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ASSESSMENT OF METEOROLOGICAL DROUGHT AND ANNUAL RAINFALL TRENDS OF DIFFERENT AREAS IN BANGLADESH

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ABSTRACT

In this assessment an effort has been set to calculate the condition of meteorological drought at different areas of Bangladesh by using Standardized Precipitation Index (SPI) method. For this investigation, the precipitation historical data of eight different rain gauge stations such as Dhaka, Sylhet, Mymensingh, Barisal, Chittagong, Rangpur, Khulna and Rajshahi areas were collected from Bangladesh Meteorological Department (BMD) over 30 years duration from 1988 to 2017. In Rajshahi area the meteorological drought was of nearly normal to severely dry, Barisal, Rangpur, and Mymensingh cities are nearly normal, Sylhet city moderately wet to extremely wet, Chittagong city nearly normal to severely wet, Dhaka and Khulna moderately dry to nearly normal over the last 30 years. It was found from the study that the northwest part (Rajshahi city) is the maximum drought prone and least annual rainfall area in the country. Also, It was established that Chittagong and Sylhet areas are the minimum drought prone area among all. By the rainfall trends analysis, it was visible that Khulna and Chittaging areas rainfall tends are increasing and remaining areas are declining.

Keywords: *Meteorological drought, Rainfall trends, Standard precipitation index.*

1. INTRODUCTION

Usually, Drought is a natural hazard due to scarcity of water in the soil for long period. This deficiency marks in a water inadequacy for various activities such as climatic influences the rising temperature, high wind and low relative humidity are responsible for drought. Drought is an interim of period, normally give privilege of months of years in a time, during which the genuine moisture supply of a definite place rather gradually reductions of the climatically anticipated or climatically appropriate moisture supply (Palmer, 1965). Overall, drought may be classified as meteorological, agricultural or hydrological depending on the intensity, duration and spatial coverage (World Meteorological Organization, 2012). Drought is a consistent climatic phenomenon which occurs in different parts of the world, with changing frequency, severity and time (Wilhite, 1993; Shatanawi et al., 2013). It is difficult to determine the beginning and ending of a drought. It develops slowly, and its impact may remain for years after end of the event (Morid et al., 2006).

Typically, in Bangladesh, drought happens once in each 2.5 years (Adnan, 1993; Hossain, 1990). In the year from 1960 and 1991, nineteen droughts occured at several areas inside Bangladesh (Mirza and Paul.1992). The key reason of drough in Bangladesh includes insufficient water accessibility due to not as much of rainfall than the amount required for crop production. It is important to note that Bangladesh is a country which is vulnerable to the impacts of climate change due to its geographical location (Mondol et al., 2017).

The current study intended to assess the trends of annual rainfall as well as meteorological drought at different areas in Bangladesh from the year 1988 to 2017.

2. Study Area

For this study, the obtainable data containing daily entire rainfall of eight different rain gauge stations in Bangladesh was collected from the Bangladesh Meteorological Department (BMD) for the year 1988 to 2017. The rain gauge stations at different areas of Bangladesh shown in Figure 1.

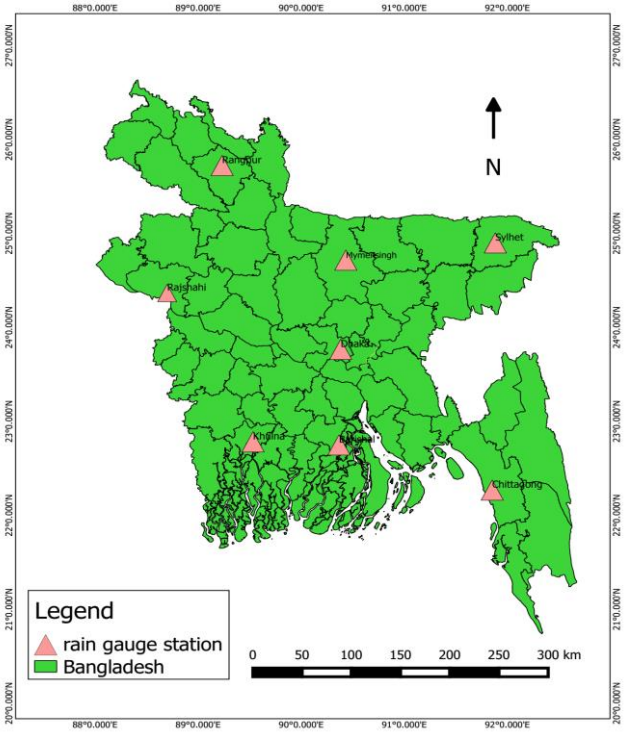

Figure 1: GIS map showing different rain gauge stations in Bangladesh.

2.1 Standardized Precipitation Index (SPI) and Meteorological Drought

The SPI was advised by (McKee et al., 1993) and has been used commonly throughout the past two decades (Hirschi et al., 2011; Vicente-Serrano et al., 2015). SPI is a extensive meteorological drought index that is merely recognized on rainfall data. Additional significant advantage is its suppleness in quantity of the drought for different time measures. In scheming of the standardized precipitation series, only the arithmetic average of the rainfall series and the standard deviation are needed. Standardized precipitation series for any x_1, x_2,… x_n precipitation time series, SPI value, is calculated using Eq. 1.

$$SPI = \frac{x_i - x_m}{S_x} \quad (1)$$

Where, x_i is precipitation record of the station; x_m is the arithmetic average of rainfall; and S_x is the standard deviation.

$$\boldsymbol{Sx} = \sqrt{\frac{\sum_{i=1}^{n}(x-\bar{x})^2}{n-1}} \quad (2)$$

SPI values are figured for each station on seasonally and annually time scales. Database is made for SPI consequences from 1988-2017 as exposed in Table 2. The SPI values and equivalent drought severity indices are shown in Table 1.

Table 1. The SPI ordering system according to McKee *et al*. 1993.

SPI value	Category
2.00 or more	Extremely wet
1.50 to 1.99	Severely wet
1.00 to 1.49	Moderately wet
−0.99 to 0.99	Near normal
−1.00 to −1.49	Moderately dry
−1.49 to −1.99	Severely dry
−2.00 or less	Extremely dry

3. RESULTS AND DISCUSSIONS

Figure 2 represents the trends of annual total rainfall for the study time of 30 years in different areas in Bangladesh. From this figure it can seen that the maximum rainfall occurs in Sylhet and the minimum rainfall occurs in Rajshahi city. A linear declining trends are detected for all considered raingauge stations excluding Chittagong and Khulna in the year 1988 to 2017. In Chittagong and Khulna stations, the trend line mounting upward that refers that rainfall at Chittagong and Khulna areas are increasing with time.

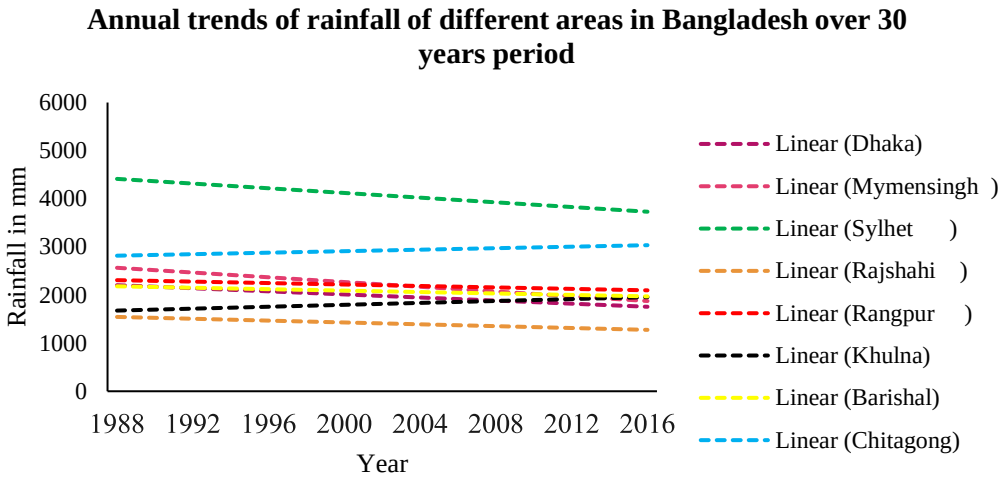

Figure 2: Annual rainfall trend lines for the studied raingauge stations in Bangladesh.

The maximum, minimum and average annual rainfall in all the area is within the last 30 years is given the figures 3 & 4, from this figures it is shown that the maximum precipitation occurs in Sylhet is in 2017 of almost six thousand millimeter (5944 mm) that means in year 2017, no chance to occurs drought in that region. The minimum rainfall occurs in Rajshahi is 792 mm in the year of 2010 which is exact less than the average value of 1412 mm. refers that the most drought occurs in Rajshahi is in 2010. The minimum rainfall occurred in Dhaka and Barisal in year 1992 and the minimum rainfall occurred in Rangpur, Khulna and Chittagong occurred in year 1994 that means the maximum drought occurred in that time in Bangladesh.

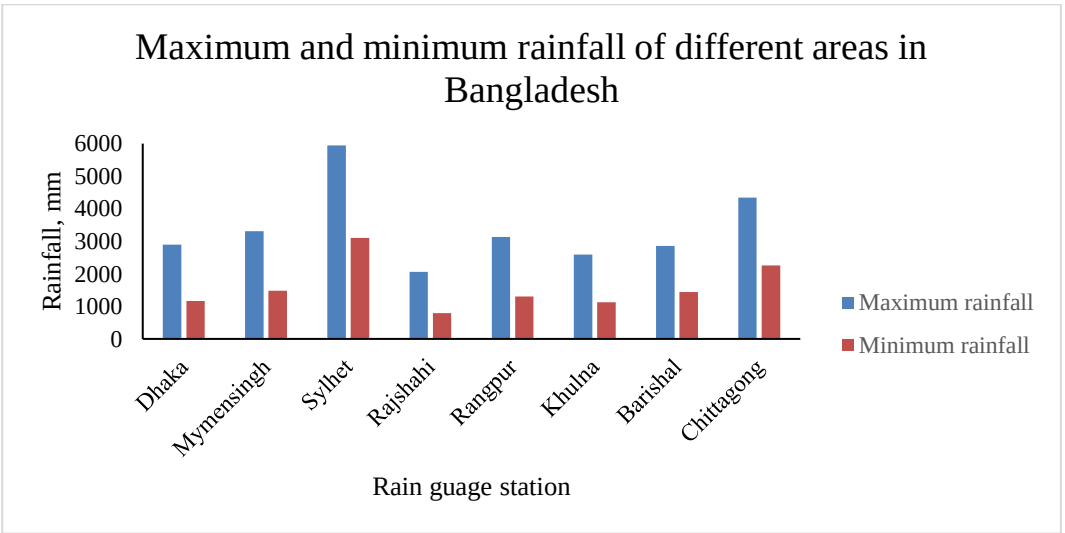

Figure 3. Annual maximum and minimum for the different raingauge stations in Bangladesh

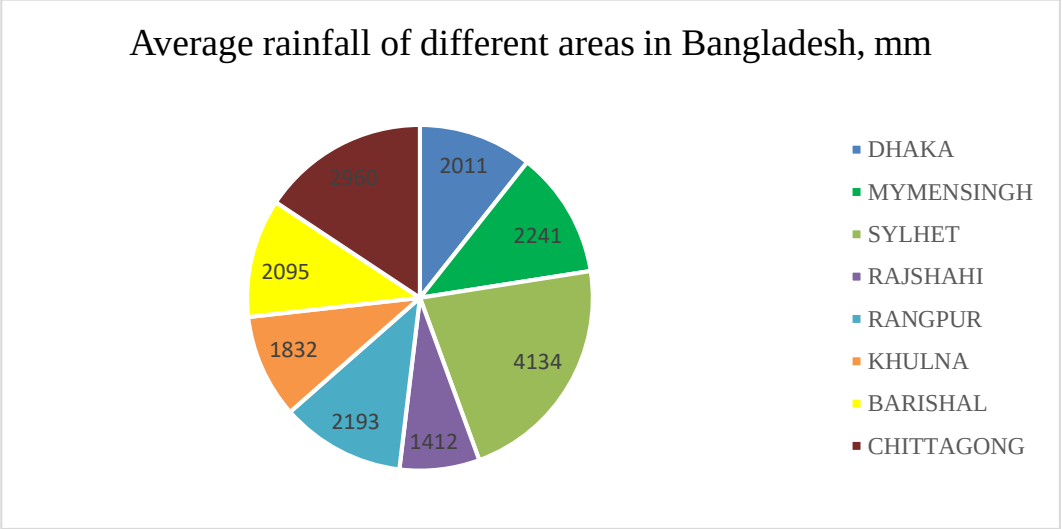

Figure 4: Annual average rainfall for the different raingauge stations in Bangladesh

Meteorological drought hazard detected by SPI during selected years of 1988 to 2017. From Table 2 SPI value can be easily observed that all five station except Sylhet, Rajshahi and Chittagong are as normal as SPI value within the normal range of -0.99 to 0.99. SPI value of Sylhet station is inside the value of 1.37 to 2.26 which references that the Sylhet city is in extremely wet or moderately wet condition in last 30 years. In Chittagong city the range of SPI value is within -0.2 to 1.56 which appears most of the year within that 30 years is in normal condition but several of few years are in moderately wet situation of the years are 1997 to 1998, 2007 to 2009, 2011, 2014 and 2015. In Rajshahi area the SPI value range is -1.55 to -0.70 that means the condition of Rajshahi is in severely dry to near normal condition in last 30 years.

Table 2: From the year 1988 to 2017 SPI values of different rain gauge stations in Bangladesh.

Year	Dhaka	Mymensingh	Sylhet	Rajshahi	Rangpur	Khulna	Barisal	Chittagong
1988	-0.312	0.278	2.232	**-1.040**	-0.278	-0.739	-0.326	0.184
1989	-0.519	-0.031	2.342	-0.746	-0.329	-0.688	-0.242	0.213
1990	-0.540	-0.125	2.243	-0.956	-0.065	-0.744	-0.200	0.386
1991	0.132	0.599	1.924	**-1.237**	-0.463	-0.972	-0.332	0.349
1992	-0.694	-0.203	2.073	**-1.080**	0.298	-0.636	-0.374	0.616
1993	-0.045	0.373	1.983	**-1.315**	-0.373	-0.831	-0.314	0.521
1994	-0.308	-0.228	2.193	-0.807	-0.607	-0.822	-0.012	0.591
1995	-0.840	0.385	2.068	**-1.277**	0.133	-0.435	-0.145	0.110
1996	-0.110	-0.580	2.073	-0.968	-0.154	-0.745	-0.359	0.843
1997	-0.594	-0.130	1.996	-0.347	-0.483	-0.713	-0.799	1.071
1998	-0.413	-0.374	1.762	**-1.219**	-0.355	-0.743	0.161	1.181
19999	-0.121	-0.431	1.366	-0.914	0.742	**-1.150**	-0.770	1.278
2000	-0.181	-0.108	2.153	-0.705	-0.653	-0.643	-0.629	0.766
2001	-0.702	-0.293	2.032	**-1.154**	0.535	-0.778	0.134	0.225
2002	**-1.060**	-0.169	1.648	**-1.549**	0.802	0.057	-0.023	0.295
2003	-0.599	-0.432	1.996	-0.990	0.388	-0.704	-0.457	0.798
2004	-0.368	-0.175	2.167	**-1.109**	0.073	-0.856	-0.127	0.395

2005	0.169	0.211	2.022	**-1.328**	0.431	-0.627	-0.674	-0.203
2006	-0.241	-0.179	2.115	**-1.376**	-0.588	-0.033	-0.125	0.427
2007	0.073	-0.027	1.494	**-1.126**	-0.755	-0.683	-0.471	1.496
2008	-0.004	0.026	1.532	**-1.226**	-0.424	-0.845	-0.482	1.422
2009	-0.240	-0.596	1.557	**-1.417**	0.139	-0.406	-0.387	1.349
2010	-0.469	-0.011	2.263	**-1.054**	-0.006	-0.602	-0.358	0.236
2011	-0.658	-0.049	1.517	**-1.153**	-0.402	-0.376	-0.440	1.561
2012	-0.665	-0.539	2.077	-0.803	-0.207	-0.401	-0.424	0.962
2013	-0.735	-0.501	2.166	**-1.129**	-0.275	-0.086	0.243	0.317
2014	-0.655	-0.019	1.692	-0.906	-0.375	-0.582	-0.590	1.435
2015	-0.481	-0.561	1.808	**-1.205**	-0.237	-0.334	-0.221	1.231
2016	-0.972	-0.311	2.239	-0.961	-0.095	-0.033	0.108	0.024
2017	-0.066	-0.101	2.109	**-1.081**	-0.778	-0.497	-0.257	0.671

From figure 5, it was seen that maximum times drought occured in Rajshahi area and others area are not remarkable.

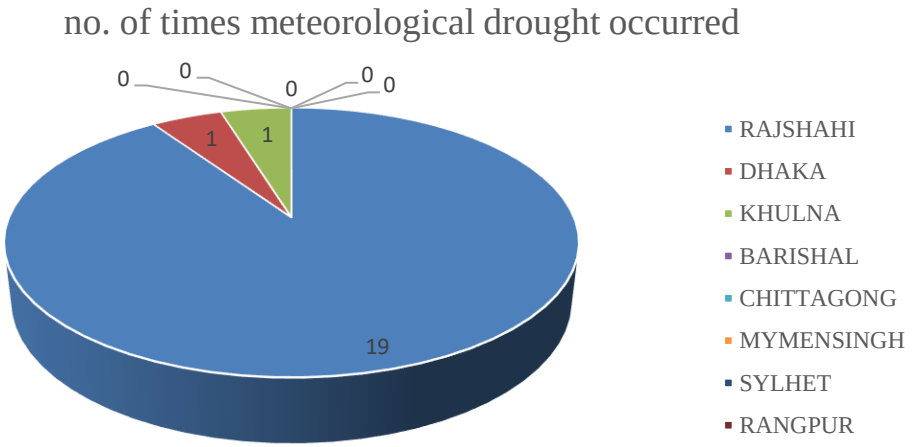

Figure 5. No. of times meteorological drought occurred of different raingauge stations in Bangladesh

4. CONCLUSIONS

The main objective of the study was to assess on the rainfall trends at different rain gauge stations of Bangladesh during the last 30 years and identify meteorological drought by Standardized Precipitation Index (SPI) method. From the investigation it is marked that the maximum precipitation occurred in Sylhet and the minimum precipitation occurred in Rajshahi city in the last 30 years (1988 to 2017). In Chittagong and Khulna areas annual rainfall are increasing and others areas are decreasing with time. In Rajshahi area annual drought occurred 19 times, whereas moderately drought occurred 18 times and severe drought occurred once in last 30 years. In Dhaka and Khulna regions drought occurred only once and for other regions, drought was insignificant.

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