Analysis of Flood and Drought Years Between 1901-2020 in Seven Northeastern States of India

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Abstract- **Northeast India (NEIN) is one of India's wettest areas. Due to its geographical location, this region is vulnerable to water-related calamities. Because of the heavy precipitation, NEIN is subject to severe natural disasters such as sporadic flooding, erosion, and so on. These natural disasters are common among the people of NEIN and act as a barrier to agricultural growth, economic development, and industry development. The presence of flood and drought years influenced the overall development of this region, which is heavily reliant on agriculture. This study used rainfall data from the National Water Informatics Centre India to investigate flood and drought years in seven Northeastern states, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, and Tripura, from 1901 to 2020. The Normalized index (NI) has been utilized to determine the flood and drought years. Flood and drought years are also classified based on their severities for each state.**

Keywords: Rainfall, Flood, Drought, Normalized Index (NI), NEI

I. INTRODUCTION

Climate variabilities like floods and droughts has a negative impact on agriculture, crops production and water purity specially over NEIN which is one of the wettest areas of India and is highly dependent on agriculture. This region is prone to flooding and other natural calamities due to its geographical location [1]. Because of climate change there is a noticeable change observed in rainfall pattern in this region which leads to the frequent occurrence of floods and droughts [2].

In that context, the present study aims to compute the flood and drought years using India's water resources and Information systems rainfall data for the seven states of NEIN, namely Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura to understand the relationship of extreme weather events like floods and droughts with the changing rainfall pattern.

II. STUDY AREA

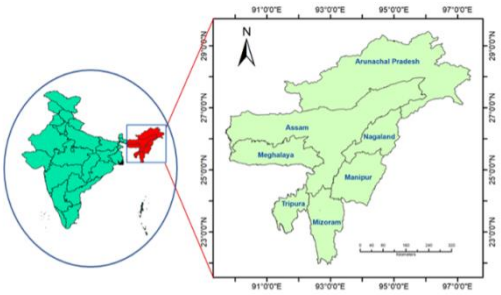

Fig.1 Study area

he study area is located between 89º46' to 97 º 30' East longitudes and 21º57'to 29º30' North latitude, which consists of the seven states of NEI namely, Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura. The area has a rich biodiversity, high rainfall, and high seismic activities and highly dependent on agriculture for livelihood. The climate of NEIN is subtropical, and the region is known for its wide range of weather and climate. The study area is shown in Fig.1

III. MATERIALS AND METHODS

In this study, the monthly rainfall data for 120 years (1901-2020) have been collected for the seven states of Northeast India, from India's Water Resources and Information system (https://indiawris.gov.in). The month wise rainfall data of June, July, August, September, October (JJASO) have been converted into total monsoon rainfall during 1901-2020. The NI method has been used to compute the flood and drought years [3,4]. For this purpose, the mean monsoon (JJASO) rainfall of each year, the climatological mean and standard deviation of the same have been calculated for each of the seven states of NEIN. The

standardized values were used as the indices of meteorological drought and flood severity. The value of -0.99 to 0.99 are considered as 'normal' condition, the value of $-1.0\,(+1.0)$ to $-1.49\,(+1.49)$ as 'moderate' drought (flood) condition, the values of $-1.5\,(+1.5)$ to $-1.99\,(+1.99)$ are assigned as 'severe' drought (flood) and the value below (above) $-2\,(+2)$ is 'extreme' drought (flood) [4]. The NI is given by,

$$NI = \frac{R_i - \bar{R}}{\sigma} \qquad (1)$$

Where, R_i is the total monsoon rainfall of i^{th} year, $\bar{R}$ is the climatological mean of monsoon rainfall and σ is the standard deviation.

IV. RESULTS AND DISCUSSION

The time series plots for total monsoon rainfall (JJASO) along with the mean monsoon rainfall for the states Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland and Tripura from 1901-2020 are shown in the Fig.2. The graphical representation of NI for the above mentioned states is shown in the Fig.3. The classification of flood and drought years based on the severities for the seven states of NEIN are given in the Table I and Table II respectively.

The occurrence of extreme flood events is found to be highest over Meghalaya followed by Arunachal Pradesh and Tripura and lowest extreme flood events has been reported over Nagaland. The severe flood events are highest over Meghalaya and Manipur followed by Arunachal and Tripura and lowest occurrence is in Assam and Nagaland. The moderate flood events are taking place in all the states where the highest occurrence has been observed in Assam and Nagaland shown in table 1.

Similarly, the extreme drought event is highest over Assam and Nagaland and there is no extreme drought event is observed over Meghalaya in the study period. Assam has showing maximum severe droughts event followed by Nagaland and Tripura whereas minimum severe drought events are obtained over Meghalaya and Mizoram. All the states have moderate drought events but among all states, Arunachal Pradesh has the maximum occurrence as shown in the table 2.

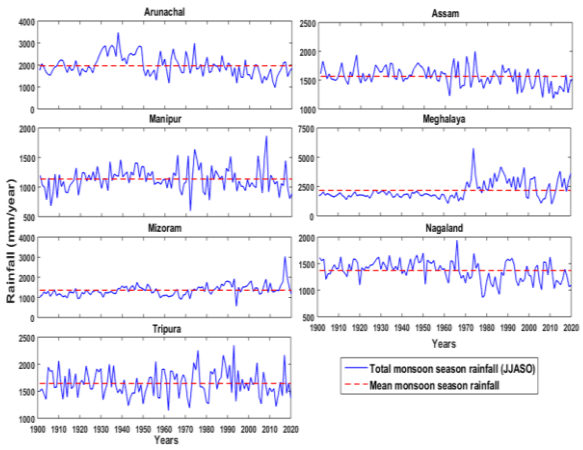

Fig.2 The time series plots for total monsoon rainfall (JJASO) along with the mean monsoon rainfall for the seven states of NEIN (1901-2020)

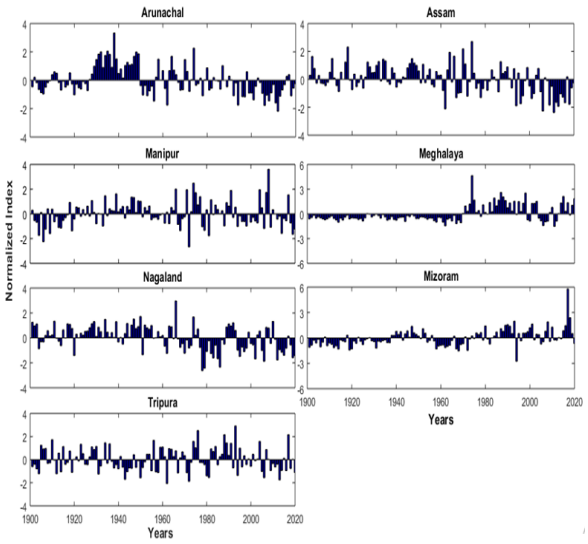

Fig.3 The graphical representation of NI for the seven states of NEIN (1901-2020)

TABLE I. Classification of floods based on their severities for the seven states of NEIN (1901-2020)

States	Floods		
	Moderate	***Severe***	***Extreme***
Arunachal Pradesh	1930, 1943, 1944, 1945, 1946, 1958, 1970, 1987	1931,1934, 1936,1947, 1949, 1964	1932, 1935, 1938, 1974
Assam	1911, 1917, 1927, 1932, 1934, 1935, 1946, 1947, 1948, 1952, 1971, 1987	1902,1964, 1966	1918, 1970, 1974
Manipur	1928, 1934, 1946, 1947, 1949, 1950, 1977, 1982	1939, 1971, 1975, 1991, 2004, 2007, 2017	1966, 1974, 2008
Meghalaya	1973, 1979, 1982, 1991, 1995, 1997, 2001, 2002, 2014, 2017, 2019	1975, 1984, 1986, 1989, 1993, 2003, 2020	1974, 1987, 1988, 1998, 2015
Mizoram	1947, 1952, 1980, 1987, 1989, 1991, 2000, 2010, 2016	1990, 1993, 2001, 2008	2017, 2018
Nagaland	1901, 1903, 1911, 1917, 1918, 1928, 1929, 1934, 1939, 1944, 1946, 1952, 1990, 1992, 2010	1947, 1950, 1974	1966
Tripura	1905, 1915, 1923, 1928, 1930, 1934, 1936, 1959, 1960, 1975, 1984, 1989, 1991	1910, 1956, 1974, 2004	1976, 1988, 1993, 2017

TABLE II. Classification of droughts based on their severities for the seven states of NEIN (1901-2020)

States	Droughts		
	Moderate	***Severe***	***Extreme***
Arunachal Pradesh	1920, 1951, 1953, 1956,1978, 1992, 1996, 1997, 2001, 2007, 2008, 2013, 2018	1962, 1994, 2006, 2011	2012
Assam	1967, 1972, 1978, 1997, 2001, 2002, 2014, 2015	1994, 1996, 2009, 2012, 2013, 2016, 2018	1962, 2006, 2011
Manipur	1907, 1913, 1914, 1919, 1968, 1978, 1979, 1994, 2006, 2009, 2020	1904, 1909, 1981, 2014, 2019	1906, 1972
Meghalaya	1914, 1961, 1962, 1967, 1969, 2006	2011	Nil
Mizoram	1901, 1906, 1912, 1914, 1919, 1920, 1931, 1958, 1962, 1963, 1967, 1972	1968	1994
Nagaland	1920, 1951, 1962, 1970, 1980,, 1982, 1995, 1997, 2005, 2014, 2015, 2020	1983, 1985, 2002, 2006, 2012, 2019	1978, 1979, 1986
Tripura	1904, 1912, 1914, 1919, 1931, 1944, 1957, 1958, 1967, 1971, 1980, 1994, 2005, 2020	1943, 1950, 1972, 1981, 2006, 2013	1962

V. CONCLUSION

This study deals with the computation of flood and drought years in the seven states of NEIN for the period of 1901-2020 using Normalized Index. The occurrence of extreme flood events is found to be highest in Meghalaya and the

occurrence of extreme drought events is found to be highest in case of Assam and Nagaland. The states having high rainfall years show more flood years and vice-versa. The occurrence of flood and drought years can also be related with the phenomena like ENSO.

ACKNOWLEDGEMENT

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