

# Study of Rainfall Variability over India in Climate Change Scenario

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## Abstract:

It is widely accepted that various elements of climate, especially rainfall, is extremely sensitive to climate change phenomena and it is reflected through the variability in its amount. In the present study, annual rainfall of India for the period of 1871-2014 has been analyzed to represent variability of rainfall. Rainfall data has been procured from India Meteorological Department (IMD), Pune. The mean annual rainfall of India is 1160 mm, having great temporal variation. Year 1917 received maximum amount of rainfall on record which is 1463 mm whereas, year 1899 received minimum amount of rainfall on record which is just 811 mm. The rainfall over India is characterized by variability with time. Many high rainfall years are followed by low rainfalls. Whereas, many low rainfall years are followed by high rainfalls. Though not clearly, but the period before 1920 was characterized by below average rainfall. In contrast with above situation, from 1920 to 1960, many years recorded above-average rainfall showing high variability. The period after 1960 is featured by low rainfall with some high episodes of annual rainfall.

**Key words:** Climate change, rainfall variability,

## 1.0 Introduction

Climate change is one of the comprehensively studied as well as debatable issues of recent times. In many areas of the world, human activities resulted into serious issues regarding environment, biodiversity and climate change. Rainfall is one of the principal natural hydrological factors which is extremely sensitive to climate change phenomena. The economy of some south-Asian countries, particularly India, is mainly dependent on the monsoon rainfall (Singh et al., 2006). The monsoon plays an important role in agricultural production and development of Pant and Rupa Kumar (1997) noted that, rainfall over India is mainly due to the summer monsoon systems, with only a small amount related with cyclonic storms mostly during transition periods. The rainfall over the region is highly seasonal and is mainly concentrated in just four months of the summer monsoon season (June to September), and the rest of the year is generally dry. There is a large variability in the monsoon rainfall on both space and time scales. In the present study, an attempt has been made to present the temporal properties of rainfall over India. Rainfall data has been procured from India Meteorological Department (IMD), Pune. The data have been analyzed to examine some important aspects of rainfall of the country. India forms the major part of the South Asian monsoon region. A systematic study of variability of annual rainfall (and drought) over South Asia, was made by Blanford (1886) for British India. The rainfall in India is highly seasonal and there is large variability in the rainfall on both, time and space. Mooley and Parthasarthy (1984) have made a countrywide mean monsoon rainfall series for India. Comprehensive analyses of breaks in monsoon rainfall, during 1987 to 1997 have been attempted by De and Mukhopadhyay (2002). The investigation of Mooley and Parthasarthy (1984) specified the fact that the monsoon rainfall is trendless and is

mainly random in nature over a long period of time, particularly on the all India scale. Short period, i.e. pentad rainfall has been extensively analyzed by Shukla (1968), Ramamurthy (1972), Raghavendra (1974), Khambete and Biswas (1978), Chaudhary et al. (1979) and Sarkar and Subramanian (1995).

## 2.0 Introduction to the study area

India is situated north of the equator between  $8^{\circ}4'$  and  $37^{\circ}6'$  north latitude and  $68^{\circ}7'$  and  $97^{\circ}25'$  east longitude. It is the seventh-largest country in the world, with a total area of 3,287,263 square kilometers (1,269,219 sq mi). India measures 3,214 km (1,997 mi) from north to south and 2,933 km (1,822 mi) from east to west. It has a land frontier of 15,200 km (9,445 mi) and a coastline of 7,517 km. The northern frontiers of India are defined largely by the Himalayan mountain range, where the country borders China, Bhutan and Nepal. Its western borders lie in the Punjab Plain and the Thar Desert. The peninsular part of the study area is surrounded by Arabian Sea to the west, Bay of Bengal to the East and by Indian Ocean towards south.

## 3.0 Data and methodology

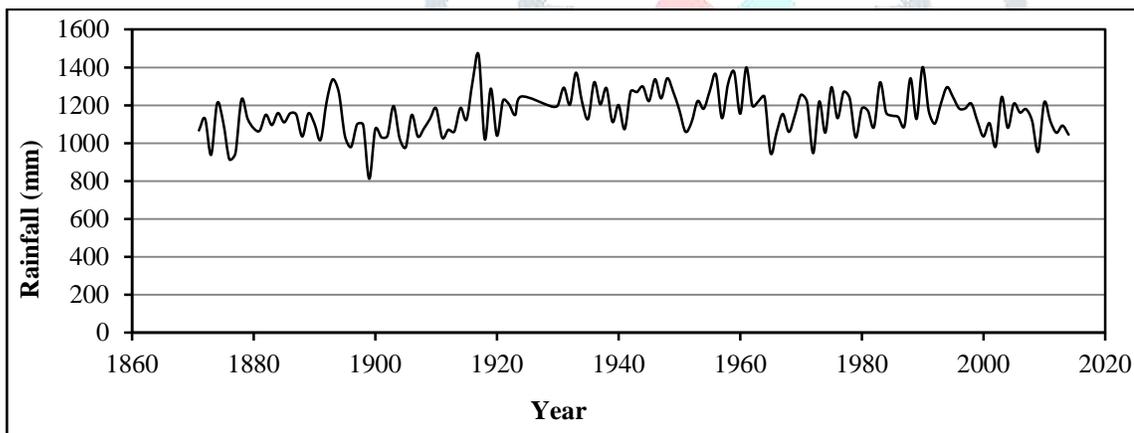
The principal objective of the present study is to understand the temporal variability of rainfall over the India. Therefore, Rainfall data were obtained from India Meteorological Department (IMD), Pune. The data of mean monthly rainfall and average annual rainfall have been obtained for the study. The rainfall data for the period of 1871 to 2014 is utilized for the present work. In order to achieve the objectives of the present study, the following methodology has been adopted. Simple statistical parameters such as mean, moving averages etc. are obtained to reduce and summarize the rainfall data. The short- and long-term variations in the rainfall are responsible for fluctuations in the annual rainfall series. Therefore, to ascertain short-term fluctuations and long-term trends or changes, time series analysis of the rainfall data have been undertaken and the results are presented by line and bar graphs.

## 4.0 Inter-annual variability of rainfall

The rainfall regime in India is not identical. The significant variations in different aspects of the rainfall over time and region are found in the country. A small range in the variability of the annual as well as in the monthly rainfall is the prominent feature of the monsoon rainfall in the area. The variability in the rainfall most of the times reflect into the occurrence of droughts or floods. Therefore, annual and monthly rainfall data around 144 years have been analyzed to know the annual rainfall characteristics of India. The time series of annual rainfall for 144 years is illustrated in Figure 1. The diagrams show noteworthy inter-annual variability and high range in the annual rainfall totals. The observations show high range of annual rainfall in the region. For example, the minimum annual rainfall on the record is 811 mm. Year 1899 received minimum amount of rainfall on record which is just 811 mm. Similarly year 1876, 1873, also obtained average annual rainfall over

1400 mm. Year 1877, 1972, 1965, 2009, 1905, 1896, and 2002 also featured by significant low amount of average annual rainfall. Year 1917 received maximum amount of rainfall on record which is 1463 mm. Similarly year 1990 also obtained average annual rainfall over 1400 mm. Year 1961, 1959, 1933, 1956, 1948, 1988, 1946 and 1893 also featured by high average annual rainfall. Though the average annual rainfall over the country is 1160 mm, high variations in the annual rainfall can be found from one year to another. Rainfall over the study area is predominantly due to summer monsoon system. The southwest monsoon season from June to September contributes about 76% of the annual rainfall of the nation. Therefore, the rainfall over the nation is highly seasonal and mainly concentrated in just four months of the summer monsoon season. The rest of the year is generally dry. There is not only spatial variation but also temporal variation in the rainfall. Investigation of the graph indicates rainfall fluctuates from one year to another. Large inter-annual variability is the typical feature of the monsoon rainfall which clearly reveals from the graph. Many high rainfall years are followed by low rainfalls. Whereas, many low rainfall years are followed by high rainfalls.

**Figure 1:** Average annual rainfall: Time Series Graph



Though not clearly, but the period before 1920 was characterized by below average rainfall. In contrast with above situation, from 1920 to 1960, many years recorded above-average rainfall showing high variability. The period after 1960 is featured by low rainfall with some high episodes of annual rainfall (Figure 1).

### 5.0 Decadal variability of rainfall

Changes in rainfall cannot be visualized on the short period scale. Therefore, in this section annual rainfall figures over India are analyzed to detect the variability of rainfall from one decade to another. Figure 2 presents decadal rainfall averages in the country.

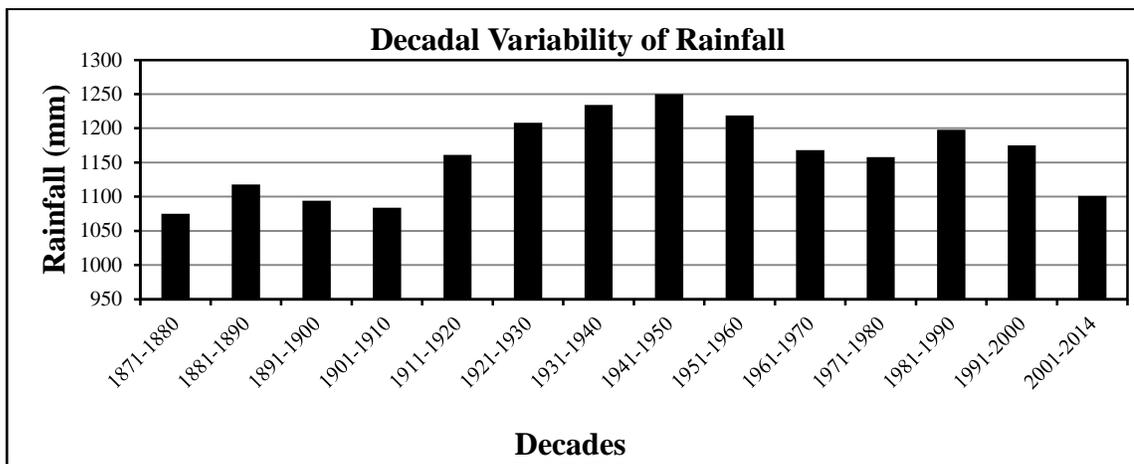
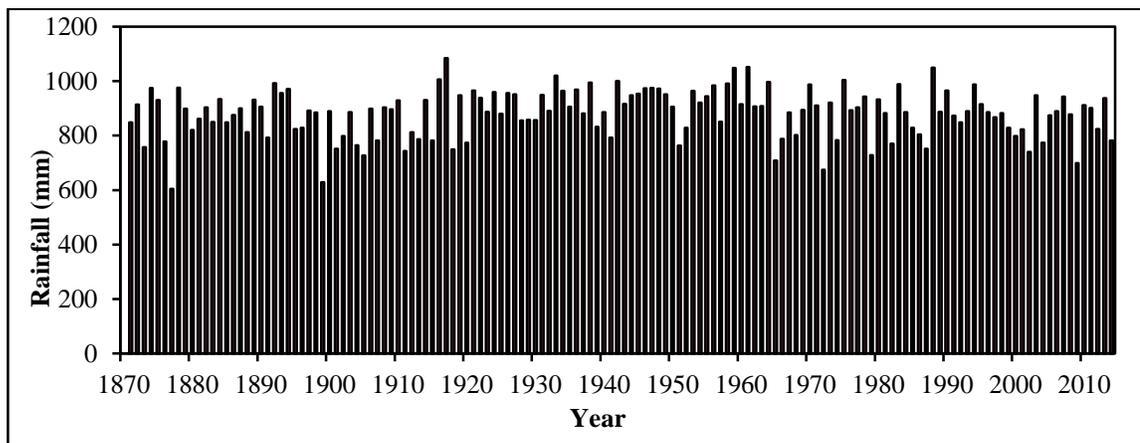
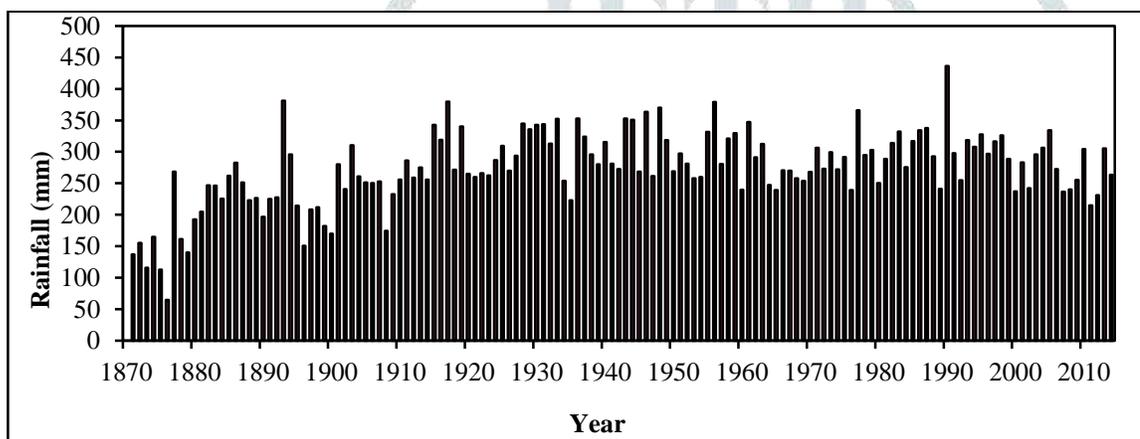
**Figure 2:** Decadal variability of rainfall

Figure 2 represents variability of rainfall on decadal scale. The average rainfall of different decades is not identical. Though the average annual rainfall of India is 1160 mm; some decades received rainfall less than the average annual rainfall of India and vice-versa. Out of 14 decades under study, 6 decades received rainfall less than the average annual rainfall of India. The minimum decadal total is found in the decade 1871-1880, which is 1075 mm only. Decades 1881-1890, 1891-1900, 1901-1910, 1971-1980 and 2001-2014 also gain rainfall which is less than average annual rainfall of India (Figure 2). Among 14 decades under study, 7 decades obtained rainfall more than the average annual rainfall of India. The maximum decadal total is found in the decade 1941-1950, which is 1250 mm. Decades 1921-1930, 1891-1900, 1901-1910, 1971-1980 and 2001-2014 also gain rainfall which is less than average annual rainfall of India. Only the decade of 1911-1920 shows rainfall close to the long-term average annual rainfall of the nation (Figure 2).

Rainfall in India is mainly concentrated in monsoon season (June to September) however; non-monsoon season also gains some amount of rainfall. Therefore, an attempt is made to search the variation in monsoon and non-monsoon rainfall over the period of 1871-2014 for the study area. Figure 3 and figure 4 represent the variation in monsoon and non-monsoon rainfall respectively. It is observed that the monsoon rainfall over the period of 1871-2014 in India is fairly consistent (Figure 3). The non-monsoon rainfall represents inconsistency prior to 1920 and thereafter it became consistent (Figure 4).

**Figure 3:** Variation in monsoon rainfall: India (1871-2014)**Figure4:** Variation in non-monsoon rainfall: India (1871-2014)

## 6.0 Conclusions of the study

1. The mean annual rainfall of India is 1160 mm, having great temporal variation.
2. Year 1917 received maximum amount of rainfall on record which is 1463 mm. Similarly year 1990 also obtained average annual rainfall over 1400 mm. Year 1961, 1959, 1933, 1956, 1948, 1988, 1946 and 1893 also featured by high average annual rainfall.
3. Likewise high rainfall years there are several low rainfall years also found over the period under study. Year 1899 received minimum amount of rainfall on record which is just 811 mm. Similarly year 1876, 1873, also obtained average annual rainfall over 1400 mm. Year 1877, 1972, 1965, 2009, 1905, 1896, and 2002 also featured by significant low amount of average annual rainfall.
4. The rainfall over India is characterized by variability with time. Many high rainfall years are followed by low rainfalls. Whereas, many low rainfall years are followed by high rainfalls. Though not clearly, but the period before 1920 was characterized by below average rainfall. In contrast with above situation, from 1920 to 1960, many years recorded above-average rainfall showing high variability. The period after 1960 is featured by low rainfall with some high episodes of annual rainfall.

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