Original Research Article

SPATIAL AND TEMPORAL VARIATION OF RAINFALL AND TEMPERATURE IN SAMBALPUR DISTRICT OF ODISHA

ABSTRACT

The aim of this research was conducted to determine the extent of climate change in Sambalpur district, Odisha from the year 1990 to 2019. The climate change was studied for rainfall and temperature by running Mann-Kendall test at 5% significance level on time series data for each of the 9 blocks for the time period 1990 to 2019. The resultant Mann-Kendall test statistics indicated how strong the trend in rainfall and temperature was and whether it was increasing or decreasing. For seasonal rainfall six of the nine blocks showed increasing trend but only 3 blocks showed significant increasing trend. Similarly, for maximum temperature six of the nine blocks showed increasing trend and of these six blocks five blocks showed significant increasing trend. For temperature extreme ≥ 40^0C, the trend was increasing but insignificant. For temperature extreme ≥ 45^0C, the trend was decreasing but insignificant. For temperature extreme ≤ 10^0C, a significant decreasing trend was observed.

Key words- Climate change, Mann-kendall test, Trend analysis

1. INTRODUCTION

In our planet climate is one of the most important key component. Rainfall, temperature are the main constituent of weather and climate. Climate is the statistical description of variability and mean of different weather parameters over a period of time ranging from month to thousands or millions of years (IPCC, 2007). Detection of climate change is the long term changes in the climate variables. Through extensions and improvements of various meteorological datasets and advance sophisticated data analysis, the past and recent climate change has gained sizable consideration across the globe (Kumar *et al.*, 2010). The changes in temperature and rainfall are likely to influence the Indian agriculture, variation in rainfall affect the soil moisture storage which ultimately relates to the growing degree days of cropping system. Similarly high or low temperature due to climate change in a region plays crucial role in shifting of cropping pattern of that particular area. Extreme weather patterns have resulted in unreasonable biotic and abiotic stress in agriculture sectors influencing the productivity of crop. Trend analysis focus on overall pattern of change over the time which help in temporal and spatial comparison for deriving the future projection. Climate change alter rainfall patterns and increases the frequency of extreme events like drought, heat wave cold wave, etc. The main objective of the study was to know the significance of temperature and rainfall variability in nine blocks of Sambalpur district by employing different statistical technique. The changes in temperature, precipitation, and other climatic variables are likely to influence the amount and distribution of runoff in all river systems globally. Rainfall is an important factor in shaping the hydrology, water quantity and quality and the vegetal cover throughout the earth. A higher or lower rainfall or changes in its distribution would influence the spatial and temporal distribution of runoff, soil moisture, and ground water reserves and would increase the frequency of droughts and floods. The detection of trends in hydro-climatic data, particularly temperature, precipitation, and streamflow is essential for the assessment of impacts of climatic variability and its change on the water resources of a region. Trend analysis may thus focus on the overall pattern of change over time, help temporal and spatial comparisons for deriving future projections. Estimates of rainfall and temperature anomaly were better estimated using long-term series data. Several statistical methods apply parametric and nonparametric approach for the detection of trends he changes in temperature, precipitation, and other climatic variables are likely to influence the amount and distribution of runoff in all river systems globally. Rainfall is an important factor in shaping the hydrology, water quantity and quality and the vegetal cover throughout the earth. A higher or lower rainfall or changes in its distribution would influence the spatial and temporal distribution of runoff, soil moisture, and ground water reserves and would increase the frequency of droughts and floods. The detection of trends in hydro-climatic data, particularly temperature, precipitation, and streamflow is essential for the assessment of impacts of climatic variability and its change on the water resources of a region. Trend analysis may thus focus on the overall pattern of change over time, help temporal and spatial comparisons for deriving future projections. Estimates of rainfall and temperature anomaly were better estimated using long-term series data. Several statistical methods apply parametric and nonparametric approach for the detection of trend

2. METHODOLOGY

The meteorological data (Rainfall and Temperature) were collected from the year 1990 to 2019 i.e. 30 years of time span. The rainfall data (mm), daily and month wise were collected from the Special Relief Commission (SRC) website, Odisha. The maximum and minimum temperature data in ^{0} Celsius were collected from NASA power from the year 1990 to 2019.

The daily rainfall series was converted to monthly, annual and seasonal data series. As the seasonal rainfall was contributing most part of annual rainfall hence only monsoon seasonal (seasonal) rainfall was calculated. The mean (μ), standard deviation (SD), and coefficient of variation (CV) of seasonal (monsoon) rainfall was calculated using following formulae

$$\text{Mean } (\mu) = \frac{S \qquad\qquad i}{i}$$

$$\text{SD } (\sigma) = \sqrt{\sum(x - \mu)}$$

$$CV = \frac{S \qquad\qquad\qquad i \quad i}{} \times 100$$

Mean annual maximum and minimum temperature were calculated with standard deviation and coefficient of variation from daily temperature data, for 9 blocks from the year 1990 to 2019.This calculation provided the information regarding the temperature profile of all blocks of Sambalpur district.

Extreme temperature frequency was calculated by using daily T_{max} and T_{min} data separately. Extreme temperature was taken as ≥40^0 C and ≥ 45^0 C for T_{max}. Extreme temperature was taken as ≤ 10^0 C for T_{min}. Temperature frequency was calculated to know the pattern of extreme temperature over the years from 2001-2019 for the Sambalpur district.

Addinsoft's XLSTAT 2012 software was run to perform Mann-Kendall test. The output of the trend analysis was obtained in the form of p-value of test statistics which was tested against significance level 0.05 (α value) for both temperature and rainfall data for the nine blocks. In addition, to compare the results obtained from the Mann-Kendall test, linear trend lines are plotted for each block using Microsoft Excel 2016.

3.RESULTS AND DISCUSSION

3.1 MONTHLY RAINFALL (TABLE 1)

The Sambalpur district had received maximum amount of rainfall i.e. 30.43% of rainfall in August followed by 28.44% in July. Except Bamra, Jamankira and Kuchinda, all others block received the highest rainfall in August. Bamra, Jamankira and Kuchinda received highest amount of rainfall in July. The district had received the lowest amount of rainfall in February (0.46 %) followed by March (0.47 %). Jujumura, Kuchinda and Rengali block had received the lowest amount of rainfall in March. Dhankauda, Jamankira, Maneswar, Naktideul and Rairakhol had received lowest rainfall in February. Only Bamra block had received lowest amount of rainfall in January.

3.2 SEASONAL RAINFALL (TABLE 2)

It was observed that Sambalpur district received most of its annual rainfall (85.4%) during the south-west monsoon followed by post-monsoon which had received 7.9 per cent, and 5.9 per cent in pre-monsoon season. The mean seasonal rainfall of the district had been recorded as 1293 mm ± 368 mm. The spatial variability of mean seasonal rainfall had been recorded at each block. It was observed that Jujumura had received the highest seasonal rainfall of 1752 ± 603 mm. Jamankira block had received lowest seasonal rainfall i.e. 1151 ± 373 mm. Sheoran *et al.* (2008) examined the daily rainfall data of 21 years (1984-2004) of RRSKA, Ballowal Sounkri, district Nawanshahr, Punjab. They observed for the long-term averages of monthly and seasonal and its temporal variability. Result showed that with 21.1 percent of Coefficient of variation (CV), the annual rainfall was more or less stable over the years. Within the monsoon season, August was the rainiest month representing 35.8% of monsoon rain followed by July (35.4%).

3.3 TREND ANALYSIS OF SEASONAL RAINFALL (TABLE 3, Fig.1)

It was observed that Dhankauda, Naktideul and Rairakhol were showing the decreasing trend, where only in Rairakhol, it was significantly decreasing trend. All other blocks were showing the increasing trend, where Jamankira, Jujumura and Kuchinda were showing significantly increasing trend of annual seasonal rainfall. In all the blocks the seasonal trend followed the annual trend excepting the Dhankauda and Rengali block. Looking into the annual and seasonal rainfall, Rengali block was showing decreasing trend in annual rainfall but increasing trend in the seasonal rainfall. The trend in annual and seasonal rainfall in Dhankauda block was just reverse of the Rengali block. In a study conducted by Du and Ma., 2004 by using the data of annual rainfall from the year 1971 to 2000 in Tibet, analyzed the linear trends of the annual and seasonal rainfall. The results showed that, there was an increase in annual rainfall trend in most parts of Tibet. It was also found that, there was an increase in trend of mean annual and seasonal rainfall of Tibet over the 30 years.

3.4 MAXIMUM TEMPERATURE (TABLE 4)

The mean maximum temperature of the district was 33.06^0 C ± 0.618 and CV of 1.8 %. The highest mean maximum temperature was observed in Maneswar block i.e. 33.42 ± 0.747 with CV of 2.3 % followed by Jamankira block which was 33.29 ± 0.606 with CV of 1.8. With 32.42^0 C the Naktideul block had experienced the lowest mean maximum temperature.

2.5 TREND ANALYSIS FOR MAXIMUM TEMPERATURE (TABLE 5, Fig.2)

It was concluded that Kuchinda, Maneswar, and Naktideul blocks were showing the decreasing trend of which, the trend in Kuchinda block was only significant. Other blocks were showing the significantly increasing trend except Jamankira block where the trend was not significant. A similar study had been conducted by Karnewar *et al.,*2015 by taking temperature data from the year 1969 to 2007 i.e. 38 years of time span, at Nanded station, for determination of temperature trends. An increasing trend was observed for maximum temperature.

3.5 MINIMUM TEMPERATURE (TABLE 6)

It was concluded that the Rengali block had experienced the lowest minimum temperature i.e. 19.56 ± 0.495. The mean minimum temperature of the district was 20.13^0 C ± 0.455 along with CV of 2.2 per cent.

3.6 EXTREME TEMPERATURE DAYS (TABLE 7)

It was observed that Sambalpur district had experienced a mean (2001-2019) of 48 days > 40^0C, a mean (2001-2019) of 5 days >45^0C and a mean of 22 days <10^0C. From the result it was observed that year 2009 (78 days >40^0C and 15 days >45^0C) and 2010 (75days> 40^0C and 18 days > 45^0C) were the hottest year. It was also observed that the number of hot days had increased over year from 2001 to 2019. From the result table it was observed that year 2001 was the coldest year with number of days < 10^0C was 67 followed by 2003 i.e. 53. The Sambalpur district had experienced a mean (2001-2019) of 22 colder days with temperature < 10^0C. Over the years the number of days < 10^0C had decreased. Finally, it was observed that, in Sambalpur district the average number of hot days was 26 days higher than that of cold days.

3.7 TREND ANALYSIS OF TEMPERATURE EXTREME (TABLE 8, Fig.3)

On running the Mann-Kendall test for temperature extreme (≥ 40^0 C and 45^0 C for T_{max} and ≤ 10^0 C for T_{min}) in Sambalpur district from the year 2001 to 2019, it was observed that for temperature extreme ≥ 40^0C, the trend was increasing but insignificant. For temperature extreme ≥ 45^0C, although trend was negative but the Kendall's tau value was very small i.e. -0.006 and was also insignificant. For temperature extreme ≤ 10^0 C, a significant decreasing trend was noticed.

4. CONCLUSION

The time series analysis of long term climatic data of Sambalpur district claimed that six blocks out of nine blocks experienced increasing trend in rainfall but not significant, whereas maximum temperature in most of the blocks exhibited a significant increase over the years (1990- 2019) with the increasing frequency of hot days > 40^0 C and decreasing frequency of cold days <10^0 C. Hence there is an overall increase in temperature in Sambalpur district from the year 1990 to 2019. It clearly indicates global warming. Changing climate brings a cascade of risks from physical impact on agroecosystem, agricultural production, and food chains to economic and social impacts on livelihood, income and trade, food security and nutrition (FAO 2016).

ACKNOWLEDGEMENT:

The infrastructure provided by OUAT for my research work is highly acknowledged.

References

1. Du J and Ma Y. Climatic trend of rainfall over Tibetan Plateau from 1971 to 2000. 2004; *Acta GeographicaSinica*, *59*(3), pp.375-382.
2. IPCC 2007 Climate change (2007) climate change impacts, adaptation and vulnerability. Working Group II Contribution to the Intergovernmental Panel on Climate Change, Fourth Assessment Report, Summary for Policymakers, **23**
3. Karnewar Kailas and Kadam Avinash. Study of temperature trends of Nanded, Maharastra, India*.2015; Rural observations* 2015:7(2) http://www.sciencepub.net/rural
4. Kendall, M.G. (1975) *Rank Correlation Methods*, 4th edition. London, UK: Charles Griffin.
5. Kumar V, Jain S.K. and Singh Y. Analysis of long term rainfall trends in India. 2010; *Hydrological Sciences Journal*, **55**(4), 484– 496.
6. Mann, H.B. Non-parametric tests against trend. 1945; *Econometrica*, **13**, 163– 171.
7. Sheoran P, Singh S and Sardana V. Rainfall analysis and crop planning in lower Shiwalik foothills of Punjab. 2008; *Journal of Agrometeorology*, *10*(2), pp.193-197.

Table.1 Long term mean monthly rainfall (mm) of Sambalpur district (1990-2019)

Sl. No.	Block	Jan	Feb	Mar	April	May	June	July	Aug	Sep	Oct	Nov	Dec	MAR
1	Bamra	5.54	8.29	7.09	16.68	32.66	228.95	403.67	363.54	225.54	43.85	12.46	14.71	**1362**
2	Dhankauda	11.84	5.26	10.51	10.84	26.82	221.33	410.15	470.10	242.84	53.43	7.62	14.49	**1485**
3	Jamankira	11.45	5.56	6.38	16.86	32.36	198.32	373.29	354.49	224.40	51.84	9.90	15.92	**1300**
4	Jujumura	11.68	8.25	6.86	12.57	44.77	256.53	554.71	590.38	350.47	73.80	14.29	15.73	**1940**
5	Kuchinda	8.37	9.79	5.89	8.58	25.55	197.46	382.30	365.89	215.57	53.13	10.87	17.36	**1340**
6	Maneswar	7.89	6.05	6.48	9.16	28.51	218.26	413.77	457.83	239.30	47.23	8.85	9.89	**1453**
7	Naktideul	10.16	4.71	5.04	14.60	35.70	201.67	366.69	384.34	202.14	66.72	8.35	10.10	**1310**
8	Rairakhol	9.03	3.39	7.23	11.44	30.34	191.83	400.17	428.14	237.11	65.25	10.91	8.69	**1403**
9	Rengali	7.79	9.59	6.74	11.89	34.17	214.85	401.09	423.81	228.41	53.61	12.09	13.87	**1417**
	District	**9.30**	**6.76**	**6.91**	**12.51**	**32.33**	**214.36**	**411.76**	**426.50**	**240.64**	**56.54**	**10.59**	**13.42**	

Table.2 Statistical characteristics of mean seasonal rainfall block wise

Sl. No.	Name of the Block	Mean seasonal rainfall (mm)	Standard deviation	Coefficient of variation (%)
1	Bamra	1222	312	25
2	Dhankauda	1344	403	30
3	Jamankira	1151	373	32
4	Jujumura	1752	603	34
5	Kuchinda	1161	356	30
6	Maneswar	1329	357	26
7	Naktideul	1155	261	22
8	Rairakhol	1257	364	29
9	Rengali	1268	285	22
	District	**1293**	**368**	**27**

Table.3 Statistical table for trend analysis of seasonal rainfall

Sl. No.	Name of the block	Kendall's Tau	p-value (two tailed test)	Alpha	Trend interpretation
1	Bamra	0.237	0.069 (NS)	0.05	Increase
2	Dhankauda	-0.246	0.059 (NS)	0.05	Decrease
3	Jamankira	0.269	0.038 (S)	0.05	Increase
4	Jujumura	0.264	0.042 (S)	0.05	Increase
5	Kuchinda	0.274	0.035 (S)	0.05	Increase
6	Maneswar	0.021	0.887 (NS)	0.05	Increase
7	Naktideul	-0.011	0.943 (NS)	0.05	Decrease
8	Rairakhol	-0.260	0.046 (S)	0.05	Decrease
9	Rengali	0.053	0.695 (NS)	0.05	Increase

Table 4 Statistical characteristics of maximum temperature (^{0}C) block wise

Sl. N0.	Name of the Block	Mean maximum temperature(^{0}C)	Standard Deviation	Coefficient of variation (%)
1	Bamra	33.250	.562	1.9
2	Dhankauda	33.110	.500	1.5
3	Jamankira	33.290	.606	1.8
4	Jujumura	33.150	.591	1.7
5	Maneswar	33.420	.747	2.3
6	Kuchinda	33.180	.582	1.7
7	Naktideul	32.420	.754	2.9
8	Rairakhol	33.310	.623	1.8
9	Rengali	32.520	.598	1.1
	District	**33.060**	**.618**	**1.8**

Table 5 Statistical table for trend analysis of maximum temperature (^{0}C) block wise

Sl. No.	Name of the block	Kendall's Tau	p-value (Two tailed test)	Alpha	Trend interpretation

7	Bamra	0.306	0.018 (S)	0.05	Increase
2	Dhankauda	0.325	0.012 (S)	0.05	Increase
6	Jamankira	0.138	0.292(NS)	0.05	Increase
1	Jujumura	0.339	0.009 (S)	0.05	Increase
5	Kuchinda	-0.369	0.005 (S)	0.05	Decrease
4	Maneswar	-0.189	0.148 (NS)	0.05	Decrease
9	Naktideul	-0.170	0.193 (NS)	0.05	Decrease
8	Rairakhol	0.314	0.016 (S)	0.05	Increase
3	Rengali	0.306	0.018 (S)	0.05	Increase

Table.6 Statistical characteristics of minimum temperature (^{0} C) block wise

Sl. No.	Name of the Block	Mean minimum temperature(^{0}C)	Standard deviation	Coefficient of variation (%)

1	Bamra	19.710	.323	1.6
2	Dhankauda	20.000	.556	2.7
3	Jamankira	19.890	.501	2.5
4	Jujumura	20.870	.602	2.8
5	Kuchinda	20.250	.322	1.5
6	Maneswar	19.730	.688	3.4
7	Naktideul	20.530	.298	1.4
8	Rairakhol	20.630	.317	1.5
9	Rengali	19.560	.495	2.5
	District	**20.130**	**.455**	**2.2**

Table.7 Extreme (high and low) temperature of Sambalpur district

Sl. No.	Year	No of Days >40^0C	No of Days >45^0 C	No of Days < 10^0C

1	2001	38	4	67
2	2002	44	6	49
3	2003	63	16	53
4	2004	32	0	38
5	2005	47	5	26
6	2006	13	0	22
7	2007	35	1	17
8	2008	43	0	3
9	2009	78	15	16
10	2010	75	18	26
11	2011	21	0	6
12	2012	53	0	11
13	2013	54	11	17
14	2014	60	0	18
15	2015	31	7	19
16	2016	64	3	13
17	2017	66	1	7
18	2018	52	4	11
19	2019	55	6	15
	Mean	**48**	**5**	**22**

Table.8 Statistical table for trend analysis of temperature extreme

Sl. No.	Temperature extreme class	Kendall's Tau	p-value (Two tailed test)	Alpha	Trend interpretation
1	$\geq 40^0$ C	0.240	0.164	0.05	Increase
2	$\geq 45^0$ C	-0.006	0.972	0.05	Decrease
3	$\leq 10^0$ C	-0.519	0.002	0.05	Decrease

Fig.1 Trend of seasonal rainfall in all the blocks of Sambalpur district

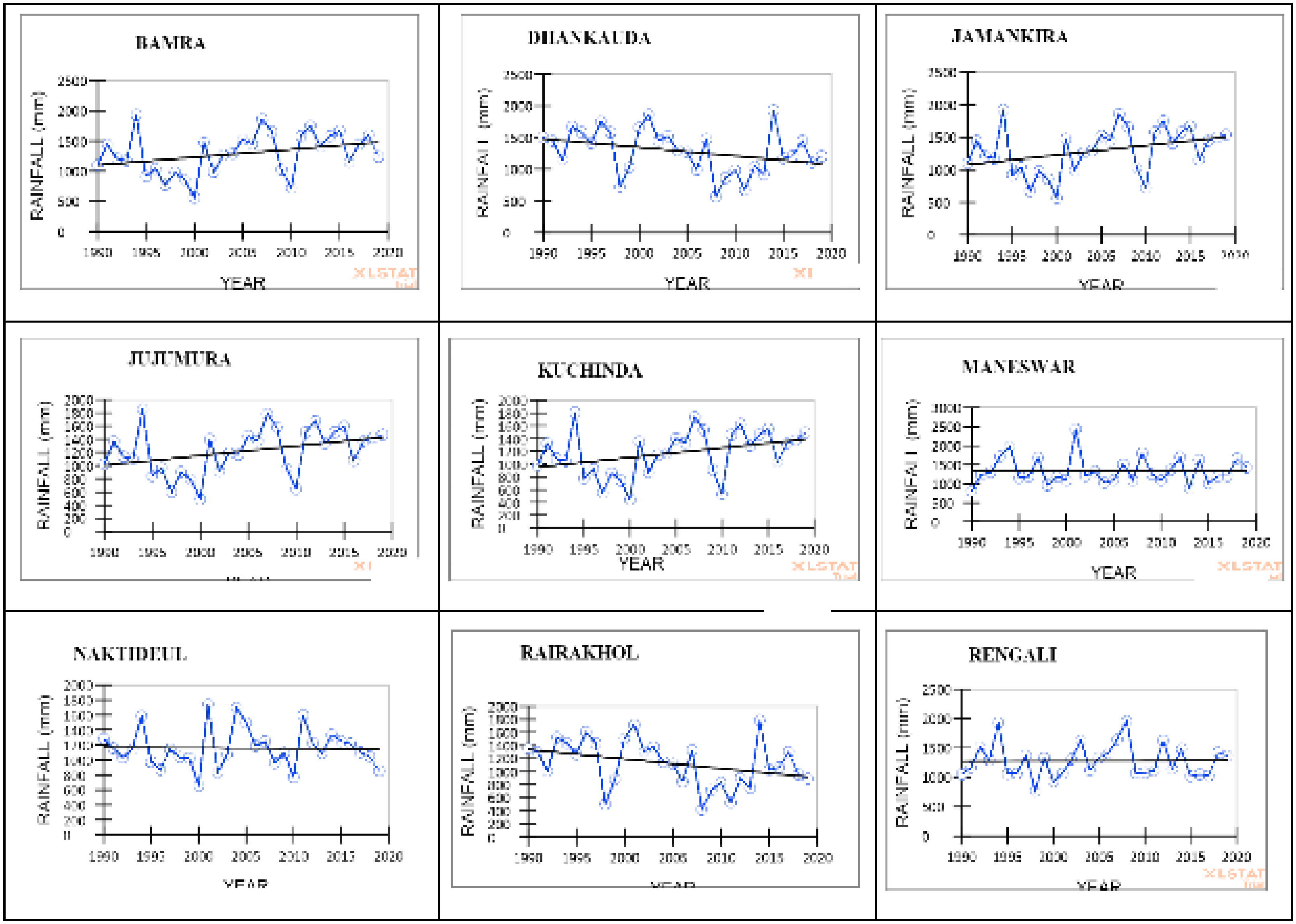


Fig.2 Trend of maximum temperature in all the blocks of Sambalpur district

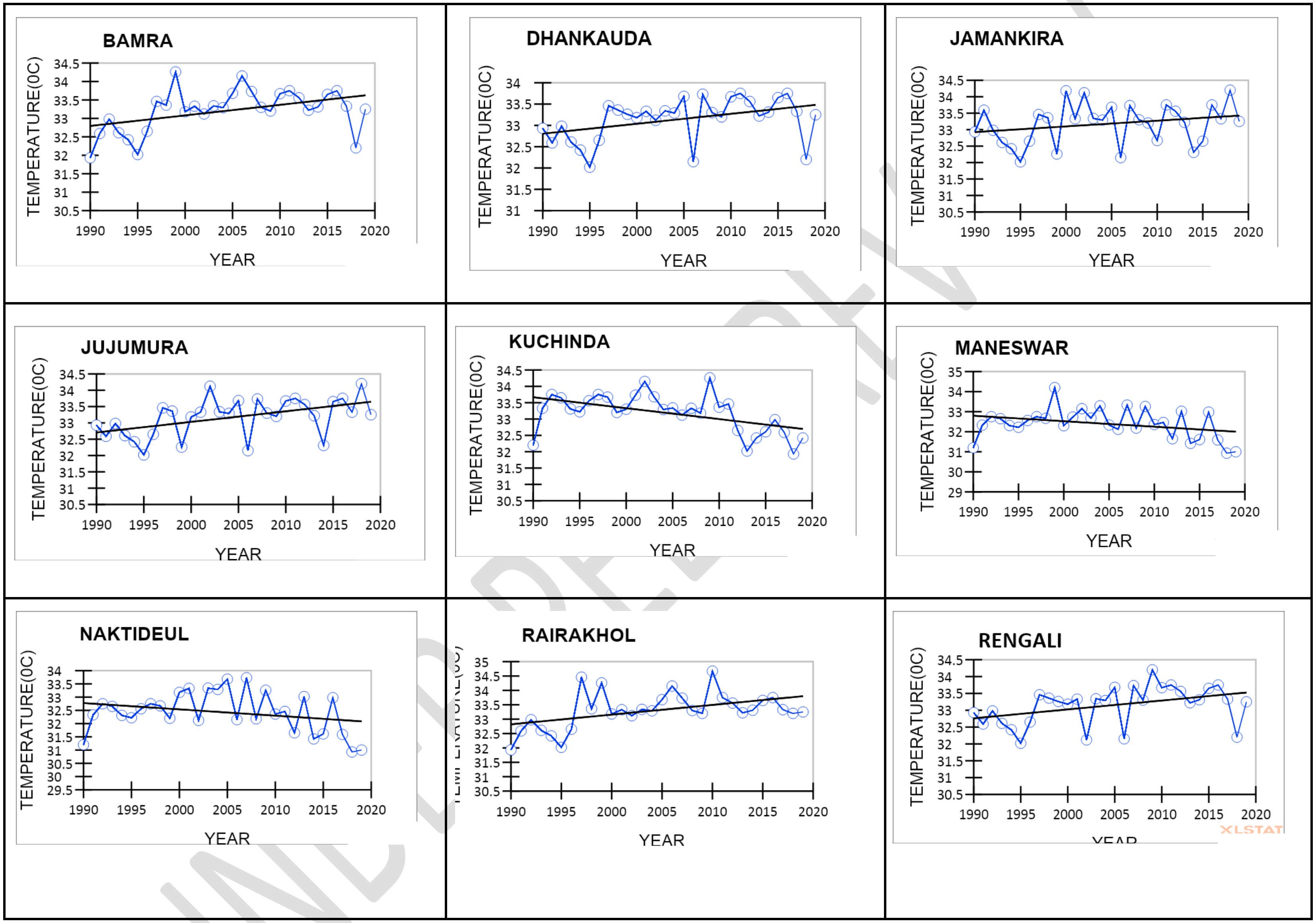
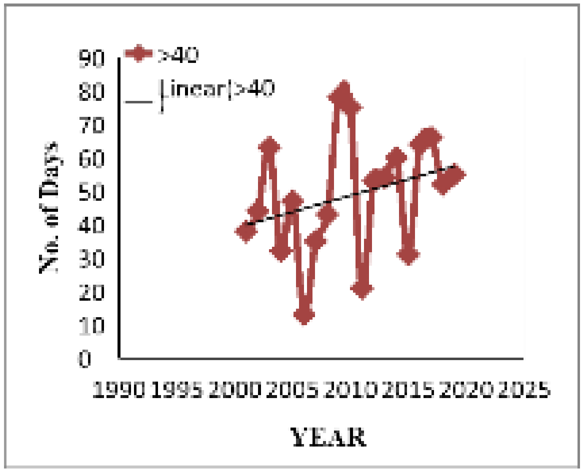
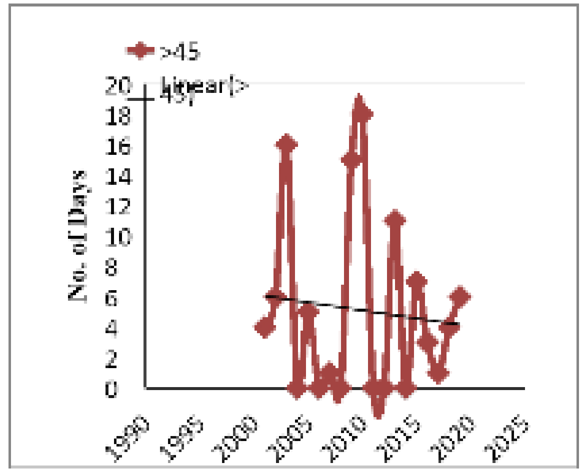
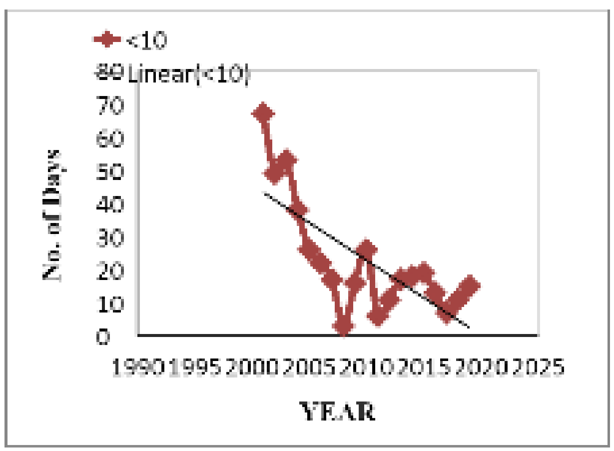

BAMRA
TEMPERATURE(0C)
YEAR
DHANKAUDA
TEMPERATURE(0C)
YEAR
JAMANKIRA
TEMPERATURE(0C)
YEAR
JUJUMURA
TEMPERATURE(0C)
YEAR
KUCHINDA
TEMPERATURE(0C)
YEAR
MANESWAR
TEMPERATURE(0C)
YEAR
NAKTIDEUL
TEMPERATURE(0C)
YEAR
RAIRAKHOL
YEAR
RENGALI
TEMPERATURE(0C)
YEAR
XLSTAT

Fig.3 Trend of extreme temperature in Sambalpur district


>40
Linear(>40
90
80
70
60
50
40
30
20
10
0
No. of Days
1990 1995 2000 2005 2010 2015 2020 2025
YEAR


>45
Linear(>
45)
20
18
16
14
12
10
8
6
4
2
0
No. of Days
1990 1995 2000 2005 2010 2015 2020 2025


<10
80
Linear(<10)
70
60
50
40
30
20
10
0
No. of Days
1990 1995 2000 2005 2010 2015 2020 2025
YEAR