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# Rainfall variation and trend analysis of Garhwa district, Jharkhand: An assessment of spatial and seasonal variability

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## Abstract
Rainfall pattern of the world is changing with frequent occurrence of heavy rainfall events and drought due to global warming. Agriculture is highly dependent on rainfall, and change in rainfall pattern will affect agricultural production. Therefore characterization of rainfall pattern and trend within a geographical area is becoming necessary for better crop planning. Present study on characterization of seasonal and spatial variation of rainfall and its trend at block level of Garhwa district, Jharkhand have been carried out with a view to plan the crops under changing rainfall scenario. Rainfall in almost all blocks differed in its annual and seasonal distribution as well as its amount over the years. District received about 873.3 mm of mean annual rainfall with 89.5% in monsoon and rest (10.5%) in post-monsoon seasons. Rainfall during Kharif season in Garhwa district was more consistent and reliable than that of Rabi season as indicated by small coefficient of variation during Kharif season (19.1 to 43.3 %) as compared to Rabi season (82.1 to 120.1%). Most of the blocks showed decreasing trend in annual rainfall with sharp decline in Bhandaria (-42.25 mm/yr) while, Bhawnathpur showed increasing trend i.e. (+20.18 mm/year). Occurrence of late drought was more frequent than early season drought in most of the blocks.

**Keywords:** Garhwa, rainfall pattern, climate change

## Introduction
The global warming and associated climate change is one of the major concerns worldwide. The globally averaged surface temperature (land + ocean) has increased by 0.85 (0.65 to 1.06 °C) from year 1880 to 2012 (IPCC, 2014) [1]. Warming of earth surface is resulting in to change in precipitation pattern and frequency of occurrence of extreme events in almost all the continents. The number of heavy precipitation events has increased in most of the regions of the world while in some regions it has also decreased. According to Indian Meteorological Department, in India also, significant rise in annual mean temperature has been observed in most of the states, while annual mean precipitation has increased as well as decreased between 1951 to 2010 (Rathor *et al*., 2013) [6]. This change in precipitation pattern is altering hydrological systems, affecting water resources and agricultural production. Almost all the ecosystems of the world are being negatively affected by changing climate.
Agriculture is one of the most sensitive and vulnerable ecosystem to the climate change due to its dependency on atmospheric temperature and rainfall pattern. Study from wide range of the regions and crops are reporting negative impacts of climate change on crop yields (IPCC, 2014) [1]. Therefore, to minimise the risk toward sustainable production under changing climate, characterization of rainfall pattern of an area become necessary in framing out the strategies for suitable crop planning especially in rain fed agriculture.
The northwestern region of Jharkhand especially Palamu, Garhwa and Latehar districts, has been suffering from an extended dry spell. Frequent occurrence of drought with uneven spatial and temporal distribution of rainfall in the region has been affecting agriculture production and sustainable development of society and economy of the district. The rainfall pattern of Palamu district has been studied and reported (Kumari *et al*., 2014) [2], however, rainfall pattern of Garhwa district has not been studied well. Thus, detailed monitoring and assessment of rainfall pattern over Garhwa district requires to be evaluated for understanding the changes in climate and better crop planning in this zone. Therefore, with this background, present study to characterised the rainfall variability of Garhwa district over the years at block level were done.

## Material and methods
The study was undertaken during 2014-15 in 8 blocks of Garhwa district, Jharkhand. The district is located in the north-western part ($3^0 60'$ to $24^0 39'$ N and $83^0 22'$ to $84^0 00'$ E) at altitude from 160 to 295 m above mean sea level. The district has 422540.76 ha total

geographical area with 25.96% net shown, out of which 8.23% is irrigated. It is located in the Western Plateau sub-zone (zone V) of Jharkhand state, is a unique district to have a typical monsoon climate which often becomes a rain-shadow area. The region is classified as sub- humid to sub-tropical with an average rainfall of 1237.3 mm. Minimum and maximum temperature fall upto $3.9^{0}$C and $45^{0}$C during the winter and summer seasons respectively. Daily rainfall data for a period of 13-18 years were collected from the office of District Statistical and District Agricultural office of Garhwa. The detail analysis of rainfall for agricultural drought was done using a Weather cock v 1.0 software developed by VUM Rao, AVMS Rao, GGSN Rao, T. Satyanarayana, N. Manikandan, B. Venkateswarlu of All India Coordinated Research Project on Agrometeorology, Central Research Institute for Dryland Agriculture Hyderabad, India. The criteria used under the software for individual parameters are as under.

**Agricultural drought**: As laid down by National Commission on Agriculture, 1976

**Kharif** - At least four consecutive weeks receiving rainfall less than half of the normal (>5mm)

**Rabi -** Six such consecutive weeks

**Input to the software:** Weekly rainfall data

## Results and discussion

### Rainfall distribution and seasonal variability

Result showed that, all blocks differed in annual and seasonal rainfall distribution as well change in rainfall over the year. Garhwa district received about 873.3 mm of mean annual rainfall with highest in Ranka (1122.0 mm) block followed by Bhandaria (1038.2 mm) and Meral (939.4 mm) while lowest in Majhiyaon (610.2 mm) followed by Bhawnathpur (779 mm) and Dhurki (786.9 mm) block (Table 1). Out of the total annual rainfall received, 89.5% was received in monsoon months and rest (10.5%) in post-monsoon seasons (Table 1). The analysis of seasonal variability showed that coefficient of variation of rainfall received during in Rabi season was high (82.1 to 120.1 %) as compared to Kharif season (19.1 to 43.3 %) (Table 2). It indicated that rainfall during Kharif season in Garhwa is more consistent and reliable than that of Rabi season (Table 2). Distribution in rainfall with time and space has been observed in many parts of India (Singh *et al*. 2003; Karthikeyan *et al.* 2008 and Kumari *et al.*, 2014) [2, 7]. Similar variability has been also reported by Kumari *et al* (2014) [2] for adjoining district of Garhwa i.e. Palamu district of Jharkahnd. The mean annual rainfall of Garhwa district is low (873.3 mm) as compared to Palamu district (1138 mm), however, both districts has similar seasonal variability (Kumari *et al.*, 2014) [2]

**Table 1:** Annual and seasonal rainfall distribution in blocks of Garhwa district

| Blocks | Annual rain (mm) | Monsoon rain (mm) | Post monsoon rain (mm) | Winter rain (mm) | Summer rain (mm) |
|---|---|---|---|---|---|
| Bhandaria | 1038.2 | 886.4 (86.1)* | 58.6 (6.0) | 53.0 (4.6) | 40.2 (3.3) |
| Bhawnathpur | 779 | 712.9 (91.5) | 26.1 (3.4) | 24.9 (3.3) | 15.1 (1.8) |
| Dhurki | 786.9 | 703.6 (89.4) | 33.0 (4.7) | 16.1 (1.8) | 34.2 (4.1) |
| Garhwa | 839.1 | 755.8 (90.0) | 42.1 (4.9) | 24.4 (3.1) | 16.9 (2.0) |
| Majhiyaon | 610.2 | 559.0 (91.2) | 28.0 (4.6) | 12.0 (2.3) | 11.2 (1.9) |
| Meral | 939.4 | 867.6 (92.1) | 37.5 (4.3) | 20.0 (2.3) | 14.3 (1.3) |
| Nagar-Untari | 871.2 | 765.2 (87.8) | 46.7 (5.6) | 34.1 (3.7) | 25.2 (2.9) |
| Ranka | 1122 | 1002 (88.8) | 60.3 (5.6) | 28.8 (2.6) | 30.9 (2.9) |
| Mean | 873.25 | 781.5625 (89.5) | 41.5375 (4.76) | 26.6625 (3.05) | 23.5 (2.69) |

**Table 2:** Variability in seasonal rainfall in blocks of Garhwa

| Blocks | Season | Av. Rain(mm) | % of total rain | SD | CV % |
|---|---|---|---|---|---|
| Bhandaria | Kharif | 942.7 | 91.7 | 244.9 | 26.0 |
| | Rabi | 79.7 | 7.0 | 65.5 | 82.1 |
| Bhawnathpur | Kharif | 738.0 | 94.7 | 225.0 | 30.5 |
| | Rabi | 36.7 | 4.8 | 40.6 | 110.6 |
| Dhuraki | Kharif | 734.9 | 93.9 | 226.1 | 30.8 |
| | Rabi | 32.2 | 3.6 | 38.7 | 120.1 |
| Garhwa | Kharif | 795.0 | 94.5 | 277.2 | 34.9 |
| | Rabi | 39.5 | 4.8 | 42.0 | 106.5 |
| Majhiyaon | Kharif | 586.0 | 95.7 | 240.0 | 41.0 |
| | Rabi | 19.6 | 3.6 | 24.3 | 124.0 |
| Meral | Kharif | 904.5 | 96.3 | 391.7 | 43.3 |
| | Rabi | 28.1 | 3.2 | 30.2 | 107.8 |
| Nagar–Untari | Kharif | 810.0 | 93.2 | 154.8 | 19.1 |
| | Rabi | 46.8 | 5.1 | 46.7 | 99.9 |
| Ranka | Kharif | 1058.7 | 94.1 | 331.3 | 31.3 |
| | Rabi | 52.8 | 4.8 | 50.7 | 96.1 |

### Annual and seasonal rainfall trend

Trend analysis for total as well as monsoonal rain (Table 3) indicated variable trend both in annual and seasonal rainfall among the blocks. Most of the blocks showed decreasing trend in annual rainfall with sharp decline in Bhandaria (-42.25 mm/yr) and Garhwa (-10.96 mm/yr) while slightly decreasing in Dhurki (-4.621 mm/yr), Nagar-untari (-4.483 mm/yr), Majhiyaon (-2.737 mm/yr), Meral (-1.161 mm/yr) and Ranka (-0.209 mm/yr). Contrary to this, Bhawnathpur showed increasing trend i.e. (+20.18 mm/year). Monsoonal rain almost followed the trend of annual rainfall except in Ranka block where it exhibited slightly increasing trend. Variable trend in total and seasonal rain with space and time has also been reported by Mukherjee and Banerjee (2009) [4] in west Bengal, Lungaria *et al.* (2012) [3] in Saurashtra region and Kumari *et al.* (2014) [2] in Palamu. According to Indian meteorological department, the mean annual rainfall of Jharkhand is on increasing trend (Rathor *et al.*, 2013) [6].

However, trend in Garhwa district is opposite. The trend analysis on rainfall of past 56 years of Palamu district also showed decreasing pattern of 8.33 mm and 7.04 mm per year in annual and kharif season rainfall, respectively (Kumari *et al.*, 2014) [2]. Thus, overall increase in rainfall trend in Jharkhand might be due to increase in total rainfall of other districts of Jharkhand.

**Table 3:** Rainfall trend in blocks of Garhwa

| Block | Annual rain equation | Monsoonal rain equation |
|---|---|---|
| Bhandaria | y = - 42.25x + 1439 | y = - 35.08x + 1219 |
| Bhawnathpur | y = 20.18x + 587.2 | y = 17.46x + 546.9 |
| Dhurki | y = - 4.621x + 830.7 | y = - 3.678x + 738.5 |
| Garhwa | y = - 10.96x + 943.3 | y = - 7.996x + 831.7 |
| Mahjiyaon | y = - 2.737x + 636.2 | y = - 0.018x + 559.1 |
| Meral | y = - 1.161x + 950.4 | y = - 1.728x + 884.0 |
| Nagar-untari | y = - 4.483x + 913.7 | y = - 2.182x + 785.9 |
| Ranka | y = - 0.209x + 1124 | y = 2.454x + 978.6 |

## Agricultural Drought

Two critical periods i.e. early season drought (22-28 SMW) and late season drought (36-42 SMW) were analysis for agricultural drought. Result showed that occurrence of late drought was more frequent than early season drought in most of the blocks (Fig. 1). Among the blocks Garhwa block faced both late (38% years) and early drought (31 % years). High late drought years was recorded in Garhwa block (38%) followed by Majhiyaon (31%), Meral (23% years) and Dhurki (23%). In rest of the blocks late season droughts fluctuated between 8 and 15 per cent years. Early season drought fluctuated within the blocks were in between 8 and 31 per cent years. In most of the blocks it fluctuated between 8 and 15 per cent within a period of 13 years. Similar agricultural drought in different SMW has also been reported by Tomar and Ranade (2002) and Rai and Singh (2008) [5].

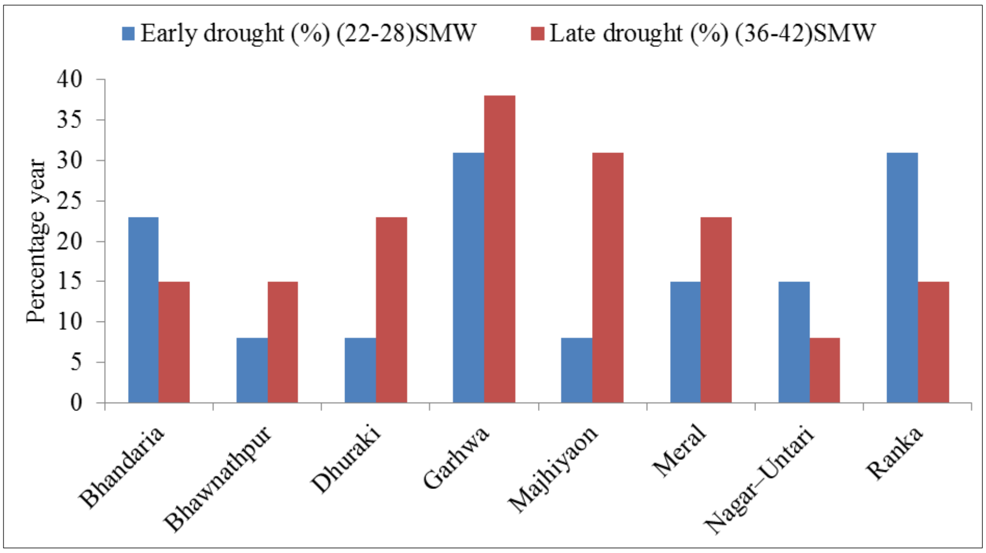


**Fig 1:** Early and late agricultural drought during kharif season in blocks of Garhwa

## Conclusion

The average annual rainfall of Garhwa district is relatively low and is highly variable among the blocks. The mean annual and monsoonal rainfall in almost all the blocks of the district is also decreasing (except Bhawnathpur). The total annual rainfall of Bhandaria and Garhwa district is decreasing with high rate so these blocks may need water conservation strategies in coming future for crop production. Further all blocks also varied in percentage distribution of early and late agricultural drought. Therefore, block wise crop planning is needed for better crop production in this zone.

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