<u>**Original Research Article**</u>

Trend Analysis and Change Point Detection of Climatic Parameters inAmbedkar Nagar District of Uttar Pradesh

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Climate change is one of the most serious challenges confronting humanity today, and its effects can be seen all over the world. The assessment of changes in the long-term weather trend is critical for developing water resource management strategies under climate change scenarios. Long-term trends for annual, monsoon, non-monsoon rainfall, rainy days, maximum temperature, and minimum temperature of Akbarpur, Allapur, Bhiti, Jalalpur, and Tanda stations in Uttar Pradesh's Ambedkar Nagar district were examined in this study. The Mann-Kendall test revealed a non-significant decreasing trend for annual and monsoon rainfall at Akbarpur, Bhiti, and Jalalpur stations with an average rate of 1.64 mm/year whereas, it shows a non-significant increasing trend for annual and monsoon rainfall at the Allapur and Tanda stations with an average rate of 3.168 mm/year. Non-monsoon rainfall showed an in-significant decreasing trend at Allapur and Jalalpur stations with an average rate of 0.415 mm/year, whereas a non-significant increasing trend was shown at Akbarpur, Bhiti, and Tanda stations with an average rate of 0.197 mm/year. Annual rainy days shows non-significant decreasing trend for all stations of Akbarpur district with an average rate of 0.117 day/year (one day decrease with in nine year). It indicates seasonal shift and increased possibility of high intensity rainfall. The impact of extreme events of rainfall on the trend was evaluated on the whole and partial series before and after the break point and it was observed that there was no significant climate change in Ambedkar Nagar district and non-significant changing year of precipitation data series was found in 1995. A significant increasing trend in maximum temperature was observed for all stations in the months of August and December, with an average rate of 0.02 ^{0}C per year, while Allapur station also shows a significant increasing trend in maximum temperature in September, with a rate of 0.012 ^{0}C per year. However, asignificant decreasing trend was observed in minimum temperature in the month of May at Akbarpur, Allapur, Jalalpur, Tanda station with an average rate of 0.027 ^{0}C per year. Rainfall and temperature are a principal climatic parameter which regulates the environmental condition of a particular region by directly influencing the agricultural productivity and water

ABSTRACT

Keywords: Climate change, Trend analysis, Mann–Kendall test, Sen's slope, Worsley Likelihood Ratio Test.

1. Introduction

There are two-term weather and climate, both are different. Weather is defined as the state of the atmosphere at a particular place over a short period. Weather is term used for atmosphere over a limited area for a short period. It can change rapidly and is difficult to predict [1,2,3]. On the contrary the term climate is defined as the average weather pattern for a specific area over a long period of time [4]. Thus, the term climate is used for atmospheric conditions of a wide area over a long period of time. The climate of a location/area essentially provides information about the possibility of a type of flora, fauna, and feasibility of living conditions of human beings. It is broadly governed by precipitation (rainfall), temperature, humidity, sunshine availability, wind speed and its direction on a long-term basis [5]. Climate is affected by some factors; natural and anthropogenic. In natural factors there are some sub factor like ocean currents, volcanic activity, solar radiation, orbital variations, and plate tectonics which have some impact on climate [6]. Human activities since the beginning of the Industrial Revolution (around 1750) have produced around 45% increase in the atmospheric concentration of carbon dioxide (CO_2), from 280 ppm in 1750 to 406 ppm in early 2017. The increase in CO_2 level has resulted because of combustion of fossil fuels, principally coal, oil, and natural gas, with additional contributions coming from deforestation, changes in land use, soil erosion and agriculture [7]. The concentration of CH_4 in the atmosphere was 722 ppb before the 19th century but it increased to 1840 ppb in the 21thcentury. The concentration of N_2O in atmosphere was 270 ppb before the 19th century but the present level has gone up to 330 ppb [8]. According to report of Intergovernmental Panel on Climate Change (IPCC), the surface temperature of the earth has risen by 0.6 $\pm$0.2^{0}C over the 20th century. Also, in the last 50 years, the rise in temperature has been about 0.13 $\pm$0.07^{0}C per decade [9,10]. As warming depends on emissions of GHG_s (Green House Gases) in the atmosphere, based on the rate of such emission the IPCC has a projected warming of about 0.2^{0}C per decade. Further surface air temperature could rise between 1.1^{0}C to 6.4^{0}C over the 21st century. However, the IPCC report argues that the previous three decades, from 1983 to 2012, are most likely to be the warmest periods of the 1400 years in the Northern Hemisphere, whereas the global average surface temperature data for the land and sea combined show a warming of 0.85 (0.65 to 1.6)^{0}C over the period from 1880 to 2012 [11,12,13,14,15]. The projected increase in temperature will affect the ecosystem and biological behavior [16]. Some of the effects that have widely been discussed include snow melting and glacier retreat, drought desertification, floods, frequent fire, sea level rise, species shifts, and heightened diseases increases [17,18,19]. Changes in temperature and precipitation also are projected to influence extreme weather events (floods, drought and storms); affect food production and prices; water availability and access; nutrition and health status [20,21]. During the last century, surface temperature over India has shown a significant increasing trend [22,23] which is attributed to a rise in maximum temperature. It was shown that the frequency of heavy rains during the southwest monsoon showed an increasing trend over certain parts of the country. On the other hand, a decreasing trend is seen during winter, pre-monsoon and post-monsoon season [24,25]. Extreme weather events such as high and low temperature, heavy rainfall in connection with the climate change over India and concluded that during summer 60-70% of the coastal station is showing an increasing trend in critical extreme maximum day temperature and increase in night temperatures [26,27,28,29,30]. Average annual rainfall in the country is 119.4 cm, about 60% of the country's total cultivable land still remains as rain-fed [31,32,33].Overall decreasing trend, although statistically not significant in annual rainfall with the 33 years (1974-2007) rainfall data of the Pieria Region, Greece [34]. In Indialarge spatial and temporal variations in rainfall trend. Out of 30 subdivisions in the country, half of the regions showed an increasing trend in annual rainfall and a significant increasing trend in Haryana, Punjab and coastal Karnataka [35]. Rainfall trend and change point detection in Haridwar, Dehradun, Udham Singh Nagar, Almora, and Nainital showed a long term insignificant declining trend of annual as well as monsoon rainfall, whereas an increasing trend in the post-monsoon season. During the monsoon season, the monthly rainfall in June, July, and September months were found to be in decreasing trend, but there was an increasing trend in August [36]. In the past ten years, the trend has become even more noticeable [37].Over the past few decades, Uttar Pradesh's climate variability has also been significantly impacted. Many districts in Uttar Pradesh experienced drought, while some districts suffered flooding [38]. The Ambedkar Nagar district in Uttar Pradesh focuses heavily on agriculture, with rainfall being the primary factor influencing its operations. In order to discover rainfall variability and analyse rainfall and temperature trends as well as their magnitude, this study was carried out in the Uttar Pradesh district of Ambedkar Nagar. This study also examines the change point year for the temperature and rainfall time series data. Additionally, the rainfall's spatial representation was displayed both before and after the change point year.

2. Study Area

Ambedkar Nagar district is situated in the eastern part of Uttar Pradesh and covers 2350 km^2 geographical area. It lies between latitude 26^{0}09'N and 26^{0}40'N, and longitude 82^{0}13'E and 83^{0}09'E. As per the provisional figures of the 2011 census [39], the total Population of the district is 2398709, with a density of population 1021 persons/per Sq. Km. The rural population constitutes 88.26% of the total population. More than 70 percent of population is directly or indirectly engaged in agriculture. In the district average annual rainfall 1029 mm, the district comes under a sub-tropical sub-humid climate zone. The Soil Map of UP published by the National Bureau of Soil Sciences and Land Use Planning shows that in the almost entire district, the soil is mainly deep, well or moderately well drained and fine-loamy, with the loamy surface. In the narrow belt along Ghaghra, the coarse loamy soil (Balua) is also present along with soil of the above nature. In west-central parts, however, the soil is moderately well or poorly drained, exhibiting calcareous nature and is slightly saline and sodic. In a small portion in eastern fringes, the soil is poorly drained, fine loamy and calcareous and is associated with slightly saline and sodic soils.Ambedkar Nagar district is situated in north-eastern part of Uttar Pradesh. Index map of Ambedkar Nagar district is shown in fig. 1.

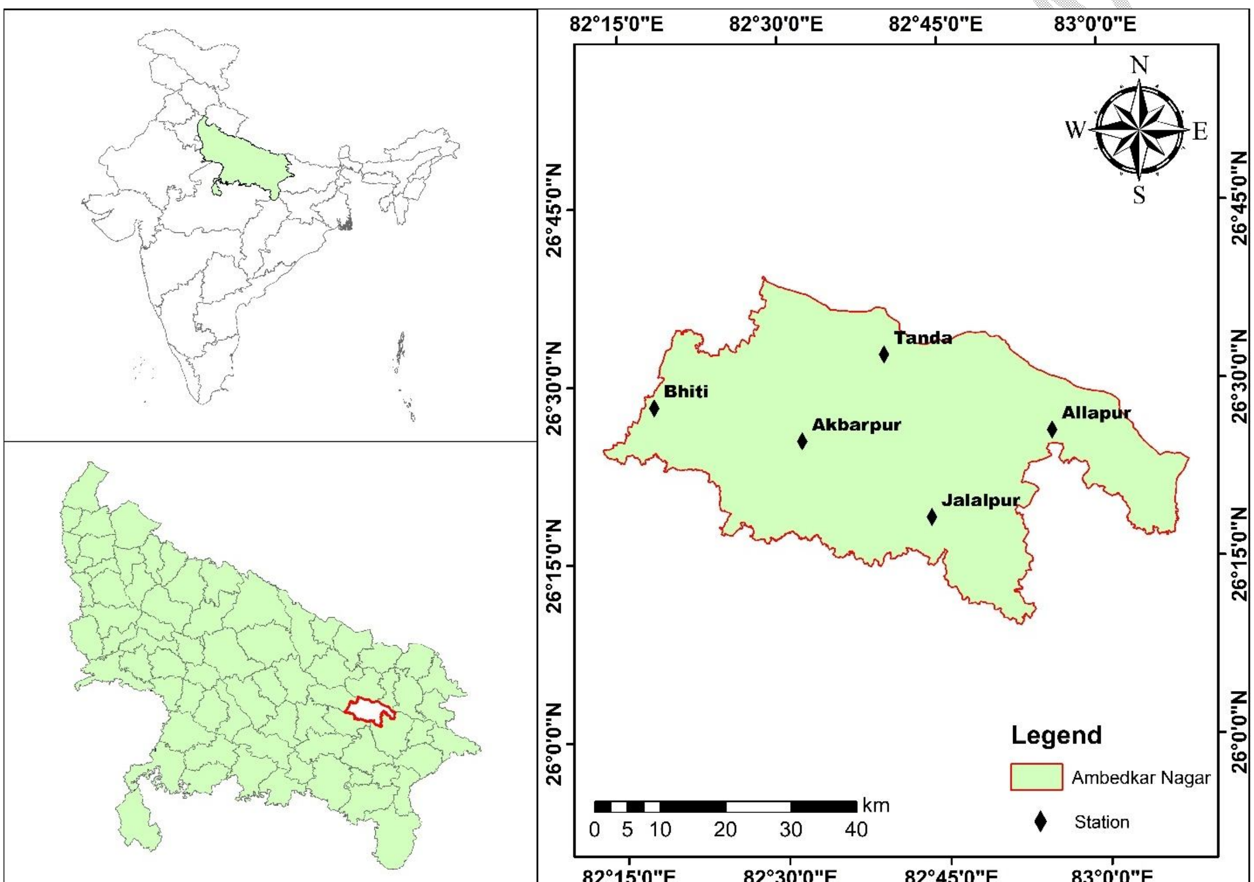

Figure 1: Index map of Ambedkar Nagar district

In this research work five station have been taken for the study purpose in Ambedkar Nagar district, geographic location of these station written in Table 1.

Table 1: Location of stations

S.N.	Station(Tehsil)	Latitude	Longitude
1	Akbarpur	$26^0$25'12"	$82^0$31'48"
2	Allapur	$26^0$25'48"	$82^0$55'12"
3	Bhiti	$26^0$28'12"	$82^0$18'0"
4	Jalalpur	$26^0$18'36"	$82^0$43'48"

5	Tanda	26^{0}32'24"	82^{0}39'36"

2.1 Data collection

For the studying climate change of Ambedkar Nagar district at least 30 years or more data was required. The daily rainfall and temperature data for this study from 1951 to 2022 was obtained from the website of the Indian Meteorological Department (IMD) (https:// www.imdpune.gov.in/Clim_Pred_LRF_New/Grided_Data_Download.html). [40,41] compiled this data using India's 395 quality-controlled data stations.

3. Materials and methods

3.1 Non-parametric test

Non-parametric statistics are usually much less affected by the presence of outliers and other forms of non-normality. The most frequently used non-parametric test for identifying trends in hydrologic variables is the Mann-Kendall (MK) test. The statistical significance trend detected using a non-parametric model such as Mann-Kendall (MK) test can be complemented with Sen's slope estimation to determine the magnitude of the trend.

3.1.1 Mann–Kendall Trend Test

Mann-Kendall statistics (S) is defined as follows:

$$S = \sum_{i=1}^{n-1} \sum_{j=i+1}^{n} \operatorname{sgn}(x_j - x_i) \qquad \text{……..(1)}$$

Where,

$$\operatorname{sgn}(x_j - x_i) = \begin{cases} +1, \text{ if } (x_j - x_i) > 0 \\ 0, \text{ if } (x_j - x_i) = 0 \\ -1, \text{ if } (x_j - x_i) < 0 \end{cases}$$

The trend test is applied to x_i data values (i = 1, 2, 3, 4…... n–1) and x_j data value (j= i + 1, 2, 3……. n). The data values of each x_i is used as a reference point to compare with the data values of x_j.

When n > 10 the S statistic is approximately normally distributed with zero mean and variance as follows:

$$\sigma^2 \text{or } \operatorname{Var}(S) = \frac{1}{18}\left[n(n-1)(2n+5) - \sum_{p=1}^{g} t_p(t_p - 1)\left(2t_p + 5\right)\right] \qquad \text{.... (2)}$$

Where,

g is the number of tied (zero difference between compared values) groups, and t_p is the number of data values in the p^{th} group. The values of S and VAR(S) are used to compute the standard normal deviation (Z value) as;

$$Z = \begin{cases} \dfrac{S-1}{\sigma} \text{ if } S > 0 \\ 0 \quad \text{if } S = 0 \\ \dfrac{S+1}{\sigma} \text{ if } S < 0 \end{cases}$$

A very positive value of Z is an indicator of an increasing trend, and a negative value indicates a decreasing trend, when Z value lies between +1.96 to -1.96 then null hypothesis is accepted, and when the value of Z > +1.96 or Z < -1.96 then null hypothesis (H_0) is rejected at 95% confidence level.

3.1.2 Sen's Slope Estimator Test

The slope of n pairs of data points was estimated using Sen's slope estimator which is given by the following relation:

$$\beta = Meadian\ \frac{x_j - x_i}{j-i} \qquad for\ all\ i \leq j$$

In which $1<j<i<n$ and β is the robust estimate of the trend magnitude. A positive value of β indicates an 'upward trend' while a negative value of β indicates a 'downward trend'.

3.1.3 Worsley Likelihood Ratio Test

The ratio test developed by Worsley gives the jump between the time series and this indicates the initiation of change. This method tests whether the means in two parts of a record are different (for an unknown time of change). The test assumes that the data are normally distributed. The formula of Worsley Livelihood Ratio Test is given below-

$$Z_w = \frac{SS}{\sqrt{K(N-K)}} \qquad \text{… … … . (3.8)}$$

$$z_w = \frac{Z_w}{d_x} \qquad \text{… … . . (3.9)}$$

Test statistics W is defined by Worsley as:

$$W = \frac{\sqrt{(N-2)} * V}{\sqrt{(1-V^2)}} \qquad \text{… … … (3.10)}$$

Where,

$$V = \text{Max}|Z_w| \qquad \text{… . . (3.11)}$$

N = No. of observations.

K = weight assigned to SS

SS = sum of squares

W = Worsley Likelihood Ratio Test

Z_w = Worsley Test statistic

z_w = Test quotient

V = any convenient statistic

The critical test statistic values for various significance levels for all selected observations are 2.869, 3.159 and 3.79 at 90, 95 and 99 % confidence levels.

4. Result and discussion

Trend analysis of monsoon, non-monsoon, annual rainfall and rainy days is carried out over the period of 1951-2022 of for Ambedkar Nagar district using Mann-Kendall test. Magnitude of trend was estimated using Sen's slope estimator and change point detection analysis was carried out using Worsley Likelihood test and discussed in detail under following subheadings.

4.1 Analysis for the Monsoon rainfall from 1951-2022

From the results shown in Table 2, it is observed that monsoon rainfall at Akbarpur, Bhiti and Jalalpur stations are exhibiting decreasing trend over the period of 72 year, however it is not found significant as Z values are greater than -1.96. At these three stations, the Sen's slope indicator indicated the rates change as 1.18, 0.49 and 3.343 mm/year respectively. The Worsley likelihood test detected year 1994 as a year of change point at Jalalpur and 1995 for Akbarpur and Bhiti, but these test values are not significant. Allapur and Tanda station shows non-significant rising trend for monsoon rainfall at the rate of 2.95 and 2.98 mm/year respectively, the year 1979 was detected as a change point for these two stations however the change has not been seen significant at 95% confidence level. From overall trend analysis of all five stations of Ambedkar Nagar district it is seen that three stations have shown decreasing trend over the period of 72 years from 1951 and two stations have shown rising trend, however all these trends are found non-significant.

Table 2: Trend and change point detection of monsoon rainfall for the period 1951 to 2022

Station	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope B	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Akbarpur	-0.640	-1.180	NS	1.620	1995	NS
Allapur	1.181	2.954	NS	2.825	1979	NS
Bhiti	-0.156	-0.490	NS	1.353	1995	NS
Jalalpur	-1.575	-3.343	NS	2.552	1994	NS
Tanda	1.234	2.986	NS	2.730	1979	NS

NS: Not Significant, S: Significant, (+): Increasing, (-): Decreasing

4.2 Analysis for the non-monsoon rainfall

From the results shown in Table 3. it is observed that non-monsoon rainfall at Allapur and Jalalpur stations are exhibiting decreasing trend over the period of 72 year, however it is not found significant as Z values are greater than -1.96. At these two stations, the Sen's slope indicator indicated the rates change as 0.279 and 0.273 mm/year respectively. The Worsley likelihood test detected year 2012 as a year of change point at Allapur and 1963 for Jalalpur, but these test values are not significant. Akbarpur, Bhiti and Tanda station shows non-significant rising trend for non-monsoon rainfall at the rate of 0.370, 0.052 and 0.169 mm/year respectively. The year 2012 was detected as a change point for these three stations however the change has not been seen significant at 95% confidence level. From overall trend analysis of all five stations of Ambedkar Nagar district it is seen that three stations have shown increasing trend over the period of 72 years from 1951 and two stations have shown rising trend, however all these trends are found non-significant.

Table 3:Trend and change point detection of non-monsoon rainfall for theperiod 1951 to2022

Station	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Akbarpur	0.970	0.370	NS	2.190	2012	NS
Allapur	-0.364	-0.279	NS	1.942	2012	NS
Bhiti	0.116	0.052	NS	2.339	2012	NS
Jalalpur	-0.533	-0.273	NS	2.077	1963	NS
Tanda	0.417	0.169	NS	2.534	2012	NS

NS: Not Significant, S: Significant, (+): Increasing, (-): Decreasing

4.3 Analysis for the annual rainfall from 1951-2022

From the results shown in Table 4, it is observed that monsoon rainfall at Akbarpur, Bhiti and Jalalpur stations are exhibiting decreasing trend over the period of 72 year, however it is not found significant as Z values are greater than -1.96. At these three stations, the Sen's slope indicator indicated the rates change as 0.96, 0.538 and 3.367 mm/year respectively. The Worsley likelihood test detected year 1994 as a year of change point at Jalalpur and 1995 for Akbarpur and Bhiti, but these test values are not significant. Allapur and Tanda station shows non-significant rising trend for monsoon rainfall at the rate of 2.81 and 3.366 mm/year respectively. The year 1979 was detected as a change point for these two stations however the change has not been seen significant at 95% confidence level. From overall trend analysis of all five stations of Ambedkar Nagar district it is seen that three stations have shown decreasing trend over the period of 72 years from 1951 and two stations have shown rising trend, however all these trends are found non-significant.

Table 4: Trend and change point detection of annual rainfall for the period 1951 to 2022

Station	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Akbarpur	-0.440	-0.960	NS	1.700	1995	NS
Allapur	1.135	2.861	NS	2.626	1979	NS
Bhiti	-0.255	-0.538	NS	1.511	1995	NS
Jalalpur	-1.448	-3.367	NS	2.663	1994	NS
Tanda	1.315	3.366	NS	2.804	1979	NS

NS: Not Significant, S: Significant, (+): Increasing, (-): Decreasing

4.4 Analysis for the annual rainy days from 1951-2022

From the results shown in Table 5, it is observed that annual rainy days at Akbarpur, Allapur, Jalalpur and Tanda stations are exhibiting decreasing trend over the period of 72 year, however it is not found significant as Z values are greater than -1.96. At these two stations, the Sen's slope indicator indicated the rates change as 0.11, 0.133, 0.139 and 0.078 mm/year respectively. The Worsley likelihood test detected year 1996 as a year of change point at Akbarpur and Tanda, 2001 for Allapur and 1994 for Jalalpur, but these test values are not significant. Bhiti station shows significant falling trend for annual rainy days at the rate of 0.125 mm/year. The year 1995 was detected as a change point for Bhiti station however the change has been seen significant at 95% confidence level. From overall trend analysis of all five stations of Ambedkar Nagar district it is seen that all stations have shown decreasing trend over the period of 72 years from 1951, however all these trends are found non-significant except Bhiti station.

Table 5: Trend and change point detection of annual rainy days for the period 1951 to 2022

Station	Trend Analysis			Change point		
	Mann-Kendall statistic	Sen's Slope β	Trend Significance at 95%	Worsley Likelihood test	Year Of Change	Change Significance at 95%

	Z		confidence level	Statistic W		confidence level
Akbarpur	-1.350	-0.110	NS	2.770	1996	NS
Allapur	-1.906	-0.133	NS	3.053	2001	NS
Bhiti	**-1.570**	**-0.125**	**S**	**3.361**	**1995**	**S**
Jalalpur	-1.628	-0.139	NS	2.291	1994	NS
Tanda	-1.245	-0.078	NS	2.464	1996	NS

NS: Not Significant, S: Significant, (+): Increasing, (-): Decreasing

4.5 Comparison of rainfall distribution before and after change point year

The aim of this exercise was to analyze the changes occurred in rainfall distribution in Ambedkar Nagar district after the change point year. This analysis gives the insight of climate change signals detection after change point year and comparison with the previous period. As per the change point detection analysis carried out year 1995 was observed as overall change point year for rainfall in Ambedkar Nagar district. Therefore annual, monsoon, non-monsoon rainfall and rainy-day distribution of in the district was analyzed graphically using GIS and discussed below.

4.5.1 Average annual rainfall distribution before and after change point

The spatial distribution of the average annual rainfall distribution before and after change point year 1995 for the Ambedkar Nagar district is shown in Figure 2.

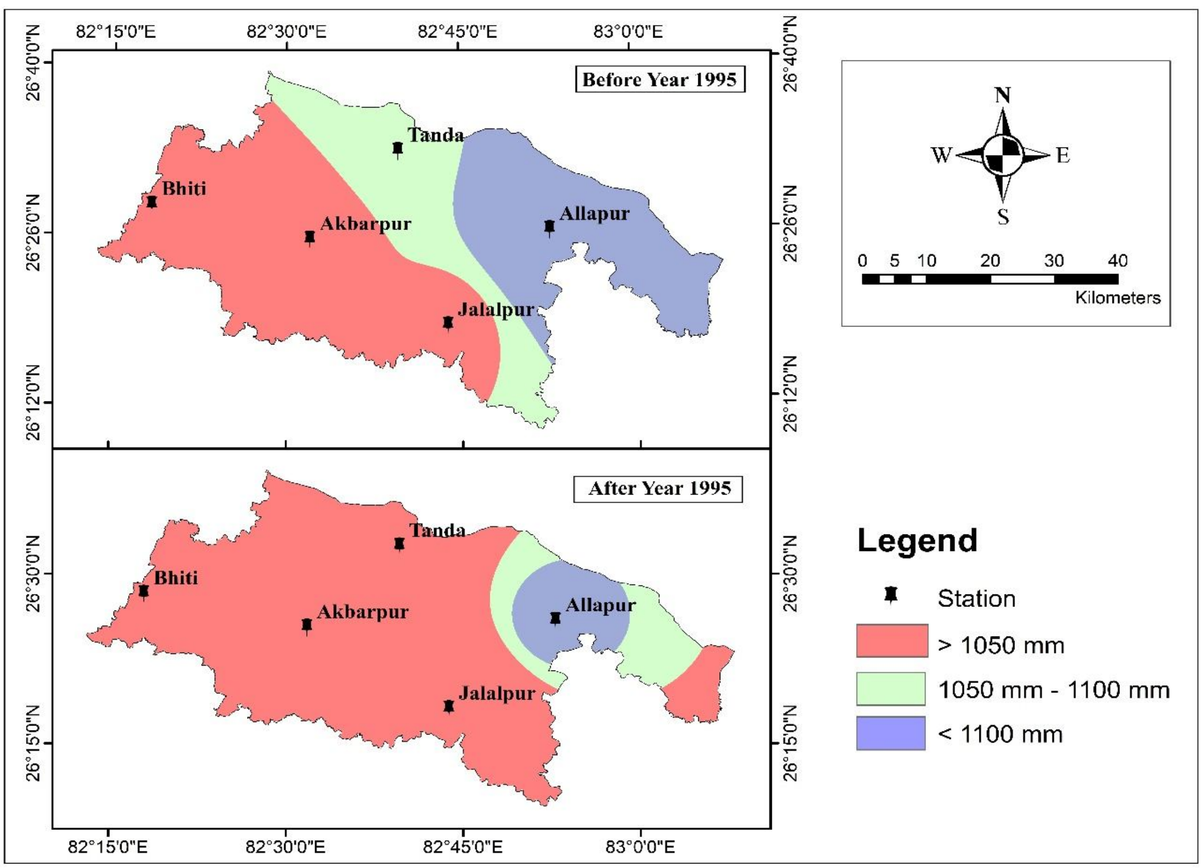

Figure 2: Average annual rainfall distribution before and after change point year 1995

Before change point year 1995, the average annual rainfall in the district varies in the range of 1001 mm to 1257 mm. The average annual rainfall varies in the range of 1001 to 1050 mm in Akbarpur, Bhiti and Jalalpur. However, the average annual rainfall in the range of 1050 to 1100 mm occurs in the Tanda and partly in the Jalalpur. However, the eastern part of the district has a higher average annual rainfall range from 1100 mm to 1257 mm.

After the change point year 1995, the average annual rainfall in the district varies in the range of 786 mm to 1167 mm. The average annual rainfall varies in the range of 786 to 1050 mm in the major part of district Akbarpur, Bhiti and Jalalpur and Tanda stations. However, some parts of station Allapur received average annual rainfall in the range of 1050 to 1100 mm and some parts received range from 1100 mm to 1167 mm. From the above comparison of distribution of annual rainfall in Ambedkar Nagar district it can be seen that the area receiving good amount of rainfall has been reduced after the year 1995.

The analysis has also been carried out to assess the area coverage of Ambedkar Nagar district under different rainfall range before and after change point year 1995 and results are given in Table 6.

Table 6: Area under various average annual rainfall classes before and after change point year 1995

Before change point year 1995		After change point year 1995	
Annual RF (1951-1994)	**Area %**	**Annual RF (1995-2022)**	**Area %**
1001-1050 mm	51	886-1050 mm	82
1050-1100 mm	22	1050-1100 mm	10
1100-1257 mm	27	1100-1168 mm	8

Before change point year 1995, about 51% of the area of the district was observed receiving rainfall up to 1050 mm, 27% of the area was observed receiving rainfall in range 1100-1257 mm and 22% of the area was observed receiving rainfall in range 1050-1100 mm and.

From the table 6 it can be seen that the situation has been seen changed drastically after change point year 1995 in the district. It was seen that after year 1995, majority area of the district i.e. 81% area observed rainfall in the range of 886 to 1050 mm. Only 10% area was observed receiving rainfall in the range of 1050 to 1100 mm and 8% area was seen receiving good rainfall in the range of 1100 to 1168 mm. Thus, it can be seen that the area receiving good rainfall in the district has been found reduced after the change point year 1995.

4.5.2 Average monsoon rainfall distribution before and after change point year

The spatial distribution of the average annual rainfall distribution before and after change point year 1995 for the Ambedkar Nagar district is shown in Figure 3.

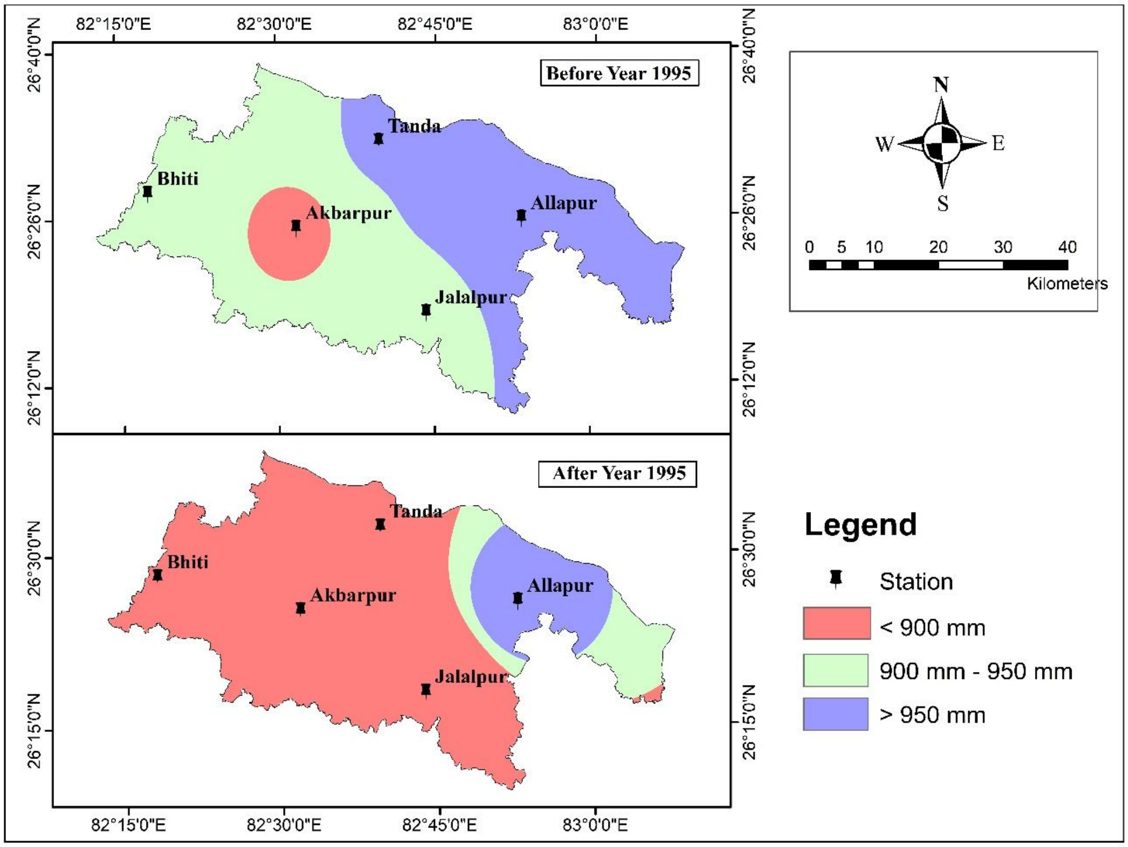

Figure 3: Average monsoon rainfall distribution before and after change point year 1995

Before change point year 1995, the average monsoon rainfall in the district varies in the range of 885 mm to 1108 mm. The average monsoon rainfall varies in the range of 885 to 900 mm in the Akbarpur and monsoon rainfall varies in the range 900 to 950 mm in part of Bhiti, Jalalpur and some part of Tanda. However, the average monsoon rainfall in the range of 900 to 1108 mm occurs in some parts of Tanda and Allapur.

After the change point year 1995, the average monsoon rainfall in the district varies in the range of 692 mm to 1039 mm. The average monsoon rainfall varies in the range of 692 to 900 mm in the most part of the district such as Akbarpur, Bhiti, Jalalpur and Tanda, monsoon rainfall varies in the range 900 to 950 mm in some part of Tanda and some part of Allapur. However, the average monsoon rainfall in the range of 900 to 1039 mm occurs in only Allapur. From the above comparison of distribution of monsoon rainfall in Ambedkar Nagar district it can be seen that the area receiving good amount of rainfall has been reduced after the year 1995.

The analysis has also been carried out to assess the area coverage of Ambedkar Nagar district under different rainfall range before and after change point year 1995 and results are given in Table 7.

Table 7: Area under various average monsoon rainfall classes before and after change point year 1995

Before change point year 1995		After change point year 1995	
Monsoon rf (1951-1994)	**Area %**	**Monsoon rf (1995-2022)**	**Area %**
885-900 mm	4	692-900 mm	76

900-950 mm	53	900-950 mm	10
950-1108 mm	42	950-1039 mm	14

Before change point year 1995, about 4% of the area receives rainfall up to 900 mm, 53% of the area receives rainfall in range 900-950 mm and 42% of the area receives rainfall in range 950-1108 mm.

From the table 7 it can be seen that the situation has been seen changed drastically after change point year 1995 in the district. It was seen that after year 1995, area received rainfall up to 900 mm has increased from 4% during the period 1951-1994 to 76% after the change point. 10% of area received rainfall in range 900-950 mm, and 14% of area received rainfall in range 950-1039 mm. Thus, it can be seen that the area receiving good rainfall in the district has been found reduced after the change point year 1995.

4.5.3 Average non-monsoon rainfall distribution before and after change point

The spatial distribution of the average non-monsoon rainfall distribution before and after change point year 1995 for the Ambedkar Nagar district is shown in Figure 4.Before change point year 1995, the average non-monsoon rainfall in the district varies in the range of 107 mm to 149 mm. The average non-monsoon rainfall varies in the range of 107 to 110 mm in the minor part of the district such as Jalalpur and rainfall varies in the range 110 to 120 mm in Bhiti, Akbarpur and also some part of Jalalpur. However, the average rainfall in the range of 120 to 149 mm occurs in Tanda and Allapur, also some minor part of Jalalpur.

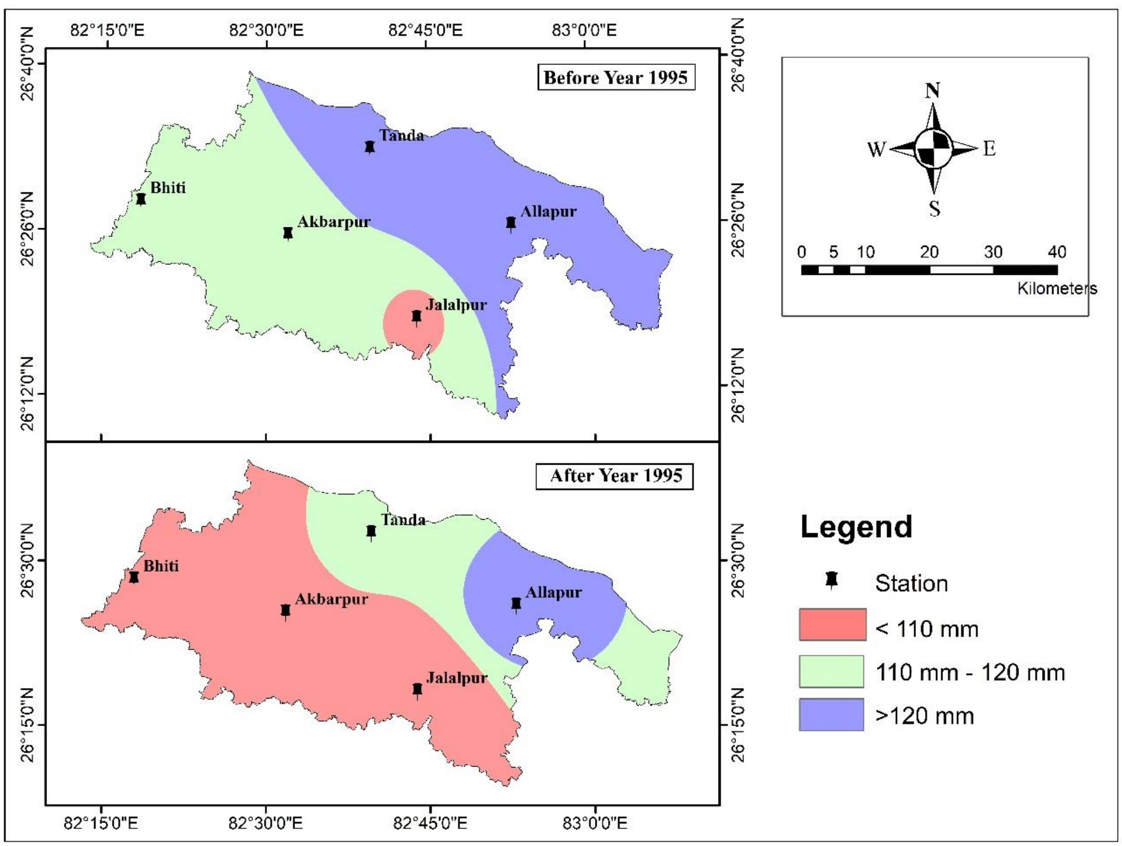

Figure 4: Average non-monsoon rainfall distribution before and after change point year 1995

After the change point year 1995, the average non-monsoon rainfall in the district varies in the range of 90 mm to 130 mm. The average rainfall varies in the range of 90 to 110 mm in the major part of the district such as Akbarpur, Bhiti and Jalalpur and rainfall varies in the range 110 to 120 mm in some parts of Tanda, Jalalpur and Allapur also. However, the average rainfall in the range of 120 to 130 mm received in only Allapur.

The analysis has also been carried out to assess the area coverage of Ambedkar Nagar district under different rainfall range before and after change point year 1995 and results are given in Table 8.

Table 8: Area under various average non-monsoon rainfall classes before and after change point year 1995

Before change point year 1995		After change point year 1995	
Non-monsoon rf (1951-1994)	**Area %**	**Non-monsoon rf (1995-2022)**	**Area %**
107-110 mm	3	90-110 mm	62
110-120 mm	50	110-120 mm	24
120-149 mm	47	120-130 mm	14

Before change point is given in table 8 and it can be observed that about 3% of the area receives rainfall up to 110 mm, 50% of the area receives rainfall in range 110-120 mm and 47% of the area receives rainfall in range 120-149 mm.

From the table 8 it can be seen that the situation has been seen changed drastically after change point year 1995 in the district. It was seen that after year 1995, the area received rainfall up to 110 mm has increased from 3% during the period 1951-1994 to 62% after the change point. 24% of area received rainfall in range 110-120 mm, and 14% of area received rainfall in range 120-130 mm.Thus, it can be seen that the area receiving good rainfall in the district has been found reduced after the change point year 1995.

4.5.4 Average annual rainy days distribution before and after change point year

The spatial distribution of the average annual rainy days before and after change point year 1995 for the Ambedkar Nagar district is shown in Figure 5.

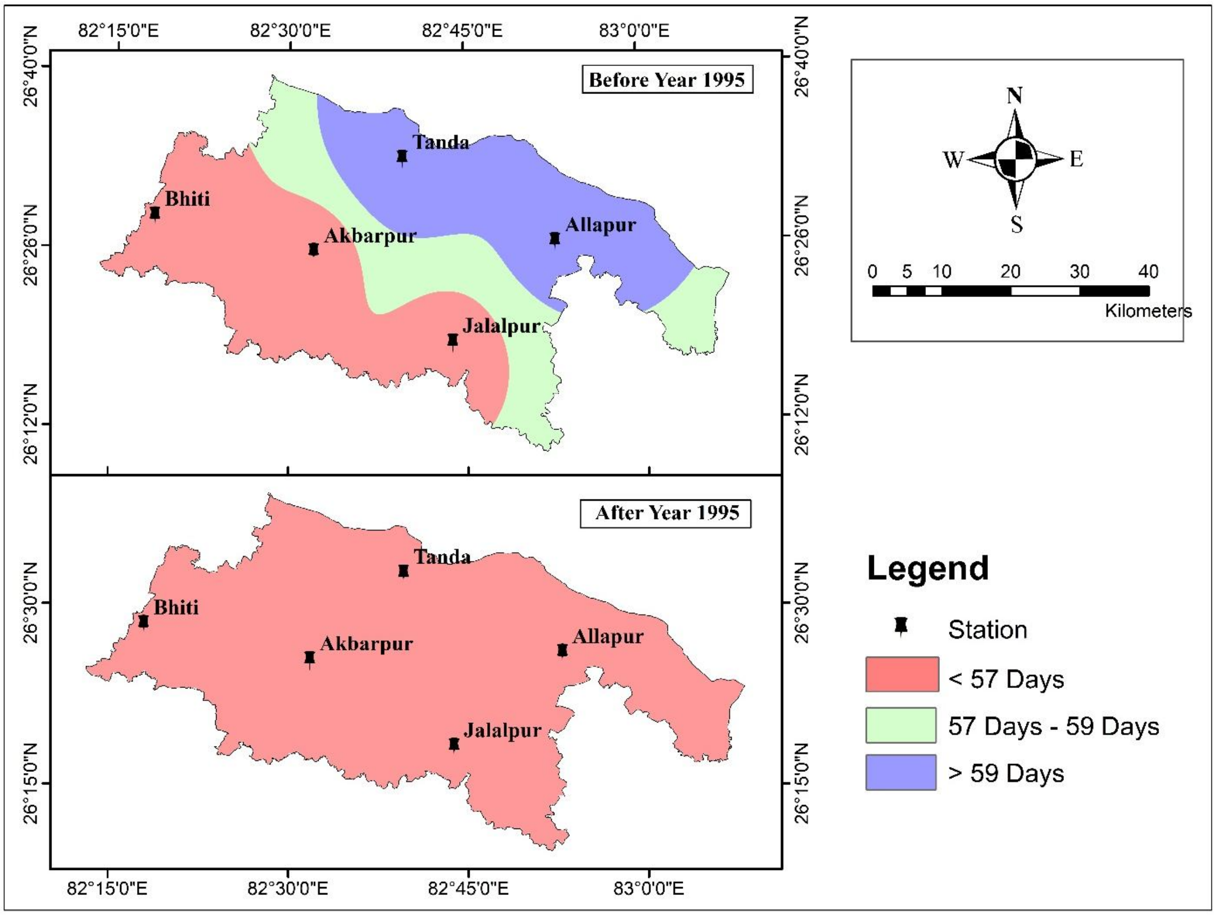

Figure 5: Average annual rainy days distribution before and after change point

Before change point year 1995, the average annual rainy days in the district varies in the range of 55 days to 62 days. The average annual rainy days varies in the range of 55 to 57 days in some part of Bhiti, Akbarpur and Jalalpur, average annual rainy days varies in the range 57 to 59 days mostly in Tanda and also some part in Akbarpur, Jalalpur and Allapur. However, the average annual rainy days in the range of 59 to 62 days occur in Allapur and Tanda.

After the change point year 1995, the average annual rainy days in the district varies in the range of 45 days to 55 days. The average annual rainy days are less than 55 days for all stations of the Ambedkar Nagar district.

The analysis has also been carried out to assess the area coverage of Ambedkar Nagar district under different rainy days range before and after change point year 1995 and results are given in Table 9.

Table 9: Area under various average annual rainy days classes before and after change point year 1995

Before change point year 1995		After change point year 1995	
Rainy days (1951-1994)	Area %	Rainy days (1995-2022)	Area %
55-57 days	35	45-55 days	100
57-59 days	45		

59-62 days	34

Before change point is given in Table and it can be observed that about 35% of the area receives up to 57 days, 45% of the area receives rainy days in range 57-59 days and 34% of the area receives rainy days in range 59-62 days.

From the table 9 it can be seen that the situation has been seen changed drastically after change point year 1995 in the district. It was seen that after year 1995, that the total area of Ambedkar Nagar received rainy days in range only 45-55 days. Thus, it can be seen that the area receiving good rainy days in the district has been found reduced after the change point year 1995.

4.6 Analysis of monthly maximum temperature trend and change point

Trend of monthly maximum temperature, trend magnitude (^{0}C) and change point analysis carried out over the period of 1951-2022 of all the stations (Akbarpur, Allapur, Bhiti, Jalalpur and Tanda) using Mann-Kendall test for trend, Sen's slope estimator for the magnitude of trend and Worsley Likelihood test for the change point analysis in discussed under following.

4.6.1 Analysis of monthly maximum temperature of Akbarpur station

The monthly maximum temperature of Akbarpur station is depicted in Table 10. It shows that non-significant decreasing trend in February, May, June and November month with the rate of 0.008, 0.012, 0.007 and 0.005 ^{0}C/year respectively and also non-significant change point observed in the year 2013, 1970, 1956 and 1961 for February, May, June and November month respectively. January, March, April, July, September and October month show not significant increasing trend with the rate of 0.009, 0.008, 0.004, 0.005, 0.011, and 0.004 ^{0}C/year respectively and not significant change point observed in the year 2013 for January, 1998 for March and April, 1957 for July, 2003 for September and 1952 for October. A significant increasing temperature trend found in August and December month with the rate of 0.02 and 0.023 ^{0}C/year and a significant change point for this trend was detected as year 1999 and 1998 respectively.

Table 10: Trend and change point detection of monthly maximum temperature for the period 1951 to 2022 of Akbarpur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	**Sen's Slope β**	**Trend Significance at 95% confidence level**	**Worsley Likelihood test Statistic W**	**Year Of Change**	**Change Significance at 95% confidence level**
Jan	0.892	0.009	NS Increasing	1.877	2013	NS
Feb	-0.649	-0.008	NS Decreasing	2.266	2013	NS
Mar	0.782	0.008	NS Increasing	1.552	1998	NS
Apr	0.620	0.004	NS Increasing	1.696	1998	NS
May	-1.356	-0.012	NS Decreasing	1.791	1970	NS
Jun	-0.550	-0.007	NS Decreasing	1.476	1956	NS
Jul	0.342	0.005	NS Increasing	1.589	1957	NS
Aug	**2.955**	**0.020**	**S Increasing**	**3.220**	**1999**	**S**
Sep	1.616	0.011	NS Increasing	2.722	2003	NS
Oct	0.492	0.004	NS	2.187	1952	NS

			Increasing			
Nov	-0.811	-0.005	NS Decreasing	2.034	1961	NS
Dec	**3.233**	**0.023**	**S** Increasing	**3.609**	**1998**	**S**

NS: Not Significant, S: Significant

4.6.2 Analysis of monthly maximum temperature of Allapur station

From the Table 11 the values show that station Allapur have not significant negative trend of maximum temperature in February, May, June, and November month with the rate of 0.005, 0.012, 0.007 and 0.001 ^{0}C/year respectively and not significant positive trend of maximum temperature in January, March, April, July and October with the rate of 0.007, 0.009, 0.004, 0.005 and 0.004 ^{0}C/year respectively. There is not any significant change point found except in August, September and December month. A significantly positive trend shown in August, September and December month with a rate of 0.019, 0.012 and 0.022 ^{0}C/year and a significant change point observed in 1999 for August 2003 for September and 1998 for December.

Table 11 Trend and change point detection of monthly maximum temperature for the period 1951 to 2022 of Allapur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	**Sen's Slope β**	**Trend Significance at 95% confidence level**	**Worsley Likelihood test Statistic W**	**Year Of Change**	**Change Significance at 95% confidence level**
Jan	0.857	0.007	NS Increasing	1.673	2005	NS
Feb	-0.411	-0.005	NS Decreasing	2.308	2013	NS
Mar	0.869	0.009	NS Increasing	1.851	1998	NS
Apr	0.562	0.004	NS Increasing	1.895	1998	NS
May	-1.558	-0.012	NS Decreasing	1.762	1970	NS
Jun	-0.585	-0.007	NS Decreasing	1.541	1956	NS
Jul	0.417	0.005	NS Increasing	1.653	1957	NS
Aug	**3.181**	**0.019**	**S Increasing**	**3.738**	**1999**	**S**
Sep	**2.265**	**0.012**	**S Increasing**	**3.290**	**2003**	**S**
Oct	0.643	0.004	NS Increasing	2.034	1952	NS
Nov	-0.116	-0.001	NS Decreasing	2.419	1961	NS
Dec	**3.383**	**0.022**	**S Increasing**	**3.713**	**1998**	**S**

NS: Not Significant, S: Significant

4.6.3 Analysis of monthly maximum temperature of Bhiti station

The monthly maximum temperature of the Bhiti station is depicted in Table 12. It shows that non-significant decreasing trend in February, May, June and November month with the rate of 0.009, 0.011, 0.008 and 0.006 ^{0}C/year respectively and also non-significant change point observed in the year 2013, 1980, 1956 and 1961 for February, May, June and November month respectively. January, March, April, July, September and October month show not significant increasing trend with the rate of 0.007, 0.005, 0.005, 0.002, 0.011, and 0.003 ^{0}C/year respectively and not significant change point observed in the year 2013 for January, 1998 for March and April, 1956 for July, 2003 for September and 1952 for October. A significant increasing temperature trend found in August and December month with a rate of 0.017 and 0.018 ^{0}C/year and a significant change point for the trend was detected as the year 1997 for December but a non-significant change point for August in 1999.

Table 12: Trend and change point detection of monthly maximum temperature for the period 1951 to 2022 of Bhiti station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	**Sen's Slope β**	**Trend Significance at 95% confidence level**	**Worsley Likelihood test Statistic W**	**Year Of Change**	**Change Significance at 95% confidence level**
Jan	0.655	0.007	NS Increasing	2.101	2013	NS
Feb	-0.603	-0.009	NS Decreasing	2.255	2013	NS
Mar	0.550	0.005	NS Increasing	1.425	1998	NS
Apr	0.550	0.005	NS Increasing	1.673	1998	NS
May	-1.419	-0.011	NS Decreasing	1.759	1980	NS
Jun	-0.649	-0.008	NS Decreasing	1.371	1956	NS
Jul	0.174	0.002	NS Increasing	1.533	1956	NS
Aug	**2.526**	**0.017**	**S Increasing**	2.713	1999	NS
Sep	1.657	0.011	NS Increasing	2.582	2003	NS
Oct	0.487	0.003	NS Increasing	2.317	1952	NS
Nov	-0.736	-0.006	NS Decreasing	2.038	1961	NS
Dec	**2.961**	**0.018**	**S Increasing**	**3.268**	**1997**	**S**

NS: Not Significant, S: Significant

4.6.4 Analysis of monthly maximum temperature of Jalalpur station

The monthly maximum temperature of Jalalpur station is depicted in Table 13. It shows that non-significant decreasing trend in February, May, June and November month with the rate of 0.006, 0.012, 0.007 and 0.002 ^{0}C/year respectively and also non-significant change point observed in the year 2013, 1970, 1956 and 1961 for February, May, June and November month respectively. January, March, April, July, September and October month show non-significant increasing trend with the rate of 0.006, 0.009, 0.005, 0.005, 0.011, and 0.005 ^{0}C/year respectively and not significant change point observed in the year 1989 for January, 1998 for March and April, 1957 for July, 2003 for September and 1952 for October. A significant increasing temperature trend found in August and December month with the rate of 0.019 and 0.023 ^{0}C/year and a significant change point for this trend was detected as year 1999 and 1998 respectively.

Table 13: Trend and change point detection of monthly maximum temperature for the period 1951 to 2022 of Jalalpur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Jan	0.875	0.006	NS Increasing	1.636	1989	NS
Feb	-0.429	-0.006	NS Decreasing	2.221	2013	NS
Mar	0.788	0.009	NS Increasing	1.686	1998	NS
Apr	0.660	0.005	NS Increasing	1.824	1998	NS
May	-1.379	-0.012	NS Decreasing	1.873	1970	NS
Jun	-0.498	-0.007	NS Decreasing	1.435	1956	NS
Jul	0.527	0.005	NS Increasing	1.555	1957	NS
Aug	**2.995**	**0.019**	**S Increasing**	**3.260**	**1999**	**S**
Sep	1.831	0.011	NS Increasing	2.821	2003	NS
Oct	0.579	0.005	NS Increasing	2.083	1952	NS
Nov	-0.284	-0.002	NS Decreasing	2.340	1961	NS
Dec	**3.320**	**0.023**	**S Increasing**	**3.664**	**1998**	**S**

NS: Not Significant, S: Significant

4.6.5 Analysis of monthly maximum temperature of Tanda station

From the Table 14 the values show that station Tanda have non-significant negative trend of maximum temperature in February, May, June, and November month with the rate of 0.006, 0.012, 0.008 and 0.003 ^{0}C/year respectively and non-significant positive trend of maximum temperature in January, March, April, July, September and October with the rate of 0.008, 0.009, 0.005, 0.006, 0.012 and 0.004 ^{0}C/year respectively.

Table 14: Trend and change point detection of monthly maximum temperature for the period 1951 to 2022 of Tanda station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Jan	0.915	0.008	NS Increasing	1.658	2013	NS
Feb	-0.498	-0.006	NS Decreasing	2.288	2013	NS
Mar	0.846	0.009	NS Increasing	1.702	1998	NS

Month	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Apr	0.591	0.005	NS Increasing	1.785	1998	NS
May	-1.396	-0.012	NS Decreasing	1.796	1970	NS
Jun	-0.556	-0.008	NS Decreasing	1.501	1956	NS
Jul	0.533	0.006	NS Increasing	1.607	1957	NS
Aug	**3.088**	**0.020**	**S Increasing**	**3.499**	**1999**	**S**
Sep	1.877	0.012	NS Increasing	3.038	2003	NS
Oct	0.632	0.004	NS Increasing	2.136	1952	NS
Nov	-0.324	-0.003	NS Decreasing	2.234	1961	NS
Dec	**3.349**	**0.022**	**S Increasing**	**3.685**	**1998**	**S**

NS: Not Significant, S: Significant

There is not any significant change point found except in August and December month. A significantly positive trend shown in August and December month with a rate of 0.020 and 0.022 ^{0}C/year and a significant change point observed in 1999 for August and 1998 for December.

4.7 Analysis of monthly minimum temperature trend and change point

Trend of monthlyminimum temperature, trend magnitude (^{0}C) and change point analysis carried out over the period of 1951-2022 of all the stations (Akbarpur, Allapur, Bhiti, Jalalpur and Tanda) using Mann-Kendall test for trend, Sen's slope estimator for the magnitude of trend and Worsley Likelihood test for the change point analysis in discussed under following.

4.7.1 Analysis of monthly minimum temperature of Akbarpur station

The monthly minimum temperature of Akbarpur station is depicted in Table 15. It shows that non-significant decreasing trend in January, June and September month with the rate of 0.009, 0.011 and 0.001 ^{0}C/year respectively and non-significant increasing trend in February, March, April, July, August, October, November and December with the rate 0.010, 0.001, 0.001, 0.003, 0.005, 0.003, 0.012 and 0.001 ^{0}C/year respectively, a significant decreasing trend shown in May month with the rate of 0.025 ^{0}C/year. All month have non-significant change point except March and May month. A significant change point observed in March and May month as the year 1953 and 1959 respectively.

Table 15: Trend and change point detection of monthly minimum temperature for the period 1951 to 2014 of Akbarpur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Jan	-1.025	-0.009	NS Decreasing	2.508	2012	NS
Feb	1.078	0.010	NS Increasing	2.287	1985	NS
Mar	0.093	0.001	NS Increasing	**3.505**	**1953**	**S**
Apr	0.168	0.001	NS Increasing	2.251	1997	NS
May	**-2.787**	**-0.025**	**S Decreasing**	**3.778**	**1959**	**S**

Jun	-1.871	-0.011	NS Decreasing	2.287	1973	NS
Jul	0.678	0.003	NS Increasing	2.186	1990	NS
Aug	1.112	0.005	NS Increasing	3.132	1993	NS
Sep	-0.168	-0.001	NS Decreasing	2.665	1961	NS
Oct	0.290	0.003	NS Increasing	2.533	1951	NS
Nov	1.333	0.012	NS Increasing	2.079	1993	NS
Dec	0.220	0.001	NS Increasing	2.460	1953	NS

NS: Not Significant, S: Significant

4.7.2 Analysis of monthly minimum temperature of Allapur station

From the Table 16 the values show that station Allapur have non-significant negative trend of minimum temperature in January, March, April, September, October and December month with the rate of 0.012, 0.004, 0.001, 0.005, 0.001 and 0.001 ^{0}C/year respectively and non-significant positive trend of minimum temperature in February, July, August and November with the rate of 0.006, 0.001, 0.001 and 0.010 ^{0}C/year respectively. A significant decreasing trend found in May and June month with a rate of 0.029 and 0.013 ^{0}C/year respectively.

Table 16: Trend and change point detection of monthly minimum temperature for the period 1951 to 2022 of Allapur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Jan	-1.524	-0.012	NS Decreasing	2.499	2012	NS
Feb	0.771	0.006	NS Increasing	1.965	2002	NS
Mar	-0.516	-0.004	NS Decreasing	**3.998**	**1953**	**S**
Apr	-0.093	-0.001	NS Decreasing	1.997	1964	NS
May	**-3.279**	**-0.029**	**S Decreasing**	**4.114**	**1959**	**S**
Jun	**-2.260**	**-0.013**	**S Decreasing**	2.707	1973	NS
Jul	0.209	0.001	NS Increasing	1.741	1951	NS
Aug	0.232	0.001	NS Increasing	2.282	1993	NS
Sep	-0.724	-0.005	NS Decreasing	2.998	1961	NS
Oct	-0.081	-0.001	NS Decreasing	2.642	1951	NS
Nov	0.933	0.010	NS Increasing	1.750	1996	NS
Dec	-0.197	-0.001	NS Decreasing	2.491	1953	NS

NS: Not Significant, S: Significant

All the month have a non-significant change point except March and June month. March and June month have significant change point in the year 1953 and 1959 respectively.

4.7.3 Analysis of monthly minimum temperature of Bhiti station

The monthly minimum temperature of the Bhiti station is depicted in Table 17. It shows that non-significant decreasing trend in September and December month with the rate of 0.002 and 0.001 ^{0}C/year respectively.

Table 17: Trend and change point detection of monthly minimum temperature for the period 1951 to 2022 of Bhiti station

Month	**Trend Analysis**			**Change point**		
	Mann-Kendall statistic Z	**Sen's Slope β**	**Trend Significance at 95% confidence level**	**Worsley Likelihood test Statistic W**	**Year Of Change**	**Change Significance at 95% confidence level**
Jan	0.035	0.001	NS Increasing	2.802	1961	NS
Feb	1.304	0.012	NS Increasing	2.835	1984	NS
Mar	0.747	0.006	NS Increasing	2.660	1994	NS
Apr	0.666	0.006	NS Increasing	2.357	1998	NS
May	0.800	0.006	NS Increasing	2.716	1992	NS
Jun	0.933	0.005	NS Increasing	**3.440**	**1997**	**S**
Jul	**2.068**	**0.011**	**S Increasing**	**5.382**	**1997**	**S**
Aug	1.211	0.006	NS Increasing	**4.148**	**1993**	**S**
Sep	-0.516	-0.002	NS Decreasing	3.030	1964	NS
Oct	0.017	0.001	NS Increasing	2.956	1952	NS
Nov	1.170	0.010	NS Increasing	1.833	1996	NS
Dec	-0.232	-0.001	NS Decreasing	2.766	1960	NS

NS: Not Significant, S: Significant

A non-significant increasing trend in January, February, March, April, May, June, August, October and November with the rate 0.001, 0.012, 0.006, 0.006, 0.006, 0.005, 0.006, 0.001 and 0.010 ^{0}C/year respectively. A significant increasing trend shown in July month with the rate of 0.011 ^{0}C/year. All the month have a non-significant change point except June, July and August month. June, July month has a significant change point in the year 1997 and August month has a significant change point in the year 1993.

4.7.4 Analysis of monthly minimum temperature of Jalalpur station

From the Table 18 the values show that station Jalalpur have non-significant negative trend of minimum temperature in January, March, April, September and December month with the rate of 0.011, 0.002, 0.001, 0.003 and 0.001 ^{0}C/year respectively and non-significant positive trend of minimum temperature in February, July, August, October and November with the rate of 0.009, 0.002, 0.002, 0.001 and 0.012

^{0}C/year respectively. A significant decreasing trend found in May and June month with a rate of 0.027 and 0.011 ^{0}C/year respectively. All the month have a non-significant change point except March and May month. March and May month have significant change point in the year 1953 and 1959 respectively.

Table 18: Trend and change point detection of monthly minimum temperature for the period 1951 to 2022 of Jalalpur station

Month	Trend Analysis			Change point		
	Mann-Kendall statistic Z	Sen's Slope β	Trend Significance at 95% confidence level	Worsley Likelihood test Statistic W	Year Of Change	Change Significance at 95% confidence level
Jan	-1.309	-0.011	NS Decreasing	2.520	2012	NS
Feb	0.881	0.009	NS Increasing	2.117	2002	NS
Mar	-0.185	-0.002	NS Decreasing	**3.781**	**1953**	**S**
Apr	-0.075	-0.001	NS Decreasing	2.116	1997	NS
May	**-3.024**	**-0.027**	**S Decreasing**	**3.930**	**1959**	**S**
Jun	**-2.016**	**-0.011**	**S Decreasing**	2.478	1973	NS
Jul	0.475	0.002	NS Increasing	1.865	1990	NS
Aug	0.632	0.002	NS Increasing	2.731	1993	NS
Sep	-0.435	-0.003	NS Decreasing	2.817	1961	NS
Oct	0.122	0.001	NS Increasing	2.588	1951	NS
Nov	1.124	0.012	NS Increasing	1.900	1953	NS
Dec	-0.006	-0.001	NS Decreasing	2.503	1993	NS

NS: Not Significant, S: Significant

4.7.5 Analysis of monthly minimum temperature of Tanda station

The monthly minimum temperature of the Tanda station is depicted in Table 19. It shows that non-significant decreasing trend in January, March, April, September and October month with the rate of 0.010, 0.003, 0.001, 0.004 and 0.001 ^{0}C/year respectively and non-significant increasing trend in February, July, August, November and December with the rate 0.007, 0.003, 0.003, 0.010 and 0.001 ^{0}C/year respectively, a significant decreasing trend shown in May and June month with the rate of 0.027 and 0.011 ^{0}C/year. All month has shown a non-significant change point except May month. May month has a significant change point in the year 1959.

Table 19: Trend and change point detection of monthly minimum temperature for the period 1951 to 2022 of Tanda station

Month	Trend Analysis			Change point		
	Mann-Kendall	Sen's Slope	Trend Significance	Worsley Likelihood	Year Of Change	Change Significance

	statistic Z	β	at 95% confidence level	test Statistic W		at 95% confidence level
Jan	-1.211	-0.010	NS Decreasing	2.382	2012	NS
Feb	0.730	0.007	NS Increasing	2.037	2002	NS
Mar	-0.295	-0.003	NS Decreasing	3.925	1953	NS
Apr	-0.104	-0.001	NS Decreasing	2.031	1997	NS
May	**-2.897**	**-0.027**	**S Decreasing**	**3.887**	**1959**	**S**
Jun	**-1.970**	**-0.011**	**S Decreasing**	2.608	1973	NS
Jul	0.614	0.003	NS Increasing	2.042	1990	NS
Aug	0.655	0.003	NS Increasing	2.869	1993	NS
Sep	-0.481	-0.004	NS Decreasing	2.807	1961	NS
Oct	-0.023	-0.001	NS Decreasing	2.573	1951	NS
Nov	0.985	0.010	NS Increasing	1.821	1993	NS
Dec	0.093	0.001	NS Increasing	2.398	1953	NS

NS: Not Significant, S: Significant

5. Summery and conclusion

This study was focused on analysing the trend and assess climate change in Ambedkar Nagar district. For this purpose, daily rainfall data for 72 years from 1951-2022 were used to assess the trends, its magnitude, and change point detection. It is observed for overall district that annual rainfall and monsoon rainfall shows insignificant decreasing trend, non-monsoon rainfall shows insignificant increasing trend and annual rainy days for Ambedkar Nagar district also shows insignificant decreasing trend. Change year of rainfall pattern in most seasons shows in year of 1995. Yearly maximum temperature shows an insignificant decreasing trend for all the stations, over the period 1951-2022. Maximum temperature shows a significant increasing trend in August and December for all stations with an average rate of 0.02 ^{0}C/year, while Allapur station also shows a significant increasing trend in September with a rate as 0.012 ^{0}C/year. Minimum temperature, four stations (Akbarpur, Allapur, Jalalpur, Tanda) out of five shows a significant decreasing trend in May, three stations (Allapur, Jalalpur and Tanda) shows a significant decreasing trend in June and a significant increasing trend in July shown at Bhiti station.The result of this study can be used as an input information for planning of water resources, agriculture practices, irrigation, soil and water conservation measures etc.

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