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# Effect of Vegetation Cover on Pre-Monsoonal Rainfall Trend over Ranchi Region, Jharkhand, India

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***Abstract: In the present study, trend of changing rainfall pattern and its correlation with vegetation cover during pre-monsoonal season were determined for Ranchi district of Jharkhand for the last 20 years. In the year 1998 the western side of the district received a good amount of rainfall but the scenario after that was observed quite alarming. In the next 20 years the western region received very low rainfall except in the year of 2005 and 2014. While year 2005 received a good rainfall in south-western region of the district. Eastern region having a good amount of green cover received plenty of rainfall consistently in last two decade. The central part is the most urbanized zone of the study area having least green cover. This zone has never received good rainfall in last two decade. On the contrary despite of having good vegetation over the north-western side; the region never received good rainfall. The Non-Parametric trend analysis for last 20 years shows an overall increase in rainfall with 0.141625 mmyear$^{-1}$. While the analysis for last 117 years showed a significant positive trend in pre-monsoonal month of February, March, and April while a negative trend was observed in May. The maximum decrease in rainfall was found in the month of February (-0.1804803 mmyear$^{-1}$) and minimum (-0.0007663818 mmyear$^{-1}$) during the month of April. The trend of rainfall during month of May was found increasing (0.1296284 mmyear$^{-1}$ ).While the overall trend of rainfall during pre-monsoonal season (March-May) was found increasing (0.02156622 mmyear$^{-1}$). Rainfall variability pattern showed the maximum value of CV as 105.7%, whereas pre-monsoonal rainfall showed the minimum value of CV as 60.52%. High variation of CV indicated that the study are is vulnerable to droughts and floods. Disturbance in uniformity of distribution in rainfall pattern and extreme event cases over the district during the pre-monsoonal season in last two decade was observed.***

***Keywords: Trend analysis, Temporal series, Non-parametric, CV, Pre-monsoon.***

## I. INTRODUCTION

The spatial and temporal pattern of climatic variability of a region is governed by the rainfall over a region which also helps in managing the water resource in the agricultural production system [1,2,3].

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The extreme change in the trend of rainfall variability causes flood and drought [4]. Any considerable changes in the rainfall intensity or rainfall inflict serious challenge to rural economy due to the livelihood dependency on agriculture which largely depend on southwest monsoon [5]. Therefore, rainfall trend analysis at different spatial and temporal time scales becomes a matter of concern to all scientific community because it is directly connected to global climate change. As per report of IPCC (2007), the global surface warming is happening at the rate of 0.74 ± 0.18°C during 1906–2005 and any future variability in the climate will affect the prospect of agriculture, availability of freshwater, livelihood security and melting of the glacier [6]. Effect of land use change on regional climate especially rainfall is best elaborated which contended that the differences are due to scale [7]. He further elaborated that hydrologists normally choose small areas and use limited observed data for study, whereas, the effect of change in vegetation on atmospheric processes may be observed for larger area in the range of several hundred square kilometers. In the tropical areas, crop yields and water resources availability over a large area are hardly affected by a small change in rainfall amount.

In one of his study, [8] opined that amount of evapotranspiration is reduced if forest plantations are replaced by pasture or crops field. This leads to lowering of atmospheric humidity and thus reducing the overall precipitation amount. [9] observed that 60 % of the tropical land surface produced two times of the rainfall amount when air passed over the dense vegetation as compared to the region where air passed over sparse vegetation. The empirical correlation was found to be consistent with evapotranspiration maintaining atmospheric moisture in air passed over dense vegetation. Blanford (1888) assigned the reason of higher rainfall of Assam to the wide forest cover of the Assam and not the physiographic factors [10]. When the ban on shifting cultivation was come into force in Central part of India in 1875 and later this led to an increase in rainfall at 14 stations. No such increase was observed in the regions where shifting cultivation continued. More number of rainy days at Udhagamandalam (Ootacamund) was confirmed during 1886-1890 in wooded areas [11]. During 1870-1874, less number of rainy days were noted in sparse tree population area. It was feared about deforestation and release of carbon dioxide from combustion of fossil fuels might affect the regional environmental parameters [7]. It was demonstrated that 3% increased rainfall due to forest by 3%. One percent due to the plantations of 30 m height which may interfere with atmospheric air movement and 2% due to the effect of the canopy friction.

The ocean is the main source of evaporation and about 75 tons of water vapor are transported across the West Coast of India during monsoon season [13]. The second largest source of evaporation occurs from water on land surfaces and transpiration from vegetation. It was submitted that the disappearance of tropical forests would modify the local climatic conditions and any increase in carbon dioxide level of the atmosphere may affect the global climate [14]. It was observed that deforestation and land management in Amazonia by using fires will increase the impact of droughts associated with variability in natural climate [15]. Significant correlation between forest cover and seasonal rainfall at local level was observed [16]. High precipitation with higher reference evapotranspiration was observed in next few decades [17]. Two peaks of the increase were noticed in reference evapotranspiration for the month of April, May and October. It was observed a significant decrease in precipitation during annual, winter and monsoon months while increase in overall pre-monsoonal and post-monsoonal precipitation over the Ranchi district [18].
Ranchi was famous for its core tropical weather, city used to experience a frequent rainfall almost after every sunny day (convectional rainfall), but scenario has been changing continuously. Presently it is experiencing the rainfall in patches of weeks with huge unevenness and irregularities. There are number of factors responsible for it. The present study aim to assess monthly pre-monsoonal variation in rainfall trend as well as its yearly changing pattern with change in vegetation cover over Ranchi district of Jharkhand state (India) during 1998–2018 using non-parametric methods and remote sensing technique.

## II. MATERIALS AND METHODS

### Study area description

Ranchi is situated on the Chotanagpur plateau of eastern India having area of 5097Km$^2$. It lies between 22°52′–23°45′ North latitude and 84°45′–85°50′ East longitude. It is situated at mean sea level height ranging from 500 to 700m. The district is well known for its natural beauty. The district is bisected by the tropic of cancer; and characterized by subtropical climate. The area receives a good amount of annual rainfall. The annual average rainfall is around 1394 mm; 90% of the total annual rainfall occurs because of southwest monsoon during June to October. District also experiences unique convectional rainfall (equatorial feature) during summer season. The location map as well as the study area is shown in Fig.1.

### A. Input data preparation

The monthly rainfall data for the period 1998–2018 of Ranchi district were obtained from the website of India Water Portal, India metrological Division (IMD), Pune to evaluate pre-monsoonal rainfall trend in data series.

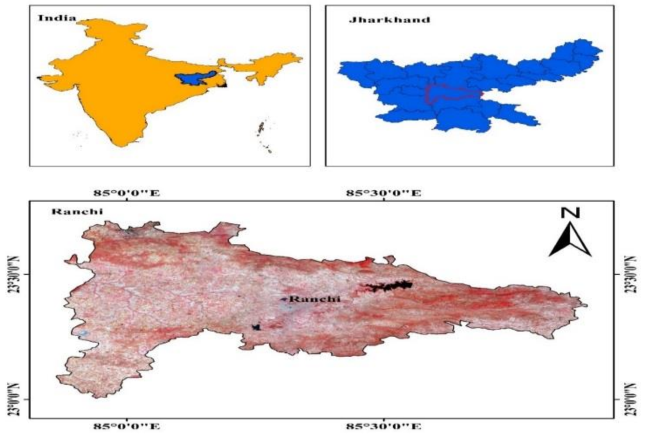



**Fig.1. Location map of the study area.**

Landsat-5TM, Landsat-7ETM and Landsat-8OLI dataset with spatial resolution of 30m was used to prepare the normalized difference vegetation index (NDVI) map for the year 1998, 2003, 2008, 2013 and 2018. Landsat-8OLI dataset with spatial resolution of 30m was used to prepare the LULC map for the year 2018. Tropical Rainfall Measuring Mission (TRMM) dataset with resolution of 0.25$^0$ was used to prepare pre-monsoonal rainfall map for year 1998 to 2018. A total of 21 rainfall map was prepared.

### B. Preparation of NDVI and LULC map

The forest cover of the Ranchi district was mapped using Arc-GIS. The Normalized Differential Vegetation Index (NDVI) is standardized vegetation cover index for extracting the vegetation cover areas. The NDVI extracts the vegetation cover by measuring the difference between Near-infrared (NIR) and Red band. NIR band is basically reflects the vegetation and Red Band is absorbs the vegetation cover areas. The value of NDVI is ranging from -1 to +1, the positive value indicates the vegetation cover areas and negative values indicates the other features such as water bodies, built up areas, waste land etc. The NDVI is uses the NIR and Red Band images in equation for extraction the vegetation and is given by

$$\text{NDVI}=\frac{\text{NIR}-\text{R}}{\text{NIR}+\text{R}} \qquad (1)$$

NIR is the reflectance in the near infrared band (760-900 nm), which is strongly reflected by leaf cellular structures; while, R is the reflectance in the red band (630-690 nm) which is characterized by chlorophyll content absorption at the canopy. In present research, Landsat 8 satellite imagery of the year 2018 was used for extracting the vegetation cover areas.
The Landsat 8 satellite image was downloaded from USGS earth explorer website (https://earthexplorer.usgs.gov/). The satellite image was processed and atmospheric corrections were carried out with QGIS. All the bands of satellite imagery were layer stack into a single image. Different maps were prepared by using ArcGIS. The NDVI Map at an interval of 5 years (1998, 2003, 2008, 2013, 2018) was prepared using Landsat-5TM, Landsat-7ETM and Landsat-8OLI dataset, to analyze the pattern of change in the vegetation cover over the Ranchi district.

NDVI map for the respective years is shown in Fig.2. The FCC map for the considered year of NDVI preparation is shown in Fig.3. Land Use Land Cover map of Ranchi district was prepare for the year 2018 using Landsat-8OLI dataset. Land use denotes man's activities and the various uses which are carried on land. Land cover refers to natural vegetation, water bodies, rocks/soils, artificial cover and other resulting due to land transformations. The final LULC map generated for the study area is depicted in Fig.4. The Area statistics of the prepared LULC map is shown in Table.1.

**Table 1. Area Statistics of LULC**

| S. No. | Pixel Count | Resolution in Meter | CLASS | Area In Sq Km |
|---|---|---|---|---|
| **1** | 838751 | 30*30 | Dense Vegetation | 755 |
| **2** | 2104330 | 30*30 | Agricultural Land | 1894 |
| **3** | 241368 | 30*30 | Built-up Land | 217 |
| **4** | 432774 | 30*30 | Sparse Vegetation | 389 |
| **5** | 608519 | 30*30 | Barren Land | 548 |
| **6** | 72031 | 30*30 | Water Body | 65 |

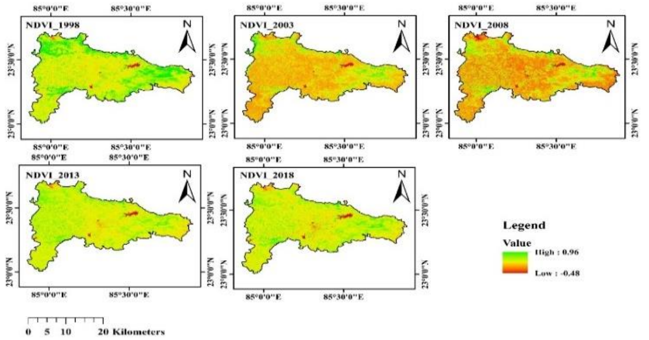



**Fig.2. NDVI Map of Ranchi district, Jharkhand**

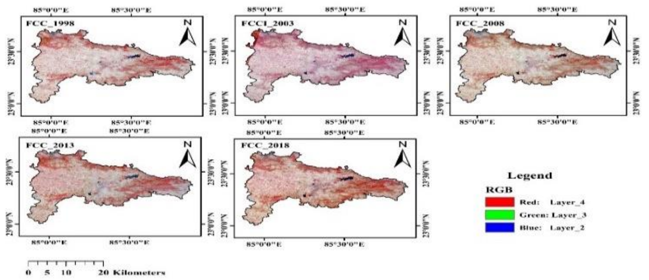



**Fig.3. FCC Map of Ranchi district, Jharkhand**

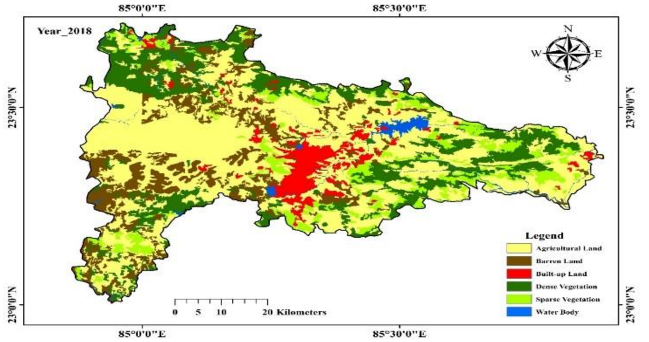


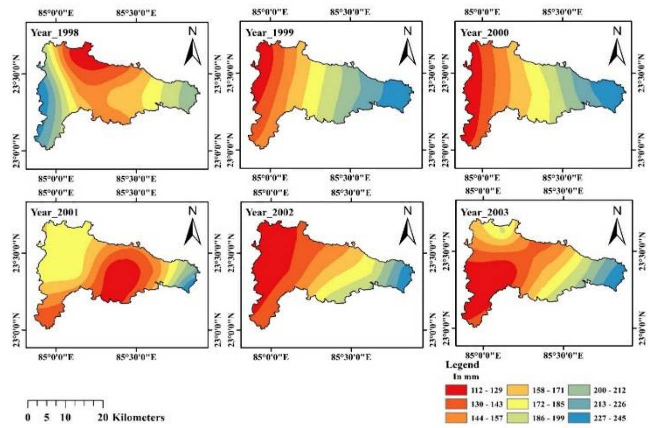

**Fig.4. LULC Map of Ranchi district**

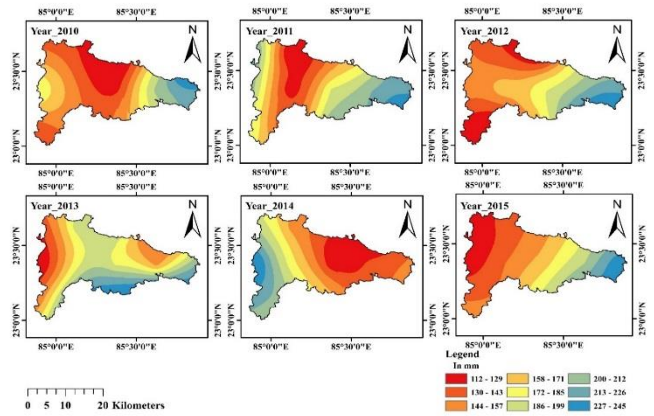
## C. Rainfall map preparation

The Tropical Rainfall measuring Mission (TRMM) was started in the year 1997. It is a joint programme of JAXA, (Japanese Space agency) and NASA (American Space Agency). The Pre-monsoonal Rainfall Map for the study area was prepared using TRMM dataset. The map was prepared to analyze the annual variation of pre-monsoonal rainfall over the Ranchi district for last 2 decades. Total 21 maps was prepared. The rainfall Maps for pre-monsoonal season of respective year is shown in Fig.5. Further, Sen's estimator (Sen 1968) was applied to estimate the magnitude of the trend in the time series while Mann–Kendall (MK) test (Mann 1945; Ken-dall 1975) was applied to determine the statistical significance of the trend in the rainfall data series.

## III. RESULTS AND DISCUSSION

The rainfall maps obtained for the years 1998-2018 clearly depicts that in the year 1998, the western side of the district received a good amount of rainfall but the scenario after that was observed quite alarming. In the next 20 years, the region received very low rainfall except in the year of 2005 and 2014. The rainfall pattern observed in the eastern region is quite consistent throughout the two decade. Eastern region received plenty of rainfall consistently in last two decade. This supports the fact of positive correlation between presence of dense forest cover and good amount of rainfall. NDVI maps in Fig.2 shows ample amount of green cover in

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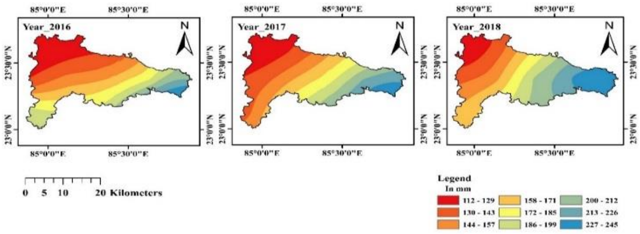


**Fig.5. Rainfall Map (1998-2018) of Ranchi District.**

the eastern side. The central part has never received good rainfall in last two decade, LULC map (Fig.5.) of district shows that this is mostly the built up/ Urbanized zone of the district with least green cover as shown in Fig.2. On the contrary, despite of having good vegetation over the north-western side the region never received good rainfall. The calculated value of statistics such as mean, standard deviation (σ) and coefficient of variation (CV), % of rainfall data series for each month under consideration are shown in Table.2.

**Table 2. Mean, Standard Deviation (σ) and Coefficient of variation (CV) for different months and season under consideration for the period 1901-2017**

| Month/Season | Mean | Standard Deviation (σ) | Coefficient of Variation (CV) |
|---|---|---|---|
| March | 23.50 | 24.86 | 105.7 |
| April | 21.34 | 21.04 | 98.62 |
| May | 39.99 | 35.04 | 87.62 |
| Pre-monsoonal (March-May) | 28.27 | 17.11 | 60.52 |

The estimation of Mann–Kendall test (Z-statistics) and Sen’s slope for the trend of last 117 years is presented in Table 3. Result of Mann–Kendall test (Z-statistics) and Sen’s slope estimator for rainfall series for the month of March, April and May during 1998–2018 are presented in Table 4. The positive and negative values of Z-statistics indicated increasing and decreasing trends, respectively.

**Table 3 Result of Rainfall trend analysis for pre-monsoonal season and months (at 5% significance level) over Ranchi district (1998–2018)**

| parameters | March | April | May | Pre-Monsoonal (March-May) |
|---|---|---|---|---|
| Z statistics value | 0 | 0.57374 | 0.51335 | 0.21138 |
| Sen’s slope Confidence level -95%) | 0 | 0.33188 | 0.485873 | 0.141625 |

Last 20 year’s trend showed an overall increase in the rainfall during pre-monsoonal season with Z-statistics value 0.21138 and Sen’s slopes estimated value of 0.141625 mm/year. While the results obtained for the analysis of last 117 years was different. The months of February march and April showed significant negative trend while May indicated insignificant positive trends. the values of Z-statistics were -3.0154, -0.80579, -0.028268 and 1.8633, for the month of February, March, April and May respectively, while the value of Z-statistics for overall pre-monsoonal season was found 0.67608. The month of February showed the highest negative value for the Z-statistics whereas April showed the least negative value of Z-statistics.

**Table 4. Result of Rainfall trend analysis for pre-monsoonal season and months including January and February (at 5% significance level) over Ranchi district (1901–2017)**

| parameters | January | February | March | April | May | PRE-MONSOONAL (MARCH-MAY) |
|---|---|---|---|---|---|---|
| Z | 1.204 | -3.0154 | -0.8057 | -0.0282 | 1.8633 | 0.67608 |
| Sen’s slope Confidence level - 95%) | 0.03589 | -0.18048 | -0.02546 | -0.00076 | 0.12962 | 0.02156 |

The Sen’s slope estimated value for the rainfall trend series was found negative for the month of February (-0.1804803 mm/year), March (-0.02546635 mm/year) and April (-0.0007663818 mm/year) while the positive value was observed for the month of May (0.1296284 mm/year). This is in agreement with the finding of [19], who determined positive Z-statistics value for pre-monsoon rainfall time series over the region of Ranchi district for the period of 1901–2014. This conformed to the findings of [20] who observed an increasing trend over the entire state of Jharkhand during pre-monsoon and post-monsoon precipitation while winter, monsoon and annual rainfall series demonstrated the decreasing rainfall trends during the time period of 102 years.

### A. Rainfall variability patterns

The result of rainfall variability pattern was determined by using CV for the study period for Ranchi district which shows high inter seasonal (pre-monsoonal) variation. Rainfall in the month of March showed the maximum value of CV (105.7%), whereas overall pre-monsoonal (March – may) rainfall exhibited the minimum value of CV (60.52%). Value of CV for rainfall during the month of February, March, April and May were 93.24%, 105.7%, 98.62% and 87.62%, respectively, and presented in Table 2. The CV (105.7%) is higher than that of rainfall in April (98.62%), rainfall in February (93.24%) and rainfall in May (87.62%) which shows the more inter seasonal (pre-monsoonal) variability of rainfall in month of March than rainfall in other months of pre-monsoon. The degree of rainfall variability was found to be higher during the month of February, March, April and May, whereas overall pre monsoonal (March-May) rainfall indicated the low degree of rainfall variability. Overall, the entire Months during pre-monsoonal season reflect high rainfall variation.

## IV.CONCLUSION

The results showed that last 20 years received an increasing amount of rainfall in the district during the pre-monsoonal season. But the pattern of rainfall has changed. The Western and the Central part of the district having the least dense forest cover is receiving less rainfall, on the other hand Eastern side of the district receives a good amount of rainfall throughout the last two decade. This supports the fact of good precipitation in the more vegetated zone; as this part of district has a considerable dense forest cover. Therefore it may be concluded that although rainfall during the season has increased but its uniformity of distribution is disturbed. The 117 years of rainfall trend through the Sen's slope test has shown some very interesting results in the pre-monsoonal season. February, March and April has shown a negative trend in their values, out of which the highest negative trend slope line was observed to be -0.1804803 mm/year in the month of February and the only positive trend line was observed in May with 0.1296284 mm/year. A significant variation in rainfall trend was observed during the time period of the 117 years. The analysis of rainfall variability indicated high inter-seasonal (pre-monsoonal) variation. Rainfall in the Month of March shows the maximum variation in rainfall (105.7%), whereas overall pre-monsoonal (March-May) rainfall demonstrated minimum rainfall variation (60.52%). In general, high inter Seasonal variation in rainfall strengthened the view that the entire region is vulnerable to droughts and floods [21, 22]. This shows although overall increase in seasonal rainfall is there, but the cases of extreme events has also increased.

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