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Estimating rainfall variability over five districts of northern hill zone of Chhattisgarh state

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Abstract
An attempt has been made to study the variability for long term (40 year) rainfall data of five district of northern hill zone of Chhattisgarh state *viz.* Balrampur, Jashpur, Korea, Surajpur and Surguja. Maximum rainfall and highest rainy days was found at Jashpur (1396.5 mm) followed by Surguja (1360.4 mm). The coefficient of variation of rainfall shows bellow 50 % in all the five districts. The coefficient of variation has been found highest 28.06 % in Surajpur district with least amount of rainfall while it was least (18.20 %) in Jashpur district and it was almost similar in Balrampur 26.89 % Korea 27.02 and Surguja 26.12% in general the annual CV varried from 18-29 %. In case of decadal rainfall variability Jashpur shows maximum rainfall during 1987-96 with lowest (14.83 %) of CV while it was highet 19.9 % during 1997-2006. CV was highest during the decades 2004-2013 (34.7%) and lowest 23.9 during 1994-2003 in Korea but in Surajpur district CV values for annual rainfall was around 30% for all decades except during 1983-1992 which had a of 11%. In Surguja the decade 2001-2010 was drier year over other decades. Whereas the CV was highest (32.8 %) while lowest CV (24.0%) was found during decade of 1991-2000.

Keywords: annual and decadal rainfall, rainfall variability, data analysis, weather cock

1. Introduction
The study of the distribution of rainfall in time and space is very important to know the spatial and temporal variations of rainfall. It helps to understand the hydrological balance on regional scale and water management in agriculture. Activities heavily depend on micro-level rainfall, variability analysis of rainfall in Indian context require urgent and systematic attention due to significant possible implications on fresh water availability, agriculture, etc. It is Important for water resources planning and management. Changes in rainfall trend, variability, amount and its spatial and seasonal distribution critically modify the river runoff pattern and regimes (Gosain *et al.* 2006) [3], soil moisture, (Jain and Kumar, 2012) [2], ground water reservoirs, frequency of rainfall extremes, including floods and droughts, cropping pattern and agricultural productivity vegetation activity Dore, 2005 [1] and Kumar *et al.* 2010. Interpreted that rainfall is the most important but variable climatic parameter in the semiarid tropics. Trend and variability analysis of rainfall in Indian context require urgent and systematic attention due to significant possible implications on fresh water availability, agriculture, food security and primary economic activities, etc. Jain and Kumar 2012 [2]. Stated, that Change in climate and change in rainfall pattern is the most concern issue now days in India. Scientists are studying and trying to mitigate this change occurring in environment by various techniques. Changes in climate over the Indian region, particularly the South West monsoon, have a significant impact on agricultural production, water resources management and overall economy of the country. Any variation in climatic variables affects the crop growth stages thereby degrading the yield stability and quality. Dore, 2005 [1] and Kumar *et al.* 2010 [4]. Interpreted that rainfall is the most important but variable climatic parameter in the semiarid tropics. Trend and variability analysis of rainfall in Indian context require urgent and systematic attention due to significant possible implications on fresh water availability, agriculture, food security and primary economic activities, etc.

2. Materials and Methods
Chhattisgarh state is divided into three distinct agro climatic zone i.e. Chhattisgarh plains, Bastar plateau and Northern hills zone. Northern hill zone lies between $23^0 37' 25''$to $24^0 6' 17''$ north latitude and $81^0 34' 40''$ to $84^0 4' 40''$ east longitude and there is a lot of topographical variation in the zone as compared to plain zone. The analysis was carried out with five districts of northern hill zone. The districts and their co-ordinates that come under northern hill zone was shown below.

Table 1: Geographical locations of selected districts of northern hill zone.

Station	Latitude	Longitude	Altitude
Balrampur	23^0 11′ N	$83^0$19E	528 meters
Jashpur	22° 53′ N	84^0 12′ E	1200 meters
Koria	23^0 38′ N	82^0 38 E	529 meters
Surajpur	22^0 94′ N	83^0 16′ E	528 meters
Surguja	23° 10' N	83^0 15' E	623 meters

Table 2: Rainfall data base

S. No.	Station	Database
1.	Balrampur	2003-2015
2.	Jashpur	1977-2015
3.	Koriya	1974-2015
4.	Surajpur	1973-2015
5.	Surguja	1991-2015

2.3 Mean rainfall

$$\text{Mean annual Rainfall} = \frac{\text{Total rainfall}}{\text{Number of Years}}$$

2.4 Standard Deviation (SD)

$$\text{Standard deviation} = SD\ (\sigma) = \sqrt{\frac{\sum(X-\bar{X})^2}{n-1}}$$

- X = Rainfall frequency
- $\overline{X}$ = Mean rainfall
- n = Number of years

2.4 Coefficient of variation

Assessment of rainfall variability through Coefficient of variation (CV %) appears to be simple. CV is defined as the Standard deviation divided by the mean value of rainfall. It shows the variability of rainfall in percentage.

$$CV\ \% = \frac{\text{Standard deviation}}{\text{Mean}} \text{ X } 100$$

2.5 Weather cock

Weather cock with version 15 is software developed by Rao *et al*. (2014) under All India Co-ordinate and Research Project CRIDA, Hyderabad. It contents various modules such as contains data management, data quality, daily data conversions, rainfall analysis, temperature analysis, length of growing period and water balance. Application under rainfall analysis have been found viz., agricultural drought, meteorological drought, high rainfall events, incomplete gamma probability, initial and conditional probabilities, probability of dry and wet weeks, rainy days etc.

3. Results and Discussion

3.1 Mean annual rainfall and rainy days with their corresponding CV

Variability of annual rainfall for five districts of northern hill zone was shown in table 3.1.1and figure 3.1.1 At Jashpur the average annual rainfall was higher (1396.5 mm) followed by Surguja 1360.4 mm. The mean annual rainfall of Korea, Surajpur and Balrampur were 1234.9, 1215 and 1146 mm respectively which the CV for the annual rainfall was examined, it was found that the CV was least at Jashpur (18.2 %) followed by Surguja 26.12%. While CV for Korea, Surajpur and Balrampur was 27.02, 28.06 % (Highest) and 26.89 % respectively. Overall decrease in rainfall and increase in its variability is seen in northern hill zone of Chhattisgarh. Highest variability is experiences in Surajpur and lowest in Jashpur. Overall a high variation in rainfall on the Northern region of Chhattisgarh was seen. District where CV was highest that means rainfall was not in stable condition. In northern hill zone Surajpur recorded highest value of CV i.e. 28.7 % means rainfall is not stable need strong planning to harvest good crop yield. The higher coefficient of variation values is responsible for the instability in the productivity of crop.

Table 3: Mean annual rainfall and rainy days at five districts of northern hill zone and their corresponding CV

Station	Mean annual rainfall	Coefficient of variation	Mean annual rainy days	Coefficient of variation
Balrampur	1146.0	26.9	68.0	15.2
Jashpur	1396.6	18.2	95.6	14.9
Korea	1235.0	27.0	52.6	21.6
Surajpur	1215.0	28.7	56.3	18.7
Surguja	1360.4	26.1	68.0	15.2

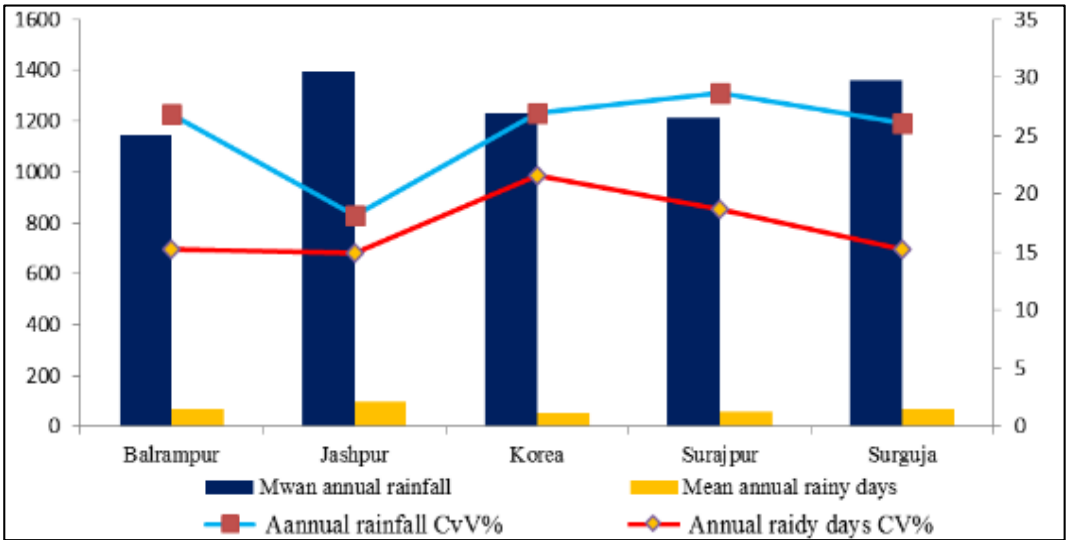

Fig 1: Mean annual rainfall, rainy days and their corresponding CV

3.2 Decadal rainfall variability at selected districts of northern hill zone

The outcome of decadal rainfall variability workout for four districts of northern hill zone except Balrampur because of low range of data availability was presented in (Table 3.2.1) and in figure (3.2.1) it was In case of district Jashpur the lowest value of CV 14.83 was recorded during 1987-1996 whereas the higher value of CV 19.9 was noted during 1997-2006. Whereas in district Korea the annual rainfall was highest during the decades 1994-2003 (1323.7 mm) with lowest value of cv, Whereas the high variation was found during decades 2004-2013 (34.7%) except these two in other decades CV value varied from 20 to 23 %. In Surajpur district Coefficient of Variation values of annual rainfall was around 30% for all decades except 1983-1992 which had a of 11% with minimum rainfall. In district Surguja two decades was considered for rainfall analysis. It was observed that the annual rainfall for the decade 1991-2000 and 2000-2010 were 1470 mm and 1275 mm respectively, the decade 2001-2010 was drier year over other decades. Where the CV was highest (32.8 %) during the decade 2001-2010, lowest CV (24.0%) was found during decade of 1991-2000. Regarding the monthly rainfall July and August months were the rainiest months with more than 350 mm rainfall. The CV value for July and August month was less. Month wise rainfall variability analysis indicates that the July and August were the rainiest months in all the districts. The rainfall in the month of June and September was least with the highest corresponding CV in these two months.

Table 4: Decadal values of rainfall and corresponding CV for the monsoon months and annual rainfall

Decade	Month	Rainfall (mm)	CV (%)	Decade	Month	Rainfall (mm)	CV (%)
Jashpur							
1977-1986	Jun	240.4	55.2	1987-1996	Jun	255.2	54.9
	Jul	481.6	22.6		Jul	447.2	20.0
	Aug	356.1	29.0		Aug	371.4	27.0
	Sep	232.0	44.0		Sep	232.8	35.7
	Annual	1465.0	18.7		Annual	1430.1	14.9
1997-2006	Jun	228.3	24.3	2007-2015	Jun	196.8	59.2
	Jul	402.4	30.2		Jul	364.8	18.3
	Aug	335.8	26.0		Aug	313.4	26.4
	Sep	252.6	49.8		Sep	228.6	43.3
	Annual	1429.0	19.9		Annual	1246.9	17.6
Korea							
1974-1983	Jun	147.1	88.3	1984-1993	Jun	194.4	73.0
	Jul	507.9	25.7		Jul	351.6	34.8
	Aug	368.8	41.2		Aug	294.4	40.7
	Sep	186.7	69.4		Sep	196.7	43.8
	Annual	1308.0	20.6		Annual	1117.0	20.0
1994-2003	Jun	194.0	58.7	2004-2013	Jun	156.6	64.0
	Jul	401.8	41.0		Jul	347.6	50.1
	Aug	359.6	27.6		Aug	341.6	65.0
	Sep	202.6	61.1		Sep	199.9	68.9
	Annual	1323.7	23.9		Annual	1149.0	34.7
Surajpur							
1973-1982	Jun	185.9	73.8	1983-1992	Jun	279.2	56.3
	Jul	390.0	45.8		Jul	389.6	38.0
	Aug	383.0	48.9		Aug	274.2	47.8
	Sep	224.1	92.6		Sep	127.2	50.1
	Annual	1284.0	33.2		Annual	1183.1	11.0
1993-2002	Jun	151.0	56.0	2003-2012	Jun	151.0	71.
	Jul	489.3	66.7		Jul	323.7	39.7
	Aug	288.8	60.2		Aug	295.0	51.0
	Sep	221.3	92.2		Sep	199.7	56.9
	Annual	1363.8	30.2		Annual	1050	29.9
Surguja							
1991-2000	Jun	243.4	78.0	2001-2010	Jun	180.4	90.0
	Jul	397.8	33.6		Jul	379.0	45.9
	Aug	412.0	31.1		Aug	314.4	35.2
	Sep	236.1	50.3		Sep	249.8	65.0
	Annual	1470.4	24.0		Annual	1275.0	32.8

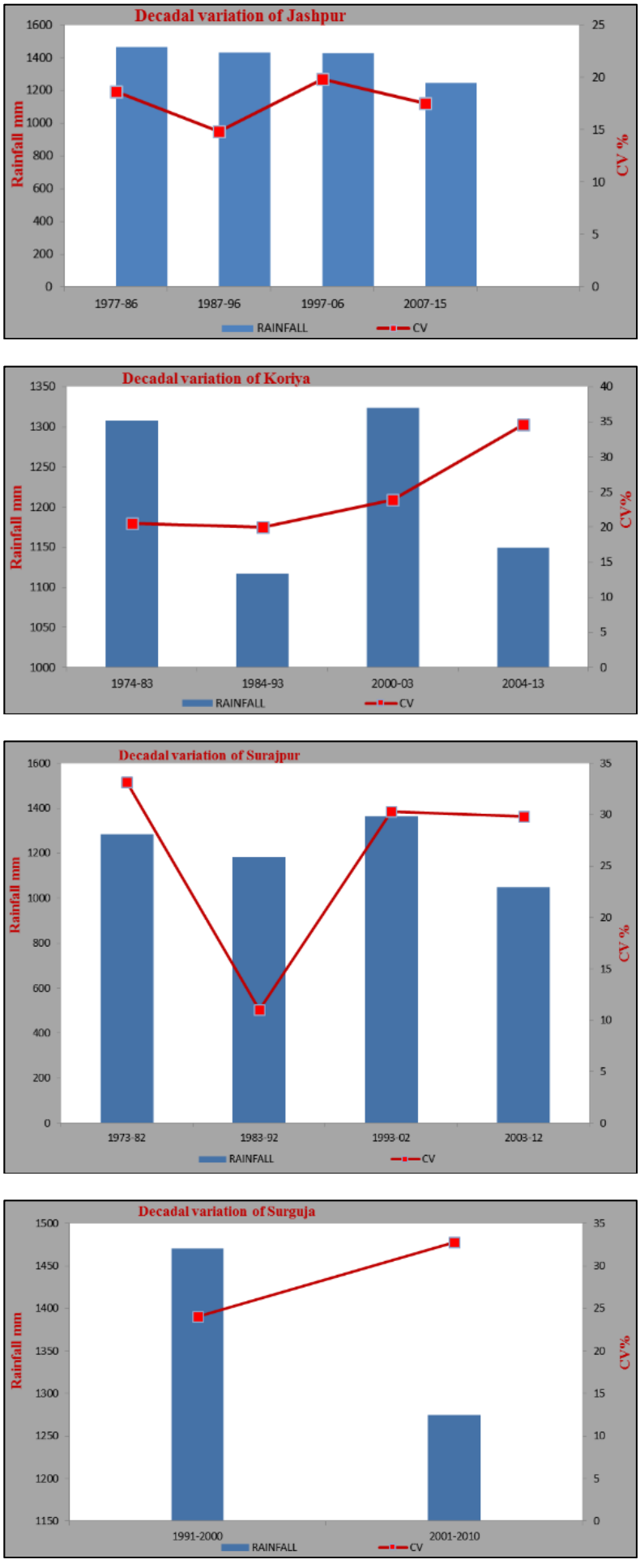

Fig 2: Decadal rainfall variation of four districts

4. Conclusion

On annual basis the highest value of coefficient of variation of rainfall was recorded in Surajpur district and it was least in Jashpur district whereas in case of seasonal variability, highest variation were recorded during winter season and least during monsoon season. When we studied monsoon moths (June–September) highest value of CV was recorded in the month of September while least variation was found in the month of August. In case of decadal variation in general decade 1980-1990 has been seen least coefficient of variation.

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