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A Study on Trends in the Rainfall Pattern over India

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Abstract – New month to month, regular and annual rainfall time arrangement of 36 meteorological subdivisions of India were built utilizing the month to month rainfall information for the fixed network of 1476 downpour check stations. In the new network, on a normal, there is one downpour check station for each 3402 Sq. km region. The new rainfall arrangement is transiently just as spatially homogenous. Linear trend investigation was completed to look at the long haul trends in rainfall over various subdivisions and month to month commitment of every one of the monsoon months to annual rainfall. During the south-west monsoon season, three subdivisions viz. Jharkhand, Chattisgarh, Kerala indicated significant diminishing trend and eight subdivisions viz. Gangetic WB, West UP, Jammu and Kashmir, Konkan and Goa, Madhya Maharashtra subdivision, Rayalseema, Coastal AP and North Interior Karnataka demonstrated significant expanding trends. It has been discovered that the commitment of June, July and September rainfall to annual rainfall is diminishing for couple of subdivisions while commitment of August rainfall is expanding in couple of different subdivisions. EOF examination is additionally done to know the spatial conveyance of rainfall.

Keywords: Rainfall, Network, Subdivisions

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1. INTRODUCTION

With regards to climate change, it is relevant to determine whether the attributes of Indian summer mon-before long are additionally evolving. The Indian summer monsoon (June–September) rainfall is urgent for the economic advancement, disaster management, hydrological arranging of the nation. Despite development in the bad habit division, economy of India is as yet reliant on agriculture. Yield disappointment, dry spell and increasingly outrageous cases like starvation because of powerless or lacking monsoons turns out to be basic to the nation. In this way, it is imperative to screen intently the rainfall variety the nation over on every day, week by week, month to month and seasonal time scale.

India Meteorological Department (IMD) after its foundation stepped up to the plate and introduces increasingly more downpour measures around the nation to catch the mind boggling variety of rainfall the nation over. The main leader of the IMD required individual exertion to gather rainfall information from every one of the provinces and had drawn out the nitty gritty examination of rainfall pattern over India. His work is all around alluded and is recognized as the most profitable data on rainfall conveyance over India. Attributable to these endeavors of the IMD, a long-lasting arrangement of rainfall information from a genuinely uniform network of stations is accessible for research work. Numerous scientists utilized these valuable information for developed all India rainfall arrangement (signified by Indian Institute of Tropical Meteorology Series (IITMS) here after) in light of 306 consistently dispersed stations in the nation. They have additionally utilized region weighted technique to compute all India rainfall utilizing rainfall information of the 306 districts outside the bumpy locales like Jammu and Kashmir, Himachal Pradesh, Hills of west Uttar Pradesh, Sikkim and Arunachal Pradesh, Bay Islands and Arabian Sea Island. By and by this time arrangement is refreshed by the Indian Institute of Tropical Meteorology (IITM), Pune (www.tropmet.res.in) and this rainfall time arrangement was widely utilized by numerous scientists.

At present, there are in excess of 500 administrative districts in the nation. It may not be perfect to speak to the mind boggling rainfall variety in the nation utilizing just 306 downpour check stations as was finished Geographical zone of all the administrative districts is in excess of 100 square km (with the exception of Andaman and Nicobar Islands). Since rainfall over India has appeared spatial changeability, increasingly number of stations is basic to deliver solid rainfall information of administrative districts the nation all in all just as for littler areas. Anyway a large portion of these examinations depended on the rainfall

arrangement developed. The monsoon rainfall is with no trend and essentially arbitrary in nature over an extensive stretch of time, especially on the all India time scale. Since rainfall is having high spatial inconstancy, presence of long haul trend in littler spatial scale. In the sub divisional scale, presence of trends.The examination by Parthasarathy proposed that monsoon rainfall more than two subdivisions viz. sub-Himalayan West Bengal and Sikkim and the Bihar Plains indicated diminishing trends while for the four subdivisions viz. Punjab, Konkan and Goa, West Madhya Pradesh and Telangana demonstrated expanding trends. In any case, considered the linear trend examination of every one of the 306 stations of the IITMS and concentrated their spatial example.

They have discovered significant expanding trend in monsoon seasonal rainfall along the west coast, north Andhra Pradesh and north-west India while significant diminishing trends over east Madhya Pradesh and abutting zones, north-east India and parts of Gujarat and Kerala. A point by point discourse of different investigations and their outcomes are accessible.

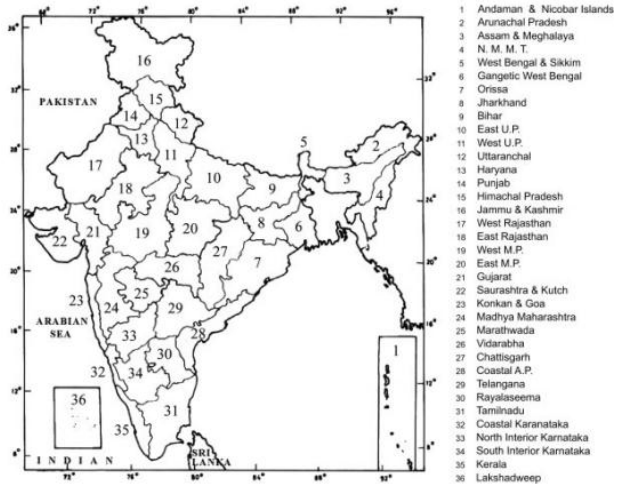

Fig 1 The 36 meteorological subdivisions of India

2. REVIEW OF LITERATURE

Banerjee AK, Raman, (2015) [1] Monsoon rainfall is known to have significant epochal variations and there was a significant change in the climate design over India during the ongoing years. Thusly, it is perfect to expand the rainfall examination with the ongoing information. In addition, as referenced over, these investigations utilized the information of rainfall time arrangement arranged utilizing just 306 stations. In this way, there was a degree to build up a homogenous rainfall time arrangement with progressively number of stations and including the information of late years.

The extent of the present investigation depends on these two goals, to build up progressively homogenous long-lasting arrangement rainfall information including the ongoing years and to look at the rainfall variations in more detail.

Blanford H,(2016)[2]the improvement of a homogeneous (spatially just as transiently) month to month rainfall information arrangement was the initial phase in this examination. From the immense informational collection filed at the National Data Center, IMD, Pune, a network of 1476 downpour check stations was chosen that have just 10% or less missing long stretches of information during the period. In the present network, we have secured all the territory including the bumpy locale to have greater consistency. The rainfall investigation secured numerous viewpoints like linear trends, epochal variations, and commitment of month to month rainfall to the annual aggregate, teleconnection with the El Nino˜ southern swaying (ENSO) and so on. As referenced before, districts are the littlest administrative unit in India. There is a genuine requirement for locale rainfall climatology for better hydrological and water management and furthermore for agriculture and for any administrative purposes.

Development of a homogenous rainfall time arrangement

Das MR, Mukhopadhyay, (2015) [3] to set up a homogenous rainfall time arrangement, we have chosen 1476 downpour check stations having most extreme information accessibility. Month to month rainfall information for these stations are accessible for in any event 90% of the years. Missing information for individual station was topped off by the rainfall information of a neighboring precipitation check station. We have thought about 458 districts for the present investigation.

Dash SK, Kumar, (2015) [4] every one of these 458 districts of the nation has at least two speaking to stations. Above all else, the region month to month rainfall is determined as the number juggling normal of rainfall information of the considerable number of stations in the region. Since there is an enormous spatial fluctuation of rainfall, it is important to apply the math mean for computing areal rainfall up to region as it were. Rainfall information for the meteorological subdivisions were then determined as the zone weighted rainfall of the districts inside the meteorological subdivisions. Figure 1 demonstrates the area of the 36 meteorological subdivisions of the nation.

The normal territory of the meteorological subdivision is in excess of 91 000 sq km. It might be referenced that the 306 stations utilized in IITMS can't speak to 458 districts. The density for example the normal region per station for every one of the arrangement is appeared in the last two sections.

There are in any event 14 subdivisions km, while the new rainfall information time arrangement has one station in each 3402 sq km zone. Other factual properties in regards to the density of stations appeared Table I obviously show that the new

arrangement is spatially increasingly homogeneous.

Rainfall over the nation in general

All India month to month, seasonal and annual rainfall arrangement were developed dependent on the region weighted rainfall of all the 36 meteorological subdivisions of the nation.. The mean, standard deviation and coefficient of variety are likewise given in a similar table. The mean (determined with the information of 1901–2003) rainfall of July is 286.5 millimeters is the most elevated and contributes 24.2% of annual rainfall (1182.8 millimeter). The August rainfall is somewhat lower, which contributes 21.2% of the annual rainfall. The June and September rainfall are practically comparable and they contribute 13.8 and 14.2% of the annual rainfall separately. The mean south-west monsoon season (June–September) rainfall (877.2 millimeter) adds to 74.2% of the annual rainfall (1182.8 mil-limetre). Commitment of pre-monsoon (March, April and May) rainfall and post-monsoon (October, November and December) rainfall to the annual rainfall is for the most part the equivalent (11%). Coefficient of variety is higher during the long stretches of November, December, January and February. The examination of the IITMS south-west monsoon season (June–September) rainfall arrangement with the new rainfall time arrangement. Despite the fact that the correlation coefficient between these two arrangement is exceptionally enormous (0.97), there are numerous contrasts between the two arrangement. The mean seasonal rainfall of IITMS arrangement is 844.5 millimeter, though the men estimation of this time arrangement is 877.2 millimeter. The high mean estimation of the new time arrangement is a result of the thought of all the 36 meteorological subdivisions, including the uneven locales. The standard deviation and coefficient of fluctuation for the IITM arrangement are 81.0 millimeter and 9.6% and the equivalent for the new time arrangement are 71.0 millimeter, 8.1% individually. Coefficient of variety of the here and now arrangement is littler contrasted with the IITM time arrangement.

3. EPOCHAL VARIATIONS OF INDIAN SUMMER MONSOON RAINFALL

It is notable that Indian summer monsoon rainfall shows multi-decadal variations in which there is a bunching of wet or dry irregularities. To look at the ages of above and beneath typical rainfall, a 31-year running mean of the Indian summer monsoon rainfall (ISMR) were determined to detach low frequency conduct. These ages of above and beneath ordinary rainfall are appeared in Figure 2. Rainfall was better than average for almost forty years. To comprehend the epochal be conduct of rainfall series for various monsoon months, we have additionally determined 31-year running methods for every one of the monsoon months .It is seen that epochal conduct of July and September rainfall is practically like that of the monsoon seasonal rainfall. In August, the better than average or positive phases began from the center of 1950s and proceeded till as far as possible. Both June and August rainfall are in positive stage in the ongoing decades while July and September rainfall are in the negative stage. The likewise discovered comparable aftereffects of 30 years of substituting groupings of dry and wet periods.The lacking or overabundance monsoon years are characterized for those years when monsoon rainfall percentage takeoffs from the mean rainfall are less or more than the standard deviation (8.1% of mean).There were four insufficient and three overabundance years. We had eight lacking years and three overabundance years. During the following three many years of wet period, we had three inadequate years and five abundance years. In the dry time of 2014-2016 there were seven lacking years and four abundance years.

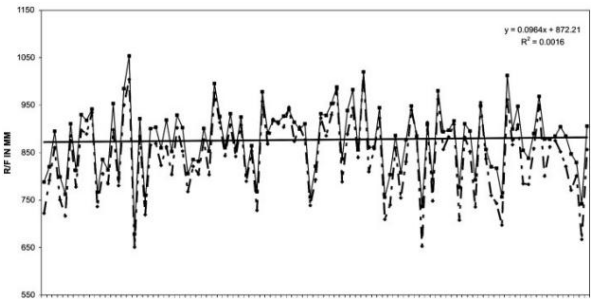

Fig 2 Comparison between IITM south-west monsoon seasonal rainfall series and the new series. Trend line drawn on the new series shows no trend in the seasonal rainfall.

4. TRENDS IN ALL INDIA MONSOON RAINFALL

Figure 2 additionally demonstrates the trend line drawn dependent on linear fit on the All India monsoon seasonal rainfall series as percentage takeoff from the extensive stretch normal. The series was exposed to a 'low-pass channel' so as to stifle the high frequency motions. The loads utilized were nine point Gaussian likelihood bends (0.01, 0.05, 0.12, 0.20, 0.24, 0.20, 0.12, 0.05, 0.01). It is plainly observed that no linear trend exists in this series. We have likewise utilized linear relapse procedure and the 'Students t - test' for testing if there is any significance in the trend in every one of the monsoon months. All India summer monsoon season rainfall too the all India rainfall during the four monsoon months (June, July, August and September) does not demonstrate any significant trend.

5. TRENDS IN SUBDIVISIONAL RAINFALL

'India all in all is too enormous to be in any way treated as a solitary unit. A few zones are negatively correlated with others, for instance, the

monsoon rainfall of Bengal and Assam with Bombay and focal India'. For the nation overall, the monsoon season rainfall and month to month rainfall for the monsoon months don't demonstrate any significant trend. In any case, there can be huge variations in the local scale. So as to contemplate the common variations of territorial rainfall we have completed the trend examination for the month to month rainfall series of June, July, August and September and furthermore for the monsoon season in general for all the 36 subdivisions.

The outcomes are appeared in Figure 3, which shows significant and wonderful variations on the local scale. We have broken down July and August rainfall, which adds to a noteworthy part of the monsoon seasonal rainfall. We find in July, six subdivisions have indicated diminishing trends and eight subdivisions have expanding trends. In August, four (ten) subdivisions have appeared (expanding) trends in rainfall. We have considered every one of the instances of 99, 95 and 90% dimensions of statistical significance. June rainfall has indicated expanding trend for the western and south-western pieces of the nation, while decreas-ing trends are watched for the focal and eastern pieces of the nation. July rainfall has diminished for most pieces of the focal and peninsular India however expanded signif-icantly in the northeastern pieces of the nation. August rainfall has expanded significantly (at 95% significance level) for the subdivisions Konkan and Goa, Marath-wada, Madhya Maharashtra subdivision, Vidarbha, West Madhya Pradesh, Telangana and west Uttar Pradesh.

The September rainfall has appeared expanding trends (at 95% dimension of significance) in Gangetic West Bengal and diminishing trends (at 90% dimension of signifi-cance) for the subdivisions Marathwada, Vidarbha and Telangana.

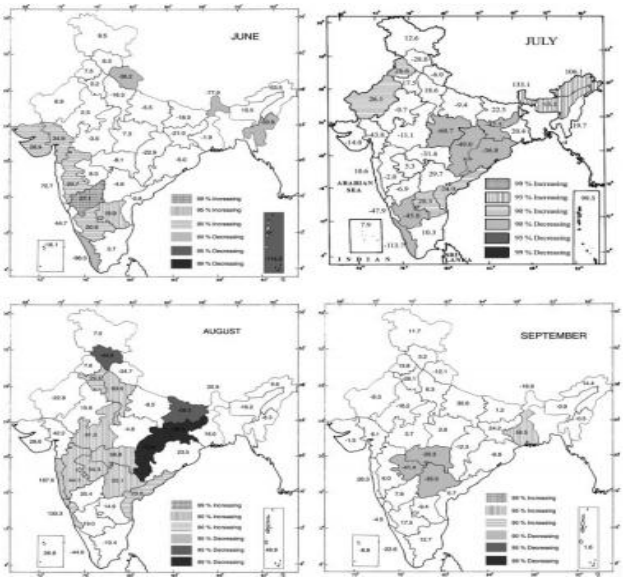

Fig 3. Increase/Decrease in rainfall in millimetre in 100 year for each of 36 subdivisions for the monsoon months. Different levels of significance are shaded.

6. QUANTIFYING THE SIGNIFICANCE OF TREND

A basic proportion of the functional significance of trend in a period series is the part of unique fluctuation of the series represented by the fitted trend line, which can be figured by

$$R^2 = 1 - \frac{Var(e_t)}{Var(x_t)}$$

Where V *ar* (x_t) is the fluctuation of the first run through series, and V *ar* (e_t) is the difference of the residuals from the trend line. The above condition estimates the significance of the trend segment in a period series to add up to fluctuation and can run from 0 for no significance to 1 if the series is absolutely trend.As expressed before we have discovered that there is a significant (95% or progressively) diminishing trend in monsoon rainfall for the subdivisions Chattisgarh, Jharkhand and Ker-ala and an expanding trend for the subdivision Konkan and Goa.The R2 esteem for every one of these four subdivisions are determined and are observed to be 0.09, 0.05, 0.05 and 0.04 separately. As it were, the trend segment clarifies around 9, 5, 5 and 4% of the all-out fluctuation of south-west monsoon rainfall of Chattisgarh, Jharkhand, Kerala and Konkan and Goa individually.

7. TRENDS IN SUBDIVISIONAL RAINFALL DURING DIFFERENT SEASONS

In spite of the fact that south-west monsoon is the real downpour delivering season over the nation, different seasons have likewise significant commitment in some particular territories. Rainfall throughout the winter (January–February) and pre-monsoon (March–May) seasons are generally overwhelming by western aggravations and convective exercises over north and northwest India. Upper east monsoon is overwhelming over southern states during the October–December period. It might be referenced that western aggravation is the term utilized in tropical nations like India, Pakistan, Nepal to depict an extratropical climate framework that carries abrupt downpour and snow toward the northwestern pieces of the Indian subcontinent during winter and pre-monsoon months. This is a non-monsoonal precipitation example driven by the Westerlies. The dampness in these tempests for the most part starts over the Mediterranean Sea and the Atlantic Ocean.

Extratropical tempests are a worldwide, as opposed to a restricted, wonders with dampness more often than not conveyed in the upper atmosphere (not at all like hurricanes where it is conveyed in the lower atmosphere). On account of the subcontinent, dampness is here and there shed

as downpour when the tempest framework experiences the Himalaya

Along these lines, trends investigation was additionally done on subdivisional rainfall series for the winter season (January–February), pre-monsoon season (March–May), post-monsoon season (October–December) and furthermore for the annual rainfall.Various dimensions of statistical significance are shaded.

8. CONCLUSION

There was a requirement for advancement of a progressively homogeneous (spatially and transiently) rainfall time series for the Indian area utilizing the latest information. The recently built rainfall series is consistently appropriated all through the nation and it speaks to practically all the current administrative districts.

The present investigation draws out a portion of the fascinating and furthermore significant changes in the rainfall example of the nation. The rotating grouping of multi-decadal periods of 30 years having successive dry spells and flood years are seen in the all India monsoon rainfall data.

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