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Analysis of the Impact of Rainfall Change on the Seasonal Monsoon over the Jaipur District

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***Abstract*—**In this work, long-term spatiotemporal changes in rainfall are investigated and assessed at the meteorological divisional level using whole-year data from Rajasthan, India. Data from each of the district's eight tehsils are studied to see how the rainfall pattern has altered over the last 10 years. We primarily compare information from the Jaipur district in Rajasthan, India, at the tehsil level. We looked at the full year, and from January to December, there was constantly more rain than any other month. Furthermore, we compare the research of annual and monthly rainfall. Havey rainfall is also shown for two months, July and August.

***Keywords*—**Climate change, temperature, seasonal monsoons, rainfall variability.

I. Introduction

THE capital of Rajasthan, Jaipur, is located on the eastern edge of the semi-arid Thar desert. A far-off location from the Bay of Bengal and the Arabian Sea gives rise to a continental climate. In response to western disturbances, humidity, cloud cover, and rainfall activities rise throughout the monsoon season, which runs from July to September, and sporadically during the year's rest period. The four main seasons of the year are as follows: the winter season, which lasts from mid-December to mid-February; the summer, or hot weather season, which lasts from March to May; the monsoon season, which lasts from mid-June to mid-September; and the transit period, or post-monsoon period, which lasts from October to November [22], [33], [35], [38], [40].

Jaipur, the state's capital and largest city, is also known as the "Pink City." Amber's king, Maharaja Sawai Jai Singh II, erected it on November 18, 1727. The district of Jaipur is located 390 meters above sea level. Amber Fort, Jaigarh Fort, Hawa Mahal, and other ancient forts may be found in Jaipur. Jaipur district covers 11,117 square kilometers and has a population density of 470 persons per square kilometer, but Jaipur city covers 467 square kilometers [1], [3], [5], [6], [12], [14].

The district spans around 180 kilometers east to west and 110 kilometers north to south. There are eight recognized tehsils: Phulera, Phagi, Dudu, Amber, Viratnagar, Bassi, Chaksu, and Chomu. Its borders are as follows: Tonk district to the south, Alwar, Sawai Madhapur, and Dauda districts to the east, and Nagaur districts to the west. To the north are Sikar and Mahendrakar districts. Based on the results of the 2011 census, Jaipur's total population is 3.9 million. On the eastern edge of the semi-arid Thar Desert is where the Jaipur district is located. There is a continental climate when it is far from the Arabian Sea and the Bay of Bengal [8], [11], [17], [19], [25], [46]. From July to September during the monsoon season, and perhaps beyond.

In the aftermath of western disturbances, humidity, cloudiness, and rainfall activities rise throughout the remainder part of the year [2], [4], [10], [13], [15]. The year is split into four seasons: winter (December to February), summer (March to May), monsoon (June to mid-September), and transit (October and November). Winters in Jaipur are terribly cold, while summers are quite hot. The maximum temperatures in May normally range between 40 and 47 °C.

During the season, a heat wave occurs when daytime temperatures are 4 to 6 °C above average for a few days [7], [9], [16], [18], [28]. Winter low temperatures normally range from 4 to 9 °C and are below zero. Or when a chilly northerly wind blows from the Himalayas. Mist and fog develop occasionally in the morning hours after the passage of western storms. The coldest temperatures ever recorded were -2.2 °C on January 31, 1905 and January 16, 1964. Other ecological processes produce rainfalls indirect impacts [21], [24], [26], [29], [30], [43]. The amount of soil water available is directly influenced by yearly rainfall, making it an important factor in determining where plants grow [20], [23], [27], [31], [32].

In Jaipur, the winters are very cold and the summers are scorching. In May, the highest temperatures range from 40 to 47 °C. Throughout a few days throughout the season, there is a heat wave when the daytime temperature climbs by 4 to 6 °C. The coldest winter temperatures range from 4 to 9 °C, often falling below zero. That is when a chilly breeze from the northwest comes from the Himalayan region. Early in the morning, mist and fog appear following the passage of western disturbances [34], [36], [37], [39], [44]. Two recorded minimum temperatures—January 16, 1964, and January 31, 1905—were as low as -2.2 °C [41], [42], [45].

II. Preliminary

Rajasthan, being a predominantly arid to semi-arid region, experiences limited and variable rainfall. Here are some key aspects of rainfall in Rajasthan, India:

- *Monsoon Dominance:* The southwest monsoon, which typically occurs from June to September, is the primary source of rainfall in Rajasthan. The arrival and withdrawal of the monsoon season play a crucial role in determining the precipitation levels in the state.
- *Low Average Rainfall:* Rajasthan has a low average annual

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rainfall compared to other states in India. The arid and semi-arid climate conditions contribute to water scarcity concerns in many parts of the state.

- *Spatial Variability:* Rainfall in Rajasthan exhibits spatial variability, with different regions receiving varying amounts of precipitation. The eastern part of the state tends to receive relatively higher rainfall compared to the western and northwestern regions.
- *Thar Desert:* The Thar Desert, which spans parts of western Rajasthan, is one of the driest areas in the state. Rainfall in the desert region is scarce, and the landscape is characterized by arid conditions and sand dunes.
- *Seasonal Distribution:* The majority of the annual rainfall occurs during the monsoon season. The months of July and August are typically the wettest, with sporadic and heavy rainfall contributing to the total precipitation.
- *Drought Vulnerability:* Rajasthan is prone to drought conditions due to irregular and insufficient rainfall. Droughts can have significant impacts on agriculture, water resources, and the overall socio-economic conditions of the state.
- *Variability and Climate Change:* Rajasthan experiences variability in rainfall patterns from year to year. Climate change may further influence precipitation levels, leading to increased uncertainty in water availability.
- *Water Conservation*: Given the scarcity of water resources, water conservation practices, such as rainwater harvesting, check dams, and efficient irrigation techniques, are crucial for sustaining agriculture and addressing the water needs of the population.
- *Impact on Agriculture:* The success of agriculture in Rajasthan is closely tied to the monsoon. Adequate and well-distributed rainfall during the monsoon season is crucial for crop cultivation. In years of deficient rainfall, crop yields may be adversely affected, leading to challenges for farmers.

Analyzed the data from each of the eight tehsils in the Jaipur district to see how the rainfall pattern has evolved over the last 10 years. Rainfall data broken down by month for the years 2012–2021 are available from the Indian Meteorological Department (IMD) in Jaipur. Once the data were gathered, accurately organize it for the monthly and annual reports. Using these sorted data, it was also possible to establish the Jaipur tehsils' monthly, monthly, and seasonal rainfall. Here, we will organize and analyze the rainfall data in each tehsil and determine which one received the highest rainfall.

Jaipur district, located in the state of Rajasthan, India, experiences a semi-arid climate with distinctive seasonal variations in rainfall. Here are some key characteristics of the rainfall in Jaipur district:

1. Monsoon Dominance: Like much of Rajasthan, Jaipur district is heavily reliant on the southwest monsoon for the majority of its annual rainfall. The monsoon season generally spans from late June to September. The arrival and intensity of the monsoon significantly influence the overall precipitation in the region.
2. Seasonal Distribution: The rainfall in Jaipur district is not evenly distributed throughout the year. The monsoon months, particularly July and August, contribute the most to the annual rainfall. These months typically witness heavy and sporadic rain showers.
3. Low Average Rainfall: Jaipur, being part of a semi-arid region, generally receives relatively low annual rainfall compared to other parts of India. The arid climate and limited water resources contribute to water scarcity concerns in the district.
4. Variability: Rainfall in Jaipur district can vary significantly from year to year. Some years may experience below-average rainfall, leading to drought conditions and agricultural challenges. Conversely, there may be years with above-average rainfall, impacting water availability and local ecosystems.
5. Impact on Agriculture: The success of agriculture in Jaipur district is closely tied to the monsoon. Adequate rainfall during the monsoon season is crucial for crop cultivation, and variations in rainfall patterns can have implications for agricultural productivity.
6. Local Factors: The topography and geographical features of the district, including the presence of the Aravalli Range, can influence local weather patterns and rainfall distribution. Eastern areas of the district may receive slightly more rainfall compared to western regions.

Jaipur, the capital city of Rajasthan, experiences a semi-arid climate with distinct seasons. The city primarily relies on the monsoon season for its annual rainfall. Here are some key points about the rainfall in Jaipur, Rajasthan:

1. Monsoon Season: The primary source of rainfall in Jaipur is the southwest monsoon, which typically arrives in the region in late June or early July and continues until September. The city receives the majority of its annual precipitation during these monsoon months.
2. Seasonal Distribution: The rainfall in Jaipur is unevenly distributed throughout the year, with a concentration during the monsoon season. During this period, heavy and sporadic rainfall is common, contributing significantly to the annual total.
3. Low Annual Rainfall: Despite the occurrence of the monsoon, Jaipur's annual rainfall is relatively low compared to other parts of India. The city falls in the arid to semi-arid zone, and water scarcity is a recurring concern.
4. Drought Risk: Jaipur and the surrounding areas are susceptible to drought conditions, especially during years with below-average rainfall. Drought mitigation strategies, water conservation, and efficient water management are essential for addressing water scarcity issues.
5. Temperature Impact: The city experiences high temperatures, especially during the summer months, which can contribute to evaporation and water loss. Adequate rainfall during the monsoon season is crucial for replenishing water sources and sustaining agriculture.
6. Impact on Agriculture: Agriculture in and around Jaipur is significantly influenced by the monsoon. Adequate rainfall is crucial for crop cultivation, and variations in the monsoon pattern can impact agricultural productivity.

III. Methodology and Data Used

The data from each of the eight tehsils in the Jaipur district were studied to determine how the rainfall pattern has evolved in the district during the previous 10 years. For 2012-2021, daily rainfall data have been made available by the IMD in Jaipur. After gathering the data, we organize it appropriately by month and year. With the use of these sorted data, the Jaipur tehsils' monthly, annual, and seasonal rainfall was also calculated. Here, we will organize and analyze the rainfall data in each tehsil and determine which one received the highest rainfall.

TABLE I
The Annual Rainfall Data of Different Tehsils

Sr. No	Tehsils	Annual Rainfall
1	Amber	854
2	Bassi	518
3	Chaksu	640.6
4	Chomu	535
5	Dudu	349
6	Jaipur	1084
7	Phagi	609
8	Phulera	515

As seen in Fig. 1, 2013 saw the highest annual rainfall of 854 mm, which is 65 mm more than the maximum rainfall of 789 mm recorded in 2012. At around 302 mm, 2017 was the year with the least amount of annual precipitation.

Fig. 2 displays the yearly rainfall at Bassi. With 1027 mm of annual precipitation, 2019 was the year with the most rain in the previous ten years. The overall yearly rainfall between 2015 and 2018 was between 590 and 400 millimeters.

As seen in Fig. 3, Chaksu had a total annual rainfall of 927 mm in 2019, which is 126 mm more than the 846 mm of rainfall that the region experienced in 2016.

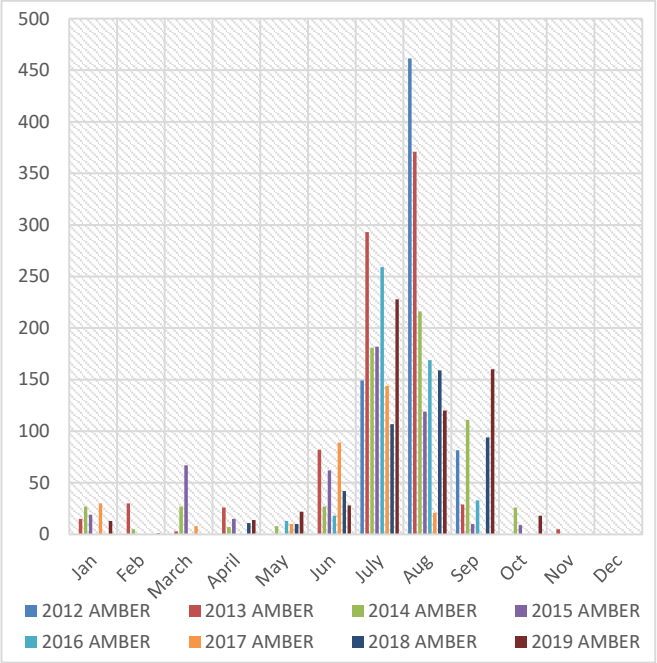

Fig. 1 Monthly rainfall analysis of Amber

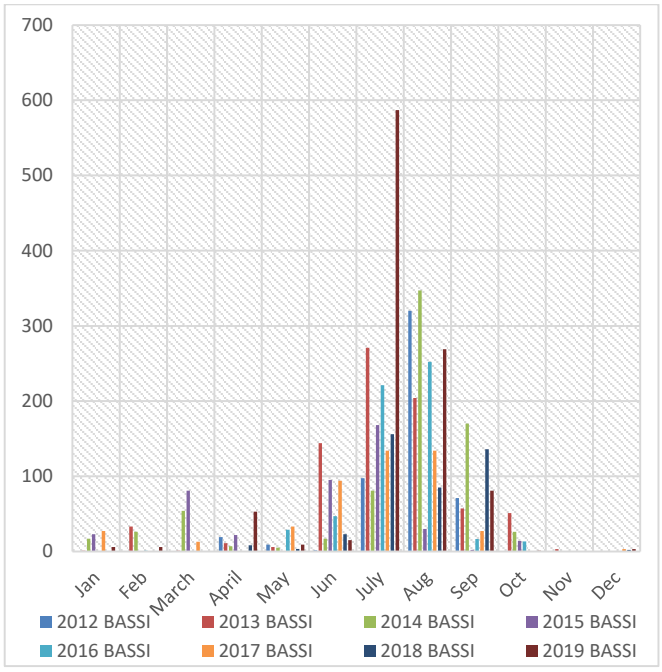

Fig. 2 Monthly rainfall analysis of Bassi

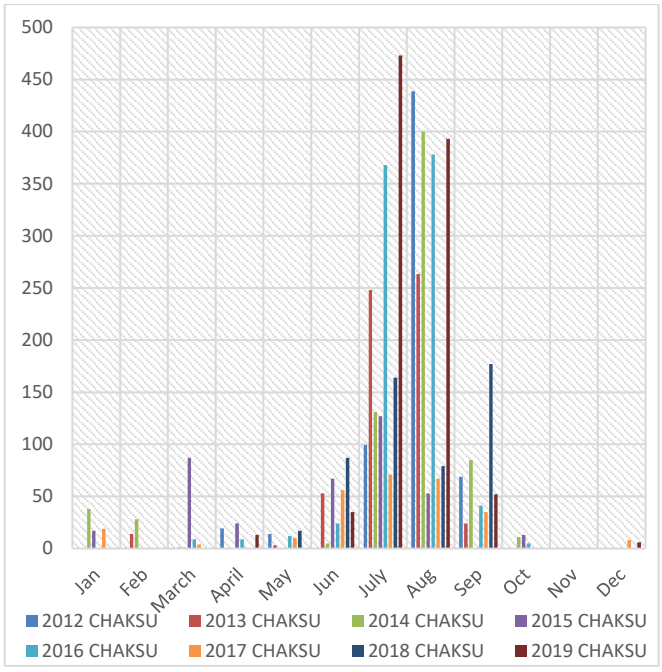

Fig. 3 Monthly rainfall analysis of Chaksu

Fig. 4 makes it abundantly evident that 2020 had the most annual rainfall of 753 mm, which was 54 mm greater than the maximum annual rainfall ever recorded in 2014. Since 2012, there has been less than 500 mm of rainfall in 2015 and 2017.

According to Fig. 5, the analyzed period's yearly rainfall falls between 250 and 550 mm; however, in 2021, the total annual rainfall exceeded the 550 mm threshold at 830 mm.

Fig. 6 shows that 2013 had the most rainfall overall, with 931 mm, which is 200 mm more than Jaipur's total rainfall of 731 mm in 2021.

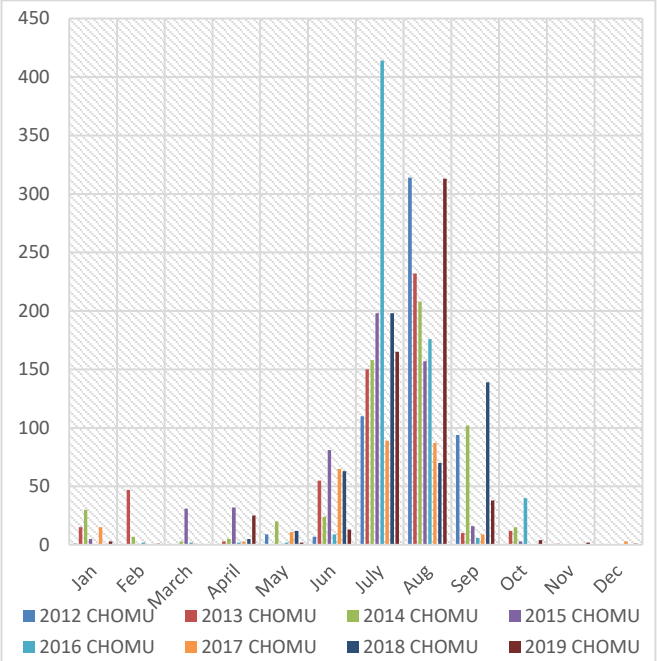

Fig.4 Monthly rainfall analysis of Chomu

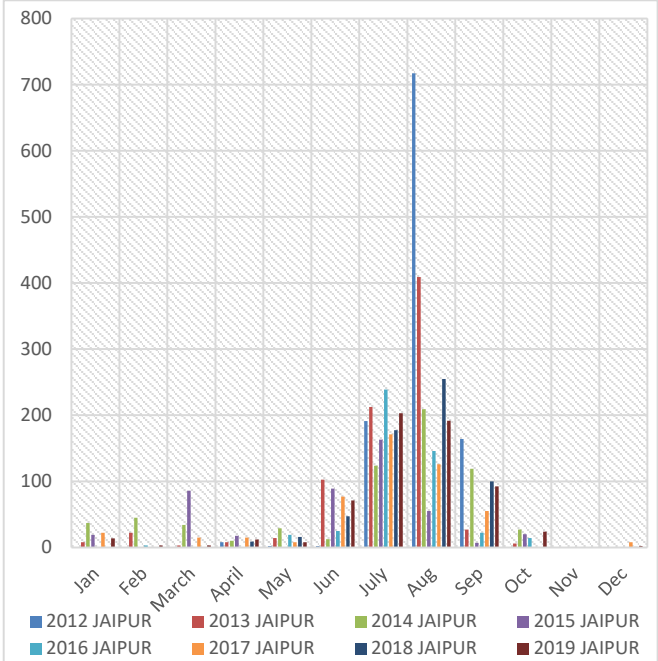

Fig. 6 Monthly rainfall analysis of Jaipur

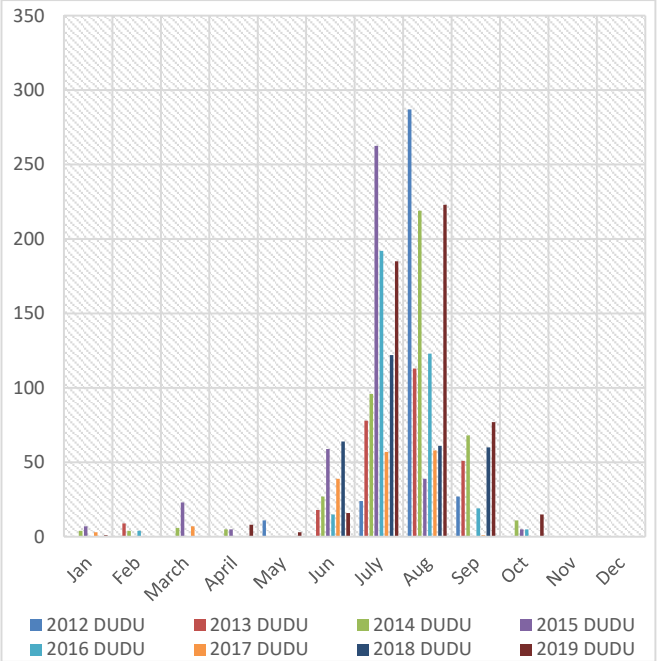

Fig. 5 Monthly rainfall analysis of Dudu

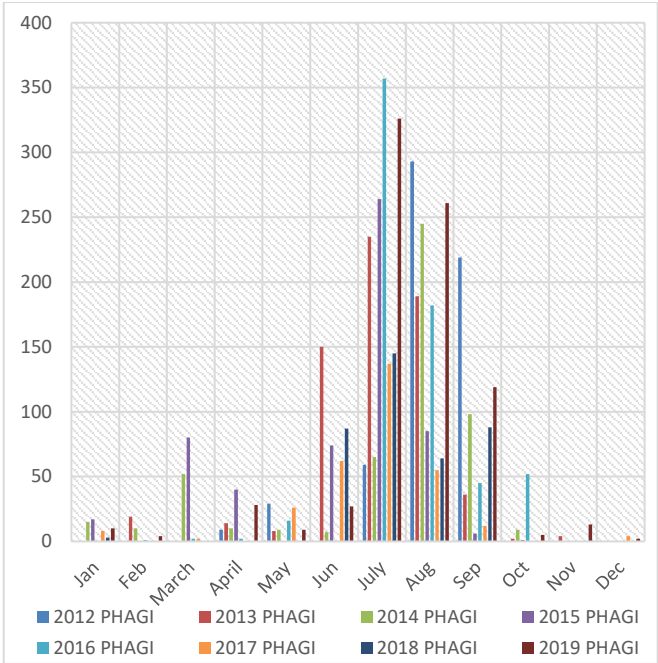

Fig. 7 Monthly rainfall analysis of Phagi

As can be seen in Fig. 7, the total annual rainfall for 2021 was in the order of 1087 mm, more than 200 mm more than any other year.

It is evident from Fig. 8 that 2021 saw the highest recorded rainfall of 744 millimeters. The average amount of rainfall is often more than 300 mm.

IV. Conclusion

As a result of our comparison of every tehsil in the Jaipur district, we can conclude that Phagi got 1087 mm of yearly rainfall in 2021 —3 mm higher than Jaipur City received in total in 2012. 2012 saw about 1084 mm of annual precipitation in Jaipur. In comparison to other tehsils, Jaipur received the highest one-day rainfall of around 300 mm throughout the analysis period. Only four times per ten years does rainfall cross the 204.5 mm barrier, making rainfall over 204.5 mm or

exceptionally heavy rainfall exceedingly unusual, akin to a supermoon. Only Dadu and Bassi, two of the eight tehsils, have rainfall that exceeds the 64.4 mm threshold five times in a decade. In the past 10 years, Bassi and Chaksu have only had two instances of heavy rainfall. It can be shown that throughout the analysis period, Jaipur City had the most rainfall of the order 300 mm, which is 160 mm more than the total rainfall received by Chomu. Chomu received the lowest rainfall, of order 140 mm. Compared to all other tehsils, Dudu has gotten the least amount of rainfall—344.38 mm—over the past ten years. The Sanganer experiences the greatest total rainfall of 628.65 mm with a standard deviation of 108.97 mm during the monsoon month. The has the most total rainfall of any subdivision during the monsoon season, measuring 628.65 mm with a standard deviation of 108.97 mm. In contrast, Dudu experiences a total rainfall of 381.65 mm with a standard deviation of 64.461 mm during the monsoon season.

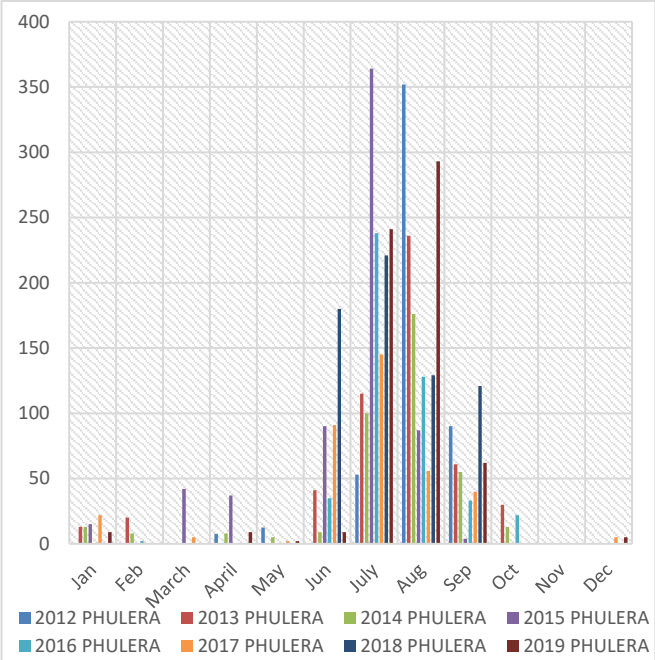

Fig. 8 Monthly rainfall analysis of Phulera

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