EXPLORATORY ANALYSIS OF RAINFALL DATA IN INDIA FOR AGRICULTURE USING DATA SCIENCE

ABSTRACT :

This article aims to review studies for rainfall trend all over India. Non-parametric tests such as Sen's Slope were used as estimator of trend magnitude which was supported by Mann-Kendall test. Regarding rainfall trend results of different studies shows variation which leads to an unclear picture of rainfall trend.

In the study of monsoon of different locations in India some places showed increasing trends however there is signifying decrease in trend allover India. It was also mentioned that analysis can vary from for a location if done using different source or types of collection of data.

Key Words: Rainfall, trends, analysis, intensity, monsoon.

Introduction :

Rainfall is a significant meteorological parameter, which has direct application in fields like agriculture and other related divisions in India. These parts are exceptionally reliant on the accessibility of water just as satisfactory climatic conditions.

The measure of precipitation in a region satisfies different needs including farming, industry, and local and pressure driven power age.

Rainfall is estimated in units of length per unit time. The standard method for estimating precipitation is the standard rain gauge, which can be found in 100 mm (4 in) plastic and 200 mm (8 in) metal. Rainfall intensity is classified by the pace of precipitation, which relies upon the time. Intensity and duration are typically inversely related.

In water resource engineering there are several applications and requirements of adequate data analysis of rainfall, for example, rainfall depth, its return period, rainfall trend, etc. Rainfall helps in designing and modeling water management studies, rainwater harvesting, estimation of the flood, pond design, groundwater recharge techniques, irrigation plans, evapotranspiration estimation, etc.

Rainfall data can be analysed in different forms in the context of different requirements. These requirements may include trend analysis, frequency analysis, rainfall intensity, extreme events analysis, future prediction, etc. Trend analysis is a method that helps in determining the spatial variations and temporal changes for different parameters of climate.

In view of the above, numerous studies have attempted to investigate the trend of variable climate in our country. These studies have looked at the trends on the country scale, regional scale and at the individual stations. The earliest of all studies was by Walker (1910) which indicated no significant trend in rainfall in the monsoon season during the second half of the 19th century. Later studies have been confined to trends and periodicities over specific regions of India using different periods of data depending on the data availability.

LITERATURE REVIEW :

To assist the objectives of the study, the literature review carried out is divided into various sections as follows:

1. Characteristics of climate data

2. Regionalization based on spatial and temporal behaviour of rainfall

3. Design storm from rainfall depths

4. Drought analysis

5. Crop planning

1. Characteristics of climate data:

- Determining statistical parameters in general
- Trends related to temperature
- Trends related to rainfall
- Trends related to other parameters

2. Regionalization based on spatial and temporal behaviour of rainfall:

Based on the influence of wind speed, solid precipitation rate, and wetting losses, the monthly amounts registered at 159 weather stations were adjusted. The results emphasized distinct temporal and spatial distributions of the adjusted magnitude. In general, the correction factors increased with altitude and they had high values in the cold season, as they highly depended on wind speed and solid precipitation percentage. In Romania, bias corrections increased monthly precipitation by less than 10% from June to September, by 1020% in the transition months, and by higher values during the water.

3. Design storm from rainfall depths:

Storm rainfall depth is the quantity of rain falling within a storm of a specific duration distributed uniformly over the watershed area. Rainfall depth is expressed in inches when using English units, and millimetres when using the International System of physical units (SI). Rainfall intensity is defined as the ratio of the total amount of rain (rainfall depth) falling during a given period to the duration of the period It is expressed in depth units per unit time, usually as mm per hour (mm/h).

4. Drought analysis:

Drought indices take thousands of bits of data on rainfall, snowpack, streamflow, etc., analyze the data over various time frames, and turn the data into a comprehensible big picture. A drought index value is typically a single number, which is interpreted on a scale of abnormally wet, average, and abnormally dry.

Types of Drought:

1.Meteorological Drought

2.Hydrological Drought

3.Agricultural Drought

4.Socioeconomic Drought

5.Ecological Drought.

5. Crop planning:

A crop plan, developed before the season starts, helps growers calculate how much of each crop to plant in the greenhouse each week, when they will be transplanted in the field, timing and quantity of harvest on a weekly basis through the growing season (to plan for CSA deliveries and farmers markets for example) and succession planting or cover cropping to make maximum use of limited acreage. These plans can be complex, and as every grower knows, often are tweaked and revised as the season progresses and from season to season as the farm develops.

METHODOLOGY:

The methodology for rainfall analysis generally follows the statistical approach. The statistical methods used included the mean, standard deviation, coefficient of variation, coefficient of Skewness, Kurtosis, Chi-Square, Anderson Darling Test, Kolmogorov - Simornov Test, and Mann-Kendall Test.

Numbers of studies have been done on rainfall data at national as well as international levels. These studies helped in creating a baseline for the new generation and gave ideas for different aspects and angel of research. A few of the studies are listed below:

Pant and Hingane17 studied geographic areas of Punjab, Haryana, Rajasthan, and west Madhya Pradesh between 1901–1982 in the year 1988 and located an increasing trend in mean annual and southwest monsoon. Kumar et al.8 performed a study in 1999 and located that the relation between the Indian monsoon and ENSO weakened in recent decades. Sen Roy and Balling24 analysed daily rain for 1910 – 2000 in 2004 that showed an increasing trend during a contiguous region from the north western range of mountains in Kashmir through most of the Deccan Plateau within the south and decreasing values within the eastern part of the Gangetic Plains and some areas of Uttarakhand. Trend detection of rain for 1901–1984 at 11 stations in Himachal Pradesh indicated an increase in annual rain at 8 stations declared by Kumar et al.11 in 2005, 8 stations showed a decreasing trend in the monsoon.

RESULT AND DISCUSSIONS:

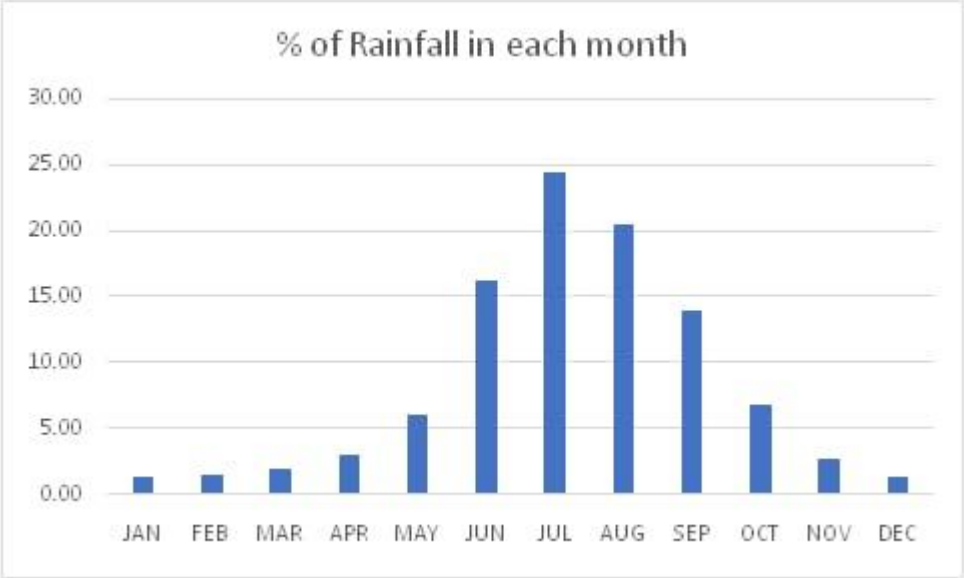
Data-set is downloaded from “data.gov.in” website. It has data for 117 years (1901–2017) consisting of monthly and seasonal data for all 36 meteorological subdivisions of India. So in total we have 117*12*36 = 50,544 observations. Our data-set had 0.7% of missing values. For the subdivision Arunachal Pradesh we had missing values for the first 15 years i.e. 1901 to 1915, so for all subdivisions we have considered data from 1916 to 2017 when we are analyzing as whole India. For the rest of the missing values we have used sequential imputation technique. Below table shows mean rainfall observed for each month over years. We can see that average rainfall is high in July and August followed by June and September.

Month	% of Rainfall
JAN	1.32
FEB	1.50
MAR	1.93
APR	3.06
MAY	6.13
JUN	16.25
JUL	24.45
AUG	20.42
SEP	13.99
OCT	6.81
NOV	2.79
DEC	1.34

Monthly mean annual rainfall

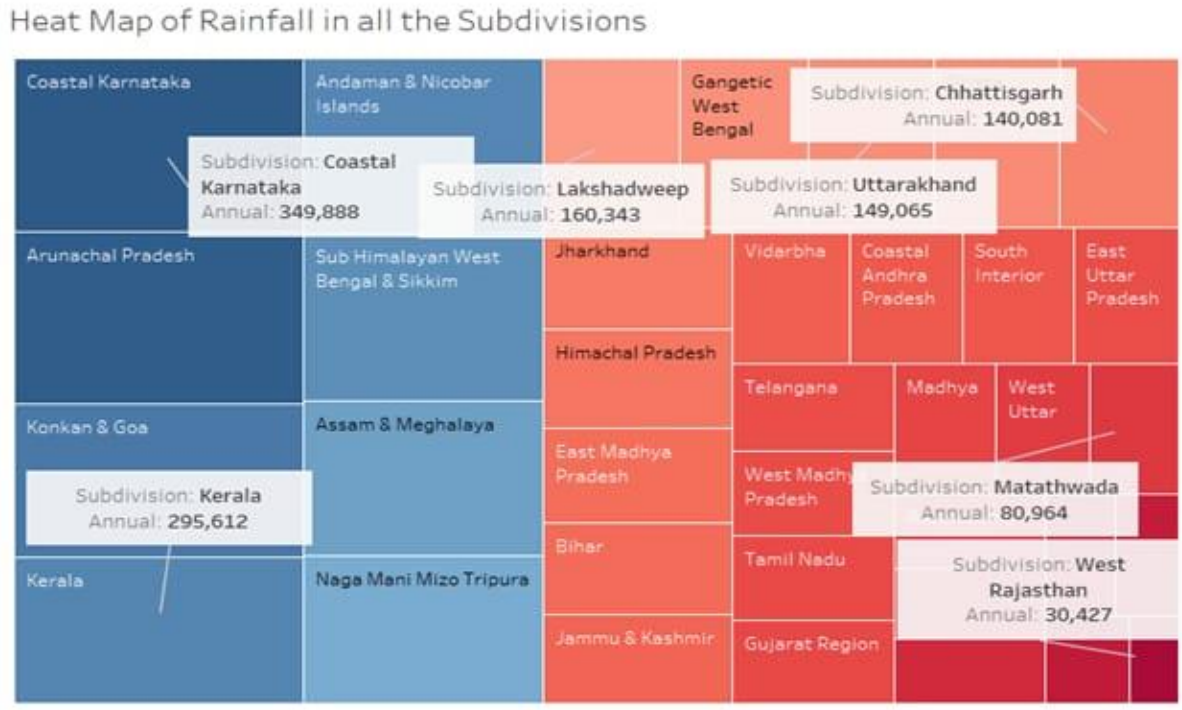
Annual rainfall by months:

The below graph shows the percentage of rainfall each month receives when we consider India as a whole. The rainfall in the months of June, July, August and September together contribute to almost 80% of the annual rainfall.



Annual rainfall by subdivision:

The following is a heat map plotted based on sum of rainfall received by each subdivision for all these years. The subdivisions with large area represents high rainfall and with small boxes represent less rainfall. We can see that the subdivision located at Southwest and Northeast part of India have received more rainfall compared to central India.



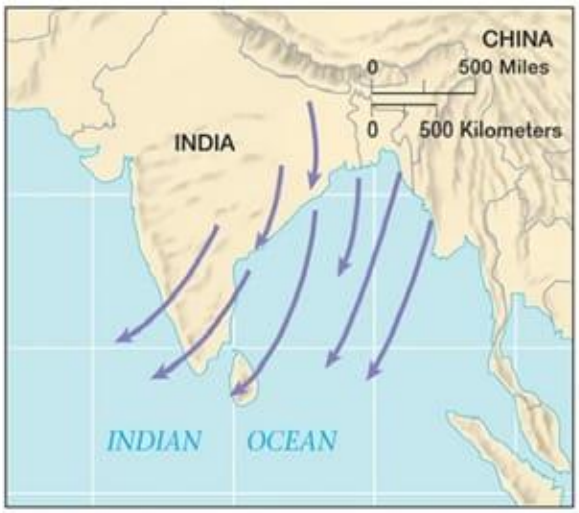
Understanding the Monsoon in India:

We will now move to a more interesting part of the analysis .We will see what exactly is monsoon, different types of monsoon winds in India, which subdivisions of India receives rainfall from which monsoon winds and why only particular subdivisions receive highest rainfall during this monsoon season. Before addressing these questions, we will see the basic concept of how rainfall actually occurs. So basically, during the summers, the Indian subcontinent heats up more as compared to the Indian ocean as the sun is directly over the landmass. This creates a low pressure over the Indian subcontinent and a relatively low pressure over the Indian ocean. And as we

know, the wind flows from high pressure area to the low pressure are in order to fill the void that was created thanks to the pressure system. So when the wind starts flowing from high pressure area to low pressure are i.e. from sea to land, it picks up the moisture from the sea and while entering the Indian subcontinent it comes in contact with the high terrains and hence precipitation occurs.

Now that we have understood how rainfall occurs we will now see what exactly is monsoon? Monsoon is traditionally defined as a seasonal reversal of wind accompanied by corresponding changes in precipitation. As seen in the image below, India receives rainfall from Southwest Monsoon winds (Summer Monsoon or Advancing Monsoon) and Northeast Monsoon winds (Winter Monsoon or Retreating Monsoon).The Southwest Monsoon usually starts in the first week of June and ends by first week of September and monsoon usually starts retreating from the Indian Subcontinent by the start of September and leaves the subcontinent completely by the end of November. And as we have seen in the previous graphs that Southwest monsoon provides almost 80% of the rainfall in India. This Southwest Monsoon has two branches, namely Arabian Sea branch and Bay of Bengal Branch.

Summer



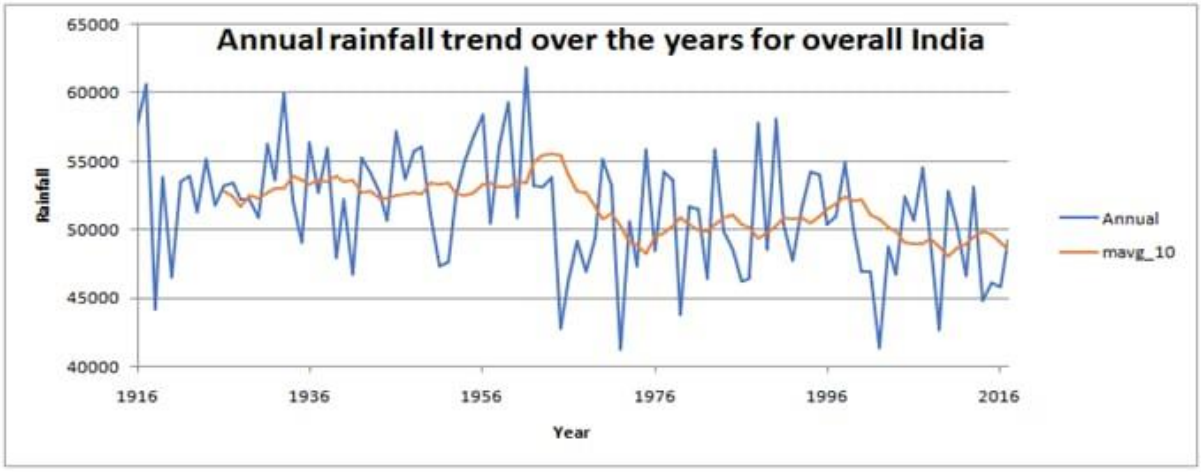
Winter

The Bay of Bengal branch of the Southwest Monsoon provides rainfall to the eastern and north eastern regions of India. Due to the presence of the eastern ghats along Orissa and West Bengal, these regions receive high rainfall in the East and when this branch reaches the north eastern part of India i.e. Sikkim, Arunachal Pradesh, Assam & Meghalaya, due to the presence of Khasi hills and other hilly areas, these subdivisions receive very high rainfall. Cherrapunji in Meghalaya is titled as one of the wettest places on earth.

The average annual rainfall in these regions is shown in the graphs below.

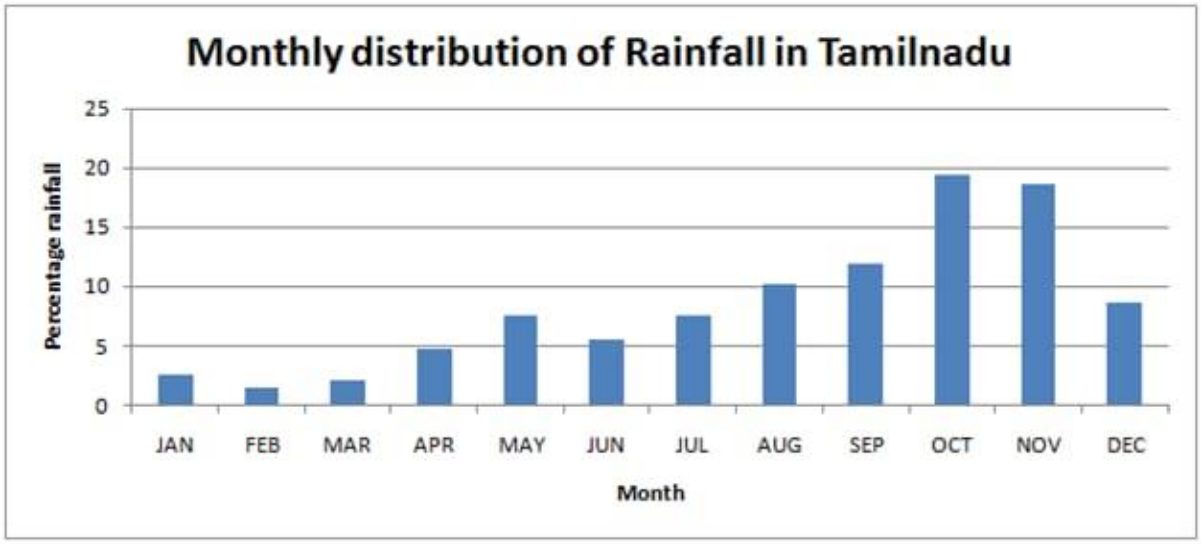
Annual Rainfall trend over the years for whole India:

10 years moving average was plotted, we can see that there is a decreasing trend in rainfall in the recent years.



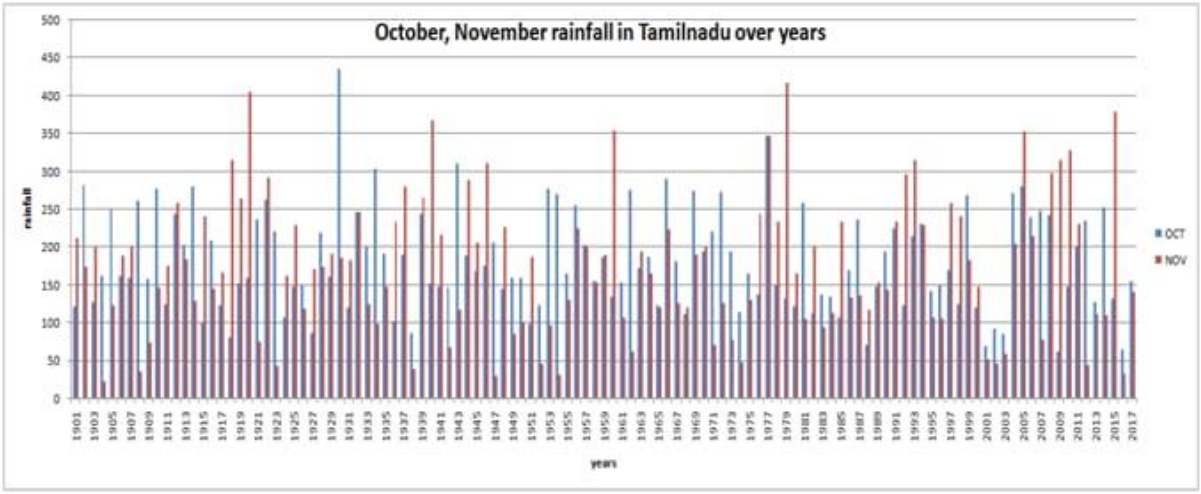
Rainfall Data Analysis for Subdivision TamilNadu:

To do rainfall data analysis of Tamil Nadu subdivision, we have considered the data from year 1901 to 2017. First we will see the distribution of rainfall over months and we can see in below figure that rainfall is more in October and November compared to other months as Tamilnadu receives rain during retreating monsoon season because of Northeast trade winds. The climate of Tamil Nadu is tropical in nature with less variation in temperature in summer and winter. This is because of its geographical location.



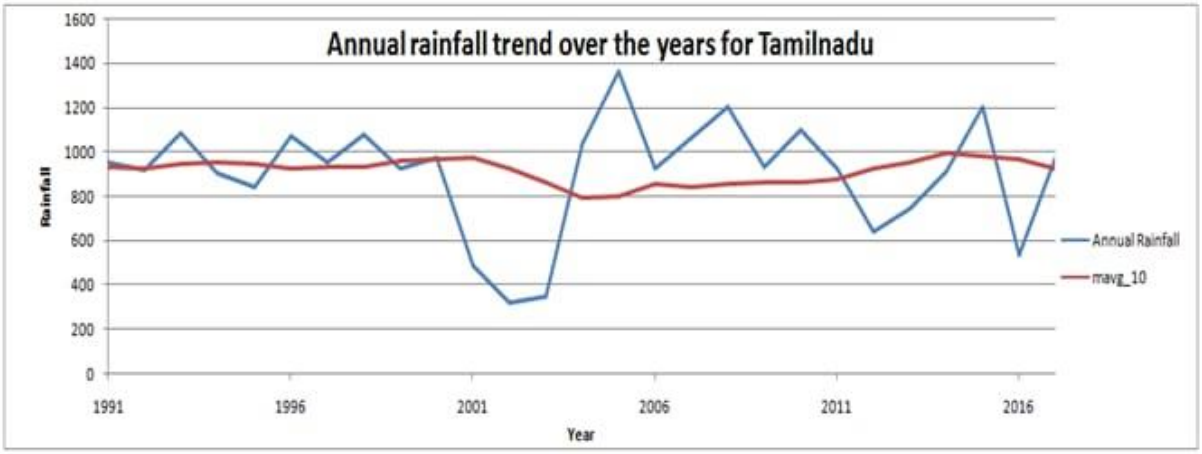
The below graph shows rainfall in Tamil Nadu in months October and November here we can see that most of the years when there is very low rainfall in October there is very high rainfall in November and vice versa. Tamil Nadu also rainfalls from tropical cyclones emerging in the neighborhood of Andaman islands during the retreat monsoon.

In 2015 there were south Indian floods, the flooding in Chennai was described as the worst in a century. In winters of 2017 the worst drought in a century happened in southern India.



Annual Rainfall trend over the years in Tamil Nadu:

10 years moving average was plotted, we can see that there is very weak increase in rainfall in the recent years.



Conclusion:

The results show that India has two main rainfall season: one is southwest monsoon(advancing monsoon) and other is Northeast monsoon(retreating monsoon). Advancing monsoon contributes almost 80% of the rainfall. Southwest and Northeast part of India receives most of the rainfall during the advancing monsoon. During the retreating monsoon, Andaman & Nicobar Islands, Kerala, Tamil Nadu receive more rainfall as compared to other subdivisions .The trend analysis of Annual rainfall considering India as whole show decreasing trend however when trend is analysed for all subdivision individually we can see some division showing increasing trend and some showing decreasing trend. It showed that is import to study subdivision for

better forecasting. We considered Tamil Nadu as one of the subdivisions to do further analysis. It receives more rainfall during October and November because of retreating monsoon. Since there are only a few months when the Tamil Nadu gets rains and its location at tropical results in high temperature which in turn results in water scarcity problem. Also because of its geographic location near it is hit sometimes by the cyclones formed in Indian Oceans which results in extreme storms and nonnormal rainfall .In an interview, Mrutyunjay Mohapatra, the director general of the IMD, explained how climate change is increasing number of days with heavy rainfall. The season started with 33% deficit rainfall but is ending with 10% higher than normal rainfall, with heavy spells of rain resulting in devastating floods in many states. He said the number of heavy rainfall days was increasing because of climate change, which was making predictions more difficult. Also, this year, the monsoon in India withdrew 40 days later than normal .Usually, the monsoon withdraws from September 1 from extreme northwest India, that is West Rajasthan, and by September 15, it withdraws from the entire country. But this year, the monsoon withdrew around October 9 or 10.The monsoon has been quite active in the month of September because of various factors. One important factor is the low-pressure systems that dropped over Bay of Bengal moved towards Rajasthan and under its influence, an East-West oriented low-pressure zone came about. This sustained the monsoon for quite a long time. Thereafter, a depression formed over the northeast Arabia Sea and it crossed the Gujarat coast and it moved in that direction sustaining the monsoon features .

References:

1. Basistha, A., Arya, D. S. and Goel, N. K., (2009) “Analysis of historical changes in rainfall in the Indian Himalayas.” International Journal of Climatology, 29, 555-572.

2. Dash, S. K., Jenamani, R. K., Kalsi, S. R. and Panda, S. K. (2007). “Some evidence of climate change in twentieth-century India.” Climatic Change, 85, 299–321.

3. Goswami, B. N., Venugopal, V., Sengupta, D., Madhusoodanam, M. S. and Xavier, P. K. (2006). “Increasing trends of extreme rain events over India in a warming environment.” Science, 314, 1442– 1445.

4. Joshi, U. R. and Rajeevan , M. (2006). “Trends in precipitation extremes over India.” National Climate Centre, India Meteorological Department, Research Report No: 3/2006, Pune.

5. Krishnakumar, K. N., Rao, G. S. L. H. V. P. and Gopal kumar, C. S. (2009). “Rainfall trends in twentieth-century over Kerala, India.” Atmospheric Environment, 43, 1940–1944.

6. Kumar, K. K., Rajagopalan, B., and Cane, M. A. (1999). “The weakening relationship between the Indian monsoon and ENSO.” Science, 284, 2156–2159.

7. Kumar, V. and Jain, S. K. (2010). “Trends in seasonal and annual rainfall and rainy days in Kashmir valley in the last century.” Quality International, 212, 64–69.

8. Kumar, V., Jain, S. K. and Singh, Y. (2010). “Analysis of long-term rainfall trends in India.’ Hydrological Science Journal, 55, 484–496.

9. Kumar, V., Singh, P. and Jain, S. K. (2005). “Rainfall trends over Himachal Pradesh, Western Himalaya, India.” Conference on Development of Hydro Power Projects – A Prospective Challenge, Shimla, 20–22 April 2005.

10. Li, H., Haugen, J. E. and Xu, C. Y. (2018). “Precipitation pattern in the Western Himalayas revealed by four datasets”, Hydrology and Earth System Science, 22, 5097-5110.