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Analysis of Rainfall and Other Weather Parameters under Climatic Variability of Parbhani (2011-2015)

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A B S T R A C T

Parbhani is intersected by 19^008' N latitude and 76^050' E longitude. The average annual rainfall at Parbhani station is 750-800mm, which is mostly received from south-west monsoon. The weather parameters include mean monthly rainfall, average weekly rainfall (AWR) and average annual rainfall. All other meteorological parameters were analysed on monthly basis to study the climatic variability. The maximum average weekly rainfall of Parbhani was 154mm recorded in 2013 during 29th meteorological week. The July month of 2013 recorded maximum rainfall of 421.2mm. Monsoon season of 2013 recorded maximum average rainfall with 1017.1mm when compared with all other seasons. Annual average maximum rainfall of 1207.3mm was observed in 2013 and minimum average annual rainfall of 569.7mm was recorded during 2014 with a mean average annual rainfall of 743.5mm. May month of 2013 recorded maximum average monthly temperature of 42.75^0C and minimum average monthly temperature of 9.51^0C was recorded in January, 2011 when compared with all other months of entire study period from 2011 to 2015.Maximum average monthly relative humidity of 91.17% was recorded in September month of 2012 while monthly minimum RH was recorded in March month with 12.39% of the same year. May month of 2013 recorded maximum evaporation rate with 15.15mm while August month of the same year recorded minimum evaporation rate of 3.71mm in the entire study period. Maximum average monthly bright sun shine hours were recorded in April, 2011 with 10.58hrs and minimum was recorded in the month of July, 2013 with 2.71hrs. June month of 2011 recorded maximum average monthly wind speed of 9.05kmph while lowest was observed in December month of the same year with 2.56kmph.

Introduction

Rainfed agriculture is a highly risky business. Uncertain precipitation is a major constraint to crop production especially when it occurs at an unexpected time and problems become aggravated if dry conditions prevail for a longer time (Jestinos Mzezewa1 *et al.,* 2010). 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 hydrologic process. 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 monsoonic winds increase from June to July and begin to weaken in September especially in north India.

The occurrence of certain amounts of rainfall at crucial times can determine the successes of failure of crop it depends on the the duration of stress period (Biswas, 1981). The average annual rainfall over the plains of India is 119.4cm and the average for the lands of the world put together is only 70cm per year. Though India has 1.7 times the average annual rainfall of whole world, its agricultural production is at low level. The average annual rainfall of Maharastra is 120cm whereas rainfall of Marathwada varies between 550mm to 1100mm with an average of 774mm. The precipitation of Parbhani varies from 700-800mm per year with an average of 745mm. Precipitation is very uncertain in this region and sometimes suffers from severe droughts.

Under such circumstances for increasing crop productivity, better crop planning for carrying out the different agricultural activities at proper time could be beneficial (Cannarozzo *et al.,* 2006). For better crop planning, information related to the dates of onset of effective monsoon, evaporation data depending on sunshine hours, temperature during the different developmental stages of the crops plays an important role.

Keeping these points in view, a special problem was undertaken with the following objectives:

To analyze monthly data of various meteorological parameters viz, Rainfall, wind speed, maximum and minimum temperature, evaporation rate, bright sunshine hours and morning and evening relative humidity of last five years for Parbahni.

To analyze rainfall data on weekly, monthly, seasonally and yearly basis of last five years for Parbhani

Materials and Methods

Features of study area

The area is located in semi-arid region of Maharastra state. Parbhani is intersected by $19^{0}08'$ N latitude and $76^{0}50'$ E longitude. It comes under moderate rainfall zone at an altitude of 409m above mean sea level. The average annual rainfall at Parbhani station is 750-800mm, which is mostly received from south-west monsoon. Monsoon is generally concentrated over the months of June to September. The average annual air temperature is about 25.95^{0}C and the coldest and warmest monthly temperatures are 9.5^{0}C and 42^{0}C in December and May respectively.

Data collection and analysis

The methodology consists of collection of long term daily weather data such in respect of rainfall (mm) and other meteorological parameters. The daily rainfall data during 2011-2015 was collected from meteorology department, Parbhani and analyzed on annual basis. The daily rainfall data collected from meteorological department was concised to annual basis from 2011 – 2015 along with deviation. The number of rainy days was also calculated yearly and was presented graphically. For monthly temporal analysis the daily data was averaged or sum up into month from January to December and grouped into years for the period of 2011 -2015.whereas for seasonal rainfall analysis monthly data was grouped into three seasons as summer (March-May), monsoon (June – September) and winter (October – February). The parameters were then analyzed using statistical tools such as Mean, Standard deviation and Coefficient of variance.

Results and Discussion

Record of daily rainfall data for 5 years for Parbhani station was obtained from the Department of Agricultural Meteorology, V.N.M.K.V, Parbhani. Data were analyzed to determine rainfall characteristics influencing agricultural operations and irrigation management.

The characteristics include mean monthly rainfall, average weekly rainfall (AWR) and average annual rainfall. All other meteorological parameters such as maximum temperature, minimum temperature, wind speed, morning relative humidity, evening relative humidity, evaporation, and bright sunshine hours of each day from 2011-2015 were collected. These parameters were analysed on monthly basis to study the climatic variability.

Weekly Analysis of Rainfall Data

The daily rainfall data of the station was grouped into weeks from January 1st to December 31st according to meteorological weeks. The weekly rainfall data for the entire period from 2011 to 2015 are tabulated in table 1.

Table 1 Indicates that 29th meteorological week of 2013 received highest rainfall (154 mm) and had highest standard of deviation (76.10) when compared with all other meteorological weeks of entire study period from 2011 to 2015. Highest coefficient of variance was observed in 17th week. Figure 1 depicts the graphical presentation of average weekly rainfall data

Monthly Average Rainfall

The daily rainfall data of the Parbhani station was grouped into months from January to December. The monthly average rainfall data

for the entire period from 2011 to 2015 are tabulated in table 2.

The table 2 Revealed that the July month of 2013 had highest rainfall of 421.2 mm with highest standard deviation of 156.28 when compared with all other months of the entire period from 2011 – 2015.

Highest coefficient of Variance of 223.68% was observed during December month. A similar finding was reported by Mohd Asim and Satyendra Nath (2015).

Monthly Maximum Average Temperature

Daily maximum temperature data was collected and analyzed into monthly basis. The table 3 depicts the monthly average maximum temperature of Parbhani from 2011-2015

The table 3 revealed that May month of 2013 recorded maximum average monthly temperature of 42.75^{0}C when compared with all other months of entire study period from 2011 to 2015. Highest coefficient of Variance was observed in July month, which was about 6.72%.

Monthly Minimum Average Temperature

Daily minimum temperature data was collected and analyzed into monthly basis. The table 4.3 depicts the monthly average minimum temperature of Parbhani from 2011-2015.

From the table 4 it was observed that January month of 2011 had minimum average monthly temperature when compared with all other months of last five years.

It recorded 9.51^{0}C. November month recorded highest coefficient of variance which was about 15.82%.

Table.1 Weekly rainfall analysis of last five years data for Parbhani (in mm)

WK	Period	Year					Mean	S.D	CV (%)
		2011	**2012**	**2013**	**2014**	**2015**			
01	01-07 Jan.	0.0	0.0	1.0	0.0	9.2	2.04	4.06	199.02
02	08-14 Jan.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
03	15-21 Jan.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
04	22-28 Jan.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
05	29-04 Feb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
06	05-11 Feb.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
07	12-18 Feb.	0.0	0.0	18.5	0.0	0.0	03.7	8.27	223.51
08	19-25 Feb.	0.0	0.0	4.2	8.0	0.0	2.44	3.06	125.41
09	26-04 Mar.	0.0	0.0	0.0	22.8	24.3	9.42	12.91	137.05
10	05-11 Mar.	0.0	0.0	0.0	70.7	16.6	17.46	30.62	175.37
11	12-18 Mar.	0.0	0.0	8.6	0.0	0.0	1.72	3.85	223.84
12	19-25 Mar.	1.0	0.0	0.0	0.0	0.0	0.2	0.45	225.00
13	26-01 Apr.	0.7	0.0	0.0	0.0	0.0	0.14	0.31	221.43
14	02-28 Apr	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	09-15 Apr	18.6	0.0	0.0	0.5	24.6	8.74	11.93	136.50
16	16-22 Apr	4.2	0.6	0.0	3.7	67.2	15.14	29.16	192.60
17	23-29 Apr.	0.6	0.0	0.0	0.0	0.0	0.12	0.27	**225.00**
18	30-06 May	15.2	0.0	0.0	8.6	22.8	9.32	9.88	106.09
19	07-13 May	0.5	0.8	0.0	1.0	2.0	0.86	0.74	86.05
20	14-20 May	0.0	0.6	0.0	4.2	0.0	0.96	1.83	190.63
21	21-27 May	0.7	4.0	0.0	10.0	0.0	2.94	4.28	145.58
22	28-03 June	3.0	0.0	0.0	12.5	0.0	3.10	5.41	174.51
23	04-10 June	11.8	8.3	107.5	6.0	27.0	32.12	42.93	133.66
24	11-17 June	0.0	1.6	29.2	13.0	61.1	20.98	25.28	120.50
25	18-24 June	5.6	58.2	24.0	24.5	37.5	29.96	19.45	64.92
26	25-01 July	15.9	14.4	41.8	0.0	0.0	14.42	17.09	118.52
27	02-08 July	64.2	37.3	80.1	0.5	5.0	37.42	35.19	94.04
28	09-15 July	75.4	27.2	107.4	73.8	0.0	56.76	42.71	75.25
29	16-22 July	17.8	134.9	**154.0**	1.5	0.6	61.76	76.10	123.22
30	23-29 July	93.7	21.0	51.5	26.2	8.0	40.08	33.88	84.53
31	30-05 Aug	65.0	18.9	77.5	32.4	19.8	42.72	26.95	63.09
32	06-12 Aug	2.8	5.9	19.7	16.7	28.8	14.78	10.57	71.52
33	13-19 Aug	39.3	4.8	50.2	0.0	21.0	23.06	21.62	93.76
34	20-26 Aug	61.3	35.4	9.3	59.8	13.6	35.88	24.60	68.56
35	27-02 Sept	36.7	40.6	0.0	91.0	0.0	33.66	37.45	111.26
36	03-09 Sep	29.3	108.4	29.8	33.9	88.1	57.9	37.57	64.89
37	10-16 Sep	50.0	28.4	84.5	7.4	38.4	41.74	28.57	68.45
38	17-23 Sep	35.0	61.9	150.6	3.4	57.4	61.66	54.85	88.96
39	24-30 Sep	10.0	21.8	0.0	0.0	0.0	6.36	9.66	151.89
40	01-07 Oct.	16.4	49.0	40.8	1.6	1.8	21.92	22.01	100.41
41	08-14 Oct.	2.8	0.0	66.2	13.8	0.0	16.56	28.33	171.07
42	15-21 Oct.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

43	22-28 Oct.	0.0	0.0	10.3	9.2	0.0	3.9	5.35	137.18
44	29-04 Nov.	0.0	3.2	0.0	0.0	0.0	0.64	1.43	223.44
45	05-11 Nov.	0.0	1.0	0.0	2.2	0.0	0.64	0.97	151.56
46	12-18 Nov.	0.0	0.0	0.0	10.8	0.0	2.16	4.83	223.61
47	19-25 Nov.	0.0	0.0	14.0	0.0	0.0	2.80	6.26	223.57
48	26-02 Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
49	03-09 Dec.	0.0	0.0	26.6	0.0	0.0	5.32	11.90	223.68
50	10-16 Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
51	17-23 Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
52	24-31 Dec.	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Total	**677.5**	**688.2**	**1207.3**	**569.7**	**574.8**	**743.5**	_	_

Table.2 Mean Monthly Average Rainfall of Parbhani (In mm)

Month	Year					Mean	S.D	CV (%)
	2011	**2012**	**2013**	**2014**	**2015**			
January	00.0	00.0	01.0	00.0	09.2	2.04	4.03	197.55
February	00.0	00.0	22.7	24.4	00.0	9.42	12.91	137.05
March	01.7	00.0	08.6	77.1	40.9	25.66	33.17	129.27
April	23.4	00.6	00.0	07.2	91.8	24.6	38.73	157.44
May	16.4	05.4	00.0	25.3	24.8	14.38	11.39	79.21
June	36.3	82.5	202.5	51.5	125.6	99.68	66.85	67.06
July	259.9	231.3	**421.2**	102.0	13.6	205.6	**156.28**	76.01
August	189.3	71.1	128.5	176.5	83.2	129.72	53.24	41.04
September	131.3	244.1	264.9	68.1	183.9	178.46	80.95	45.36
October	19.2	49.0	117.3	24.6	01.8	42.38	45.16	106.56
November	00.0	04.2	14.0	13.0	00.0	6.24	6.85	109.78
December	00.0	00.0	26.6	00.0	00.0	5.32	11.90	**223.68**
Total	**677.5**	**688.2**	**1207.3**	**569.7**	**574.8**	**743.5**	**265.14**	**35.66**

Table.3 Mean Monthly Average Maximum temperature

Month	Year					Mean	S.D	CV (%)
	2011	**2012**	**2013**	**2014**	**2015**			
January	29.85	30.04	30.86	29.86	28.95	29.91	0.68	2.27
February	32.35	33.33	32.84	31.22	33.30	32.61	0.87	2.67
March	37.00	37.34	37.25	33.66	34.65	35.98	1.71	4.75
April	38.93	40.32	39.94	39.06	37.87	39.22	0.96	2.45
May	41.09	41.78	**42.75**	39.87	41.75	41.45	1.06	2.56
June	36.03	37.30	33.12	38.60	35.63	36.14	2.05	5.67
July	31.79	31.57	29.44	33.25	35.28	32.27	2.17	**6.72**
August	30.60	31.24	29.20	32.28	31.70	31.00	1.18	3.81
September	31.18	31.07	31.98	31.00	32.48	31.54	0.66	2.09
October	33.67	32.39	31.57	33.84	35.03	33.30	1.35	4.05
November	32.13	30.79	30.35	32.15	_	31.36	0.92	2.93
December	30.52	30.83	29.05	29.40	_	29.95	0.86	2.87

Table.4 Mean Monthly minimum average Temperature

Month	Year					Mean	S.D	CV (%)
	2011	**2012**	**2013**	**2014**	**2015**			
January	**9.51**	12.25	13.73	12.95	11.41	11.97	1.62	13.53
February	13.59	14.22	15.80	13.18	13.77	14.11	1.01	7.16
March	16.88	15.56	18.15	17.81	18.09	17.30	1.10	6.36
April	21.93	23.48	22.97	20.80	20.27	21.89	1.37	6.26
May	25.51	26.00	26.85	23.17	24.93	25.29	1.38	5.46
June	24.71	25.51	23.36	25.52	24.37	24.69	0.90	3.65
July	23.19	23.25	22.43	23.09	24.57	23.31	0.78	3.35
August	22.39	22.38	22.25	21.80	23.00	22.36	0.43	1.92
September	21.80	22.13	22.40	20.52	22.17	21.80	0.75	3.44
October	18.52	18.30	20.69	18.98	19.53	19.20	0.96	5.00
November	13.68	19.02	13.95	15.56	_	15.55	2.46	**15.82**
December	10.67	12.70	10.76	9.98	_	11.03	1.17	10.61

Table.5 Mean Monthly Average Minimum Relative Humidity

Month	year					Mean	S.D	CV (%)
	2011	**2012**	**2013**	**2014**	**2015**			
January	30.32	28.32	31.87	35.71	31.77	31.60	2.71	8.58
February	29.25	23.79	31.32	29.82	21.61	27.16	4.21	15.50
March	18.81	**12.39**	18.58	35.13	28.68	22.72	9.06	**39.88**
April	20.27	15.13	17.47	19.63	24.73	19.45	3.58	18.41
May	19.77	15.97	15.77	23.48	19.10	18.82	3.17	16.84
June	42.13	35.27	58.53	31.57	45.87	42.67	10.49	24.58
July	62.00	63.35	70.94	55.32	42.20	58.76	10.79	18.36
August	66.71	62.45	67.74	60.55	58.03	63.10	4.10	6.50
September	61.17	65.00	58.33	60.63	55.37	60.10	3.57	5.94
October	36.77	39.35	57.58	38.39	34.35	41.29	9.30	22.52
November	28.87	37.40	38.87	34.37	_	34.88	4.42	12.67
December	28.32	31.52	33.77	29.10	_	30.68	2.47	8.05

Table.6 Mean Monthly Average Evaporation (mm)

Month	Year					Mean	S.D	CV (%)
	2011	**2012**	**2013**	**2014**	**2015**			
January	4.27	4.81	5.09	4.47	4.70	4.69	0.31	6.61
February	5.65	6.16	6.17	5.55	6.91	6.09	0.54	8.87
March	7.69	9.03	9.15	6.71	7.73	8.06	1.02	12.66
April	9.50	11.61	11.23	9.26	9.03	10.13	1.20	11.85
May	11.79	14.52	**15.15**	10.86	12.60	12.98	1.81	13.95
June	8.30	9.68	6.04	10.29	7.23	8.31	1.74	20.94
July	4.63	4.08	3.85	6.18	9.20	5.59	2.21	**39.53**
August	3.97	4.44	**3.71**	5.15	5.48	4.55	0.75	16.48
September	4.63	4.05	4.73	4.79	5.58	4.76	0.55	11.55
October	5.77	5.09	4.63	6.69	7.04	5.84	1.02	17.47
November	5.85	4.55	5.00	5.21	_	5.15	0.54	10.50
December	4.88	4.91	4.41	4.81	_	4.75	0.23	4.84

Table.7 Mean Monthly Average Bright Sunshine Hours (hr)

Month	Year					Mean	S.D	CV (%)
	2011	2012	2013	2014	2015			
January	9.65	9.54	8.36	7.94	7.95	8.69	0.85	9.78
February	10.05	9.86	8.69	9.44	9.26	9.46	0.53	5.60
March	10.47	10.47	8.95	8.54	8.45	9.38	1.02	10.87
April	**10.58**	9.80	9.95	9.19	9.17	9.74	0.59	6.06
May	9.65	9.81	9.64	9.01	8.97	9.42	0.39	4.14
June	6.97	7.44	4.28	7.27	6.07	6.41	1.30	20.28
July	4.59	3.20	**2.70**	4.31	6.08	4.18	1.32	**31.58**
August	3.93	4.23	3.01	5.97	5.00	4.43	1.12	25.28
September	6.55	6.05	6.28	5.59	6.92	6.28	0.50	7.96
October	9.33	7.50	6.87	7.76	8.39	7.97	0.94	11.79
November	9.70	8.13	8.38	7.83	_	8.51	0.82	9.64
December	9.74	9.32	8.84	8.31	_	9.05	0.62	6.85

Table.8 Mean Monthly Average Wind Speed (Km/Hr)

Month	year					Mean	S.D	CV (%)
	2011	2012	2013	2014	2015			
January	2.93	3.60	3.55	3.78	3.95	3.56	0.39	10.96
February	3.56	3.76	3.97	4.35	4.41	4.01	0.37	9.23
March	4.06	3.76	4.02	4.68	5.08	4.32	0.54	12.5
April	5.58	4.45	5.28	4.13	4.65	4.82	0.60	12.45
May	7.03	7.48	7.59	5.44	6.57	6.82	0.87	12.76
June	**9.05**	7.75	6.39	8.11	6.75	7.61	1.07	14.06
July	6.26	5.82	5.58	8.08	8.91	6.93	1.48	**21.36**
August	4.59	5.07	5.10	5.33	6.20	5.26	0.59	11.22
September	4.09	3.73	3.67	4.25	4.19	4.00	0.27	6.75
October	3.53	3.30	3.46	3.96	3.21	3.49	0.29	8.31
November	3.81	2.91	3.26	3.34	_	3.33	0.37	11.11
December	**2.56**	3.27	2.83	3.85	_	3.13	0.56	17.89

Fig.1 Graphical presentation of weekly average rainfall data
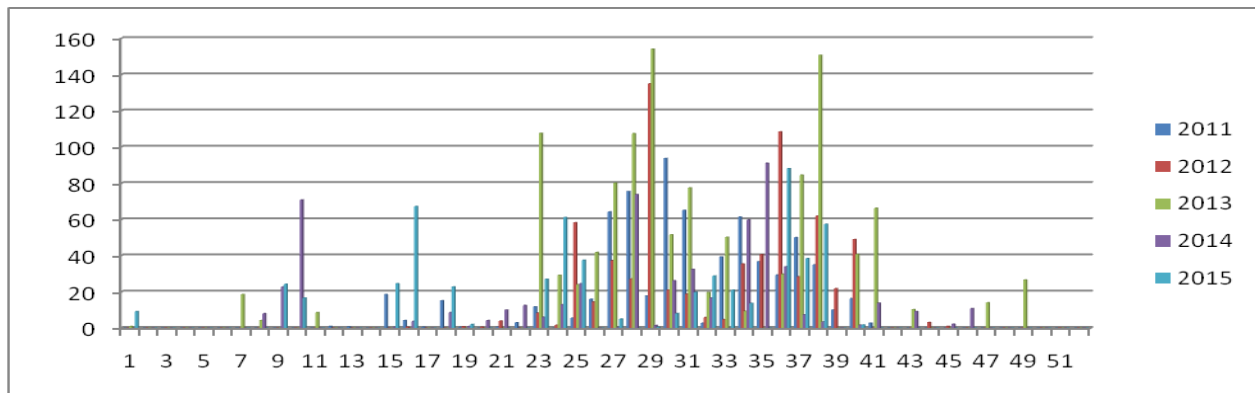
Monthly Maximum Average Relative Humidity (RH)

The table 5 indicates that March month of 2012 recorded lowest monthly minimum average RH in last five years with 12.39%. 39.88% of highest CV was also recorded in March month.

Mean Monthly Average Evaporation

Table 6 shows that May month of 2013 recorded highest monthly average evaporation with 15.15mm and August month of 2013 recorded lowest monthly average evaporation of 3.71mm in last 5 years. Highest coefficient of Variance was recorded in July month with 39.53%.

Monthly Average Bright Sunshine Hours (BSS)

From the table 7, it can be observed that April month of 2011 recorded highest monthly average BSS and July month of 2013 recorded lowest monthly average BSS. They recorded 10.58 and 2.70 hours respectively. July month recorded highest CV of 31.58% in last 5 years.

Monthly Average Wind Speed

The table 8 indicates that June month of 2011 recoded highest monthly average wind speed of 9.05km/hr and lowest monthly average wind speed of 2.56km/hr was observed in December month of the same year.

In general, July month recorded highest coefficient of Variance of 21.36% in last five years. Above results are in accordance with the results of Mohd Asim and Satyendra Nath (2015).

The daily meteorological data for Parbhani station was collected from Department of Meteorology, Vasanthrao Naik Krishi Vidyapeeth for last five years (2011 -2015). The daily rainfall data was arranged and grouped into weekly, monthly, seasonal and annual basis while all other remaining parameters like maximum temperature, minimum temperature, minimum relative humidity, maximum relative humidity, bright sun shine hours, evaporation and wind speed were converted into monthly basis from January to December all over the period from 2011 to 2015. Average, standard deviation and coefficient of variance was calculated for each parameter.

Based on the results of the study following conclusions are drawn

The maximum average weekly rainfall of Parbhani was 154mm recorded during 2013 in 29th meteorological week.

The maximum average monthly rainfall of 421.2mm was recorded in July during 2013.

Monsoon season of 2013 recorded maximum average rainfall with 1017.1mm when compared with all other seasons.

Annual average maximum rainfall of 1207.3mm was observed in 2013 and minimum average annual rainfall of 569.7mm was recorded during 2014 with a mean average annual rainfall of 743.5mm.

May month of 2013 recorded maximum average monthly temperature of 42.75^0C and minimum average monthly temperature of 9.51^0C was recorded in January, 2011 when compared with all other months of entire study period from 2011 to 2015.

Maximum average monthly relative humidity of 91.17% was recorded in September month of 2012 while minimum RH was recorded in March month with 12.39% of the same year.

May month of 2013 recorded maximum evaporation rate with 15.15mm while August month of the same year recorded minimum evaporation rate of 3.71mm in the entire study period.

Maximum average monthly bright sun shine hours were recorded in April, 2011 with 10.58hrs and minimum was recorded in the month of July, 2013 with 2.71hrs.

June month of 2011 recorded maximum average monthly wind speed of 9.05kmph while lowest was observed in December month of the same year with 2.56kmph.

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