A Comprehensive Study of Rainfall Distribution and Trends in Chiplun, Maharashtra, India. (1980-2023)

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Abstract

This study analyses long-term rainfall distribution and trends in Chiplun, a flood-prone town in Maharashtra's Konkan region, using monthly data from 1980 to 2023. The objective is to examine temporal variability, seasonal patterns, and significant rainfall shifts over four decades. Monthly and annual rainfall data were processed using statistical and graphical methods to identify key trends, extreme events, and climatic fluctuations. The analysis reveals that monsoon months, particularly July and August, contribute the highest rainfall. While the annual rainfall shows fluctuations, recent years exhibit increasing variability and instances of intense rainfall. Such patterns are critical in understanding flood risks, water resource planning, and the impact of changing climate conditions in the region. This comprehensive assessment provides a valuable reference for regional authorities and researchers focused on climate adaptation and disaster preparedness in Chiplun and similar coastal areas.

Keywords:

Rainfall Trend Analysis, Monsoon Rainfall, Long-Term Rainfall Data, Seasonal Rainfall Distribution, Rainfall Variability.

1. Introduction

The majority of Indian agriculture relies on monsoon rain. Rainfall which is dependent on the monsoon features, Supports about 70% of the total cultivated land in our nation. Despite the progress, rain-fed agriculture remains the primary source of income for marginal and small farmers, who make up 80% of agricultural income group (Das and subhash,2004). The majority of rainfall in Maharashtra state comes from the southwest during the rainy season. From the northeast, around 20% of the precipitation comes during the winter. (Patil et al. 2010).

The western cost of the Arabian sea is where the Konkan area is located. It is split in to two section, namely northern Konkan. The Chiplun area is located in the southern Konkan region. The average yearly rainfall in the Konkan area is 3200 mm. Humidity levels in the tropical Konkan area change throughout the year from 50% to 80%. For rain-fed agriculture, the most important rainfall features affecting output are the number of rainy days, drought, and average or high rainfall for the week, month, and year. The day is considered dry from a meteorological perspective if it gets less than 2.5 mm of rain, but from an agricultural perspective, a dry day receives less than 6.3 mm of rain, which is insufficient to moisten the soil around plant roots and promote growth (Chowdhary, 1979).

Karate and Sena (2004) conducted the precipitation analysis for planning soil and water conservation buildings in Gujarat semi- arid region. Research have made agricultural drought based on meteorological drought information on rainfall from various areas of India. Sharma and Verma (1983) and Sharma (1978) analysed the

using the definition of drought month, drought week, and drought year to characterize the drought in different regions 50% of the average rainfall is equivalent to the actual rainfall.

Rainfall is a key climatic parameter that significantly influences agriculture, water resource, and ecological balance, particularly in monsoon dependent regions like India. The Konkan region of Maharashtra, where Chiplun is located, receives high annual rainfall due to the southwest monsoon. Despite abundant precipitation, the are frequently faces challenges such as water scarcity during dry months and severe flooding during heavy rainfall periods. Understanding long-term rainfall trends is thus crucial for effective water resource management, flood mitigation, and sustainable development in this region.

Chiplun, a town in the Ratnagiri district, is situated near the Vashishti River and has experienced frequent flood events in recent decades, notably in 2005 and 2021. These events highlight the vulnerability of the region to extreme weather conditions. Long-term rainfall analysis can help identify patterns, shifts, and anomalies in precipitation, providing essential inputs for disaster preparedness, agricultural planning, and climate adaptation strategies. This study aims to conduct a comprehensive analysis of rainfall distribution and trends in Chiplun from 1980 to 2023. Using monthly rainfall data over 43 years, the research investigates temporal variability, seasonal rainfall behaviour, and inter- annual fluctuations. The findings are intended to support local governance, hydrological modelling, and climate-resilient planning, offering a foundational understanding of how rainfall patterns have evolved in Chiplun over four decades.

2. Material and Methods

2.1. Study Area:

Chiplun is a town located in Ratnagiri district in the Konkan region of Maharashtra, India, lying approximately at 17.53°N latitude and 73.52°E longitude. It is situated on the banks of the Vashishti River and lies between the Arabian Sea to the west and the Western Ghats to the east. Due to its geographical location, Chiplun receives substantial rainfall during the southwest monsoon, typically from June to September. However, the town is highly vulnerable to hydrological disasters such as floods and landslides, especially during peak monsoon months. The area's topography, combined with intense seasonal rainfall and changing land use, makes it an important region for hydrometeorological studies.

Understanding the rainfall patterns in Chiplun is critical due to its direct impact on agriculture, water availability, infrastructure, and flood risk. The Vashishti River has been observed to rise rapidly during heavy rains, causing recurrent flood events, as witnessed in major flood years like 2005 and 2021. Therefore, a long-term statistical assessment of rainfall trends in this area holds great value for planning and resilience building.

2.2. Data Collection

The study uses long-term monthly rainfall data covering a 43-year period from January 1980 to December 2023. The data was obtained from official meteorological records, primarily sourced from the India Meteorological Department (IMD), Pune, and cross-checked with other regional datasets, if available. Each data entry consists of the year, the month, and the total rainfall (in millimetres) received during that month.

The dataset consists of 516 monthly observations (43 years × 12 months) and was compiled into a Microsoft Excel spreadsheet for further processing. The data is continuous and complete for the entire study period, allowing for robust temporal analysis.

2.3. Data Processing and Analysis

The rainfall data from 1980 to 2023 was organized chronologically in Microsoft Excel for analysis. Using Pivot Tables, monthly and annual rainfall totals were calculated, and averages were derived to understand long-term patterns. The data was also grouped by decades to observe any shifts in rainfall distribution over time. Graphs such as bar charts and line plots were created to visually represent seasonal and yearly trends. Trendlines and moving averages were used to detect any increase, decrease, or irregularities in rainfall patterns. This process helped identify dry and wet years, seasonal variation, and years with extreme rainfall events relevant to flood risks in Chiplun.

2.4. Statistical Analysis

To understand rainfall trends in Chiplun, statistical methods such as mean, standard deviation, maximum and minimum values were applied to monthly and annual data. This helped identify both average conditions and extreme events across 43 years. Trendlines were plotted on graphs to visualize long-term increases or decreases in rainfall. Special attention was given to years and months with unusually high or low rainfall compared to the average. The dataset was also compared across time periods—pre-2000 vs. post-2000—to detect climate-related changes. Recent years (2019–2023) were closely analysed, especially flood years like 2005 and 2021, to understand abnormal rainfall behaviour.

2.5. Seasonal Analysis

Rainfall data was grouped into four seasons: pre-monsoon (March–May), monsoon (June–September), post-monsoon (October–November), and winter (December–February). Seasonal totals were calculated for each year to examine how rainfall was distributed throughout the year. The monsoon season contributed the most, but shifts were observed in other seasons. Some years showed increased rainfall during the post-monsoon or pre-monsoon periods, indicating changing rainfall patterns. This analysis helped assess whether the seasonal balance has shifted over time, which is important for water management and agricultural planning.

3. Results and Discussion

The analysis of monthly rainfall data for Chiplun over a 43-year period (1980–2023) reveals notable variability in annual precipitation. The average annual rainfall during this period was approximately 123.31 mm, indicating the region's characteristic high monsoon activity. However, significant inter-annual fluctuations were observed.

The wettest year was 1983, with a total rainfall of 167.72 mm, while the driest year was 2001, recording only 78.84 mm. Such extreme variations align with known hydrological events in the region, including major floods and periods of water scarcity. These findings suggest that Chiplun's rainfall is not only seasonally intense but also highly variable on a yearly basis.

Decadal analysis showed a general increase in rainfall over time. The 1980s, 1990s, and 2000s each received around 1150 –1180 mm of rainfall. However, the 2010s witnessed a noticeable rise, totalling 1432.54 mm, indicating increased rainfall intensity in recent years. In contrast, the early 2020s (2020–2023) show a decline, with only 504.47 mm recorded so far, possibly due to incomplete data or short-term climatic shifts.

This variability in rainfall, both annually and across decades, highlights the need for localized planning and adaptive water management strategies. The increase in rainfall during the 2010s may explain recent flood events such as the one in 2021, while drier years like 2001 underscore the risk of seasonal water shortages.

Fig. 1: Analysis of Rainfall in Monsoon Season in 1981 and 1982

Fig. 2: Analysis of Rainfall in August Month in 2017, 2019, 2021 and 2023.

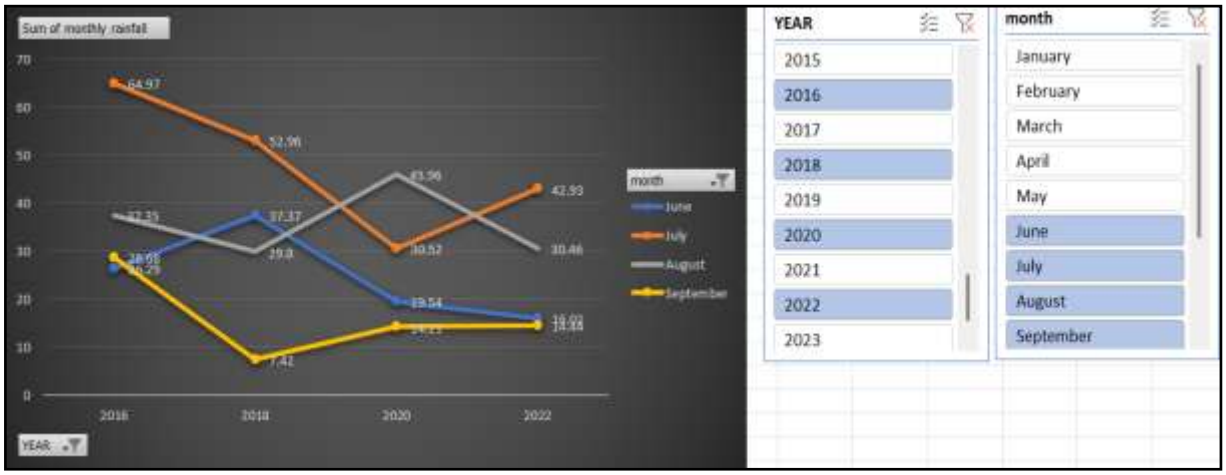

Fig. 3: Analysis of Rainfall in Monsoon in 2016, 2018, 2020 and 2022.

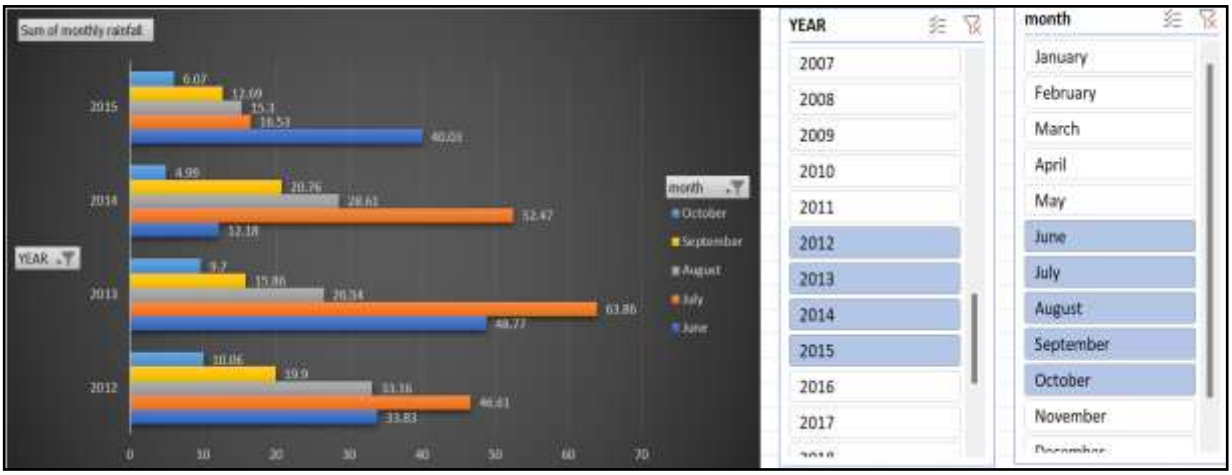

Fig. 3: Analysis of Rainfall in Monsoon in 2012, 2013, 2014 and 2015.

4. Summary and Conclusions:

This study analysed rainfall patterns in Chiplun, Maharashtra, from 1980 to 2023, to understand long-term trends and seasonal variations. The analysis showed that while average annual rainfall was around 123 mm, significant year-to-year fluctuations were observed. The wettest year was 1983, and the driest was 2001. A decadal comparison revealed increased rainfall during the 2010s, followed by a decline in the early 2020s.

Seasonal analysis confirmed that monsoon months contribute the most to annual rainfall, but variations in pre- and post-monsoon periods suggest changing climatic behaviour. These trends highlight the growing unpredictability of rainfall in the region, which has direct implications for flood risk and water management.

In conclusion, Chiplun's rainfall shows both consistency and variability over time. The findings emphasize the need for continuous monitoring, better flood preparedness, and climate-resilient planning to address future challenges in the region.

5. Acknowledgement:

The authors gratefully acknowledge the support and encouragement provided by the College of Agricultural Engineering and Technology, Dr. Balasaheb Sawant Konkan Krushi Vidyapeeth (Dr. BSKKV), Dapoli. Special thanks to the faculty and staff for their valuable guidance throughout the course of this research work.

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