International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 995-1000

Received: 19-05-2020
Accepted: 21-06-2020

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Characterization of temporal variability and trends in seasonal and annual rainfall of Bargarh, Odisha

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DOI: https://doi.org/10.22271/chemi.2020.v8.i4g.9735

Abstract
In the recent years the important scientific challenge faced by researchers worldwide is to have a better understanding about climate change at a regional scale. However, for all the regions the changes are unequal and have localized intensity. Therefore it should be quantified at a local scale. Therefore in the current study, an attempt has been made to observe the temporal rainfall variability and trend over a period of 30years (1989-2018) at regional scale for the district Bargarh of Odisha. The detailed trend analysis of rainfall during the period 1989-2018 on seasonal and annual basis was carried out in the current study. The month of June, July, August, September is getting the leading part of the rainfall, the month July is getting highest and September is getting the lowest amount of rainfall. On an average July is getting 360mm and September is getting 202mm of rainfall respectively. The annual rainfall of the location is deviating with a Percentage change in annual and seasonal rainfall was also determined to show the change in trend. Ten year moving coefficient variation (CV) of seasonal rainfall showed a decreasing trend during kharif season and a constant trend during rabi season. The coefficient of variations is 96.9% and 22.2% in rabi and kharif season respectively.

Keywords: temporal rainfall variability, seasonal and annual rainfall trend, Bargarh

Introduction
Climate describes the average weather conditions for a particular location and over a long period of time. The climate, its variations and extremes, and its influences on a variety of activities including human health, safety and welfare to support evidence-based decision-making on how to best adapt to a changing climate (WMO). At present, 20-80% of the inter-annual variability of crop yields is associated with weather phenomena and 5-10% of national agricultural production losses are associated with climate variability (FAO, 2019) [18]. In addition, agriculture suffers 26% of the damage and loss during climate-related disasters in developing countries. In parallel with these trends, the global demand for food will increase by 50% and, in the absence of ambitious climate action, yields may decline by up to 30% by 2050 (GCA, 2019).Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external factors (external variability). Variations in the mean state and other statistics (such as standard deviations, the occurrence of extremes, etc.) of the climate on all temporal and spatial scales beyond that of individual weather events. The term is often used to denote deviations of climatic statistics over a given period of time (e.g. a month, season or year) from the long-term statistics relating to the corresponding calendar period. In this sense, climate variability is measured by those deviations, which are usually termed anomalies. Variability may be due to natural internal processes within the climate system (internal variability), or to variations in natural or anthropogenic external forcing (external variability) (IPCC and WMO).
These studies have looked at the trends on country scale (Titkey *et al*., 2018, Arora *et al*., 2005, Kumar *et al*., 2010;) regional scales (John *et al*. 2017., Bhutiyan *et al*., 2007; 2010; Duhan and Pandey, 2013; Duan *et al*., 2017) [19, 5, 7, 6], and at the individual stations (Sahu *et al*., 2012, 2014, 2016; Beyene, 2015) [17, 12, 4]. In fact, local and regional scale analysis (Fischer

and Ceppi, 2012; Baber and Ramesh, 2013) is more relevant to devise-specific development and adaptation plans to mitigate negative effects of climate change. The trend analysis of seasonal rainfall (Panda and sahu, 2019; Singh & Srivastava, 2016) [13] and other climatic variables on different spatial scales will help in construction of future climatic framework.

Hence the purpose of this study is to investigate the variability of rainfall over Bargarh district of Odisha, India. Characterization of temporal variability and trends in seasonal and annual rainfall is accomplished to apprehend the uncernity and variability associated with the rainfall pattern to get a better scenario at regional level for better management of agriculture and associated allied activities.

This study keeps on track about the qualitative assessment of temporal variability and trends in seasonal and annual rainfall of district Bargarh, Odisha.

Study Area

Odisha state is situated in east coast of India and agriculture plays a vital role in the state's economy which is greatly dependent on rainfall. Bargarh is a district on the Western border of Odisha. Prior to 1992, it was a subdivision of Sambalpur district. Bargarh District formed on the 1st April 1993 being devided from Sambalpur District. It is one of the illustrious district of Odisha. Bargarh District lies on the western most corner of Odisha between 20◦ 43' to 21◦ 41' north latitude and 82◦ 39' to 83◦ 58' east longitude. The District is surrounded by Chhatisgarh state on the north, Sambalpur District on the east, Balangir and Subarnapur on the south and Nuapada District on the west.

Bargarh lies 170m above sea level Bargarh's climate is classified as tropical. In winter, there is much less rainfall in Bargarh than in summer. This location is classified as Aw by Köppen and Geiger. The average temperature in Bargarh is 27.2 °C.

Data and Methodology The long term monthly rainfall data over a period of 30 years (1989-2018) of district Bargarh was obtained from srcodisha.nic.in. The rainfall trend analysis was conducted for on monthly, seasonal (kharif & rabi) and annual basis using the rainfall analyzer developed by ICRISAT and KMD, Kenya.

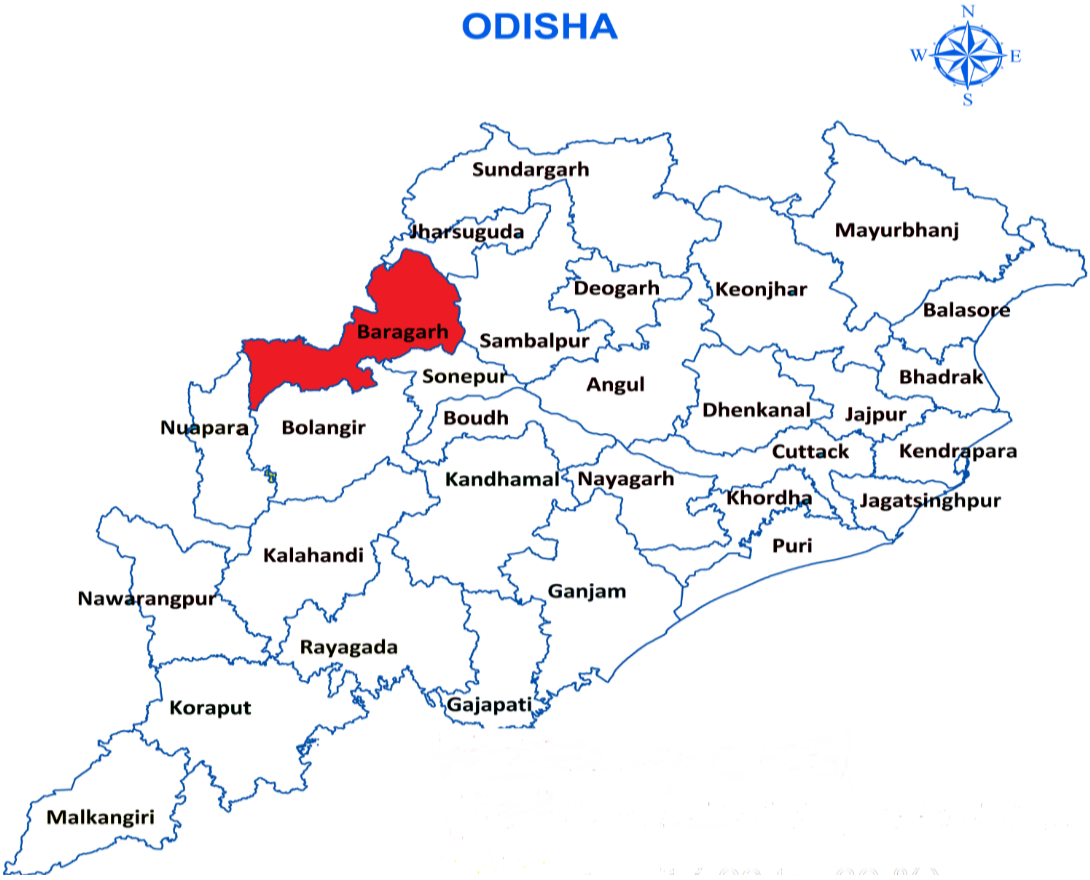


Fig 1

Result and Discussion

The number of rainy days and weekly rainfall amounts were analyzed to understand the distribution of rainfall during crop season. In this analysis, any day with ≥ 2mm or more rainfall was considered as rainy day. The district seems to be getting 87 no. s of rainy days on an average.

Variables	Annual	Kharif	Rabi
Rainfall Amount (mm) Average	1244.9	1123.5	60.3
Maximum	1727.8	1681.6	223.5
Minimum	823.8	769.8	0.2
C.V	21.2%	22.2%	96.9%

The mean annual rainfall of this location is 1244.9mm of which 84%occures during the *Kharif* (June-Sept) and 10% during (October-December) season. Annual rainfall varied from 823.8 to 1727.8 mm with a coefficient of variation of 21.2%. While that during *Kharif* average rainfall is 1123.5mm and in Rabi 60.3mm with coefficient of variation of 22.2% and 96.9% for the respective season. During the main crop season rainfall varied between to 769.8 to1681.6 mm while that in Rabi the variation of rainfall is variation is 0.2 mm to 223.5mm.The number of rainy days and weekly rainfall amounts were analyzed to understand distribution of rainfall during crop season. In this Context a week with less than

10mm rainfall and no day during week recording more than 5 mm is considered as dry week. Dry spell weeks of 166 no's have been occurred out of 30 years.

Distribution of seasonal rainfall

Distribution of rainfall, especially the length and frequency of occurrence of dry spell, was assessed using weekly totals. A week with less than 10mm rainfall and with no day during the week recording more than 5 mm is considered as dry week. Dry spell of 166 numbers have been occurred out of total 30. Ten year moving coefficient variation (CV) of annual rainfall showed a decreasing trend, seasonal rainfall showed a decreasing trend during kharif season and an increasing trend during rabi season.

Trends in variability in coefficient of variation of annual and seasonal rainfall for a 10 year moving period

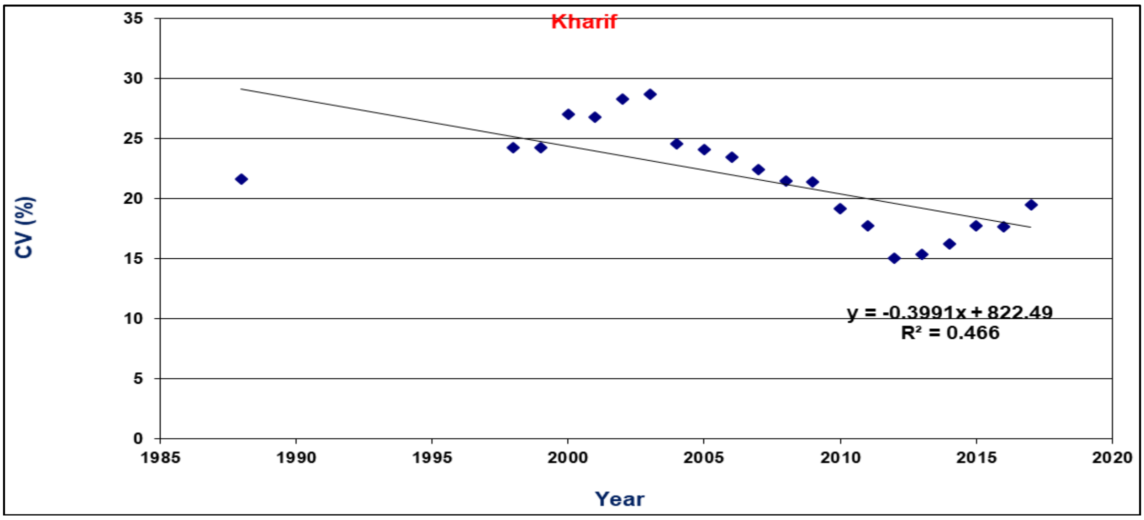
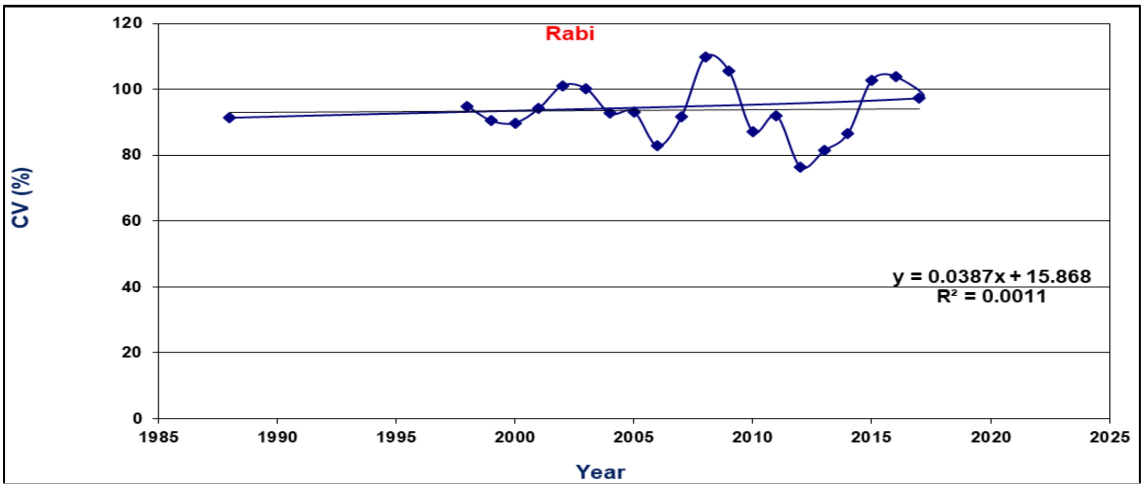


Fig 2



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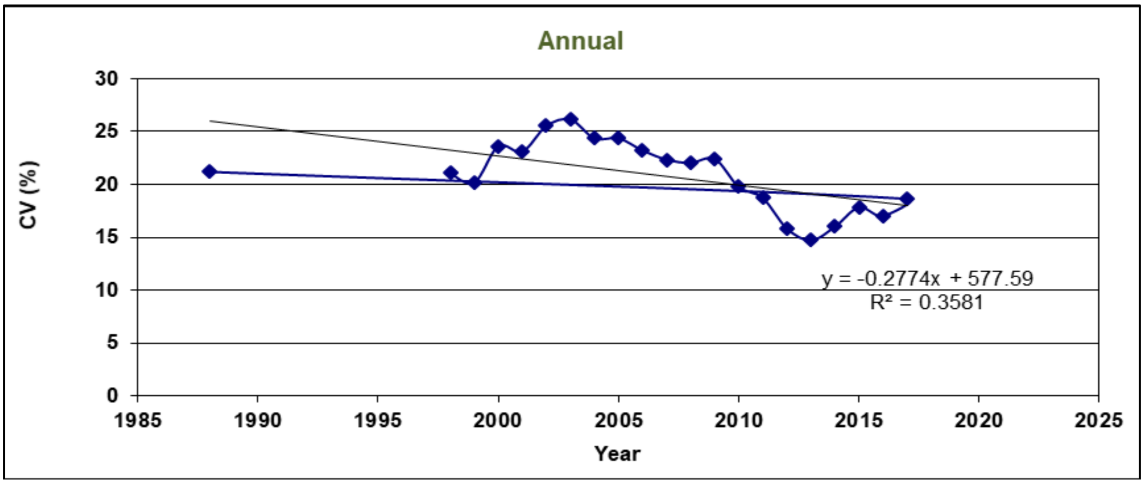

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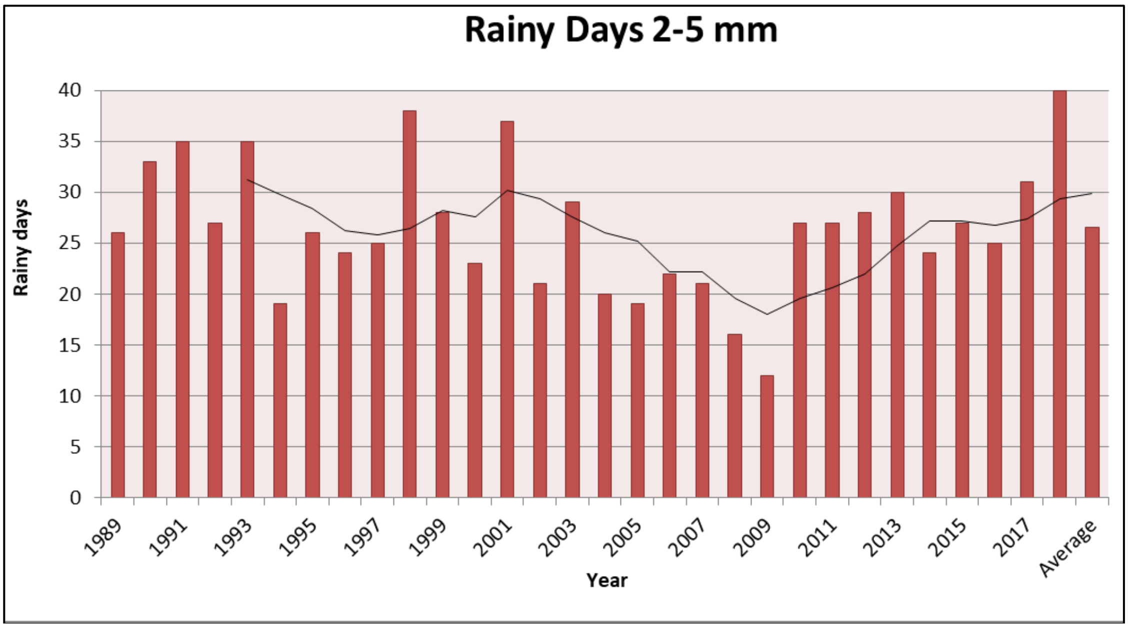

Fig 5

Rainfall variability and enso events

Several studies have indicated that statistically significant inverse relationship exists between El Nino Southern Oscillation (ENSO) phenomenon and inter-annual variability of Indian monsoon (Azad & Rajeevan, 2016) [2]. Hence most seasonal forecast including ISMR predictions uses ENSO as one of the predictors (Rajeevan *et al.*2006) [14]. An important feature of ENSO is high predictability.

The occurrence and intensity of El Nino or La Nina events is computed on magnitude and direction of change of parameters such as Oceanic Nino Index (ONI), Southern Oscillation Index (SOI) and Sea Surface Temperature (SST). Based on ONI, events are defined as warm (El Nino) events when five consecutive overlapping three month periods at or above the +0.5 anomaly and at or as cold (La Nina) events if ONI is below 0.5 anomaly. The threshold is further broken down into weak (with 0.5 to 0.9 SST anomaly), moderate (1 to 1.4), strong (1.5 to 1.9) and very strong (>2) events

Based on Oceanic Nino Index (ONI)			**ENSO year based on SOI**			**ENSO year based on SST**		
weak	**moderate**	**Strong**	**Weak**	**moderate**	**strong**	**weak**	**moderate**	**Strong**
El Nino								
1994-95	1991-92				1991-92			1991-92
2004-05	2002-03	1997-98	1993-94	1993-94	1994-95	1993-94	2002-03	1997-98
2006-07	2009-10	2015-16	2009-10	2009-10	1997-98	2006-07	2009-10	2015-16
La Nina								
1995-96	1998-99	1988-89		1988-89	2010-11	2008-09	1998-99	1988-89
2000-01	1999-00			1998-99			1999-00	2010-11
2011-12	2007-08			1999-00	2011-12		2000-01	2011-12
2016-17	2010-11			2000-01			2007-08	
				2007-08				
				2008-09				

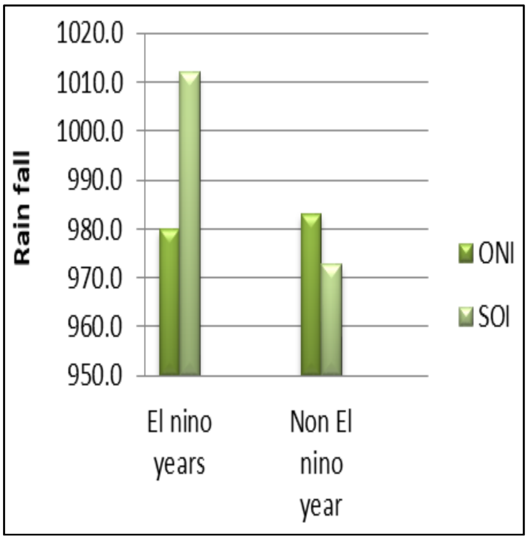

Fig 6: El nino

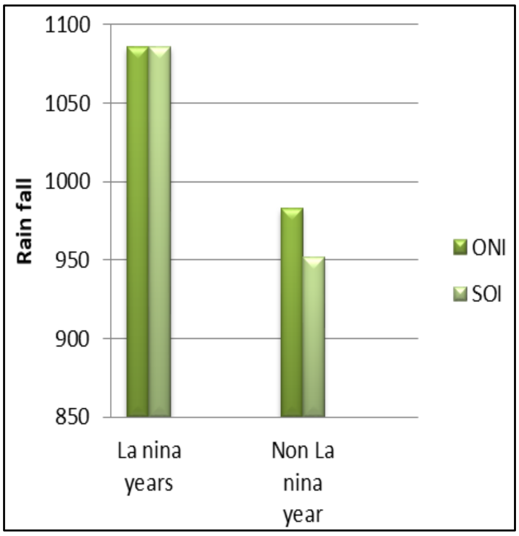

Fig 7: La nina

Rainfall during kharif season (June -September) in El Nino and non El Nino years and La Nina years a non La Nina years identified based on ONI, SOI, SST.

The descriptive statistics of rainfall e.g Range, Median, Deviation, Variance, Std Error, Kurtosis, Skewness, Coefficient of variation (CV%) are discussed. It is found that CV seems to varying from 41.7 to 307.2% for July and December month respectively. The skewness and kurtosis is highest for month of December for Bargarh. From the seasonal percentiles of rainfall it is observed that in kharif 90% of the years are getting rainfall more than 831mm of rainfall but in Rabi 90% of the years are getting only 6mm of rainfall.

Table 1: Descriptive Statistics for Bargarh

Month	Mean	Min	Max	Range	Median	Std Dev.	Variance	Std Error	Kurtosis	Skewness	Count	CV (%)
Jan	9.0	0.0	96.3	96.3	0.0	20.8	432	3.8	11.3	3.2	30	231.3
Feb	8.1	0.0	38.9	38.9	1.8	12.5	156	2.3	1.6	1.7	30	154.8
Mar	7.5	0.0	41.9	41.9	1.0	10.4	109	1.9	2.6	1.6	30	139.2
Apr	11.3	0.0	74.4	74.4	4.8	17.0	290	3.1	6.3	2.3	30	151.0
May	25.3	0.0	148.1	148.1	13.9	34.2	1166	6.2	5.3	2.3	30	135.0
Jun	204.9	13.7	506.7	493.1	190.0	104.8	10985	19.1	1.6	1.1	30	51.2
Jul	360.0	106.1	736.8	630.7	331.1	150.1	22532	27.4	0.6	1.0	30	41.7
Aug	356.3	158.8	871.7	712.8	293.9	157.4	24763	28.7	2.8	1.5	30	44.2
Sep	202.3	61.2	553.2	492.0	173.2	105.9	11223	19.3	2.6	1.2	30	52.4
Oct	45.3	0.2	186.2	186.0	29.5	48.5	2351	8.9	2.2	1.6	30	107.1
Nov	9.8	0.0	64.6	64.6	0.0	18.9	358	3.5	3.7	2.2	30	193.6
Dec	5.3	0.0	84.5	84.5	0.0	16.4	268	3.0	20.1	4.3	30	307.2

Seasonal percentiles of rainfall

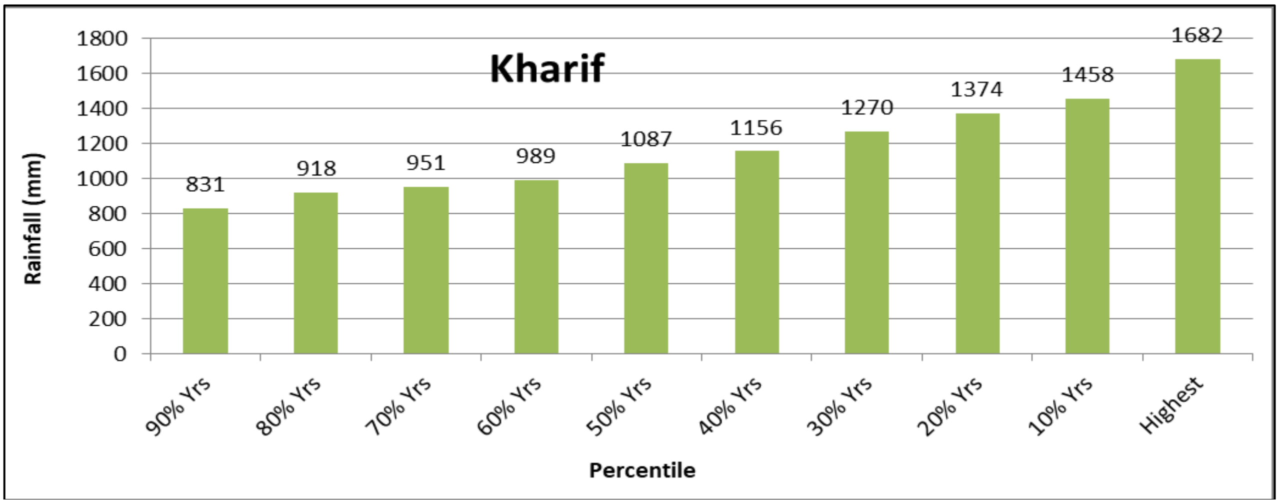

Fig 8

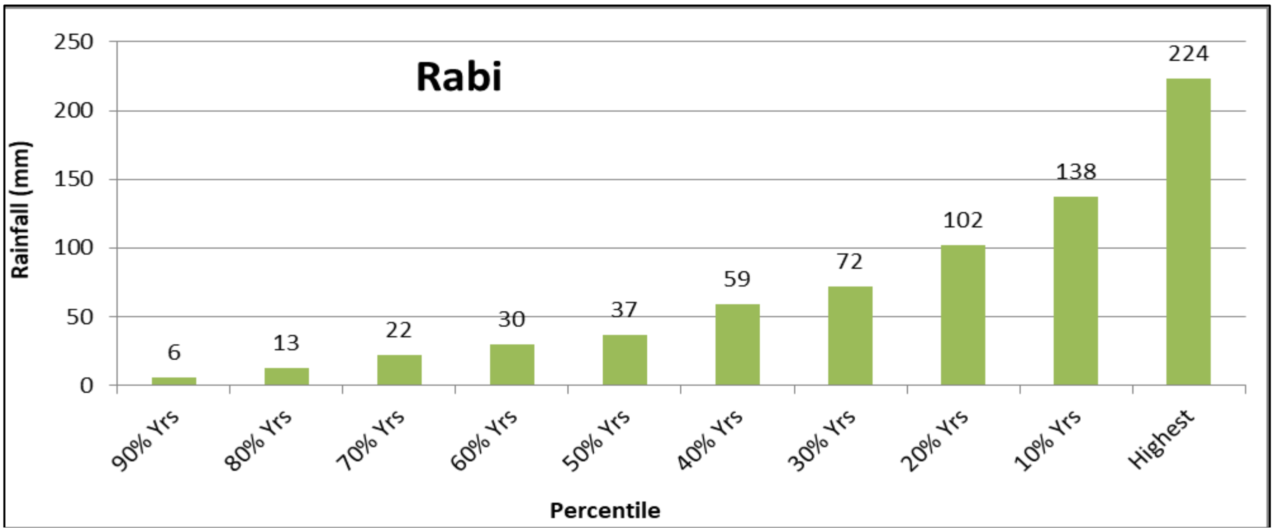

Fig 9

Conclusion

Agriculture in Odisha is mainly rainfed and affected by rainfall anomalies, Rice being main crop is affected by vagaries of climatic as well as rainfall variability. Bargarh is considered as rice bowl of Odisha needs special attention for the formation of mitigation strategies in view of this varying climatic situation. The district seems to be suspectable to occasional drought in late June and early July, the upland rice will be damaged very quickly due to early season dryspell during early kharif season, that will in tern leads to poor crop stand as a result the crop yield will be affected, so farmers can pertain to non-paddy crop. Direct seeded rice will be prone to "sprouting drought" so raising community nursery will be beneficial. The early season drought can also be addressed by varietal substitution with drought tolerant cultivars in rice fallow system.

Acknowledgement
We appreciate "International Crop Research Institute for Semi Arid Tropics" and KPC Rao sir for providing "The rainfall Analyser"- a MS Excel spread based tool for calculating the temporal variability and trends of seasonal and annual rainfall.

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