

**Short Communication**

**Trends of rainfall and temperature in Konkan region of Maharashtra**

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Konkan is a coastal strip parallel to Sahyadri hill ranges, which rises from mean sea level to 300 meter height having annual rainfall range from 2300 mm to 4100 mm (Anonymous, 2013). Climate change is acting as a trigger for changing rainfall pattern and temperature which can have significant impacts on hydrological cycle and crop calendar of the region (Abrol *et al.*, 2004). Mono-cropping with rice cultivation during *kharif* season is generally observed while the horticultural crops like mango, cashew and coconut are major crops of the region. In last few years' production, productivity and quality of mango is adversely affected due to change in different meteorological parameters in the region (Munj *et al.*, 2017). The variability in rainfall and temperature of the Konkan region has been reported by various workers (Dixit *et al.*, 2005; Yadav and Dixit, 2006; Talathi *et al.*, 2008). However no work is reported on trends in the climatic parameters of this region. Hence, the presents study was undertaken to analyse the trends in annual and seasonal rainfall and temperature in the Konkan region.

The daily rainfall, maximum and minimum temperature data of twelve locations (Table 1) was collected from Department of Agronomy, Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli and Water Resource Department, Hydrological Project, Government of Maharashtra, Nasik. The daily data were converted in to seasonal (*kharif* from 23<sup>rd</sup> to 41<sup>st</sup> SWM, *rabi* from 42<sup>nd</sup> to 8<sup>th</sup> SWM and summer from 9<sup>th</sup> to 22<sup>nd</sup> SWM) and annual.

Trend analysis was statistically examined in two phases i.e., initially the presence of a monotonic increasing or decreasing trend was tested using the non-parametric Mann-Kendall test (Mann, 1945; Kendall, 1995). Then the rate of change was estimated with the help of Sen's slope test (Sen, 1968). The slope of the trend line indicates the rate and direction of change. The significance of results were tested at 90, 95 and 99 per cent confidence levels.

**Trends of rainfall**

Average annual rainfall in the Konkan region varied from  $2324.8 \pm 591.1$  mm year<sup>-1</sup> at Harnai to  $4098.0 \pm 599.0$  mm year<sup>-1</sup> at Karak (Table 2). Suksale and Mulde exhibited significant increasing trend at 95 per cent confidence level at the rate of 26.2 mm year<sup>-1</sup> and 31.8 mm year<sup>-1</sup>, respectively, while Bhatsanagar also evinced increasing trend at 90 per cent confidence level at the rate of 38.2 mm year<sup>-1</sup>. Rainfall increasing trend at regional scale for Konkan region was also reported by Naidu *et al.* (1999). Rainfall during *kharif* season also evinced significant increasing trend at Suksale, Bhatsanagar, Karak and Mulde and decreasing trend at Karjat. During *rabi* season significant increasing rainfall trend was observed at Vengurla and decreasing trend at Harnai. Significant increasing rainfall trend was evinced at Wakawali during summer season while remaining stations did not observe any significant trend.

**Trends of maximum temperature**

Annual maximum temperature ranges between  $29.9 \pm 0.4$  °C at Harnai to  $34.5 \pm 0.5$  °C at Awalegaon (Table 3). Annual maximum temperature exhibited significant increasing trend at Harnai, Dapoli, Karak and Mulde in the range between 0.03 to 0.09 °C year<sup>-1</sup>, whereas it was significantly decreasing trend at Suksale and Pali at the rate of -0.1 and -0.19 °C year<sup>-1</sup>. Maximum temperature during *kharif* season at Suksale and Pali was dimming significantly whereas it has significant increasing trend at Harnai, Dapoli and Vengurla. During *rabi* season, the maximum temperature has significant increasing trend at Harnai, Dapoli, Karak and Mulde with a magnitude between 0.02 to 0.19 °C year<sup>-1</sup>. Maximum temperature during summer season exhibited significant decreasing trend at Suksale, Bhatsanagar and Pali. Thus the maximum temperature has decreasing trend in the north part of the Konkan region during all seasons, whereas it has increasing trend in middle part of the region during all

**Table 1:** Details of station location, period of data for analysis and source of data acquisition

Sr. No.	Name of location	Latitude	Longitude	Period	Source
1	Suksale	19°55'	73°57'	1982–2014	WRDHP Nasik
2	Bhatsanagar	19°26'	73°48'	1996–2014	WRDHP Nasik
3	Karjat	18°91'	73°33'	1990–2016	DBSKKV Dapoli
4	Pali	18°32'	73°16'	1991–2011	WRDHP Nasik
5	Sudkoli	18°30'	72°59'	1981–2012	WRDHP Nasik
6	Harnai	17°48'	73°50'	1975–2008	DBSKKV Dapoli
7	Dapoli	17°54'	73°18'	1981–2016	DBSKKV Dapoli
8	Wakawali	17°45'	73°17'	1980–2016	DBSKKV Dapoli
9	Karak	16°65'	73°52'	1984–2014	WRDHP Nasik
10	Mulde	16°38'	73°70'	1991–2016	DBSKKV Dapoli
11	Awalegaon	16°26'	73°82'	1982–2014	WRDHP Nasik
12	Vengurla	15°43'	73°42'	1981–2016	DBSKKV Dapoli

WRDHP- Water Resource Department, Hydrological Project; DBSKKV- Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth

**Table 2:** Trend statistics of annual and seasonal rainfall in Konkan region

Location	Rainfall (mm)			<i>Kharif</i>			<i>Rabi</i>			Summer		
	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q
Suksale	2531.3	2.31**	26.23	2505.3	2.4**	26.26	12.3	0.00	0.00	13.6	-0.5	0.00
Bhatsanagar	2612.3	1.88 *	38.27	2558.5	2.16**	35.85	20.3	0.00	0.00	3.2	0.00	0.00
Karjat	3429.2	-0.48	-21.1	3353.6	-0.74	-20.92	46.2	-1.14	-1.70	29.4	0.68	0.29
Pali	3464.3	0.95	15.61	3403.8	0.78	12.86	22.7	0.63	0.01	37.7	0.98	0.00
Sudkoli	3113.6	0.53	8.06	3086.5	0.25	7.2	10.8	0.00	0.00	15.9	0.00	0.00
Harnai	2324.8	1.12	9.72	2247.7	1.09	11.88	46.1	-2.10**	-1.51	58.5	1.44	0.34
Dapoli	3657.9	0.11	2.36	3684.0	-0.85	-9.62	55.5	-0.51	-0.21	58.2	0.35	0.01
Wakawali	3732.2	1.26	12.63	3630.1	1.34	12.33	56.1	-0.27	-0.23	45.7	1.75*	0.33
Karak	4098.0	1.37	21.08	3893.5	1.76*	23.36	83.4	-0.47	-0.54	119.1	0.35	0.20
Mulde	3313.9	2.01**	31.86	3081.9	1.71*	29.93	75	0.66	0.67	156.9	1.16	3.32
Awalegaon	3706.9	-0.03	-1.21	3546.1	0.30	5.08	98.3	-1.11	-1.35	90.1	0.63	0.44
Vengurla	2936.9	1.10	17.37	2872.9	0.90	14.38	34.3	2.07**	1.16	29.5	-0.23	-0.15

\* Significance at 90 per cent confidence level; \*\* Significance at 95 per cent confidence level; \*\*\* Significance at 99 per cent confidence level

seasons and during summer season in the south part of the region.

#### **Trends of minimum temperature**

Annual minimum temperature in the region varied from  $19.4 \pm 0.9$  °C at Wakawali to  $24.1 \pm 1.2$  °C at Vengurla (Table 4). It has significant decreasing trend at Suksale ( $-0.11$  °C year<sup>-1</sup>), Sudkoli ( $-0.21$  °C year<sup>-1</sup>) and Wakawali ( $-0.06$  °C year<sup>-1</sup>) and increasing trend at Karjat ( $0.07$  °C year<sup>-1</sup>) and Dapoli ( $0.04$  °C year<sup>-1</sup>). During *kharif* season

minimum temperature varied from  $22.6 \pm 1.1$  °C at Wakawali to  $25.5 \pm 0.6$  °C at Vengurla (Table 4). It has significant decreasing trend at Suksale ( $-0.05$  °C year<sup>-1</sup>) and Wakawali ( $-0.07$  °C year<sup>-1</sup>) and increasing trend at Dapoli ( $0.02$  °C year<sup>-1</sup>). During *rabi* season minimum temperature has significant decreasing at Suksale ( $-0.1$  °C year<sup>-1</sup>), Wakawali ( $-0.05$  °C year<sup>-1</sup>) and Karak ( $-0.14$  °C year<sup>-1</sup>) and significant increasing trend at Karjat ( $0.09$  °C year<sup>-1</sup>) and Dapoli ( $0.07$  °C year<sup>-1</sup>).

**Table 3:** Trend statistic of annual and seasonal maximum temperature in the Konkan region

Location	Annual			Kharif			Rabi			Summer		
	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q
Suksale	33.9	-1.86 *	-0.1	30.8	-2.88***	-0.15	33.9	0.00	0.00	38.6	-1.69*	-0.13
Bhatsanagar	33.4	0.75	0.05	29.5	0.16	0.01	33.7	-0.31	-0.04	38.3	-1.71*	-0.16
Karjat	34.2	0.86	0.02	31.0	0.00	0.00	33.9	0.58	0.02	38.7	0.74	0.02
Pali	32.4	-3.11 ***	-0.19	29.3	-3.59***	-0.18	32.5	-3.29***	-0.23	36.4	-2.75***	-0.19
Sudkoli	32.8	1.3	0.18	29.7	0.00	0.01	33.4	0.31	0.06	35.9	-0.47	-0.07
Harnai	29.9	4.27***	0.03	29.5	3.08***	0.02	30.1	2.43**	0.03	30.3	2.08**	0.02
Dapoli	30.8	3.26 ***	0.03	28.5	1.74*	0.02	31.6	1.93*	0.02	33.0	2.22**	0.03
Wakawali	32.0	-0.45	-0.01	29.3	-0.34	0.00	32.6	-0.14	0.00	35.1	-0.99	-0.02
Karak	32.9	2.22**	0.09	29.4	0.32	0.01	33.0	2.43**	0.19	37.4	1.36	0.09
Mulde	33.1	2.31 **	0.04	30.2	0.77	0.01	34.0	3.00***	0.06	35.5	3.45***	0.07
Awalegaon	34.5	-0.51	-0.01	30.1	-0.17	-0.01	35.4	-1.22	-0.03	38.7	-1.56	-0.04
Vengurla	31.7	1.22	0.01	30.0	3.78***	0.03	32.6	-0.21	0.00	32.6	0.82	0.01

**Table 4:** Trend statistic of annual and seasonal minimum temperature in the Konkan region

Location	Annual			Kharif			Rabi			Summer		
	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q	Mean	Z	Q
Suksale	20.9	-3.27 ***	-0.11	25.2	-2.88***	-0.05	15.6	-2.88***	-0.1	22.6	-2.82***	-0.08
Bhatsanagar	21.8	0.75	0.05	23.6	1.25	0.09	19.0	0.16	0.03	23.1	0.00	-0.02
Karjat	20.5	2.73 ***	0.07	24.4	0.79	0.02	15.8	2.27**	0.09	21.7	0.85	0.04
Pali	20.7	-0.11	-0.01	24.1	0.56	0.06	16.1	0.56	0.04	21.9	-0.34	-0.02
Sudkoli	21.0	-2.49 **	-0.21	24.7	-0.93	-0.08	17.0	-1.25	-0.14	21.8	-2.49***	-0.18
Harnai	24.0	1.07	0.01	24.7	0.56	0.01	22.6	1.57	0.02	25.0	0.44	0.01
Dapoli	18.8	3.32 ***	0.04	23.0	2.12**	0.02	14.4	3.65***	0.07	19.3	2.22**	0.05
Wakawali	19.4	-5.40***	-0.06	22.6	-5.0***	-0.07	15.3	-2.67***	-0.05	20.4	-3.91***	-0.09
Karak	23.3	-1.57	-0.08	25.3	-1.43	-0.04	20.2	-2.11**	-0.14	25.4	-1.71*	-0.09
Mulde	21.8	0.17	0.01	24.0	0.17	0.00	18.6	0.00	0.00	23.0	-0.37	-0.01
Awalegaon	21.5	-1.47	-0.02	24.2	0.07	0.00	17.8	-0.27	-0.01	23.0	-1.76*	-0.03
Vengurla	24.1	-1.29	-0.02	25.5	0.99	0.01	21.6	-1.43	-0.04	26.3	-1.26	-0.03

Minimum temperature has significant decreasing trend at Suksale and Wakawali during all seasons and significant increasing trend at Dapoli during all seasons. This change in rainfall and temperature aggravated crop production and quality of produce in the region.

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