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Rainfall Trend Analysis – A Review

Gunjal Tank[1], Pranali Dongre[2], Dr. G.P. Obi Reddy[3], Praveen Sen[4]

[1]B-Tech Student, Information Technology, St. Vincent Pallotti College of Engg. & Tech., Maharashtra, Nagpur
[2]B-Tech Student, Information Technology, St. Vincent Pallotti College of Engg. & Tech., Maharashtra, Nagpur
[3]Principal Scientist, Geography, ICAR National Bureau of Soil Survey and Land Use Planning, Maharashtra, Nagpur
[4]Professor, Information Technology, St. Vincent Pallotti College of Engg. & Tech., Maharashtra, Nagpur

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Abstract - *Rainfall is a prime factor for various studies like engineering, agriculture, weather, and many more. This article aims to review the rainfall trends and variability all over India. Rainfall trends vary at different places throughout the country. Precipitation analysis provides knowledge related to agricultural activities to assess the availability of water and to take proper measures for storage.*

Key Words: **Rainfall, Trends, Analysis, Variability, Statistics, Precipitation, Climate.**

1. INTRODUCTION

Rainfall is a random phenomenon; its prediction has always been a challenge for meteorologists worldwide either of two complexity and technology. India's main occupation is agriculture; rainfall is strictly associated with the agricultural region, whereas farming plays a significant role to contribute the state of a country. Rainfall is a prime input for various engineering designs such as hydraulic structures, bridges and culverts, canals, stormwater sewers, and road drainage systems. The detailed statistical analysis of each region is important to estimate the relevant input value for the planning and analysis of engineering structures and crop planning. The monthly rainfall raster data for 30 years utilized to understand habitual rainfall, deficit rainfall, excess rainfall, and seasonal rainfall.

The main reason for the inaccuracy of rainfall is: Rainfall is a random event that is nonlinear with its dependent variables like weather parameters or attributes that are not constant. Rainfall prediction will help in

1) To avoid Flood which will save human life and properties.
2) Helps in managing the Resource of Water.
3) Helps farmers to Manage their Crops.

The degree up to which rainfall varies across an area or through time is an important characteristic of the climate of an area. The study of the latter is a salient feature in understanding climate change. The study will identify rainfall trends like mean rainfall, maximum, and minimum rainfall and also statistical analysis like the coefficient of variation, standard deviation, and standard precipitation index of India. Spatial data comprises the relative geographical information about the earth and its features. A pair of latitude and longitude coordinates defines a specific location on earth. Spatial data are of two types according to the storing technique named raster data and vector data. Raster data are composed of grid cells identified by rows and columns. The geographic area is divided into groups of cells, which form an image. Satellite images, photographs are examples of raster data. Here raster data from CHIRPS monthly dataset is used for the study of various parameters to analyze the variability and climatic conditions.

Given the above, various studies have attempted to understand the trend of variable climate in our country. These studies are confined to trends and periodicities over specific regions of India using different knowledge on periods of data depending on the availability of data.

2. METHODOLOGY

The methodology for rainfall trend analysis generally follows the statistical approach. The statistical methods used included the mean, standard deviation, coefficient of variation, Standard Precipitation Index, mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE), correlation coefficient (R), Willmott's Index of agreement (WI), Nash Sutcliffe efficiency (NSE), and Legates, McCabe Index (LM), Mann–Kendall test, Sen's slope. Numbers of studies have been done on rainfall data at national as well as international levels till today. These studies have helped in creating a baseline for the new generation and gave ideas for various aspects and angel of research. A few of the studies are listed below:

The UNSEEN method, proposed by Thompson et al.[14], maybe a statistical framework under which the prospect of an unprecedented rainfall extremes are often estimated employing a large ensemble of initialized simulations of climate to sample a wide range of variability internally. Thompson et al.[14] have used this method to estimate the chance of rainfall exceeding the present record rainfall over the United Kingdom (UK) and showed that in winter, there's a 7% chance that the rainfall would exceed the observed record rainfall in a minimum of one month over south-east England. They estimated the chance of extreme summer rainfall, i.e. flood and drought over India for this climate. The

first test individual models against the observed rainfall record over India and choose models that are statistically indistinguishable from observations then calculated the probabilities of floods, droughts, and unprecedented rainfall using 1669 realizations of summer precipitation from the chosen set of models. The chances of record-breaking drought and flood are 1.6% and 2.6%, respectively. There is also an estimated chance that a 30% rainfall deficit could occur around once in two centuries, which is way beyond the record deficit over India. The ELM designed by Huang et al.[7] is an advanced data intelligent model that uses Single Layer Feedforward Neural Network (SLFN). By using monthly rainfall data from 1949 to 2013 at four meteorological stations namely, Barisal, Bogra, Faridpur, and Mymensingh, each representing a geographical region of Bangladesh that frequently experiences droughts. The model inputs were decided build on correlation statistics and therefore the prediction capability was evaluated using several statistical metrics including mean square error (MSE), root mean square error (RMSE), mean absolute error (MAE), correlation coefficient (R), Willmott's Index of agreement (WI), Nash Sutcliffe efficiency (NSE), and Legates and McCabe Index (LM). The results revealed that the proposed models are reliable and robust in predicting droughts within the region. Arpita Panda and Netrananda Sahu[3] examined long-term changes and short-term fluctuations in monsoonal rainfall and temperature over Kalahandi, Bolangir, and Koraput (hereafter KBK) districts in the state of Odisha. Both rainfall and temperature data for the period of 1980–2017 were analyzed in this study. Statistical analysis techniques namely Mann–Kendall test and Sen's slope estimator were used to check and analyze the issues. The detailed analysis of the data for 37 years indicates that the annual maximum temperature and annual minimum temperature have shown an increasing trend, whereas the monsoon's maximum and minimum temperatures have shown a decreasing trend. Statistically significant trends are detected for rainfall and also the result is statistically significant at a 99% confidence limit between 1980 and 2017.

Revadekar et al.[9] (2012) analyzed 121 stations across India to assess the temperature extremes, whereas the present study utilized 338 grids generated using 395 data points. Further, Revadekar et al. (2012) presented the spatial distribution of trends of temperature extremes along with its significance level but failed to visualize the contours of the intensity of trends. The present study showcases the strength of the gridded data to map the intensity and direction of trends along with the distribution of grids with significant trends. The study of Daily gridded (1°×1°) temperature data from 1969 to 2005 was used to recognize spatial patterns of temporal trends of monthly and seasonal maximum and minimum temperature, growing degree days (GDDs) over the crop-growing season of Kharif, rabi, and Zaid and annual frequencies of temperature extremes over India. The direction and magnitude of trends, at each grid level, were estimated using the Mann– Kendall statistics and further assessed at the homogeneous temperature regions using a field significance test that identified a general warming trend over India with considerable variations of magnitude and direction over space and time.

Padhiary J. et al.[10] performed a study coping with the variability and long trends and temperature over Jaraikela Catchment in 2018. They found that there was a big increase in each annual rain and temperature at most of the stations, however, found no clear trend within the monthly and seasonal analysis of rain and temperature. In 2019, Sharma N. K. & Sharma S.[11] founded from rainfall between 1992-2012 that one-day annual most rain was found to be 98.9mm with variance and constant of variation of 25.06 and 57.19 severally. Rain of the Dharamshala region was taken for a study by Sharma N. K. & Sharma S.[12] between 1992-2012, it showed that the average of one-day annual most rain was 142.9 mm and it was notified that the quality deviation was 54.8 whereas the constant of variation 51.34. Similarly, the coefficient of skewness is 1.1. for continuous 2 to 7 days annual most rain varying values for mean, variance, coefficient of variation, and coefficient of Skewness is 201 – 393.4 mm, 70.17 – 146.5, 41.65 – 30.47, and 0.726 – 1.593. For a repeat interval of 20 years, the most rain expected in a day as well as 2, 3, 4, 5, 6, and that of 7 is 277.7mm, 373.6mm, 445.11mm, 518.62mm, 589mm, 680.3mm and 753.79mm respectively.

In 2017 Sharma Manu Raj[13] results of rectilinear regression analysis showed a statistically vital decreasing trend in annual mean rain however monthly rain information conjointly showed decreasing trends all told months. In 2018 by H. Li et al.[8] investigated the abstraction and temporal pattern of rain in reason of the Himalayas that was supported by 4 sets namely interpolated gridded data based on gauge observations, reanalysis data, and high-resolution simulation by a regional climate model. They terminated that though datasets could be similar in terms of abstraction pattern and temporal variation and changes, there's a distinction in absolute values i.e. 497 - 819 mm/year because of source and technique. These variations were notably large in July and August and at the windward slope and high-elevation areas. it was found that summer is wetter

and winters were drier, and trends weren't statistically significant. As a result, wetter summer ends up in a lot of and greater floods and hotter and drier winter ends up in fewer glaciers accumulation.

3. CONCLUSIONS

India is susceptible to climate variability and change throughout. Fluctuations or variations in precipitation parameters are a phenomenon studied in the review. The effect of variability magnifies the social and economic encounters across the nation. Also, this agricultural success is typically rainfed. Rainfall analysis of like mean rainfall, maximum rainfall, minimum rainfall, and also statistical analysis like Standard Deviation (SD), Coefficient of Variation (CV), Standard Precipitation Index (SPI) will help in finding the various trends in rainfall across India at present and also in the future. Such analysis helps to know the previous misjudged and resulted in floods, droughts, effects on crops. Analyzing various parameters of rainfall provides information about the past years' trends in precipitation. It helps us to know about the weather trends in previous decades. It intimates about the conditions that were prevailing before, during, and after weather conditions. Thus, the analysis helps in understanding the rainfall pattern of India and also efficient crop planning and water availability of the region. The variability in the rainfall conditions will help in predicting the future weather conditions and then planning the type of yields to be grown in particular regions.

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