STUDY ON PATTERN OF RAINFALL AND ITS EFFECT IN THE CHHATARPUR (M.P), India

ABSTRACT

Agriculture is the backbone of the Indian economy. It gives employment to more than 50 percent of India's population. This sector contributes more than 15 percent to the country's GDP, which signifies its importance in our economy. Though important, it is highly susceptible to losses due to its high dependence on various variable factors such as rainfall, soil fertility, temperature etc., which varies across the region. This article analyzes various literature to help us understand the trend, effects, and impact of rainfall in the Chhatarpur district. We analyze the effects of rainfall on groundwater, cropping patterns, and irrigation facilities in that region.

Keywords: Agriculture, Groundwater, Irrigation, Rainfall.

1. INTRODUCTION

Rainfall is indeed a crucial meteorological and hydrological parameter with significant implications for a country's economy, agriculture, and cultural growth. It is the primary source of water for crop growth, and without adequate rainfall, agricultural productivity can be severely affected. Rainfall occurs when water vapor in the atmosphere condenses into water droplets and becomes heavy enough to fall to the ground. Rainfall is a form of precipitation and is essential for replenishing water bodies, groundwater, and sustaining ecosystems. India is divided into three zones based on the amount of rainfall they receive.

These are -

a) **Area Of High Rainfall** - The highest rainfall receiving areas in India are mainly the Western Ghats, Sub-Himalayan areas, North-Eastern and hills of Meghalaya. They receive abundant rainfall throughout the year. The average annual rainfall in these areas exceeds 2000 mm. Some parts of Khasi and Jaintia Hills receive an average rainfall of more than 10,000 mm.

b) **Area Of Medium Rainfall -** The average annual rainfall in these areas is between 1000 to 2000 mm. The areas that come under it are the southern parts of Gujarat, the North-East Peninsula, and the Eastern Ghats of Tamil Nadu.

c) **Areas Of Low Rainfall -** The average annual rainfall in these areas is between 500 to 1000 mm. The areas that come under it are Jammu and Kashmir, Punjab, Haryana, Delhi, West Uttar Pradesh, Eastern Rajasthan, Gujarat, and the Deccan Plateau.

d) Areas Of Inadequate Rainfall - The average annual rainfall in these areas is below 50 cm. The areas that come under it are Ladakh, West Rajasthan, Maharashtra, Karnataka and Andhra Pradesh.

Rainfall variabilities are important areas of meteorology/climatology. It is the degree to which rainfall varies through time or across an area. It determines the climate of an area. In India, the variability of annual rainfall is very high from year to year. The variability is quite higher in the regions of low rainfall than in the regions of high and medium rainfall.

1.1 Rainfall Pattern in Bundelkhand Region

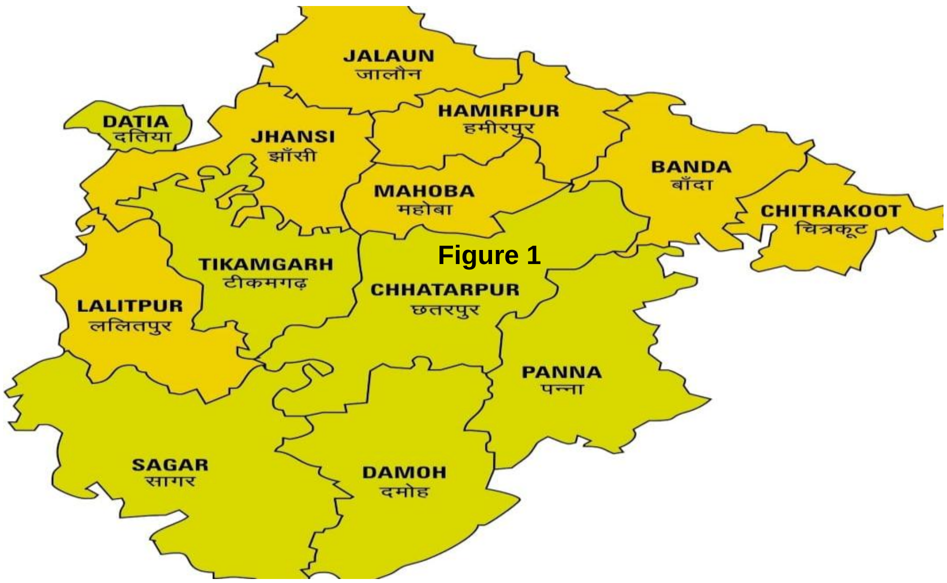

Figure 1: Districts in Bundelkhand region

Bundelkhand is a semi-arid zone that includes seven districts of Uttar Pradesh and Madhya Pradesh, **Fig.1**. These are Jhansi, Jalaun, Lalitpur, Mahoba, Hamirpur, Banda and Chitrakoot of Uttar Pradesh and Chhatarpur, Damoh, Datia, Panna, Tikamgarh and Sagar of Madhya Pradesh. Bundelkhand covers about 69,000 square kilometers of area. Bundelkhand, known as the historic region of central India, is now included in the state of Northern Madhya Pradesh, comprising the hilly Vindhyan region, which is cut by ravines and the northeastern plain.

Sadly, Bundelkhand is a backward part of India. One of the most prominent reasons for its backwardness is the severe historical droughts and famine conditions. This region is predominantly an agrarian economy where people are mainly dependent on agriculture and its other activities. Mainly rainfed agriculture is practiced in this region. Rainfall is the ultimate source of surface, ground, green and blue water resources for raising biomass and other utilities. Five out of seven districts had more than a 50% rainfall deficit. All the districts experienced meteorological drought [1]. The average rainfall experienced by the Bundelkhand region is about 800 mm to 900 mm.

1.2 About Chhatarpur

Chhatarpur is one of the districts of the Bundelkhand region situated in the Central part of India. It covers an area of 8616.82 square kilometers. It is situated in 24°06` to 20°20` north longitudes and 78°59` to 80°26` in east latitudes respectively. The district is surrounded by Panna district in the east; Tikamgarh district in the west; Mahoba district in the North and Sagar and Damoh district in the south. The district consists of 6 blocks namely Bijawar, Badha Malhara, Gaurihar, Londi, Nowgaon, and Raj Nagar, **Fig.2**.

These districts receive maximum rainfall mainly during the South West monsoon season. The normal annual rainfall in this district is 1068.3 mm. About 90.2% of the annual rainfall is received during the monsoon season as quoted by the Ministry of Water Resources.
Rainfall largely impacts the economy of the district. The main crops of this area are paddy, jowar, maize, Sesame, Soybean, Sugarcane (Kharif), Mustard, Gram, and Flaxseed and vegetables (Rabi). The total irrigated area is 2265.81 square kilometers.

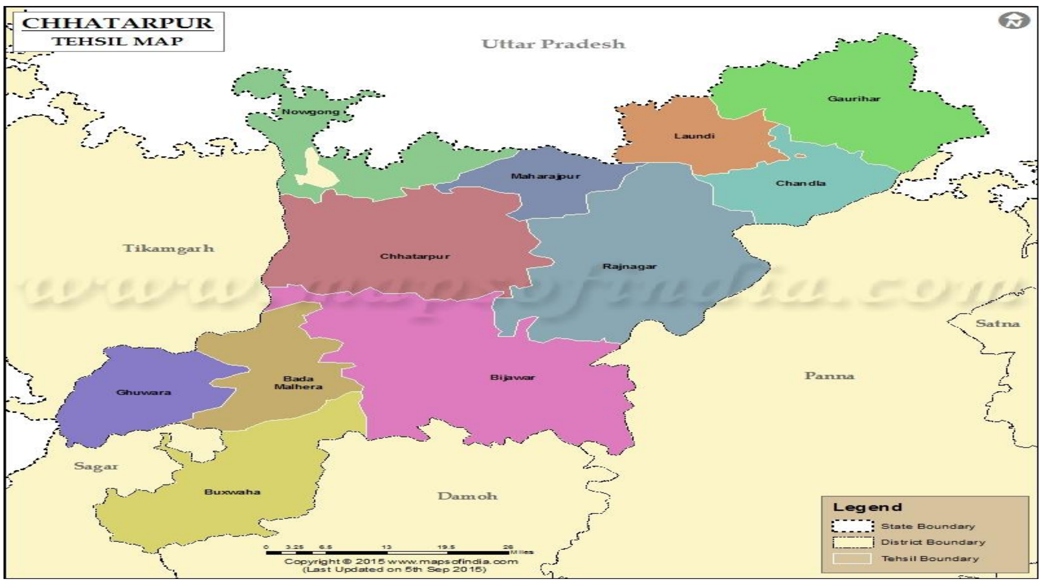

Fig. 2. The map of Chhatarpur districts with 6 blocks

2. TREND OF ANALYSIS OF METEOROLOGICAL PARAMETERS

Trend analysis is used to predict the evolving pattern and variability of climatic parameters. With the help of trend analysis rainfall and rainy days of a particular region can be estimated. It helps in laying a plan for the agricultural activities of the area.
The nonparametric Mann-Kendall test and Sen's slope estimator have been used by researchers to estimate Various Meteorological parameters.

2.1 Mann-Kendall Test

For all periods, trends were calculated using the Mann-Kendall test (Mann, 1945; Kendall, 1955). This test detects the presence of a monotonic tendency in a chronological series of a variable. It is a nonparametric method; that is, it makes no assumptions about the underlying distribution of the data, and its rank-based measure is not influenced by extreme values. This method mainly gives three types of information –

- The Kendall Tau, or Kendall rank correlation coefficient, measures the monotony of the slope. Kendall's Tau varies between -1 and 1; it is positive when the trend increases and negative when the trend decreases.

- The Sen slope, which estimates the overall slope of the time series. This slope corresponds to the median of all the slopes calculated between each pair of points in the series.
- The significance, which represents the threshold for which the hypothesis that there is no trend is accepted. The trend is statistically significant when the p-value is less than 0.05.

2.2 Sen's Slope estimator

The usual method for estimating the slope of a regression line that fits a set of (*x,* y) data elements is based on a least-squares estimate. This approach is not valid when the data elements don't fit a straight line; it is also sensitive to outliers.

Sen's Slope Definition

We now describe an alternative, more robust, nonparametric estimate of the slope, called **Sen's slope**, for the set of pairs (i, x_i) where x_i is a time series. **Sen's slope** is defined as:

$$Sen's\ slope = Median \left\{ \frac{x_j - x_i}{j - i} : i < j \right\}$$

A $1–\alpha$ confidence interval for Sen's slope can be calculated as (*lower, upper*)
where,
$N = C(n, 2)$ $k = se \cdot zcrit$
$lower = m(N–k)/2$ $upper = m(N+k)/2+1$
Here, N = the number of pairs of time series elements (x_i, x_j) where $i < j$ and se = the standard error for the **Mann-Kendall Test.** Also, mh = the h^{th} smallest in the set $\{(x_j–x_i)/(j–i): i < j\}$ and $zcrit$ = the $1–\alpha/2$ critical value for the normal distribution.

2.3 Linear regression

"Simple Linear Regression" model-

The method of linear regression requires the assumptions of normality of residuals, constant variance, and true linearity of relationship [2, 3].

The model for X (e.g., precipitation) can be described by an equation of the form:
X= at + b (1)
Where t = time (year)
a = slope coefficient; and b= least-squares estimate of the intercept

Modelling of Rainfall patterns helps in planning appropriate crops, cropping parents and appropriate utilization of palm resources. The rain code can be harvested and stored during heavy rainfalls for future use. It could be used during dry spells and critical stages of crops. The short and medium duration of Kharif crops can be grown with suitable farm management practices [4].

3. LITERATURE REVIEW

Studied [5] the rainfall pattern and its environmental impacts in the Chhatarpur district of Central India. To study the rainfall pattern, rainfall data between 1950 and 2020 was collected by IMD and the local Land Record department of Chhatarpur district MP. The study was based on the analysis of the trend in rainfall data using statistical and linear regression models on the annual time scale and seasonal for the Chhatarpur district of Madhya Pradesh, India

4. STATISTICAL ANALYSIS

During statistical analysis, it was calculated and found that the average rainfall in the Chhatarpur region was 1119.088 M. The standard deviation shows the heterogeneity of data as compared to the mean. The coefficient of skewness was between plus-minus 0.6 and Kurtosis was between 2 and 4. Then the rainfall distribution is normal. The analysis shows, that the year's rainfall data that was above the average line were favorable for groundwater recharge of the area and those years' rainfall data found below the line of average were not favorable for groundwater recharge of the area and also indicated the negative environmental impact of rainfall in the area. The statistical measurement gives a precise value of rainfall data and it reveals good variation values indicating significant fluctuation and trend.

5. TREND ANALYSIS

a) Monsoon season rainfall, post-monsoon rainfall and winter season rainfall and their rainfall deviation all show a decreasing trend.
b) The annual rainfall and the deviation trend both were showing decreasing trends to the adversely affected rainfall environment and these changes were not favorable for the agricultural development of the area.

[6] studied the statistical modeling of weekly rainfall data for crop planning in the Bundelkhand region of Central India. They used statistical methods to protect the probability of rainfall. They used many probability distribution models. Anderson -Darling test for goodness of fit test and Wald Wolfowitz run the test. They found that at 70% probability, rainfall of more than 20 mm was assured and expected from Standard Meteorological Week 27 onwards. As the rainfall is expected to be heavy, run-off is likely to occur. This runoff is harvested and used during dry spells or critical stages of Crop growth. The analysis showed that the total assured rainfall of 299 mm and 410 mm during the crop-growing period is mandatory. Average rainfall of 644 mm during the critical period of crop indicates that there is no need for irrigation. In the study, they stated that long-term average rainfall should not be taken as the criteria for sowing the crops because the total actual rainfall is unlikely to match the long-term average rainfall in a given year for the crop-growing period.

[7] Analyzed the rainfall pattern in the Chhatarpur district to identify the onset and withdrawal of effective monsoon and the number. The date of onset of an effective monsoon can be defined as the date of commencement of a wet spell. According to their study in Chhatarpur district, the mean date of onset is the 2nd of July. The standard deviation was calculated to be 15, the median date of onset was 3rd July and the mean date of withdrawal was 22nd September. According to their trend analysis, the rainfall data suggests that even though there is a falling trend in annual and monsoon season rainfall amounts, no block depicts a significant trend at a 95% significance level. The results of the analysis show that agriculture is impossible without Supplementary irrigation during critical dry spells.

A thesis was presented in JNKVV, where they studied the rainfall pattern of 25 years i.e., between 1987 and 2011 of Chhatarpur district which was collected for friend analysis from the Department of Agro-Meteorology located at JNKVV College of Agriculture Jabalpur, MP, India. They used both parametric and non-parametric statistical methods to analyze the rainfall pattern and rainy days, they used Pettit's test for change point analysis.

From this study, they concluded the different methodologies, the monsoon rainfall accounts for 81.20% of the annual rainfall and is received in 76.32% of the annual rainy days. Pre-monsoon winter rainfall accounts for 11.60 and 2.57% of the annual rainfall and is received in 14.68% and 3.17% of the annual mean rainy days.

According to trend analysis, the results revealed that a significant decreasing trend is observed in annual monsoon and September rainfall. From Sen’s Slope, it was observed that the annual rainfall showed a downward trend for the period of 1987 to 2011.

6. DISCUSSION

With the ever-increasing global warming, the climate shift has become a genuine concern. Our country is an Agri-based country which gives livelihood to more than 50% of its population. Rainfall is an important hydrological and meteorological parameter on which agriculture is dependent. The uneven distribution of rainfall and high spatial variability lead to high rainfall in one region and dry spells in another region. The studies that were made by the researchers showed decreasing trends in rainfall patterns across the Chhatarpur region. Various statistical methods were used to identify the rainfall patterns and number of rainy days. Frequent dry spells from 1 to 3 years have also been observed in this region[7]. As per the studies, the rainy days have decreased in recent years in the Chhatarpur region due to which crop planning has become extremely challenging. High rainfall during the harvesting period leads to crop failures, adversely affecting the farmer's income and the country's economy.

The recharging of the groundwater table is also predominantly dependent on rainfall. Due to the over-exploitation of groundwater and decreasing trends in rainfall patterns and rainy days, the level of groundwater has significantly decreased in this region. According to the Ministry of Water Resources, Chhatarpur district shows a declining trend in groundwater level during the Pre-Monsoon period, ranging from 0.0015-0.64 m/year. During the post-monsoon period, water level ranges from 2.26-9.24 mg/l shallow water level in northern central and southern parts of India while deep water levels can be observed in North West i.e.,710 mg/l. This region receives about 81.20% of rainfall during monsoon. This water should be stored judiciously and in well-framed structures and should be used during the critical crop growth phase. Supplemental irrigation should be made mandatory in this region as the amount of rainfall and rainy days are not enough to meet the crop water requirement. Fertigation systems through drip irrigation and sprinkle irrigation should be promoted.

Observation of declining trends in rainfall and recurrent droughts has led to drought resistance crop farming such as pulses and oilseeds [8] and their study which examined the impacts of climate change on agriculture in the Chhatarpur district, suggested that we should move towards climate-resilient agricultural practices such as conservation agriculture and crop cultivation. The introduction of various agroforestry practices can also become a game changer advice in this matter. Early forecasting of rainfalls and scheduled irrigation can help us prevent the adverse effects of lack of rainfall.

7. CONCLUSION

Chhatarpur region is a region in Madhya Pradesh that has been known for its high agricultural productivity but due to a declining trend in annual rainfall, it has been observing various drawbacks such as depletion of groundwater table, low productivity, and decrease in crop diversity. Due to a lack of rainfall, crop monoculture has been adopted in many regions of this area due to which soil fertility has been decreased. The declining trend in light and medium rainfall in the Chhatarpur region indicates the drying of this region. Therefore, it is of paramount importance that we understand the climate thoroughly and move towards water harvesting techniques, supplemental irrigation and climate-resilient agricultural practices. Lack of rainfall can be seen as a potential challenge to rained farming practiced in this area.

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COMPETING INTERESTS

The authors declare that they have no known competing financial interests or personal relationships that could have influenced the work reported in this paper. The funders had no role in the design of the study; in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results. All authors have approved the manuscript and agree with its submission.

AUTHORS' CONTRIBUTIONS

Author Priyanshi Garg designed the study, performed the statistical analysis, wrote the protocol, literature searches and wrote the first draft of the manuscript. Author Vineet Kumar and Author Anshu Dhaka helped in the analyses of the study. All authors read and approved the final manuscript.

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