

Identifying the Frequency and Intensity of Dry and Wet Years over Sub-Himalayan West Bengal, India using Rainfall Anomaly Index

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ABSTRACT

As there is great variability of precipitation in the different parts of India, it is urgent to use climatic indices for monitoring and characterizing precipitation. Monsoon season in West Bengal broadly coincides with four months namely June, July, August and September. This paper aims to study the spatio-temporal distribution of Rainfall Anomaly Index (RAI) in some selected districts of sub-Himalayan West Bengal namely Jalpaiguri, Cooch Behar, Uttar Dinajpur and Dakshin Dinajpur. In order to do so, rainfall data of the aforesaid districts have been collected from the Agricultural Meteorology Division of the State Agriculture Department, Government of West Bengal and India Meteorological Department through the Indian water-portal website (<http://www.indiawaterportal.org/>) for the time period of 1901 to 2010.

It is possible to infer from the study that the number of years with negative RAI exceeds the number of years with positive RAI. Also the most extreme values of negative RAI appeared from 1962 to 1968, 2001 to 2010, 1996 to 2000 and 2001 to 2008 in Cooch Behar, Dakshin Dinajpur, Jalpaiguri and Uttar Dinajpur respectively.

1. Introduction

Precipitation is that climatic phenomena that vary in space, time, and intensity. The increasing variability of rainfall creates serious problem for human societies and ecosystems. Over the years, different parts of the world have witnessed a lot of changes in climatic phenomena (Pal et al. 2015). Dash et al. (2007) indicated decreasing trend of summer monsoon rainfall and increasing trend of pre-monsoon and post-monsoon rainfall in India. There is a strong interconnection between rainfall variability and food security in India (Lacombe and McCartney 2014). People depending entirely on rain-fed agriculture have to rely on the seasonality, amount, distribution and timely occurrence of rainfall (Huho et al. 2012). The impact of climate variability is maximum on the less economically developed countries in the tropics as they are exposed to climate variability at different spatio-temporal scale (Shisanya et al. 2011).

The main source of livelihood for majority of the people in the study area is agriculture and most of the crops are cultivated using the timely occurrence of rainfall. Growth and harvesting of crops may be hampered by a minor fluctuation of rainfall. Irrigation facilities in the agricultural fields are also controlled by the rainfall pattern vis-à-vis the ground water potentials. A proper study of rainfall anomaly and its positive and negative severities is highly needed to predict the abnormal situation caused by water scarcity and formulate effective agricultural and hydrological planning. For the present study, four districts of sub-Himalayan West Bengal namely Jalpaiguri, Cooch Behar, Uttar Dinajpur and Dakshin Dinajpur have been selected where more than 80% of rainfall occurs during monsoon season. The number of depressions and deep depressions form over Bay of Bengal during this time determines the amount of rainfall in the state (West Bengal). If in any year, the number of depressions and deep depressions are less, the amount of monsoon rainfall will be subsequently

lower. The position of monsoon axis also determines the amount and distribution of monsoon rainfall in the state. If the monsoon axis is positioned over the southern Gangetic West Bengal, it will receive higher rainfall. On the contrary, sub-Himalayan West Bengal will face a drought like situation and vice-versa.

Though a number of studies were carried out by the researchers to identify the trend and variability of rainfall and its impact on the agricultural activities of any region (Huho et al. 2012; Lacombe and McCartney 2014; Longobardi and Villani 2009; Merabtene et al. 2016; Pal et al. 2015; Chakraborty and Das 2016; Shisanya et al. 2011) but a little attention was paid to identify the positive and negative severities of rainfall anomalies of West Bengal using the Rainfall Anomaly Index (RAI). Rainfall Anomaly Index (RAI), developed by Rooy (1965), is a tool for the classification of positive and negative severities in rainfall anomalies (Rodrigues 2017). Therefore, the aim of the present paper is to study the space-time variation of rainfall over the sub-Himalayan West Bengal utilizing the Rainfall Anomaly Index (RAI) as a tool.

2. Materials and methods

The present study deals with the rainfall data of the four districts (Jalpaiguri, Uttar Dinajpur, Cooch Behar and Dakshin Dinajpur) of sub-Himalayan West Bengal for the time period of 110 years i.e. from 1901 to 2010 of the four monsoon months (June-September). Rainfall data of the aforesaid districts were collected from Agricultural Meteorology Division of the State Agriculture Department, Government of West Bengal and India Meteorological Department through the Indian water-portal website (<http://www.indiawaterportal.org/>) for the time period of 1901 to 2010. From the precipitation data, frequency and intensity of dry and rainy years in the study area was identified using the annual Rainfall Anomaly Index (RAI) method as

discussed by Rodrigues (2017) to analyze the frequency and intensity of the dry and rainy years for the Salgado Basin of Brazil. Drought (dry year) is represented in terms of (-) numbers; for example, 0 to -2 is dry, -2 to -4 is very dry and below -4 is extremely dry. Wet condition is shown in terms of (+) numbers; for example, 0 to +2 is humid, +2 to +4 is very humid and above +4 is extremely humid.

3. Results and discussion

These four districts of sub-Himalayan West Bengal received an average rainfall of 376 mm during monsoon which varies from 291.55 mm (lowest) over Dakshin Dinajpur to

480.69 mm (highest) over Jalpaiguri district. Maximum and minimum monsoon rainfall were recorded by the study area in 1904, 1913, 1922, 1942, 1984, 2007 and 1903, 1932, 1972, 1982, 2004 respectively. Analysis of average rainfall data of individual month from June to September revealed that the study area experienced highest rainfall in the month of July (471.16 mm) followed by August (376.79 mm), June (351.34 mm) and September (303.05 mm). Maximum rainfall of 608.37 mm was recorded by the district Jalpaiguri in the month of July (608.37 mm) and the district Dakshin Dinajpur recorded the minimum rainfall of 236.45 mm in the month of September (Table 1).

Table- 1
Monthly average rainfall (mm) during monsoon

Districts	June	July	August	September
	Rainfall (mm)			
Jalpaiguri	461.65	608.37	466.93	385.83
Uttar Dinajpur	263.96	397.29	324.16	259.89
Dakshin Dinajpur	259.20	363.91	306.63	236.45
Cooch Behar	420.56	515.05	409.45	330.01

Source: Calculated by the author

The dry years and the rainy years can be visualized from the RAI diagram (Fig. 1.) during the time period of 110 years i.e. from 1901 to 2010. The positive values indicate the wet or

humid years and dry years are indicated by the negative values.

Table- 2
Rainfall Anomaly Index (RAI) for the four districts of sub-Himalayan West Bengal

Districts	Rainfall Anomaly Index (RAI)	Total	June	July	August	September
Jalpaiguri	Positive	41	51	48	45	49
	Negative	69	59	62	65	61
Cooch Behar	Positive	45	52	49	49	53
	Negative	65	58	61	61	57
Uttar Dinajpur	Positive	55	47	54	47	50
	Negative	55	63	56	63	60
Dakshin Dinajpur	Positive	57	46	50	53	47
	Negative	53	64	60	57	63

Source: Calculated by the author

It is observed from Table 2 that the district Dakshin Dinajpur experienced 57 years with the positive values of RAI followed by Uttar Dinajpur (55), Cooch Behar (45) and Jalpaiguri (41). Similarly, the occurrence of 69 years with negative RAI is observed in Jalpaiguri followed by Cooch Behar (65), Uttar Dinajpur (55) and Dakshin Dinajpur (53). In other words, Jalpaiguri and Cooch Behar experienced more years of drought (dry years) than the wet years. In the case of Dakshin Dinajpur, the number of wet years exceeds the number of dry years and the number of dry and wet years is equal for the district Uttar Dinajpur. Month-wise analysis of RAI brings out the fact that the number of dry years exceeds the number of wet years for all the studied districts of sub-Himalayan West Bengal. In the month of June, the occurrences of 46, 47, 51 and 52 years with positive RAI were noticed for the districts Dakshin Dinajpur, Uttar Dinajpur, Jalpaiguri and Cooch Behar respectively while in the month of July, the number of wet years were found to be 50, 54, 48 and 49 respectively in the aforesaid districts. The longest period of dry years was from 1959 to 1967 and 1913 to 1922

respectively in the district Dakshin Dinajpur. The consecutive years of dry event occurrences for the district Jalpaiguri were from 1956 to 1972 which is found to be much higher compared to Dakshin Dinajpur. District Cooch Behar and Uttar Dinajpur experienced consecutive 12 and 11 years of drought occurrences from 1901 to 1912 and 1960 to 1970 where as from 2003 to 2008 and 1933 to 1943, these two districts recorded consecutive wet years. Positive and negative values of RAI vary from humid to extremely humid and dry to extremely dry situation respectively. The number of humid and dry years is maximum for all the districts. Dakshin Dinajpur experienced 35, 42, 43 and 46 humid years in the month of June, July, August and September respectively whereas the occurrence of 60, 52, 51 and 58 years with the negative RAI, values ranging between 0 to -2 is observed for the four monsoon months respectively. District Jalpaiguri faced 3, 3 and 35 years of extremely humid, very humid and humid years respectively from 1901 to 2010 while 68 dry years were experienced by the same district. It is possible to observe that the number of years with negative RAI (values ranging

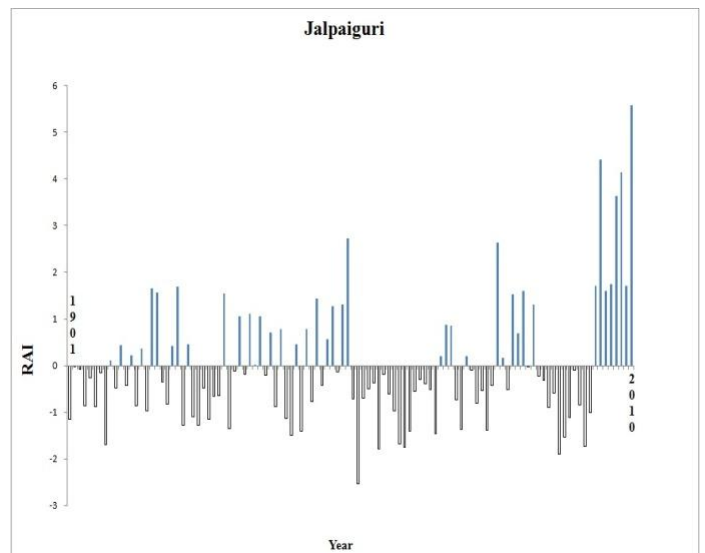
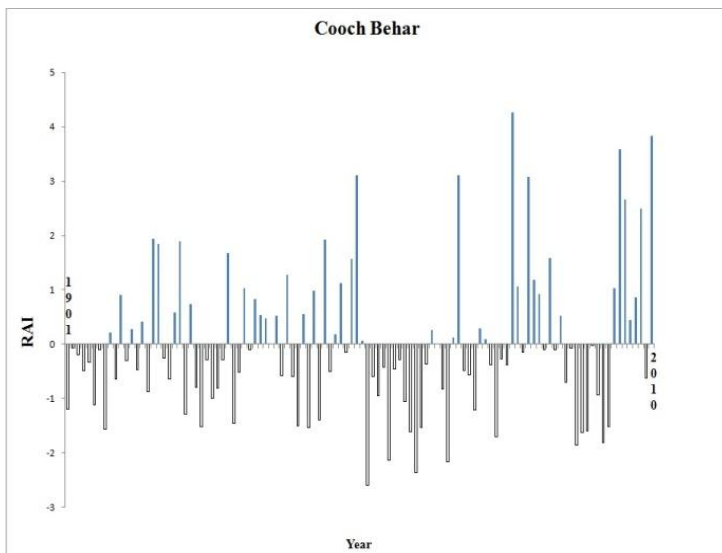
between 0 and -2) is much higher in the month of August (61) compared to the month of June (48), July (57) and September (55) for the district Jalpaiguri. Month wise analysis of RAI indicates that the number of years with negative RAI (value ranging between -2 and -4) is maximum for the district Cooch Behar. In light of this context, it is possible to infer that the district Uttar Dinajpur experienced 36, 45, 36 and 41 years with positive values of RAI and 54, 45, 58 and 55 years with

negative RAI from June to September respectively. From the year 1916 to 1922, RAI was positive throughout the territorial extension of sub-Himalayan West Bengal. On an average, RAI was negative in the four districts from 2001 to 2010. The most extreme values of negative RAI appeared from 1962 to 1968, 2001 to 2010, 1996 to 2000 and 2001 to 2008 in Cooch Behar, Dakshin Dinajpur, Jalpaiguri and Uttar Dinajpur respectively.

Table- 3
Frequency of dry and wet years for the four districts of sub-Himalayan West Bengal

Jalpaiguri						
Classification of RAI	Extremely humid	Very humid	Humid	Dry	Very dry	Extremely dry
Total	3	3	35	68	1	0
June	1	14	36	48	11	0
July	2	9	37	57	5	0
August	1	11	33	61	4	0
September	0	13	36	55	6	0
Cooch Behar						
Classification of RAI	Extremely humid	Very humid	Humid	Dry	Very dry	Extremely dry
Total	1	7	37	61	4	0
June	2	9	41	48	10	0
July	2	6	41	59	2	0
August	1	11	37	55	6	0
September	1	10	42	44	13	0
Uttar Dinajpur						
Classification of RAI	Extremely humid	Very humid	Humid	Dry	Very dry	Extremely dry
Total	1	9	45	44	11	0
June	2	9	36	54	9	0
July	2	7	45	45	11	0
August	0	11	36	58	5	0
September	1	8	41	55	5	0
Dakshin Dinajpur						
Classification of RAI	Extremely humid	Very humid	Humid	Dry	Very dry	Extremely dry
Total	2	11	44	40	13	0
June	1	10	35	60	4	0
July	2	6	42	52	8	0
August	0	10	43	51	6	0
September	1	10	36	58	5	0

Source: Calculated by the author



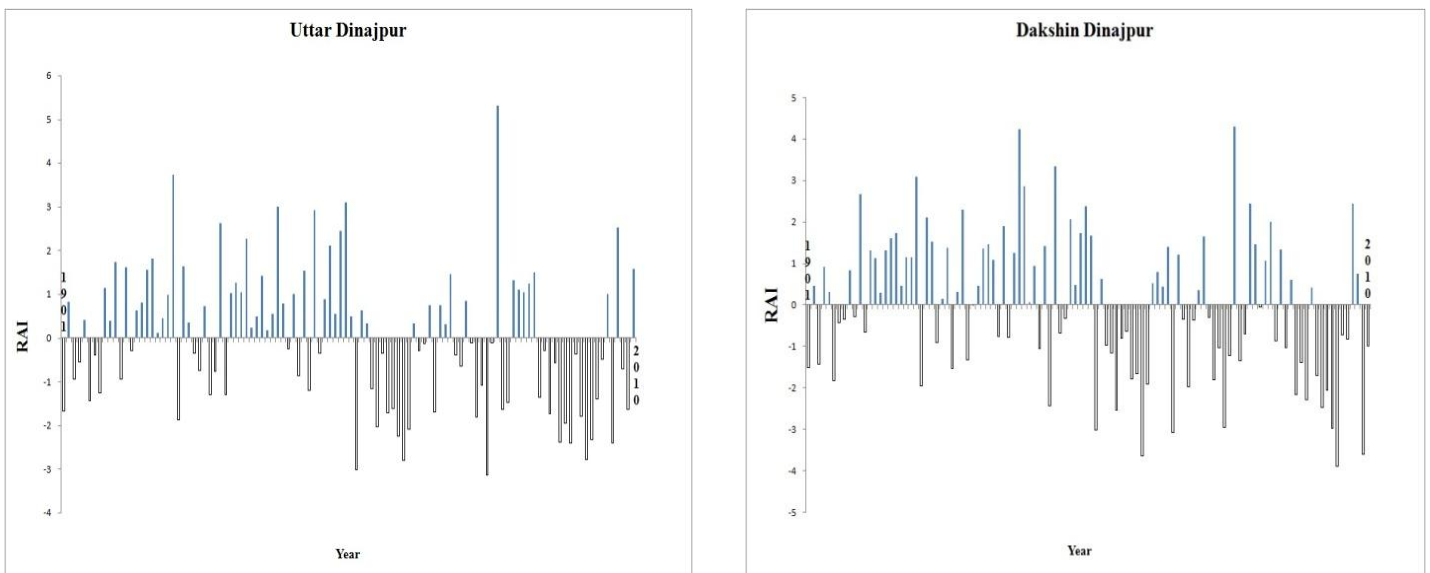


Fig. 1. RAI of the four districts of sub-Himalayan West Bengal (1901-2010)

4. Conclusion

Agriculture plays the crucial role in providing food and income for majority of the population of the developing countries. Successful growth of agriculture requires adequate and timely occurrence of rainfall. Entire kharif crop cultivation in the state starting from seed bed preparation to harvesting depend on the timely occurrence of monsoon rainfall. While the success of rabi crops cultivation in the state largely depends on the favourable temperature regime and abundant sunshine, cultivation of kharif crops largely depends on the spatial distribution of monsoon rainfall. Investigation and characterization of Rainfall Anomaly Index is crucial for the successful planning of agricultural activities and efficient management of water resources. The present study concludes that the number of years with dry situation (values ranging between 0 to -2) exceeds the number years with humid condition (values ranging between 0 to 2) for all the studied districts of sub-Himalayan West Bengal. The number of dry years exceeds the number of wet years for the two districts of sub-Himalayan West Bengal namely Jalpaiguri and Cooch Behar whereas the number of wet years is greater than the number of dry years for the district Dakshin Dinajpur. The number of dry and wet years is equal for the district Uttar Dinajpur. It is possible to infer from the present study that the districts Jalpaiguri, Cooch Behar, Uttar and Dakshin Dinajpur experienced 27, 35, 41 and 36 years of very dry situation (value ranging between -2 and -4) respectively. The number of very humid years is maximum for the district Jalpaiguri (50)

followed by Dakshin Dinajpur (47), Uttar Dinajpur (44) and Cooch Behar (43) in the four monsoon months. The present study exhibits that the month of June is more vulnerable for the occurrence of dry situation which can pose severe threat to the cultivation of summer paddy and some major vegetables. The study area depends on the timely occurrence of south-west monsoon rainfall depending on which the cultivation of some major crops is done. The greater number of dry and very dry years will hamper the agricultural activities particularly the land preparation in the non-irrigated areas. Resolutions, based on Rainfall Anomaly Index, are required to cope up with the extreme dry and extreme humid situation. Crop calendar needs to be modified depending on the changing pattern of spatio-temporal distribution of rainfall. Furthermore, it is very essential to provide the climatic data and information to the farming community so that they can take the necessary steps for the cultivation of a wide range of crops. Otherwise, there will be a huge gap between the actual and desired rate of crop production. It is hoped that the study in general will assist the policy makers and scientists to suggest suitable measures for the successful growth of kharif crops in this region.

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