reservoir. Uneven distribution of rainfall, affect the agricultural production remarkably. The daily rainfall data was collected for each taluka of Nanded district for the period of 20 years (1998-2017) and it was to be summed up on meteorological weekly, monthly, seasonally, annual basis for each taluka of Nanded district basis for the study of rainfall characterization. The results indicated that weekly mean annual basis total rainfall was ranged between 720.0 mm in Deglur and 1009.9 mm in Mahur. The weekly highest rainfall on annual basis was recorded in Himayat Nagar (53.7 mm) in the 30th MW amongst all the taluka considering monsoon period (23 to 42 MW). The monthly mean rainfall indicated that the lowest and highest monthly mean rainfall amongst all the taluka was observed in Nanded, Kandhar, Loha, Hadgaon, Bhokar, Kinwat, Mahur, Dharmabad, Ardhapur, Naigaon talukas (0.0 mm) in the December month and in the Mahur taluka (283.1 mm) in July month. The seasonal distribution of Nanded district was obtained in winter season (6.1 mm), in summer (15.5 mm), in monsoon (578.3 mm), in post monsoon (216.6 mm). The annual rainfall data is statistical analyzed for Nanded district and within the year and taluka to taluka ranged C.V. (%) were between 25.0 to 46.9 %. The data of taluka-wise annual normal of weather parameter (i.e. rainfall and rainy days) calculated. Here, the results indicated that the onset of monsoon was observed in 23th MW and withdrawal in 43rd MW in Nanded district. It showed that average rainfall of Nanded district is 816.4 mm with 45.0 rainy days per year. The results clearly indicated the onset of monsoon in 23th MW and withdrawal of monsoon in 43rd MW for the Nanded district should be considered. The statistical analysis for rainfall variability was worked out and it was intra-annual as well as intra-taluka variation in Nanded district. It was ranged between 19.0 to 51.0 per cent with annual mean 45.0 rainy days per year.

Keywords

Monsoon, Rainfall pattern, Rainy days, Statistical analysis and Nanded district

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Introduction

Rainfall is an important weather factor for living entity especially to human being. About 60 per cent of the total cultivable area of the country is rainfed. However, prolonged dry periods affect the final crop production. Monsoon is an important season for water supplies, from surface reservoir. Uneven distribution of rainfall, affect the agricultural production remarkably. Economy of the nation significantly depends on the agricultural production. In India 70 per cent population lives in rural areas and two third of this population depends on agricultural production comes from rainfed areas. Prospects of rainfed crops are determined by the times of onset and end of rains, the temporal March of times of occurrence and quantum of rainfall in the rainy season. Primarily rains comes from South-West monsoon rainfall that accounts for the 74 per cent of the annual rainfall over India as where North-East monsoon, pre monsoon and winter rainfall contribute 13, 10 and 3 per cent respectively.

Monsoon is the important season of Indian Agriculture; because of 60 per cent total cultivated area of the country is under rainfed. The study includes rainfall variability, commencement and withdrawal of monsoon, sequence of wet and dry spell, length of growing period and probability of rainfall etc.

The study of rainfall and their interaction with soil are useful for the places of various management of farm operations like land preparation, preparation of seed bed, manuring, sowing time, fertilizer application, irrigation, harvesting and threshing etc. The selection of a crop for the zone is based on the rainfall, soil type and climatic condition i.e. rainfall of locality, the probable information about weather condition in adverse is used for planning suitable management strategy to escape of weather (Maniyar *et al.*, 2007).

Marathwada region of Maharashtra states comprises of eight districts geographically lies between 17° 35' to 20° 40' latitude and 74° 40' to 78° 10' longitude. The altitude ranges between 300 to 900 meters above mean sea level (MSL). Total geographical area is 64.5 lakh ha with 57.0 lakh ha suitable for agriculture. Godavari is the main river; flows through some districts likes Aurangabad, Jalna, Parbhani, Beed and Nanded district of region. However, Nanded district lies between 18.5 to 19.55 North latitude and 77.7 to 78.18 East longitude. It is the Eastern district of Marathwada region of Maharashtra state and surrounded on the North by Yeotmal district of Vidarbha region, on the west by Parbhani, Latur and Osmanabad districts, on the South by Bidar district of Karnataka state and on the East by Nizamabad and Adilabad districts of Andhra Pradesh. The important rivers of the Nanded district are Godavari, Manjara, Manyad, Sarswati, Penganga, Sita and Lendi. The river Godavari, which is the major river of the district, enters from western part of the district, and flows from middle part of the Andhra Pradesh.

The main business in the district is Agriculture, but adequate and timely rains rarely occur, consequently there is at times a scarcity period; as most of the agriculture depends on the rain. Two harvest as *Kharif* and *Rabi* are adopted, In *Kharif*, the crops are high-breed and include jowar, bajra, tur, udad, cotton, soybean and groundnut, while in *Rabi*, the crops are jowar, wheat, gram, safflower etc. In the annual pattern, main crops are sunflower and summer groundnut. Fruits and vegetables are grown as per water resources. The commercial crops are sugarcane and cotton and as the number of sugar factories increases, there is more area under sugarcane. The information on different aspects of rainfall pattern of each taluka of Nanded district will be helpful for suggesting agricultural cropping plans to the farmers.

Materials and Methods

In methodology describes material and techniques used for carrying out present study to suggest crop planning for sustainable agriculture production in any particular district as block level under rainfed condition. The important aspects like onset and withdrawal of monsoon, distribution of monsoon, break in monsoon of Nanded district we are analyzed by using suitable statistical techniques. The methodologies and techniques used for described in this chapter under appropriate heads.

Collection of data

Meteorological data

Taluka wise daily rainfall data for Nanded district of last 20 years (1998-2017) was downloaded from the website of Dept. of Agriculture, Govt. of Maharashtra (Anonymous 2018) for statistical analysis.

Processing of data

The collected data of each taluka was summed up on meteorological weekly, monthly, seasonally and annually basis. The year was partitioned into standard meteorological week (MW) as per meteorological calendar, starting from 1st January of each year and ending on 31st December of the same year. Calendar month wise data was processed and tabulated for further analysis.

Statistical analysis

The data collected for each taluka of Nanded district (*viz.*, Nanded, Biloli, Mukhed, Kandhar, Loha, Hadgaon, Bhokar, Deglur, Kinwat, Mudkhed, Himatat Nagar, Mahur, Dharmabad, Umri, Ardhapur, Naigaon etc.) were subjected to statistical analysis such as mean (A), standard deviation (SD), coefficient

of Variation (CV), extreme lowest and highest and rainy days (Panse and Sukhatme, 1967).

Annual, seasonal, monthly, weekly rainfall variability

$$\text{Mean (A)} = \sum_{i=1}^n x/n$$

Standard Deviation

$$\delta = \frac{\sqrt{\sum (x - y)^2}}{n - 1}$$

C.V. (%) coefficient variation

$$\text{C.V.(\%)} = \frac{\text{Standard deviation}}{\text{Mean}} \times 100$$

Where,

x = Annual/Seasonal/Monthly/Weekly rainfall of ith year,

n = Number of year,

y = Mean Annual/Seasonal/Monthly/Weekly rainfall

Results and Discussion

The present investigation entitled “Taluka-wise study of rainfall and cropping pattern in Nanded district of Marathwada region” was carried out during the period of 2018-19 at Department of agricultural Meteorology, Marathwada Krishi Vidyapeeth, Parbhani. The each Taluka wise daily rainfall data was collected for Nanded district of last 20 years (1998-2017) and the collected data of each taluka was summed up on meteorological weekly, monthly, seasonally and annually

basis. The year was partitioned into standard meteorological week (MW) as per meteorological calendar, starting from 1st January of each year and ending on 31st December of the same year. Calendar month wise data was processed and tabulated for further analysis. The statistical analysis for seasonal rainfall variability showed that within the year season to season in Nanded district. It is ranged between 9.13 per cent (post-monsoon) to 32.45 per cent (winter). Annual mean rainfall for Nanded district was observed as 816.4 mm with annual variation 10.50 per cent. The seasonal distribution of Nanded district was obtained in winter season (6.1 mm), in summer (15.5 mm), in monsoon (578.3 mm), in post monsoon (216.6 mm) and it means that Nanded district received maximum rainfall in monsoon season.

Taluka-wise rainfall characterization of Nanded district

Monthly rainfall

The taluka wise data of monthly mean rainfall for the study period (i.e.1998-2017) of Nanded district are presented in 1st table. The observed data indicated that the lowest and highest monthly mean rainfall amongst all the taluka was observed in Nanded, Kandhar, Loha, Hadgaon, Bhokar, Kinwat, Mahur, Dharmabad, Ardhapur, Naigaon talukas (0.0 mm) in the December month and in the Mahur taluka (283.1 mm) in July month. However, in intra-taluka the variation in monthly mean rainfall was observed as well as monthly variation in rainfall was very high within the talukas and it was recorded as lowest and highest in Nanded 0.0 mm (December) and 206.4 mm (July), Biloli 0.2 mm (December) and 210.4 mm (August), Mukhed 0.3 mm (December) and 211.8 mm (August), Kandhar 0.0 mm (December) and 219.7 mm (August), Loha 0.0 mm (December) and 194.4 mm (July), Hadgaon 0.0 mm (December) and

221.5 mm (July), Bhokar 0.0 mm (December) and 249.7 mm (July), Deglur 0.1 mm (December) and 208.2 mm (August), Kinwat 0.0 mm (December) and 265.5 mm (August) Mudkhed 0.7 mm (December) and 244.5 mm (July) and Himayat Nagar 0.2 mm (December) and 261.3 mm (July), Mahur 0.0 mm (December) and 283.1 mm (July), Dharmabad 0.0 mm (December) and 207.7 mm (August), Umri 1.3 mm (April) and 226.4 mm (August), Ardhapur 0.0 mm (December) and 226.8 mm (July), Naigaon 0.0 mm (December) and 199.5 mm (July). While, considering the district as a whole monthly mean rainfall on annually basis the highest rainfall of 219.6 mm was received in July and lowest rainfall of 0.2 mm during December each in Nanded district. Similar results were obtained for Beed district by Shende (2016).

The mean monthly rainfall gradually increased generally from January onward and received peak in July which there after decreased and it was minimum in month of December (Chakraborty and Mandai., 2008.). Taluka to taluka Coefficient of Variation (i.e. C.V. (%)) on annual rainfall basis of Nanded was noted as 10.50 per cent.

Monthly rainy days

The taluka-wise data of monthly mean rainy days for the study period (i.e. 1998-2017) of Nanded district are given in 2nd table. From the data it is clearly seen that the taluka-wise highest monthly mean rainy days was observed in Nanded taluka in the month of July (11.9 rainy days), in Biloli in the month of July (11.9 rainy days), in Mukhed in the month of July (14.7 rainy days), Kandhar in the month of August (10.9 rainy days), Loha in the month of July (10.8 rainy days), Hadgaon in the month of July (11.9 rainy days), Bhokar in the month of July (12.2 rainy days), Deglur in the month of July and August (11.0 rainy days), Kinwat in the month of July

(13.7 rainy days), Mudkhed in the month of July (11.7 rainy days), Himayat Nagar in the month of July (15.5 rainy days), Mahur in the month of July (12.4 rainy days), Dharmabad in the month of September (11.2 rainy days), Umri in the month of July (12.1 rainy days), Ardhapur in the month of August (11.1 rainy days), Naigaon in the month of July (10.4 rainy days). While, considering whole district of Nanded it was observed highest rainy days were recorded in the month of July (11.9 rainy days).

Seasonal rainfall

The data of mean seasonal rainfall during 1998-2017 of each taluka in Nanded district are presented in 3rd table. The statistical analysis for seasonal rainfall variability showed that within the year season to season in Nanded district. It is ranged between 9.13 per cent (post- monsoon) to 32.45 per cent (winter). Annual mean rainfall for Nanded district was observed as 816.4 mm with annual variation 10.50 per cent. The seasonal distribution of Nanded district was obtained in winter season (6.1 mm), in summer (15.5 mm), in monsoon (578.3 mm), in post monsoon (216.6 mm) and it means that Nanded district received maximum rainfall in monsoon season (i.e. *kharif* season) and thereafter in post- monsoon (i.e. *Rabi* season).

Hence, this region comes under assured *kharif* season and also useful to *rabi* season to cultivate the crops. These results are in conformity with Maniyar *et al.*, (2007).

The data from the 4.5 table in summer season 15.9 mm, 20.3 mm, 18.9 mm, 15.3 mm, 11.8 mm, 16.8 mm, 19.3 mm, 13.5 mm, 15.5 mm, 14.6 mm, 17.0 mm, 11.7mm, 9.7mm, 9.8mm, 22.9mm and 14.7mm mean rainfall was observed in Nanded, Biloli, Mukhed, Kandhar, Loha, Hadgaon, Bhokar, Deglur, Kinwat, Mudkhed, Himayat Nagar, Mahur,

Dharmabad, Umri, Ardhapur and Naigaon taluka, respectively. In monsoon season 524.8 mm, 510.5 mm, 528.7 mm, 538.8 mm, 513.6 mm, 566.0 mm, 623.9 mm, 504.0 mm, 745.6 mm, 592.4 mm, 639.1 mm, 780.8 mm, 550.2 mm, 569.4 mm, 563.0 mm, 501.6 mm rainfall was observed in Nanded, Biloli, Mukhed, Kandhar, Loha, Hadgaon, Bhokar, Deglur, Kinwat, Mudkhed, Himayat Nagar, Mahur, Dharmabad, Umri, Ardhapur and Naigaon taluka, respectively. The post-monsoon season rainfall was observed in Nanded as 204.9 mm, Biloli 185.4 mm, Mukhed 230.6 mm, Kandhar 218.1 mm, Loha 246.7 mm, Hadgaon 196.0 mm, Bhokar 245.5 mm, Deglur 196.8 mm, Kinwat 220.4 mm, Mudkhed 201.5 mm, Himayat Nagar 199.3 mm, Mahur 214.5 mm, Dharmabad 199.4 mm, Umri 242.2 mm, Ardhapur 235.5 mm and Naigaon taluka 228.6 mm. The highest rainfall in monsoon season was observed in Mahur (i.e. 780.8 mm) and the lowest rainfall of monsoon season was observed in Naigaon (i.e. 501.6 mm). These result showed that generally, the winter, Pre-monsoon, and post-monsoon rainfall were found much more variable than SW monsoon (Lokhande *et al.*, 2017).

Seasonal rainy days

The data of seasonal mean rainy days during 1998-2017 of each taluka in Nanded district are given in 4th table. The seasonal rainy days were recorded during summer season showed mean rainy days in Nanded (1.4 rainy days), Biloli (1.4 rainy days), Mukhed (1.8 rainy days), Kandhar (1.2 rainy days), Loha (1.3 rainy days), Hadgaon (1.4 rainy days), Bhokar (1.2 rainy days), Deglur (0.6 rainy days), Kinwat (1.6 rainy days), Mudkhed (1.5 rainy days), Himayat Nagar (1.2 rainy days), Mahur (0.9 rainy days), Dharmabad (1.1 rainy days), Umri (1.0 rainy days), Ardhapur (1.0 rainy days) and Naigaon (1.6 rainy days). The monsoon season rainy days were recorded in Nanded (29.4 rainy days), Biloli (30.0 rainy

days), Mukhed (34.4 rainy days), Kandhar (30.0 rainy days), Loha (29.1 rainy days), Hadgaon (31.5 rainy days), Bhokar (32.3 rainy days), Deglur (29.3 rainy days), Kinwat (37.3 rainy days), Mudkhed (30.2 rainy days), Himayat Nagar (34.3 rainy days), Mahur (33.4 rainy days), Dharmabad (29.3 rainy days), Umri (31.1 rainy days), Ardhapur (28.8 rainy days) and Naigaon (27.6 rainy days). Similarly, post-monsoon season mean rainy days are (12.2 rainy days), (11.3 rainy days), (12.1 rainy days), (12.6 rainy days), (11.8 rainy days), (11.3 rainy days), (12.3 rainy days), (11.5 rainy days), (13.6 rainy days), (10.5 rainy days), (12.4 rainy days), (11.7 rainy days), (14.6 rainy days), (12.7 rainy days), (12.9 rainy days) and (11.9 rainy days) in Nanded, Biloli, Mukhed, Kandhar, Loha, Hadgaon, Bhokar, Deglur, Kinwat, Mudkhed, Himayat Nagar, Mahur, Dharmabad, Umri, Ardhapur and Naigaon taluka, respectively.

Annual rainfall

The data of mean annual rainfall are given in 5th table. The annual rainfall data is statistical analyzed for Nanded district and within the year and taluka to taluka ranged C.V. (%) were between 25.0 per cent to 46.9 per cent and the annual mean rainfall for Nanded district was observed as 816.4 mm. The data indicated that mean annual rainfall ranges from lowest 720.0 mm (Deglur) and highest 1009.9 mm (Mahur). While, it was observed that the lowest and highest annual mean rainfall in as Nanded 384.0 mm (2008) and 1300.3 mm (1998), Biloli 309.0 mm (2014) and 1129.3 mm (2016), Mukhed 427.6 mm (2014) and 1142.7 mm (2016), Kandhar 344.8 mm (2014) and 1187.0 mm (2001), Loha 389.0 mm (2012) and 1562.4 mm (1998), Hadgaon 443.0 mm (2009 and 2014) and 1335.0 mm (2005), Bhokar 460.0 mm (2011) and 1394.0 mm (2005), Deglur 300.9 mm (2014) and 1126.2 mm (1998), Kinwat 579.0 mm (2009) and 1367.9 mm (2013), Mudkhed

373.9 mm (2014) and 1611 mm (2005), Himayat Nagar 360.0 mm (2004) and 2142.0 mm (2005), Mahur 543.7 mm (2017) and 1589.8 mm (2013), Dharmabad 382.9 mm (2014) and 1452.3 mm (2005), Umri 511.0 mm (2015) and 1238.6 mm (2005), Ardhapur 391.2 mm (2014) and 1782.6 mm (2005), Naigaon as 396.3 mm (2014) and 1597.0 mm (2005). From the data it is understood that the annual total mean rainfall (i.e. normal rainfall) for Nanded district was 816.4 mm. Similar results were reported by Rai and Singh (2009).

Annual rainy days

The data of annual rainy days during 1998-2017 of each taluka are given in 6th table. The statistical analysis for variability was worked out and it showed that inter-annual as well as intra-taluka variation in Nanded district ranged between 19.0 to 51.0 per cent with annual mean 45.0 rainy days yr⁻¹.

However, the lowest and highest annual mean rainy days in Nanded were 31 rainy days (2004 and 2008) and 61 rainy days (2016), Biloli 26 rainy days (2014) and 64 rainy days (2016), Mukhed 30 rainy days (2014) and 107 rainy days (2008), Kandhar 30 rainy days (2014) and 66 rainy days (2013), Loha 30 rainy days (2014) and 62 rainy days (2010), Hadgaon 29 rainy days (2006) and 60 rainy days (2013), Bhokar 30 rainy days (2002 and 2014) and 67 rainy days (2013), Deglur 28 rainy days (2002 and 2014) and 60 rainy days (2005), Kinwat 31 rainy days (2002) and 75 rainy days (2013), Mudkhed 25 rainy days (2014) and 61 rainy days (2010), Himayat Nagar 21 rainy days (2004) and 139 rainy days (2011), Mahur 29 rainy days (2002) and 63 rainy days (2013), Dharmabad 27 rainy days (2014) and 117 rainy days (2004), Umri 31 rainy days (2002) and 63 rainy days (2013), Ardhapur 28 rainy days (2014) and 64 rainy days (2010), Naigaon as 25 rainy days (2002) and 58 rainy days (2005).

Table.1 Taluka-wise monthly mean rainfall (mm) of Nanded district

MONTH	NAND	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDH	NAIG	Mean	S.D.	CV.(%)
JAN	2.9	2.9	3.0	1.8	3.1	6.7	4.8	5.0	4.3	5.9	2.3	2.9	4.6	3.4	7.3	4.1	1.57	38.49
FEB	1.5	1.1	1.9	2.9	1.6	2.1	0.9	0.8	2.2	1.8	0.6	1.9	2.8	2.2	2.2	1.8	0.68	38.49
MAR	4.7	4.8	7.8	3.9	5.7	9.1	4.6	7.9	8.2	7.1	8.4	4.9	6.0	6.6	7.1	6.6	1.66	25.23
APR	5.4	6.0	2.2	2.6	5.1	6.0	3.6	3.5	2.1	6.1	0.8	1.8	1.3	4.4	3.5	3.9	2.06	52.84
MAY	5.8	8.1	5.3	5.4	6.0	4.2	5.2	4.1	4.3	3.8	2.5	3.0	2.5	11.9	4.1	5.0	2.32	46.42
JUNE	123.1	123.3	132.5	121.5	158.2	152.4	117.4	217.0	130.8	156.1	229.6	139.6	127.3	132.6	113.4	143.0	34.37	24.02
JULY	206.4	193.7	186.6	194.4	221.5	249.7	178.3	263.1	244.5	261.3	283.1	202.9	215.7	226.8	199.5	219.6	31.97	14.56
AUG	195.4	211.8	219.7	197.7	186.4	221.8	208.2	265.5	217.1	221.7	268.1	207.7	226.4	203.6	188.7	215.6	23.18	10.75
SEP	139.6	150.3	142.4	174.2	147.8	174.1	133.7	159.1	128.0	146.7	147.8	140.3	150.5	156.7	140.9	147.8	13.26	8.98
OCT	58.7	71.1	64.6	65.4	43.6	66.6	57.6	53.4	55.5	47.0	49.7	52.9	72.6	63.5	63.4	58.4	8.74	14.96
NOV	6.5	9.2	11.1	7.1	4.6	4.8	5.5	7.9	18.0	5.6	17.0	6.2	19.1	15.3	24.3	10.4	6.33	61.00
DEC	0.0	0.3	0.0	0.0	0.0	0.0	0.1	0.0	0.7	0.2	0.0	0.0	2.1	0.0	0.0	0.2	0.53	240.74
TOTAL	750.0	782.5	777.1	776.8	783.5	897.5	720.0	987.2	815.6	863.2	1009.9	764.0	830.9	827.0	754.3	816.4	85.69	10.50

Table.2 Taluka-wise monthly mean rainy days of Nanded district

MONTH	NAND	BILO	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDHA	NAIG	Mean	S.D.	CV.(%)
JAN	0.3	0.1	0.2	0.3	0.3	0.2	0.4	0.2	0.2	0.3	0.3	0.2	0.2	0.3	0.3	0.2	0.2	0.06	25.50
FEB	0.2	0.3	0.1	0.2	0.4	0.1	0.2	0.2	0.1	0.3	0.2	0.1	0.2	0.3	0.2	0.2	0.2	0.09	45.15
MAR	0.3	0.5	0.7	0.5	0.5	0.6	0.6	0.2	0.7	0.6	0.7	0.6	0.5	0.5	0.4	0.6	0.5	0.12	24.74
APR	0.5	0.5	0.6	0.3	0.3	0.5	0.3	0.2	0.6	0.3	0.2	0.2	0.2	0.3	0.2	0.6	0.3	0.16	47.83
MAY	0.6	0.4	0.6	0.5	0.6	0.4	0.3	0.2	0.4	0.7	0.4	0.2	0.4	0.2	0.5	0.4	0.4	0.14	35.18
JUNE	7.1	8.5	8.5	8.9	7.8	8.1	8.5	8.0	10.3	7.8	7.5	9.2	8.1	7.9	7.4	7.4	8.2	0.79	9.73
JULY	11.9	11.1	14.7	10.3	10.8	11.9	12.2	11.0	13.7	11.7	15.5	12.4	10.8	12.1	10.3	10.4	11.9	1.55	12.99
AUG	10.5	10.5	11.2	10.9	10.6	11.5	11.7	11.0	13.4	10.7	11.3	11.8	10.4	11.1	11.1	9.8	11.1	0.80	7.23
SEP	8.2	7.7	7.9	8.5	8.4	8.1	8.6	7.8	9.6	7.2	8.4	8.4	11.2	8.2	8.1	7.5	8.4	0.93	11.12
OCT	3.4	3.2	3.7	3.6	3.1	2.8	3.4	3.3	3.7	2.7	3.5	2.9	3.3	3.9	4.0	3.5	3.4	0.37	11.03
NOV	0.7	0.4	0.5	0.5	0.4	0.4	0.4	0.4	0.3	0.6	0.5	0.4	0.1	0.6	0.8	0.9	0.5	0.20	42.20
DEC	0.0	0.1	0.1	0.0	0.0	0.0	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.05	219.09
TOTAL	43.4	43.1	48.6	44.3	42.8	44.5	46.3	42.4	52.8	42.7	48.4	46.2	45.4	45.5	43.2	41.5	45.0	2.93	6.50

Table.3 Taluka-wise seasonal mean rainfall (mm) of Nanded district

SEASON	NAND	BILO	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDH	NAIG	Mean	S.D.	CV.(%)
Summer	15.9	20.3	18.9	15.3	11.8	16.8	19.3	13.5	15.5	14.6	17.0	11.7	9.7	9.8	22.9	14.7	15.5	3.72	24.03
Monsoon	524.8	510.5	528.7	538.8	513.6	566.0	623.9	504.0	745.6	592.4	639.1	780.8	550.2	569.4	563.0	501.6	578.3	82.98	14.35
Post-Mon.	204.9	185.4	230.6	218.1	246.7	196.0	245.5	196.8	220.4	201.5	199.3	214.5	199.4	242.2	235.5	228.6	216.6	19.78	9.13
winter	4.4	6.5	4.2	4.9	4.7	4.7	8.8	5.8	5.7	7.2	7.9	2.9	4.8	9.5	5.6	9.4	6.1	1.97	32.45
TOTAL	750.0	722.7	782.5	777.1	776.8	783.5	897.5	720.0	987.2	815.6	863.2	1009.9	764.0	830.9	827.0	754.3	816.4	85.69	10.50

Table.4 Taluka-wise seasonal mean rainy days of Nanded district

SEASON	NAND	BILO	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDH	NAIG	Mean	S.D.	CV.(%)
Summer	1.4	1.4	1.8	1.2	1.3	1.4	1.2	0.6	1.6	1.5	1.2	0.9	1.1	1.0	1.0	1.6	1.2	0.30	24.25
Monsoon	29.4	30.0	34.4	30.0	29.1	31.5	32.3	29.9	37.3	30.2	34.3	33.4	29.3	31.1	28.8	27.6	31.2	2.57	8.25
Post-Mon.	12.2	11.3	12.1	12.6	11.8	11.3	12.3	11.5	13.6	10.5	12.4	11.7	14.6	12.7	12.9	11.9	12.2	0.98	8.08
winter	0.5	0.4	0.4	0.5	0.7	0.3	0.6	0.4	0.3	0.6	0.5	0.3	0.4	0.8	0.5	0.4	0.5	0.14	30.36
TOTAL	43.4	43.1	48.6	44.3	42.8	44.5	46.3	42.4	52.8	42.7	48.4	46.2	45.4	45.5	43.2	41.5	45.0	2.93	6.50

Table.5 Taluka-wise annual mean rainfall(mm) of Nanded district.

YEAR	NAND	BILO	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDH	NAIGA	Mean
1998	1300.3	984.2	1111.1	1133.1	1562.4	851.9	1149.7	1126.2	1017.2	1300.3	842.4	1017.2	965	1149.7	NA	NA	1107.9
1999	894	885.5	813	857.7	786	863	1232	795.9	1084	NA	NA	NA	NA	NA	NA	NA	912.3
2000	770.3	1002	866.7	717.9	853.4	721	847	964.9	863	760	666	841	988.6	850	NA	NA	836.6
2001	684.6	770	806	1187	862	662	873	691	1200	836	637	1159	669	1055	607	745	840.2
2002	510.3	485	630	808.5	694	717.3	724	521.2	996	684	755	1360	506.5	703	454.2	546	693.4
2003	740	686	687	859	879	873	887	769	1212.9	842	896	1052	495	916	1096	976.8	866.7
2004	387	625	922	694	539	556	715	717.6	719	511	360	783	587	653	710	736	638.4
2005	820	1066.4	1003	1081	982	1335	1394	1100	1339	1611	2142	1387	1452.3	1238.6	1782.6	1597	1333.2
2006	644	723	795	797	644	1021	1045	809.5	1208	530	1093	1314	1058	946	1029	900	909.8
2007	516	657	643	450	556	483	692	913	953	628	632	981	830	595	748	785	691.4
2008	384	636	657	472	642	530	624	429	884	530	794	713	734	758	672	659	632.4
2009	458	407.6	429	516	632	443	805	547	579	674	553	683	637	583	631	507	567.8
2010	1271	743	879	1213	1031	1154	1288	781	1335	1374	1315	1149	989	1209	1281	969	1123.8
2011	615.3	659.7	807.3	801	676	670	460	655	839	656	759	926	789	832	625	663	714.6
2012	506	674	745	527	389	685	685	643.4	1004	667	829	886	597	594	651	489	660.7
2013	1299.4	905.8	1073.8	855.5	871.4	1247.6	1316.5	850	1367.9	1062.6	1383.2	1589.8	926.7	1070.8	1070.3	749	1102.5
2014	443.7	309	427.6	344.8	450.9	443	473.5	300.9	635.1	373.9	479.1	618.8	382.9	482.6	391.2	396.3	434.6
2015	652.9	487.6	554.9	546	538.9	655.7	668.2	417.6	780.7	654.8	773.4	864.9	394.2	511	498.3	472.4	592.0
2016	1242.1	1129.3	1142.7	1067.2	1337.6	1114.6	1376.4	907.2	1115.4	961.2	954.5	1319.6	957.8	984	1141.8	1024.2	1111.0
2017	860.7	617.8	657.2	614.3	610	643.3	694	460.2	612.6	840.7	536.8	543.7	557.7	655.6	670.3	609.1	636.5
Total	14999.6	14453.9	15650.3	15542.0	15536.6	15669.4	17949.3	14399.6	19744.8	15496.5	16400.4	19188.0	14516.7	15786.3	14058.7	12823.8	15763.5
Mean	750.0	722.7	782.5	777.1	776.8	783.5	897.5	720.0	987.2	815.6	863.2	1009.9	764.0	830.9	827.0	754.3	816.4
S.D.	309.2	219.4	204.8	260.6	289.4	267.7	299.5	226.9	246.7	321.8	405.3	290.8	270.7	240.8	358.4	287.5	281.2
C.V%	41.2	30.4	26.2	33.5	37.3	34.2	33.4	31.5	25.0	39.4	46.9	28.8	35.4	29.0	43.3	38.1	34.6

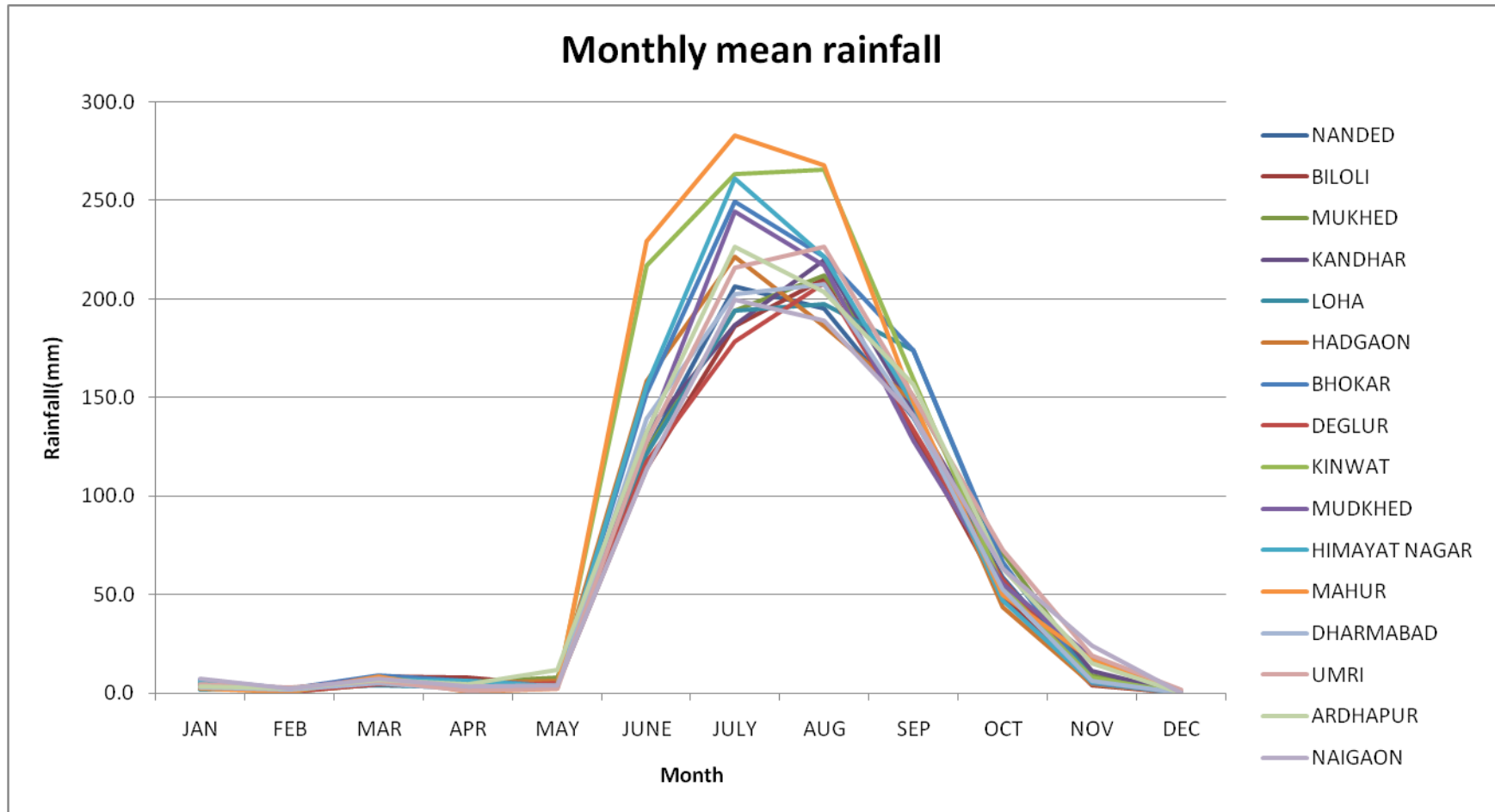
*NA- Not Available data

Table.6 Taluka-wise annual mean rainy days of Nanded district

YEAR	NAND	BILO	MUKH	KAND	LOHA	HADG	BHOK	DEGL	KINW	MUDK	HIMA	MAHU	DHAR	UMRI	ARDH	NAIG	Mean
1998	51	56	64	60	56	51	55	52	54	51	52	54	53	55	NA	NA	54.6
1999	50	52	56	53	57	48	52	44	48	NA	NA	NA	NA	NA	NA	NA	51.1
2000	39	43	45	41	41	41	44	38	43	37	37	43	41	46	NA	NA	41.4
2001	40	40	41	43	35	39	41	42	44	43	28	48	35	45	34	33	39.4
2002	38	32	32	33	31	32	30	28	31	29	31	29	28	31	29	25	30.6
2003	46	43	39	41	45	51	53	41	56	39	43	53	29	57	57	39	45.8
2004	31	37	37	42	31	34	37	38	45	38	21	46	117	39	47	30	41.9
2005	43	51	44	40	44	43	61	60	52	49	59	46	55	59	49	58	50.8
2006	36	30	38	35	32	29	42	40	49	26	39	37	40	41	39	31	36.5
2007	32	36	42	35	37	36	41	36	50	36	42	49	41	36	34	45	39.3
2008	31	29	107	41	36	36	40	33	55	33	44	48	40	37	31	33	42.1
2009	37	32	37	38	36	30	38	45	43	49	42	37	41	35	41	40	38.8
2010	58	53	51	55	62	71	61	49	64	61	64	55	48	60	64	57	58.3
2011	52	44	43	47	36	58	28	46	64	45	139	49	43	47	43	45	51.8
2012	43	45	53	46	38	51	45	44	61	45	49	42	41	44	45	36	45.5
2013	60	55	57	66	55	60	67	51	75	54	62	63	48	63	59	55	59.4
2014	28	26	30	30	30	31	30	28	41	25	31	35	27	33	28	29	30.1
2015	44	45	52	47	47	44	51	37	58	45	40	41	37	46	41	47	45.1
2016	61	64	58	55	58	57	64	58	60	60	50	61	58	48	50	57	57.4
2017	47	48	45	37	48	47	46	37	62	47	46	41	41	42	44	45	45.2
Total	867.0	861.0	971.0	885.0	855.0	889.0	926.0	847.0	1055.0	812.0	919.0	877.0	863.0	864.0	735.0	705.0	870.7
Mean	43.4	43.1	48.6	44.3	42.8	44.5	46.3	42.4	52.8	42.7	48.4	46.2	45.4	45.5	43.2	41.5	45.0
S.D.	9.8	10.3	16.5	9.4	10.2	11.5	11.5	8.7	10.2	10.4	24.7	8.8	19.3	9.6	10.5	10.8	12.0
C.V%	22.6	24.0	34.0	21.3	24.0	25.9	24.7	20.5	19.4	24.2	51.0	19.0	42.5	21.0	24.2	26.0	26.5

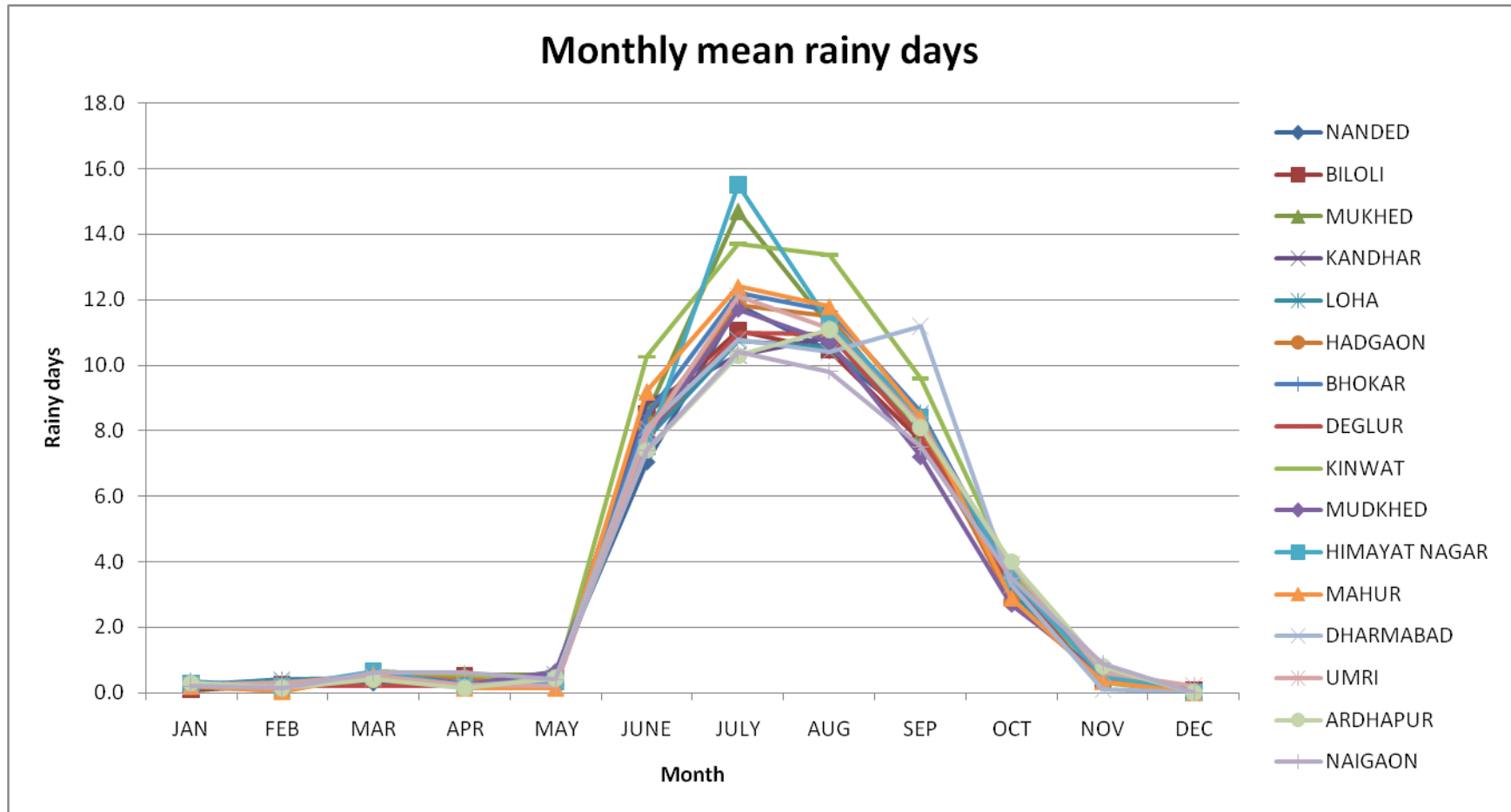
*NA- Not Available data

Fig.1 Taluka wise monthly mean rainfall (mm) of Nanded district



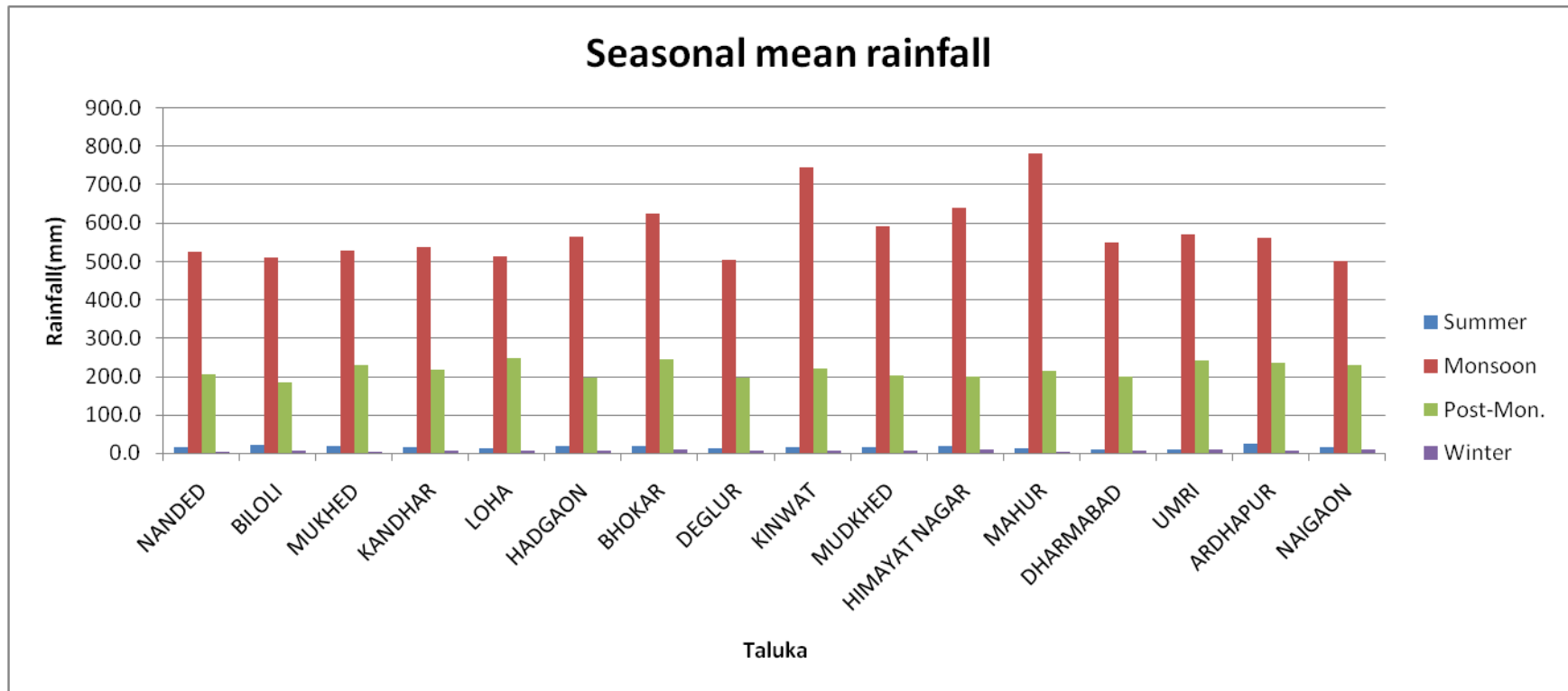
(Database 1998-2017)

Fig.2 Taluka wise monthly mean rainy days of Nanded district



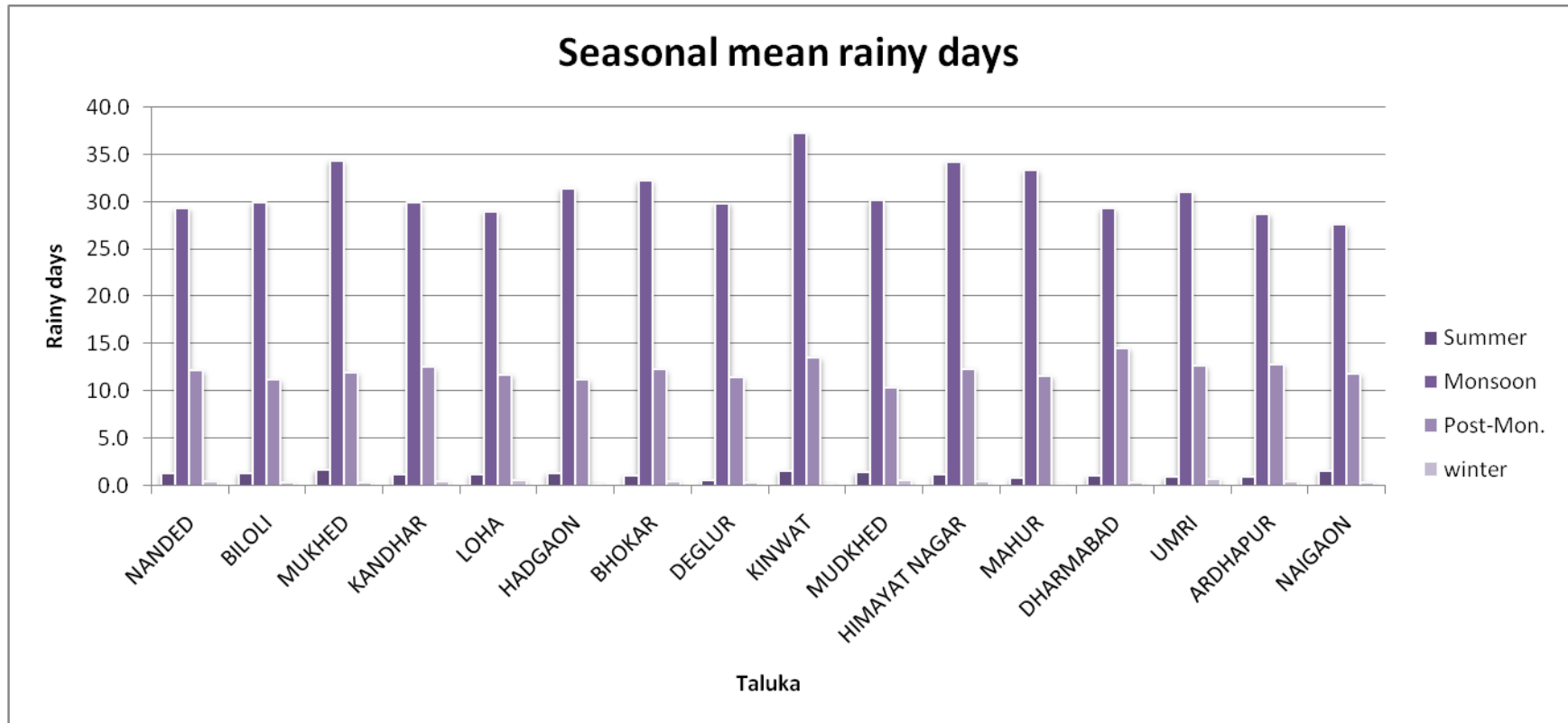
(Database 1998-2017)

Fig.3 Taluka wise season mean rainfall (mm) of Nanded district



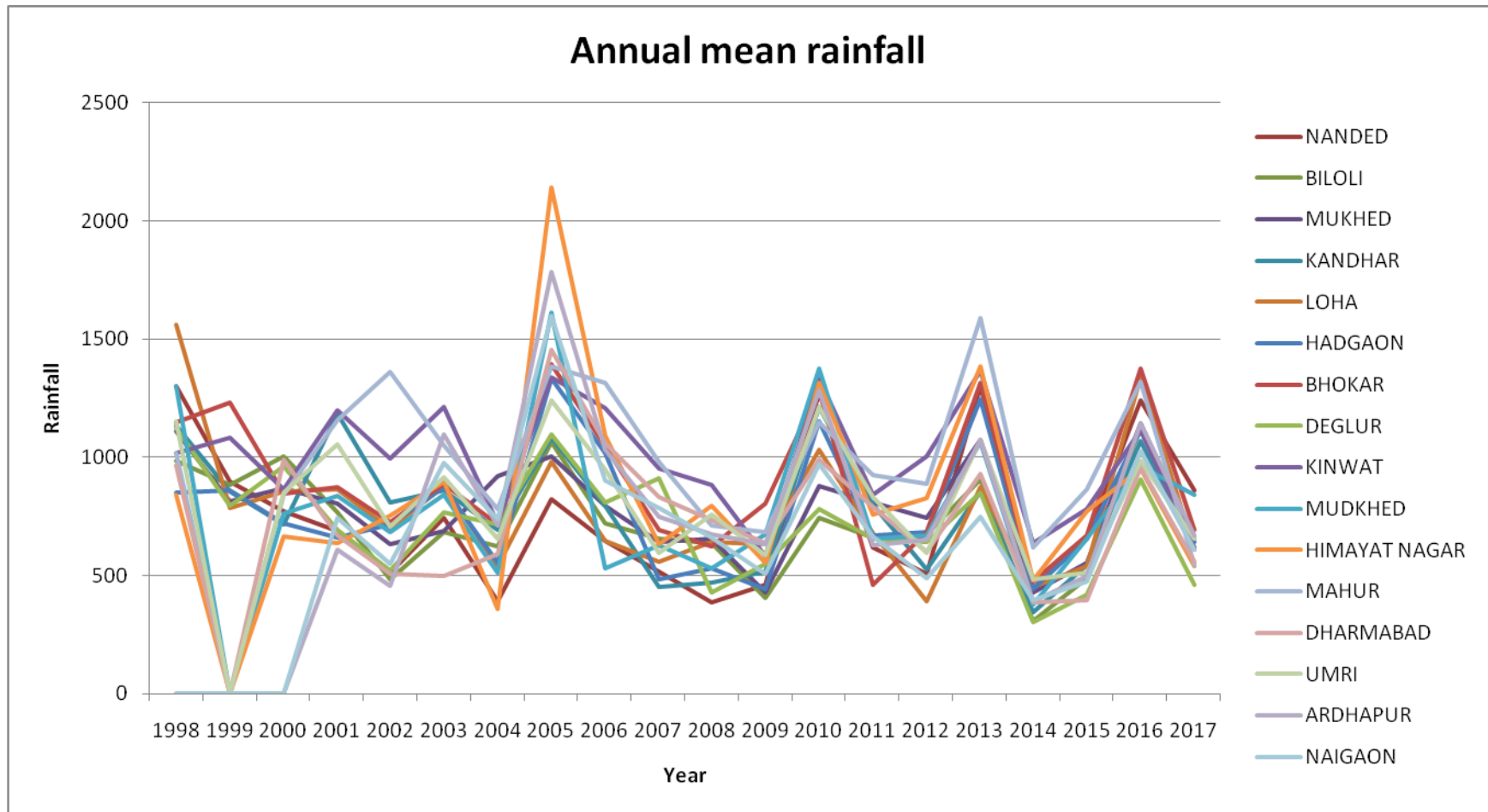
(Database 1998-2017)

Fig.4 Taluka wise seasonal mean rainy day of Nanded district



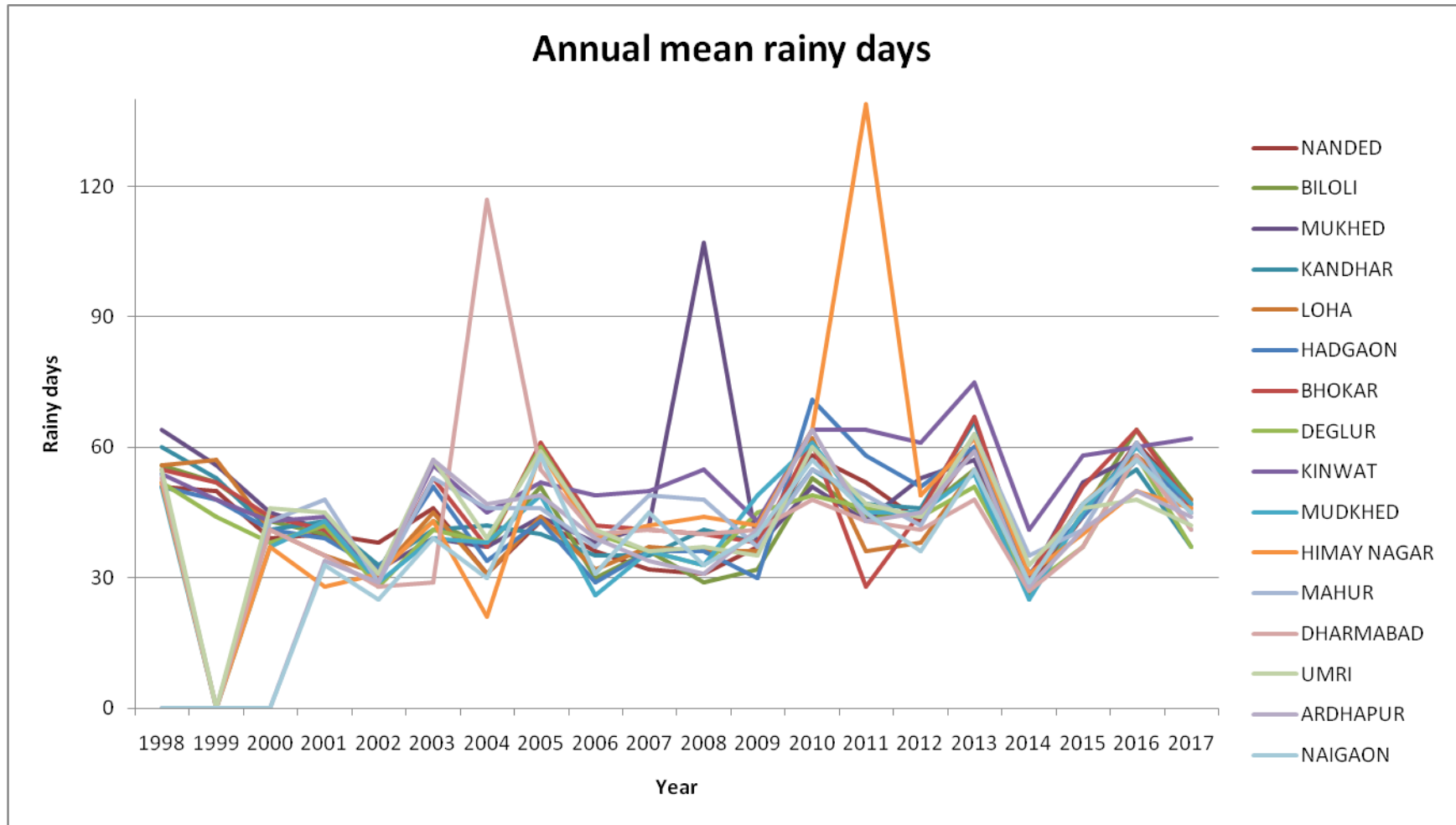
(Database 1998-2017)

Fig.5 Taluka wise annual mean rainfall (mm) of Nanded district



(Database 1998-2017)

Fig.6 Taluka wise annual mean rainy days of Nanded district



(Database 1998-2017)

Hence, the change in rainfall and rainy days is not uniform in the region and varied regionally. However, it is also not considerable for agriculture business. It is clearly understood that the micro-meteorological changes were observed in inter-taluka and intra-annual and which affects on agriculture production and productivity.

Annual normals of rainfall

The data of taluka-wise annual normal of weather parameter (i.e. rainfall and rainy days) calculated by using last 20 years (1998-2017) rainfall data of Nanded district (taluka-wise). It showed that average rainfall of Nanded district is 816.4 mm with 45.0 rainy days.

Annual mean for rainfall

The data was given in table showed the annual mean rainfall (normal) 816.4 mm for Nanded district, while taluka-wise it was for Nanded (750.0 mm), Biloli (722.7 mm), Mukhed (782.5 mm), Kandhar (777.1 mm), Loha (776.8 mm), Hadgaon (783.5 mm), Bhokar (897.5 mm), Deglur (720.0 mm), Kinwat (987.2 mm), Mudkhed (815.6 mm), Himayat Nagar (863.2 mm), Mahur (1009.9 mm), Dharmabad (764.0 mm), Umri (830.9 mm), Ardhapur (827.0 mm) and Naigaon taluka (754.3 mm).

It means that the annual mean rainfall (normal) was intra-high and it ranges 720.0 mm in Deglur and 1009.9 mm in Mahur taluka.

Annual mean for rainy days

The data was given in table showed the annual mean rainy days for Nanded district (45.0 days). While, taluka-wise it was for Nanded (43.4), Biloli (43.1), Mukhed (48.6), Kandhar (44.3), Loha (42.8), Hadgaon (44.5), Bhokar (46.3), Deglur (42.4), Kinwat (52.8), Mudkhed (42.7), Himayat Nagar (48.4), Mahur (46.2), Dharmabad (45.4), Umri (45.5),

Ardhapur (43.2) and Naigaon taluka (41.5).

The lowest normal rainy days were observed in Naigaon (41.5 rainy days) and highest in Kinwat taluka (52.8 rainy days).

The lowest monthly mean rainfall amongst all the taluka was observed in Nanded, Kandhar, Loha, Hadgaon, Bhokar, Kinwat, Mahur, Dharmabad, Ardhapur and Naigaon (0.0 mm) in the month of December and the highest monthly mean rainfall amongst all the taluka was observed in Mahur (283.1 mm) in the month of July. While, considering the district monthly mean rainfall on annually basis the highest rainfall of 219.6 mm was received in July month and lowest rainfall of 0.2 mm was received during the month of December each in Nanded district.

The highest monthly mean rainy days amongst all the taluka was observed in Nanded in the month of July (11.9 rainy days), in Biloli in the month of July (11.1 rainy days), in Mukhed in the month of July (14.7 rainy days), Kandhar in the month of August (10.9 rainy days), Loha in the month of July (10.8 rainy days), Hadgaon in the month of July (11.9 rainy days), Bhokar in the month of July (12.2 rainy days), Deglur in the month of July and August (11.0 rainy days), Kinwat in the month of July (13.7 rainy days), Mudkhed in the month of July (11.7 rainy days), Himayat Nagar in the month of July (15.5 rainy days), Mahur in the month of July (12.4 rainy days), Dharmabad in the month of September (11.2 rainy days), Umri in the month of July (12.1 rainy days), Ardhapur in the month of August (11.1 rainy days), Naigaon in the month of July (10.4 rainy days). While considering whole Nanded district of Himayat Nagar highest rainy days (15.5) were observed in the month of July. The statistical analysis for variability was observed within the year; season to season in Nanded district and it was ranged between 9.13 per cent (post- monsoon) to 32.45 per cent (winter). Whereas, in

summer season and monsoon season C.V.(%) observed was 24.03 per cent and 14.35 per cent only respectively. The seasonal rainfall distribution of Nanded district obtained in winter season 6.1 mm, in summer season 15.5 mm, in monsoon season 578.3 mm and in post monsoon season 216.6 mm.

The highest rainfall in monsoon season was recorded in Mahur taluka as 780.8 mm and the lowest rainfall of monsoon season was recorded in Naigaon 501.6 mm.

The annual mean rainfall (normal) of Nanded district was 816.4 mm. While, the taluka-wise mean rainfall (normal) was observed in Nanded (750.0 mm), Biloli (722.7 mm), Mukhed (782.5 mm), Kandhar (777.1 mm), Loha (776.8 mm), Hadgaon (783.5 mm), Bhokar (897.5 mm), Deglur (720.0 mm), Kinwat (987.2 mm), Mudkhed (815.6 mm), Himayat Nagar (863.2 mm), Mahur (1009.9 mm), Dharmabad (764.0 mm), Umri (830.9 mm), Ardhapur (827.0 mm) and Naigaon taluka (754.3 mm). It means that intra-taluka variation of normal rainfall was high and it ranged from lowest (720.0 mm) in Deglur and highest (1009.9 mm) in Mahur taluka).

The statistical analysis for rainfall variability was worked out and it was intra-annual as well as intra-taluka variation in Nanded district. It was ranged between 19.0 to 51.0 per cent with annual mean 45.0 rainy days per year.

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