

Analysis of Temperature and Rainfall Trend in South 24 Parganas District of West Bengal (1988-2017)

Chandra Shekhar Sarkar¹, Aritra Chakraborty²

¹Research Scholar, Department of Geography, Presidency University, Kolkata, India

²Assistant Professor, Dept. of Geography, Presidency University, Kolkata, India

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Abstract: This study investigated the change in the trend of temperature and rainfall in South 24 Parganas District of West Bengal. Therefore, daily temperature, total annual and monsoon rainfall data were collected from the Indian Meteorological Department (IMD), Kolkata for the period from 1988 to 2017 (30 years). Time series analysis method was used to identify the changing trend in temperature and rainfall. The study revealed that in the last 30 years (1988-2017), the average annual, average maximum annual and average minimum annual temperature were 27°C, 34.6°C and 18.8°C respectively. On the other hand, the average total annual and average monsoon rainfall were 172.7 cm. and 129.4 cm. from 1988 to 2017. The study highlighted a significant changing trend in temperature as well as rainfall. The study identified an increasing trend in average annual and average maximum annual temperature, while a slightly declining trend in average minimum annual temperature from 1988 to 2017 (30 years). The results of the study also revealed an increasing trend in the total annual and monsoon rainfall over a period of 30 years (1988-2017).

Keywords: Climate change, Trend analysis, Temperature, Rainfall

1. Introduction

Climate change is a serious concern resulting in variation of the temperature and rainfall pattern.¹ In the 21st century, worldwide climate change has taken place as a dire threatened to all life in the near future. The Inter-Governmental Panel on Climate Change (IPCC) defines climate change as a change in the climatic condition that can be identified by changes in the variability of its properties and that continues for a long period, decades or longer.^{2 3} The IPCC report (2019) states that the global mean surface temperature for the decade 2006-2015 was nearly 0.87°C higher than the average over the period of 1850-1900 and probable anthropogenic global warming is now increasing at 0.2°C per decade due to greenhouse gas emission.⁴ The World Metrological Organization (WMO) report (2020) describes that 2020 as one of the warmest year as per record and 2011-2020 as the warmest decade. The average global temperature is 1.2°C higher in 2020 than the pre-industrial level.⁷ However, the changing pattern of temperature and rainfall are not similar around the world there is regional variability. Rainfall and temperature are the two most important factors in the fields of climate science.⁶ Rainfall is a key factor in the flood as well as drought assessment and temperature play a vital role in evaporation, transpiration, evapotranspiration and water demand.⁶

The statistical and trend analysis of temperature and rainfall is a very important aspect of climate change.⁷ Several studies were carried out by a few Indian researchers to study the trend and temporal as well as spatial variability of both temperature and rainfall. Kumar et al. (2010) analyzed long-term rainfall trends in India by using climatic data of 135 years for 30 subdivisions. Results of the study highlighted that the significant changes in annual rainfall trend.⁸ Subash et al. (2011) investigated the historical trend of rainfall in five meteorological subdivisions of Central Northeast India by applying the Mann–Kendall non-parametric test.⁹ Further, Jagadish et al. (2012) attempted to detect the trends of monthly, seasonal and annual rainfall over the Orissa State from 1871 to 2006. The study revealed that the insignificant

decreasing trend in both monsoon and annual rainfall, while the increasing trend in post-monsoon rainfall over the state.⁷ Deshmukh, and Lunge (2013) also did a study on temperature and rainfall trends in Buldana District of Vidarbha in India using 30 years data during the period from 1975 to 2005.¹⁰ Goyal (2014) analyzed the 100 years rainfall trend (1901-2000) in Assam based on Mann-Kendell and Sen's slope estimator test.¹¹ Mondal et al. (2014) made an important study on temporal and spatial analysis of rainfall and temperature trend in India based on the Mann-Kendall (MK) test and Sen's slope.¹ Meshram et al. (2017) also attempted a study on the spatial and temporal variability of rainfall in Chhattisgarh by using 102 years data (1901–2002) for 16 stations.¹² Shukla et al. (2017) analysed 105 years of temperature trend (1901-2005) in the Madhya Pradesh state of India using the Mann-Kendall, Sen's slope method and Pettitt's test.¹³ Mandloi et al. (2019) conducted a study on change in rainfall pattern in Anand of middle Gujarat by using climatic data from 1958 to 2017. The study revealed that rainy days has decreased by 0.017 mm per year in the last sixty years.¹⁴ Deoli and Rana (2019) examined the seasonal trend of rainfall and temperature in Udaipur District of Rajasthan by using 39 years daily rainfall data from 1975 to 2013.¹⁷ Several Important research work on a statistical analysis of temperature and rainfall were also carried out by a few foreign researchers like Philandras et al. (2011)¹⁶, Laseter et al. (2012)¹⁷, Akinsanola and Ogunjobi (2014)¹⁸, Khattak and Ali (2015)¹⁹, Lacerda et al. (2015)²⁰, Kruger and Nxumalo (2017)²¹, Bhuyan et al. (2018)², Byakatonda et al. (2018)²², Cattani et al. (2018)²³ and Abaje and Oladipo (2019)²⁴.

There are two objectives of the study. (1) To identify the change in trend of the average annual, average maximum annual and average minimum annual temperature from 1988 to 2017 in South 24 Parganas of West Bengal. (2) To detect the change in trend of the total annual and monsoon rainfall from 1988 to 2017 in South 24 Parganas of West Bengal.

2. Methodology

2.1 Study Area

South 24 Parganas District of West Bengal is an integral part of lower Gangetic delta. The District is bounded by Kolkata in the north, North 24 Parganas District in the northeast, Howrah District in the north-west, Hooghly river in the west, Bangladesh in the south-east and Bay of Bengal in the south. The latitudinal extension of the District is from 21° 29' 00" N to 22° 33' 45" N and the longitudinal extension is from 88° 03' 45" E to 89° 04' 50" E. It is the largest District by area in West Bengal, the total area of the District is 9960 square kilometers. There is total 5 subdivisions, 29 blocks, 7 municipalities, 310 gram-panchayats, 1994 inhabited villages in the District. South 24 Parganas is the second-highest populated District after North 24 Parganas in West Bengal. The total population of the District is 8161961, population density is 819 and the total male and female population are 51.14% and 48.86% respectively as per the 2011 census. The average annual rainfall of South 24 Parganas is nearly 140 centimeters and around 75% rainfall is received during the monsoon season. The annual maximum temperature is approximately 40°C and the minimum is around 10°C.

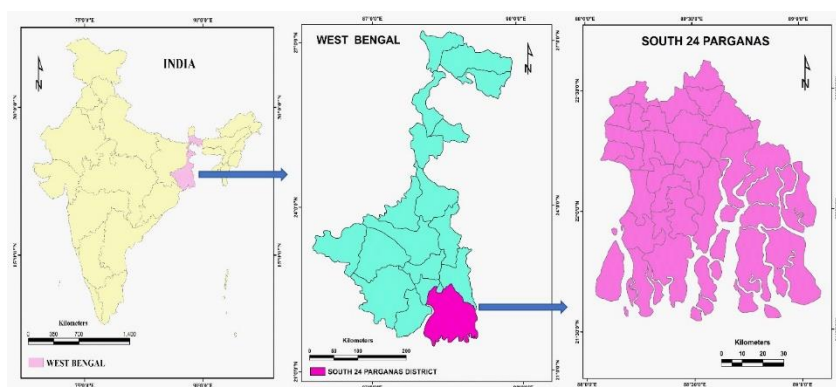


Figure 1. Location map of the study area

2.2 Data Collection

South 24 Parganas District is represented by the climatic data of Diamond Harbour weather station, which is the one of the main weather station of the District. In the study, daily temperature, total annual and monsoon (June-September) rainfall data of 30 years (1988-2017) were collected from the Indian Meteorological Department (IMD), Kolkata. The annual average, maximum and minimum temperature has been calculated based on daily data.

2.3 Data Analysis

Time series analysis of temperature and rainfall have been done by using Microsoft excel and the thematic maps were prepared by using ArcMap version 10.3 software.

3. Results and Discussions

3.1 Trend Analysis of the Average Annual Temperature in South 24 Parganas District from 1988 to 2017

Figure 2 and Table 1 represents the average annual temperature trend in the period from 1988 to 2017 in South 24 Parganas District of West Bengal. The maximum average annual temperature in the 30 years period (1988-2017) was recorded as 27.9°C in the year 2016 and minimum average annual temperature 26.3°C was recorded in the year 1992 (table-1). The average annual temperature has been calculated as 27°C. The years showing less than the average annual temperature were 1988, 1989, 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2003 and 2011 (table-1). On the other hand, the years showing more than the average annual temperature were 2002, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2012, 2014, 2015, 2016 and 2017 (table-1). Although, the linear regression trend line (Figure 2) represents the overall increasing trend of the average annual temperature in the period from 1988 to 2017 of South 24 Parganas District.

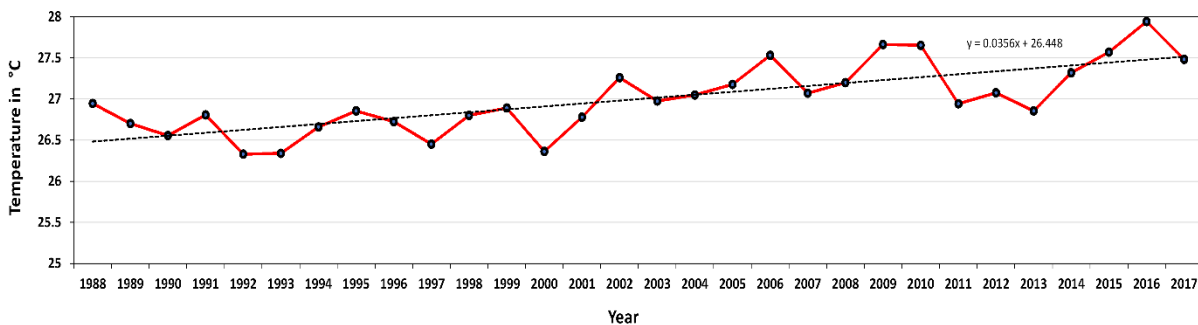


Figure 2. Showing the average annual temperature trend of South 24 Parganas District (1988 to 2017).

3.2 Trend Analysis of the Average Maximum Annual Temperature in South 24 Parganas District from 1988 to 2017

Figure 3 and Table 1 shows the average maximum annual temperature trend in the period from 1988 to 2017 of South 24 Parganas District. The highest average maximum annual temperature in the last 30 years period (1988-2017) was recorded as in the year 2016 (36.5°C) followed by the year 2015 (35.9°C), 2014 (35.9°C), 2009 (35.8°C) and 2002 (35.7°C). Whereas, the lowest average maximum annual temperature was recorded in the year 2000 (32.4°C). The average maximum temperature has been calculated as 34.6°C. The years showing less than the average maximum annual temperature were 1990, 1991, 1992, 1993, 1994, 1995, 1996, 1997, 1998, 1999, 2000, 2001, 2003 and 2008 (table-1). Conversely, the years showing more than average maximum annual temperature were 1988, 1989, 2002, 2004, 2005, 2006, 2007, 2009, 2010, 2011, 2012, 2013, 2014, 2015, 2016 to 2017 (table-1). While the linear regression trend line (Figure 3) represents the overall increasing trend of average maximum annual temperature in the period from 1988 to 2017 of South 24 Parganas District.

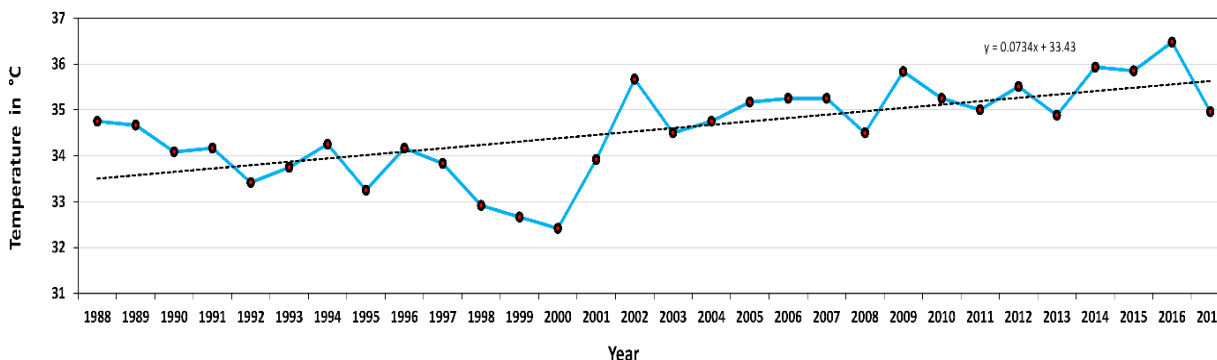


Figure 3. Showing the average maximum annual temperature trend of South 24 Parganas District (1988 to 2017).

3.3 Trend Analysis of the Average Minimum Annual Temperature in South 24 Parganas District from 1988 to 2017

Figure 4 and Table 1 illustrates the average minimum annual temperature trend in the period from 1988 to 2017 of South 24 Parganas District. The highest average minimum annual temperature in the 30 years period (1988-2017) was recorded as 19.9°C in the year 1999, followed by the year 2016 (19.8°C), 2010 (19.7°C) and 1998 (19.7°C). On the other hand, the lowest average minimum annual temperature was recorded as 17.5°C in 2011. The average minimum annual temperature has been calculated as 18.8°C. The years showing less than average minimum annual temperature were 1990, 1993, 1996, 1997, 2004, 2005, 2007, 2008, 2009, 2011, 2012, 2013 and 2014 (table-1). Contrary, the years showing more than average minimum annual temperature were 1989, 1991, 1994, 1998, 1999, 2000, 2001, 2002, 2003, 2006, 2010, 2016 and 2017 (table-1). Though, the linear regression trend line (Figure 4) represents the overall slightly decreasing trend of average minimum annual temperature in the period from 1988 to 2017 of South 24 Parganas Districts.

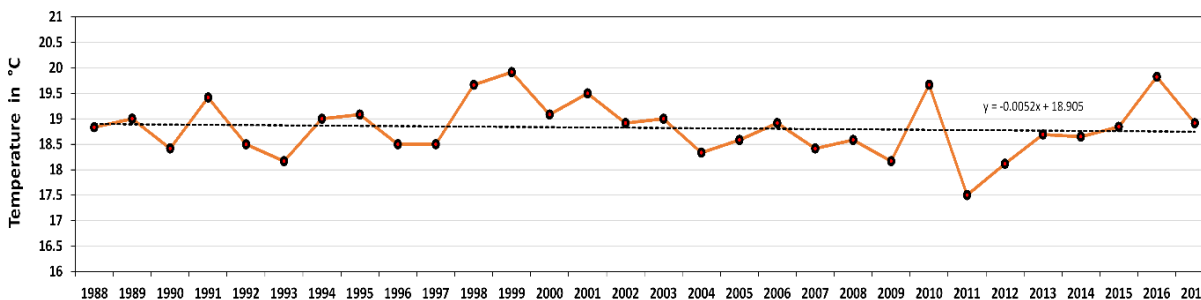


Figure 4. Showing the average minimum annual temperature trend of South 24 Parganas District (1988 to 2017).

Table 1. The average, maximum and minimum annual temperature of South 24 Parganas District from 1988 to 2017

Year	Average annual temperature in °C	Maximum annual temperature in °C	Minimum annual temperature in °C
1988	26.9	34.8	18.8
1989	26.7	34.7	19.0
1990	26.6	34.1	18.4
1991	26.8	34.2	19.4
1992	26.3	33.4	18.5
1993	26.3	33.8	18.2
1994	26.7	34.3	19.0
1995	26.9	33.3	19.1
1996	26.7	34.2	18.5
1997	26.5	33.8	18.5

1998	26.8	32.9	19.7
1999	26.9	32.7	19.9
2000	26.4	32.4	19.1
2001	26.8	33.9	19.5
2002	27.3	35.7	18.9
2003	27.0	34.5	19.0
2004	27.0	34.8	18.3
2005	27.2	35.2	18.6
2006	27.5	35.3	18.9
2007	27.1	35.3	18.4
2008	27.2	34.5	18.6
2009	27.7	35.8	18.2
2010	27.7	35.3	19.7
2011	26.9	35.0	17.5
2012	27.1	35.5	18.1
2013	26.9	34.9	18.7
2014	27.3	35.9	18.7
2015	27.6	35.9	18.8
2016	27.9	36.5	19.8
2017	27.5	35.0	18.9
Average	27	34.6	18.8

Source: Indian Meteorological Department (IMD), Kolkata

3.4 Trend Analysis of the Annual Total Rainfall in South 24 Parganas District from 1988 to 2017

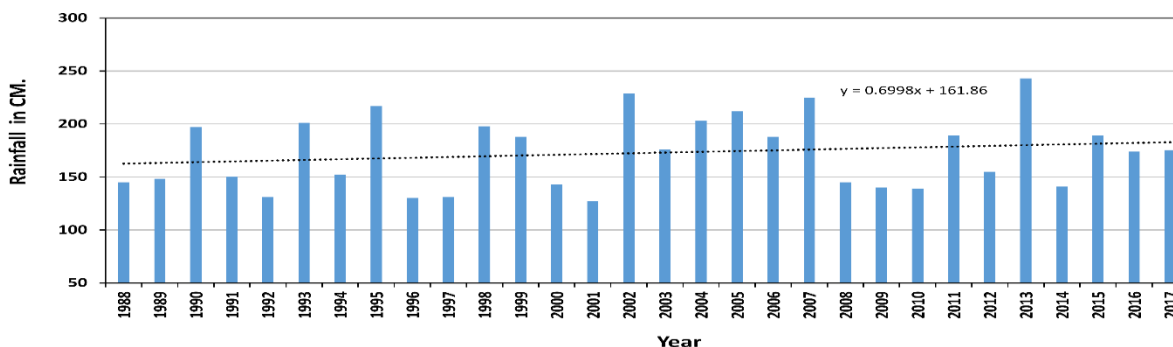


Figure 5. Showing the total annual rainfall trend in South 24 Parganas District from 1988 to 2017

Figure 5 and Table 2 represents the annual total rainfall trend in the period from 1988 to 2017 of South 24 Parganas District. The maximum total rainfall in the 30 years period (1988-2017) was recorded as 243 cm in the year 2013 and the minimum total rainfall of 130 cm was recorded in the year 1996. The average annual total rainfall of the study area was calculated as 172.7 cm. Figure 5 also shows the irregular pattern of annual total rainfall. The years showing less than the average annual total rainfall were 1988, 1989, 1991, 1992, 1994, 1996, 1997, 2000, 2001, 2008, 2009, 2010, 2012 and 2014. Especially in the year 1992, 1996, 2001 and 2010, the annual rainfall dropped to less than 140 cm. The years showing more than the average annual total rainfall were 1990, 1993, 1995, 1998, 1999, 2002, 2003, 2004, 2005, 2006, 2007, 2011, 2013, 2015, 2016 and 2017. Moreover, the higher amount of annual total rainfall was found in the year 1995 (217 cm), 2002 (229 cm), 2004 (203 cm), 2005 (213 cm) and 2013 (243 cm). Although, the linear regression trend line (Figure 5) represents the increasing trend of the annual total rainfall in the period from 1988 to 2017 of South 24 Parganas District.

3.5 Trend Analysis of the Monsoon Rainfall (June - September) in South 24 Parganas District from 1988 to 2017

Figure 6 and Table 2 shows the monsoon rainfall trend in the period from 1988 to 2017 of South 24 Parganas District. The maximum monsoon rainfall in the 30 years period (1988-2017) was recorded 202 cm in the year 2007 and minimum rainfall was 80 cm recorded in the year 1997. The average monsoon rainfall of the study area was calculated as 129.4 cm (table-2). Figure 6 also presents the irregular distribution pattern of monsoon rainfall. Here, it was seen that in some years the monsoon rainfall was increased and some years the rainfall was decreased. Especially, in the year 1997 and 2000, the monsoon rainfall was dropped to less than 90 cm. Moreover, in the year 1992, 1994, 1996, 2001, 2009 and 2014, the monsoon rainfall was between 90 to 110 cm. In addition, in the year 1988, 1989, 1990, 1991, 1998,2003,2005, 2008, 2010, 2012 and 2017 the monsoon rainfall was normal (110 to 130 cm). On the contrary, in the year 1995, 2004 and 2016, the monsoon rainfall was high; it was between 130 to 150 cm. Moderately high monsoon rainfall (150 to 170 cm) was observed in 1993,1999, 2006 2011 and 2015. More than 170 cm monsoon rainfall was in the year 2002, 2007 and 2015. But overall, the linear regression trend line (Figure 6) represents the increasing trend of the monsoon rainfall in the period from 1988 to 2017 of the South 24 Parganas District.

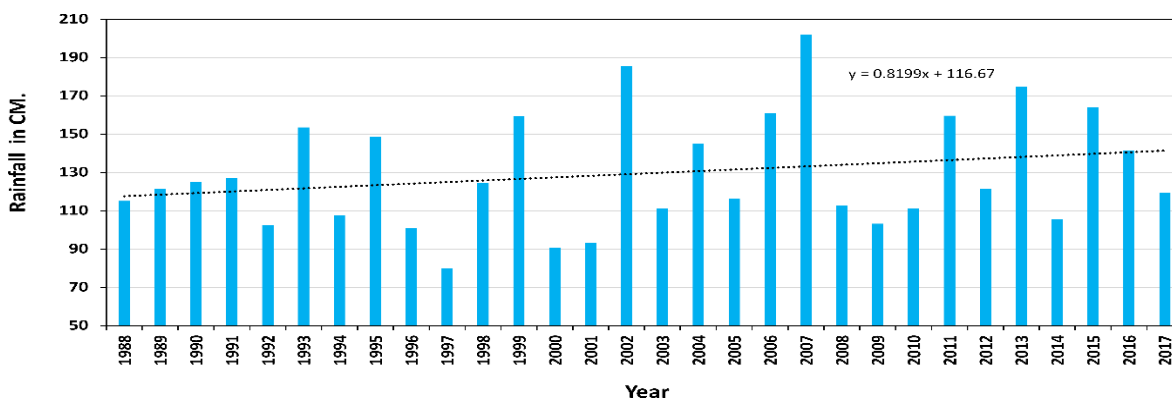


Figure 6. Showing the monsoon rainfall trend of South 24 Parganas District from 1988 to 2017

Table 2. The total annual and monsoon rainfall of South 24 Parganas District from 1988 to 2017

Year	Monsoon rainfall in cm. (June-September)	Annual rainfall in cm.
1988	115	145
1989	121.5	148
1990	125	197
1991	126.8	150
1992	102.5	131
1993	153.4	201
1994	107.6	152.2
1995	148.7	217
1996	100.7	130
1997	80	131
1998	124.2	198
1999	159.1	188
2000	90.6	143
2001	93.3	127
2002	185.3	229
2003	111	176
2004	145.2	203
2005	116	212

2006	161.1	188
2007	202	225
2008	112.6	145
2009	103.2	140
2010	110.9	139
2011	159.5	189
2012	121.3	155
2013	174.7	243
2014	105.5	141
2015	164	189
2016	141.3	174
2017	119.5	175
Average	129.4	172.7
Source: Indian Meteorological Department (IMD), Kolkata		

Conclusion

The study analysed the trend in annual mean, maximum and minimum temperature and rainfall on annual total and monsoon season from 1988 to 2017 of South 24 Parganas District in West Bengal. The study showed a very significant change in temperature as well as rainfall. The annual average and maximum temperature, both were found an increasing trend, but there was a declining trend in the annual minimum temperature. On the other hand, both the 30 years (1988-2017) monsoon rainfall and annual total rainfall were found an increasing trend. This change in temperature and rainfall will negatively affect natural resources, agriculture, fishing, livestock rearing, other economic activities and human health. The local people of South 24 Parganas District need to take adequate measures to cope with this climatic condition. It is hoped that the study will help the policymaker to make proper strategies to climate change and adaptation.

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