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Wind Speed and Sunshine Hours Duration Trends over North-Eastern Dry Zone of Karnataka

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Abstract Wind speed and sunshine hours duration scenarios over North-Eastern dry zone of Karnataka have been statistically analyzed on weekly basis and trends were analyzed on monthly basis. The data of wind speed of 35 years (1980–2015) and sunshine hours for 17 years (1999–2015) was used. The results shows that, in the recent decade (2006–2015), the parameters like mean, maximum and minimum weekly wind speeds exhibited slightly decreasing scenario in comparison to past 2.5 decades (1981–2005). The significant decreasing wind speed trends were observed during April, June, July, August, September, October, November and December months. The mean weekly sunshine hours ranged from 4.3 h (29th SMW) to 9.1 h (8, 14 and 16th SMW). The significant decreasing trends of sunshine hours were observed for March, April, November and December months during study period at Raichur, Karnataka.

Keywords Wind speed, Sunshine hours, Trends of climatological parameters.

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Introduction

Climate plays an important role in every aspect of human life. Change in climate has been documented in many locations throughout the world but most of these studies focus on changes in temperature and precipitation only [1]. Hence, in this study an attempt has been made to study in detail about wind speed and sunshine hours duration trends over North-Eastern dry zone of Karnataka. Sunshine is a key factor in most climate processes. Sunshine can have a profound impact on the systematic change in climate elements, such as temperature and wind speed and in turn affects many aspects of the human society [2]. In recent years, there has been a substantial interest in the variation of sunshine duration due to the dramatic global climate change [3]. Sunshine hours for particular region are very essential since sun is the primary source of energy to various physical, chemical, biological and geological processes taking place on the surface of the earth. Intensity and duration of sunshine hours play important role in determining evaporation rates over any region. The phenological growth and yield of crops largely influenced by the thermal regime and sunshine hours.

Wind is an important element which brings about physiological, morphological and anatomical changes in plants. Most of the exchange processes of mass, energy and momentum between crops, atmosphere and soil are brought about by wind as an agent. Wind directly affects evaporation and transpiration rates [4]. Strong winds will cause lodging of many agricul-

Table 1. Weekly wind speed statistical parameters during 1981–2005 (Past 2.5 decades) at Raichur.

SMW	Mean (km/h)	Max (km/h)	Min (km/h)	SD (km/h)	CV (%)	Skewness
1	4.5	10.4	1.6	1.7	38.0	1.2
2	4.6	11.0	1.5	1.8	39.7	0.9
3	4.9	19.0	1.5	2.5	50.2	2.1
4	5.2	10.4	1.0	2.1	40.3	0.6
5	4.8	14.0	1.2	2.0	41.5	1.6
6	5.1	12.1	0.8	1.8	35.9	0.8
7	5.2	15.0	1.8	2.1	40.3	1.7
8	5.7	21.2	2.4	2.8	49.4	2.4
9	5.5	14.8	2.1	2.1	38.1	1.6
10	5.4	12.2	1.3	1.8	34.1	0.7
11	5.4	13.0	0.9	1.9	35.4	0.7
12	5.3	10.3	2.1	1.6	30.1	0.5
13	5.6	16.0	1.1	1.8	32.4	1.4
14	5.8	15.5	1.7	1.9	33.2	1.4
15	6.0	15.3	1.2	2.2	36.7	1.3
16	6.3	13.8	2.5	1.9	29.7	1.2
17	6.5	14.5	0.6	2.0	31.7	0.8
18	7.1	17.1	2.2	2.2	31.6	0.9
19	7.7	14.9	2.0	2.4	31.9	0.4
20	8.9	21.5	1.9	3.2	36.2	0.9
21	9.5	21.3	2.5	3.4	35.8	0.9
22	10.0	24.4	3.7	4.1	41.5	1.1
23	10.6	24.6	2.5	4.4	41.3	0.6
24	11.7	20.7	2.7	4.2	35.6	0.1
25	13.4	27.1	3.1	4.3	32.3	0.3
26	12.1	29.1	4.3	4.0	33.0	0.5
27	11.7	30.3	4.0	4.5	38.9	0.9
28	11.2	33.8	3.2	4.5	39.8	1.0
29	11.6	22.7	2.1	4.1	35.0	0.1
30	11.2	22.3	3.9	3.5	31.2	0.4
31	10.5	21.9	2.1	3.5	33.8	0.2
32	11.3	21.6	3.3	4.3	38.4	0.4
33	10.5	22.3	2.6	4.3	40.4	0.5
34	10.2	23.9	2.3	4.4	43.3	0.5
35	9.4	25.8	1.0	4.0	42.9	1.1
36	8.0	18.3	2.0	3.5	44.1	0.6
37	6.7	15.4	1.1	2.6	38.6	0.8
38	5.8	14.1	1.2	2.4	42.2	0.8
39	4.8	13.9	1.1	2.3	48.7	1.4
40	4.4	13.7	0.4	2.4	53.5	1.6
41	4.0	13.6	0.5	2.1	52.2	1.7
42	3.8	12.5	1.0	1.9	49.8	1.6
43	3.4	8.2	0.5	1.5	43.3	0.7
44	4.2	10.8	1.2	1.9	45.6	1.1
45	4.0	9.2	1.3	1.5	37.0	0.7
46	3.8	10.0	1.4	1.6	42.9	1.2
47	3.6	9.5	1.1	1.4	38.2	1.2
48	3.9	11.8	1.0	1.9	48.0	1.5
49	4.2	11.3	1.0	2.0	47.1	1.1
50	4.0	9.7	0.0	1.7	43.1	0.9
51	4.3	10.9	1.1	2.2	51.2	1.1
52	4.2	11.0	1.5	1.8	43.0	1.5

Table 2. Weekly wind speed statistical parameters during 2006–2015 (Recent decade) at Raichur.

SMW	Mean (km/h)	Max (km/h)	Min (km/h)	SD (km/h)	CV (%)	Skewness
1	3.7	10.5	1.1	1.8	47.4	1.4
2	4.0	10.4	1.0	2.2	55.9	0.9
3	4.7	15.6	0.6	3.5	74.1	1.0
4	5.0	10.8	0.3	2.7	54.7	0.5
5	5.3	12.9	1.8	2.4	46.1	0.9
6	5.1	15.4	1.3	3.1	60.4	1.1
7	5.2	21.5	1.6	3.4	64.8	2.2
8	5.5	21.6	0.5	3.9	71.6	1.8
9	6.3	21.7	0.1	4.2	66.9	1.6
10	5.5	15.0	1.0	3.0	54.0	0.6
11	5.9	13.1	1.1	3.3	55.6	0.5
12	5.1	10.2	1.0	2.2	43.4	0.3
13	5.4	16.0	1.4	2.7	50.3	1.2
14	4.9	9.7	1.4	2.2	45.6	0.5
15	5.2	11.7	0.5	3.1	59.9	0.5
16	5.2	10.4	0.4	2.7	52.6	0.4
17	5.5	12.2	0.7	2.4	44.8	0.5
18	6.1	15.1	1.1	3.1	50.3	0.6
19	6.5	19.0	1.0	3.5	53.6	1.1
20	7.1	19.0	1.1	4.3	60.8	0.9
21	9.5	28.0	1.0	5.3	56.1	0.9
22	7.8	15.6	1.5	3.9	50.7	0.3
23	8.2	24.0	1.2	4.9	60.1	0.9
24	9.2	22.8	1.3	5.8	63.6	0.6
25	10.8	24.9	1.4	7.3	67.7	0.3
26	10.4	24.6	1.0	6.4	62.0	0.6
27	10.1	22.9	0.8	6.2	61.7	0.3
28	10.5	22.4	0.1	5.2	49.8	0.2
29	10.6	22.7	1.2	6.0	56.4	0.5
30	9.3	22.3	0.7	5.6	59.8	0.6
31	10.4	23.0	1.4	5.8	55.3	0.4
32	10.4	21.7	1.3	4.4	42.1	0.3
33	7.6	17.4	0.0	4.1	54.2	0.3
34	5.5	17.3	0.1	4.1	73.9	1.1
35	6.2	14.3	0.0	3.4	56.0	0.2
36	5.5	20.2	0.0	3.9	71.1	1.2
37	4.3	13.2	0.0	2.8	66.0	0.8
38	4.4	11.8	0.1	3.0	67.5	0.3
39	3.6	9.5	0.1	2.7	75.1	0.5
40	3.3	10.4	0.1	2.7	82.3	1.0
41	2.6	9.3	0.1	1.8	68.1	1.7
42	3.4	7.8	0.2	1.9	55.8	0.8
43	3.7	11.8	0.4	2.1	56.5	1.3
44	3.3	7.2	0.0	1.8	55.5	0.3
45	3.3	11.8	0.0	2.4	73.7	1.3
46	3.5	11.0	0.0	2.5	70.9	1.0
47	3.4	11.8	0.1	2.4	70.2	1.3
48	3.3	8.6	0.3	1.8	52.6	1.0
49	3.5	10.2	0.0	1.9	53.2	1.0
50	3.2	7.7	0.4	1.7	53.3	0.8
51	3.8	8.5	0.3	2.1	55.5	0.5
52	3.5	8.9	0.0	2.2	64.4	0.8

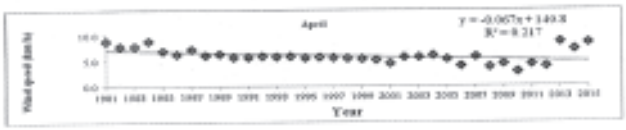

Fig. 1: Trend analysis of wind speed of April month (1981-2015) at Raichur

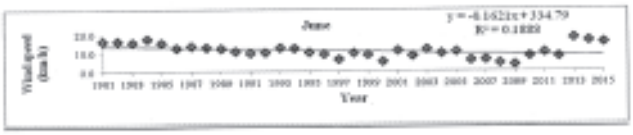

Fig. 2: Trend analysis of wind speed of June month (1981-2015) at Raichur

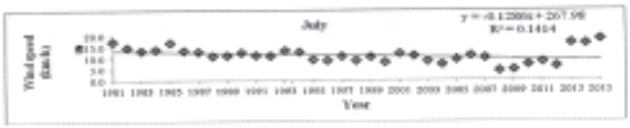

Fig. 3: Trend analysis of wind speed of July month (1981-2015) at Raichur

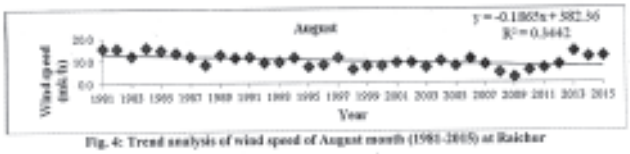

Fig. 4: Trend analysis of wind speed of August month (1981-2015) at Raichur

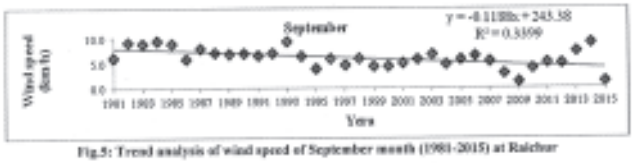

Fig.5: Trend analysis of wind speed of September month (1981-2015) at Raichur

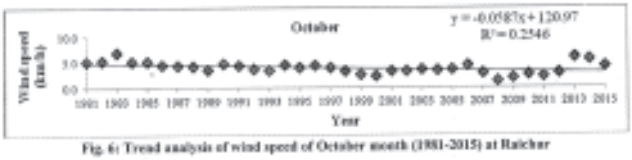

Fig. 6: Trend analysis of wind speed of October month (1981-2015) at Raichur

Fig.1. Trend analysis of wind speed of April month (1981–2015) at Raichur. **Fig. 2.** Trend analysis of wind speed of June month (1981–2015) at Raichur. **Fig. 3.** Trend analysis of wind speed of July month (1981–2015) at Raichur. **Fig. 4.** Trend analysis of wind speed of August month (1981–2015) at Raichur. **Fig. 5.** Trend analysis of wind speed of September month (1981–2015) at Raichur. **Fig. 6.** Trend analysis of wind speed of October month (1981–2015) at Raichur.

tural crops thereby cause reduction in yield of food grains. Winds have strong influence on configuration and distribution of plants in particular region [5].

Materials and Methods

Raichur district is situated in North-Eastern dry zone of Karnataka state. It falls in the Northern maiden

Table 3. Weekly sunshine hours statistical parameters (1999–2015) at Raichur.

SMW	Mean (hr)	Max (hr)	Min (hr)	SD (hr)	CV (%)	Skew-ness
1	7.3	9.4	0.6	1.9	25.5	-1.8
2	7.8	9.2	1.2	1.3	16.2	-2.2
3	8.2	9.8	2.3	1.1	13.5	-2.3
4	8.2	9.8	1.2	1.3	15.9	-2.0
5	8.1	9.8	2.4	1.6	19.2	-1.6
6	8.5	10.3	2.9	1.3	14.9	-1.8
7	8.8	10.4	1.5	1.3	14.9	-3.1
8	9.1	10.3	7.0	0.8	8.5	-0.7
9	8.9	10.3	2.2	1.2	13.8	-3.2
10	8.6	9.9	2.0	1.2	14.5	-3.0
11	8.9	10.6	4.0	1.2	14.1	-1.6
12	9.0	10.8	3.0	1.3	14.6	-1.8
13	9.0	11.0	0.0	1.7	19.0	-2.9
14	9.1	10.7	4.7	1.2	13.3	-1.4
15	8.8	10.7	0.0	1.6	17.6	-2.2
16	9.1	10.8	2.8	1.4	15.4	-1.4
17	8.8	10.8	0.0	1.9	21.3	-1.6
18	8.5	11.0	0.0	2.5	28.9	-2.2
19	8.8	10.9	0.0	1.9	21.7	-2.3
20	8.5	10.6	0.0	2.3	27.7	-2.0
21	8.0	10.7	0.0	2.2	27.3	-1.8
22	7.9	10.1	0.2	2.0	24.7	-1.7
23	7.1	10.5	0.0	2.6	36.2	-1.2
24	6.1	10.7	0.0	2.8	46.1	-0.6
25	5.9	9.3	0.0	2.6	44.4	-0.7
26	5.8	9.6	0.0	2.6	43.8	-0.5
27	5.7	9.9	0.0	2.7	46.7	-0.6
28	4.4	9.3	0.0	3.1	69.5	0.0
29	4.3	9.2	0.0	2.8	65.3	0.1
30	4.5	10.3	0.0	2.9	65.6	0.2
31	4.5	9.7	0.0	3.0	65.6	0.1
32	5.5	9.8	0.0	2.6	47.6	-0.4
33	5.0	9.6	0.0	2.8	55.8	-0.4
34	4.7	9.8	0.0	2.6	56.1	0.0
35	4.9	10.0	0.0	2.7	54.7	0.2
36	4.7	9.2	0.0	2.6	55.8	-0.1
37	5.7	9.7	0.0	3.0	53.1	-0.6
38	5.2	10.3	0.0	3.3	63.3	-0.2
39	6.3	10.0	0.0	2.6	40.6	-0.9
40	5.7	10.2	0.0	2.8	48.5	-0.5
41	5.8	9.6	0.0	2.8	47.8	-0.8
42	6.4	9.8	0.0	2.5	39.3	-1.0
43	6.4	10.0	0.0	2.7	42.0	-1.0
44	6.2	10.1	0.0	2.7	44.2	-0.8
45	7.3	10.1	0.0	2.1	29.0	-2.0
46	7.4	9.9	0.0	2.3	30.9	-1.9
47	7.1	10.3	0.3	2.1	29.1	-0.9
48	6.4	10.1	0.0	2.8	43.1	-0.8
49	7.3	9.7	0.0	2.1	29.0	-1.5
50	7.3	10.3	0.0	2.1	28.3	-1.6
51	7.4	10.1	0.6	2.1	28.2	-1.5
52	7.1	10.1	0.6	2.1	30.0	-1.4

region, between 15°33´ to 16°34´ North latitudes and 76°14´ to 77°36´ East longitudes with an elevation of 389.5 m above the mean sea level and the climate is semi-arid. The district has a total geographical area of 8,383 sq kms. Major part the year remains dry and hot. The hot season is from mid of February to the end of June. For the proposed study, the data of wind speed of 35 years (1980–2015) and sunshine hours for 17 years (1999–2015) was collected from Main Agricultural Research Station (MARS), Raichur and analysis was carried out to determine wind speed and sunshine hours duration over North-Eastern dry zone of Karnataka. The data were compiled according to different time scales and were used for further analysis.

The statistical parameters like, mean, maximum, minimum, standard deviation (SD), coefficient of variation (CV) and skewness on weekly basis were derived for wind speen for the past 2.5 decades (1981–2005) and recent decade (2006–2015). Similary, for sunshine hours statistical parameters were derived on weekly basis for study period of 17 years (1999–2015).

Trend analysis was carried out for wind speed and sunshine hours on monthly basis. The regression equations were developed and the slopes of the regression lines were compared to know the increasing or decreasing trend. The correlation coefficient values (R^2) of the developed regression equations were critically analyzed to know the significant increasing or decreasing trends at the critical limit value of 0.1 (10%) of correlation coefficient.

Results and Discussion

The weekly wind speed parameters were tabulated for past 2.5 decades (1981–2005) and recent decade (2006–2015) and are presented in Table 1 and 2 respectively. The results revealed that, during past 2.5 decades (1981–2005) the mean weekly wind speed ranges from 3.4 to 13.4 km/h. The maximum wind speed was observed to be 33.8 km/h (28th SMW). Whereas, in recent decade (2006–2015) mean weekly wind speed range varied from 2.6 to 10.8 km/h and maximum was found to be 28.0 km/h (21st SMW) respectively. It indicates that in the recent decade (2006–2015), the wins

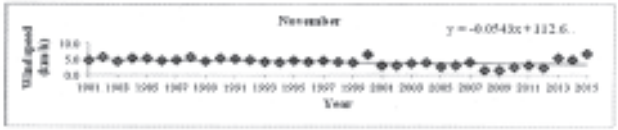

Fig. 7: Trend analysis of wind speed of Novembers month (1981-2015) at Raichur

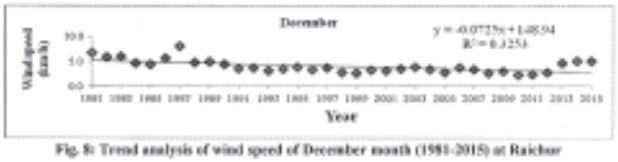

Fig. 8: Trend analysis of wind speed of December month (1981-2015) at Raichur

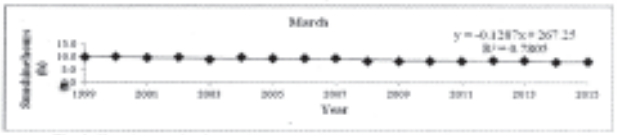

Fig. 9: Trend analysis of sunshine hours of March month (1999-2015) at Raichur

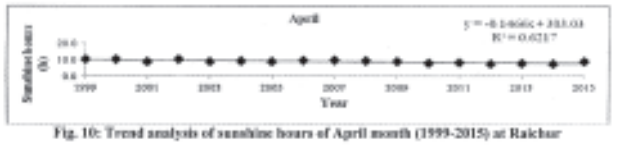

Fig. 10: Trend analysis of sunshine hours of April month (1999-2015) at Raichur

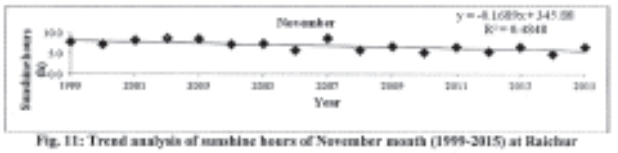

Fig. 11: Trend analysis of sunshine hours of November month (1999-2015) at Raichur

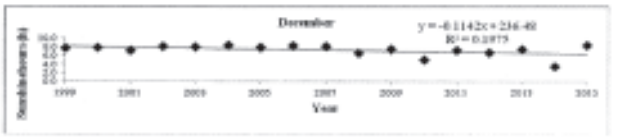

Fig. 12: Trend analysis of sunshine hours of December month (1999-2015) at Raichur

Fig.7. Trend analysis of wind speed of Novembers month (1981–2015) at Raichur. **Fig. 8.** Trend analysis of wind speed of December month (1981–2015) at Raichur. **Fig. 9.** Trend analysis of sunshine hours of March month (1999–2015) at Raichur. **Fig. 10.** Trend analysis of sunshine hours of April month (1999–2015) at Raichur. **Fig. 11.** Trend analysis of sunshine hours of November month (1999–2015) at Raichur. **Fig. 12.** Trend analysis of sunshine hours of December month (1999–2015) at Raichur.

speed exhibited declining scenario in comparison to past 2.5 decades (1981–2005). Further, CV values of recent decade showed more coefficient of variation in comparison to past 2.5 decades.

The trend analysis of monthly wind speed (1981–2015) was carried out for all 12 months (January–December). The decreasing trends of monthly wind speed were observed for all 12 months. How-

ever, significant decreasing trends ($R^2 > 0.1$) were observed during April, June, July, August, September, October, November and December months (Figs. 1–8).

The weekly sunshine hours parameters during study period (1999–2015) were tabulated and presented in Table 3. From the results, it was observed that, the mean weekly sunshine hours ranged from 4.3 h (29th SMW) to 9.1 h (8, 14 and 16th SMW). The maximum and minimum weekly sunshine hours ranged from 9.2 to 11.0 hours and 0.0 to 4.7 hours respectively. The CV for weekly sunshine hours ranged from 8.5% (8th SMW) to 69.5% (28th SMW). For weekly sunshine hours, most of the weeks showed negative skewness except 5 weeks (28–31 and 34th SMW) at Raichur.

The trend analysis of monthly sunshine hours (1999–2015) was carried out for all 12 months (January–December) where, variability in sunshine hours during different months has impact on other climatic parameters like, rainfall, temperature, relative humidity and evaporation. From results of regression analysis, it was found that the slopes of regression line were found to be negative for January–May, July, September, November and December months. The correlation coefficient value (R^2) was found to be high ($R^2 > 0.1$) for March, April, November and December months indicating significant decreasing trends (Figs. 9 to 12) during these months.

Conclusion

The significant decreasing trends were observed in wind speeds during April, June, July, August, September, October, November and December months. In the recent decade (2006–2015), the wind speed parameters have shown declining scenario in comparison to past 2.5 decades (1981–2005). Significant declining trends in sunshine hours were observed during March, April, November and December. The mean weekly sunshine hours ranged from 4.3 h (29th SMW) to 9.1 h (8, 14 and 16th SMW) during study period (1999–2015) at Raichur region, Karnataka.

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