Available online www.jsaer.com

***Journal of Scientific and Engineering Research*, 2018, 5(6):310-315**

Research Article

ISSN: 2394-2630
CODEN(USA): JSERBR

A Study on Drought Situation in Bangladesh by Using IMD Method

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Abstract Rainfall has been extensively considered as one of the initial point towards the apprehension of climate change courses. Bangladesh is recently experiencing climate change impact related to hazards like cyclone, rainfall, flood, draught etc. Climate variable like rainfall is the main parameter which is linked with agricultural aspects too for this country. The data for this study have been extracted from the Bangladesh Meteorological Department (BMD). Data used in this study were collected from 34 rain gauge stations located in different parts of the country for a period of 50 years (1967-2016). The main objective of this study is to examine the drought situation in different regions and all over country. The yearly intensity of drought was also determined using the criteria suggested by Indian Meteorological Department (IMD) which is based on the percentage deviation of rainfall from its long term mean. To analyzed the drought classification as the percentage departure of rainfall from normal for this period. The lowest percentage departure of rainfall are found –44 for South-West region in the year 1972, –38 for East region in the year 1979, –36 for North-West region in the year 1972 and -34 for Central region in the year 1992 respectively. In this study reveal that the mild and moderate droughts are happen at all stations in the different year of the study area. It is expected that the findings of the study will support drought observing and the outcomes will demonstrate lesser precipitation in the future over the Bangladesh.

Keywords rainfall, departure, drought, region, Bangladesh

1. Introduction

Most of the burning issues of our time like global warming, floods, drought, heat waves, soil erosion and many other climatic issues are directly related with rainfall. Agriculture is still the main source of economic activities in the most of the countries of the world and rainfall. In order to increase crop production and protecting crops, human life, ecosystem there is an increasing demand from the policy makers for a reliable prediction of rainfall [1]. Eight South Asian nations- Bangladesh, India, Sri Lanka, Pakistan, Bhutan, Maldives, Nepal and Afghanistan have an economic and political body, the South Asian Association for Regional Cooperation (SAARC). The SAARC region is the most vulnerable to climate change that is seriously affecting agricultural production, diminishing natural resources and limiting development options for the future in this region. The World Bank climate change experts' opinion is that the poorest of the poor in South Asia are the most affected by climate change. The impact of higher temperatures, more extreme weather events such as floods, cyclone, severe drought, and sea level rise are already being felt in South Asia, and will continue to intensify .Climate change is recognized as the greatest long-term threat to the SAARC region [2].

Bangladesh is an agricultural-based country where about 80% of its total people are directly or indirectly engaged in a wide range of agricultural activities. Rainfall is most important factor that determines the agricultural production in Bangladesh. The variability of rainfall and extreme high or low precipitations are very important for agricultural production as well as the economical growth of the country [3]. The Bangladeshi climate is comprised of four seasons: pre-monsoon (March May), monsoon (June–August), post-monsoon (September–November) and winter (December February). The pre-monsoon, monsoon and post-monsoon

seasons are basically the rainy seasons [4]. Monsoon rainfall accounts for approximately 85% of the total rainfall while occurrences of wet days are rare in the dry season. This monsoon rainfall is caused by monsoon depressions in the Bay of Bengal [5]. This makes Bangladesh a highly humid zone with a mean annual rainfall of 2488 mm. The pre-monsoon period is characterized by warm temperatures (27 °C on average) and the occurrence of thunderstorms with rainfall ranging from 15 mm/year in the western central region to more than 80 mm/year in the northeast region. This pre-monsoonal rainfall and thunderstorms are dominated by the moist air from the Bay of Bengal. The effect of the Bay of Bengal coupled with that of the Himalayas creates extremely high rainfall levels during the monsoon season [6-8]. Annual rainfall varies significantly throughout the country with a range of 1270–5000 mm. The inter-annual rainfall is highly variable (coefficient of variation 16–24 %) across the entire country, which they classified into 6 zones based on rainfall variability [9]. High rainfall variability together with low rainfall in the northern part made it "drought prone", whereas the south western coastal region is a comparatively "humid area" with low variability and high rainfall.

Droughts are the result of acute water shortage causing severe and sometimes catastrophic economic and social consequences. Climate variability and droughts are commonly known important stress factors in developing counties like Bangladesh, where rural households have adapted to such factors for decades and in extreme dry regions households have even moved beyond climate dependence. Drought is one of the main problems for many nations, and the severity of such issue goes big when it comes as obstacle to ensure an optimum agricultural production for a country. Drought is being considered as the main cause which hampers the estimated agricultural production, here in Bangladesh over the last few decades. Causes of drought are related to non-availability of surface water resources and climate variability. The direct cause of a shortage of rainfall may be because of one or more factors including large-scale downward air movement within the atmosphere or absence of available moisture in the atmosphere which suppresses rainfall. Variations in such factors involve variations in global, regional and local climate and weather. Every five years, Bangladesh is affected by the major country-wide droughts. However, local droughts occur regularly and affect crop production. The agricultural drought, linked to soil moisture scarcity, occurs at different stages of crop growth, development and reproduction. Monsoon failure often brings famine to the affected regions and as a result crop production reduces drastically. Meteorological Drought assessment is very essential in identifying climate and water supply trends and thus to detect the probability of occurrence and the anticipated severity of drought. Drought occurs when precipitation is lower than normal [10]. The drought condition in Bangladesh in the recent decades had led to a short fall of crop production (Banglapedia, 2010). The biophysical, environmental and health issues were concerning drought occurrence in northwest region of Bangladesh. The analysis revealed that, during the drought period, rainfall as the dominant factor of supplying surface water and normalizing the dryness of the nature was almost 46% lower than the previous years [11].

Drought assessment in Bangladesh is particularly spatial temporal pattern of drought using long-term data. The 0.5°gridded Standard precipitation evapotranspiration index (SPEI) base is seemed to be suitable for the detection, monitoring, and assessment of drought conditions at the regional scale. Moreover, the approach to drought characterisation based on the 0.5°gridded SPEI base calculated for various lag periods provides comprehensive results on the complexity of drought phenomena in Bangladesh [12]. The severity and spatial pattern of meteorological drought are analyzed in the North-Western part of Bangladesh using multi-temporal SPI. The maximum SPI value are found -2.27 for 6 month time scale, the -2.17 for 12 months time scale and -1.85 for 3 months time scale respectively [13]. Mild and moderate drought happen at all stations in the different year of the study area. Severe and extreme drought was mostly found in Rajshahi and Ishwardi locales in the years 1982, 1992, 1994, 1997, 2006, 2000, 2010 and 2012 [14]. It is expected that the findings of the study will support drought observing and the outcomes will demonstrate lesser precipitation in the future over Bangladesh.

2. Data and Methods

In this study, data on rainfall of 34 weather stations in Bangladesh were collected from the Bangladesh Meteorological Department (BMD). The BMD collects everyday surface data through weather stations situated all over Bangladesh. The data for the 50-years period from January 1967 to December 2016 have been used in the present study which is conducted on 34 meteorological stations in Bangladesh. Among them 30 stations

collected data for a period of 50 years during 1967 to 2016 and other 4 stations (Mongla, Chuadanga, Syedpur and Tangail) did so for 28 years during 1989 to 2016. In this study, the missing rainfall values were estimated by expectation maximization (EM) method by using the precipitation records of the nearest gauging stations. A full description of EM algorithm can be found in McLach-lan and Krishnan (1997). The collected data have been compiled, tabulated and analyzed by MS Excel and SPSS.

The yearly intensity of drought was also determined using the criteria suggested by IMD [15] which is based on the percentage deviation of rainfall from its long term mean and it is given by equation 1.

$$D_i = \frac{P_i - \overline{P}}{\overline{P}} \times 100 \text{----------} (1)$$

Where D_i is the percentage deviation from the long-term mean,

P_i is the annual rainfall and

$\overline{P}$ is the long term mean of the annual rainfall

Drought codification based on percentage departure of rainfall from normal is presented in Table 1. The percentage of deviation (D_i) is then used to categories the drought.

Table 1: Drought codification based on percentage departure of rainfall from normal value

Percentage departure of rainfall from normal	Intensity of drought
0.0 or above	No drought
0.0 to - 25.0	Mild drought
-25.0 to - 50.0	Moderate drought
-50.0 to - 75.0	Severe drought
-75.0 or less	Extreme drought

3. Results

Bangladesh enjoys generally a sub-tropical monsoon climate. The climate is controlled primarily by summer and winter winds, and partly by pre-monsoon and post-monsoon circulation. There are four prominent seasons, namely, winter (December to February), Pre-monsoon (March to May), Monsoon (June to early-October), Post-monsoon (late-October to November). It has been divided in four regions: (i) North West Region (NWR) (ii) South West Region (SWR) (iii) Central Region (CR) (iv) East Region (ER). The data were analyzed to investigate the drought situation of NWR, SWR, CR, ER and all over Bangladesh. The analysis and results of the present study on the Bangladesh have been discussed in the subsequent sub sections.

3.1 Drought Situation on North West Region

The drought situation on NWR, histograms are presented in Figure 1. This region records that 24 years were negative departure, 25 years were positive departure and 1 year was neutral. Drought classification based on percentage departure of rainfall from normal value shows that the moderately drought was seen in the years 1967, 1972, and 1994. Otherwise, mild drought years were 1968, 1969, 1970, 1971, 1975, 1980, 1982, 1989, 1992, 1996, 2000, 2006, 2007, 2008, 2009, 2010, 2011, 2012, 2013, 2014 and 2016. The analysis also shows that the years 1982, 1992, 2006, 2010, 2012, 2013, 2014 and 2016 were suffered mild drought to moderate drought situation. The analysis did not show any extremely drought year.

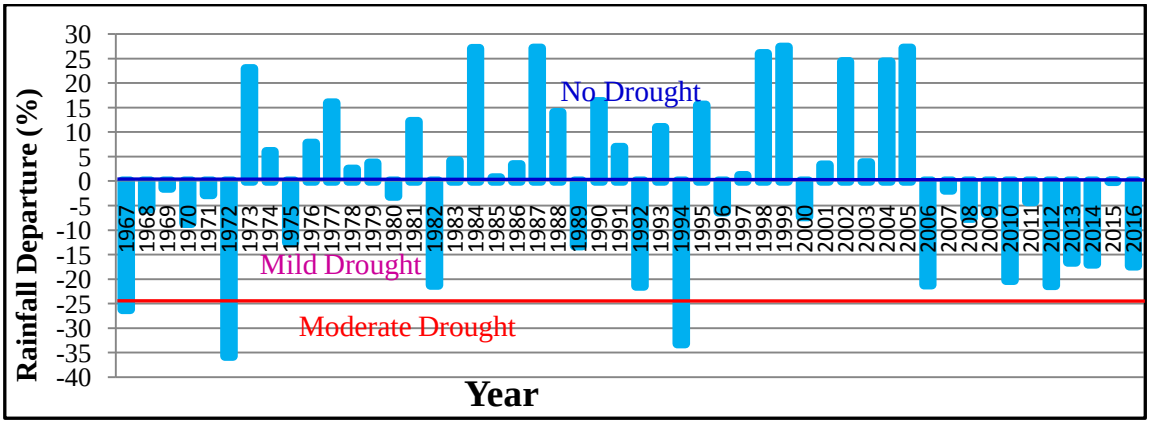

Figure 1: Drought situation on North West region in Bangladesh

3.2 Drought Situation on South West Region

The drought on SWR is shown in figure 2. In this region reveal that 23 years were negative departure and 27 years were positive departure. In the years 1972 and 2014 were faced moderate drought situation. Meanwhile, the years 1967, 1968, 1969, 1970, 1971, 1975, 1976, 1985, 1989, 1992, 1994, 1996, 1997, 2000, 2003, 2006, 2008, 2009, 2010, 2012 and 2014 were suffered from mild drought. The drought situation in this region tended from mild to moderately drought in the years 1967, 1968, 1985, 1989, 1992, 1994, 2010 and 2012.

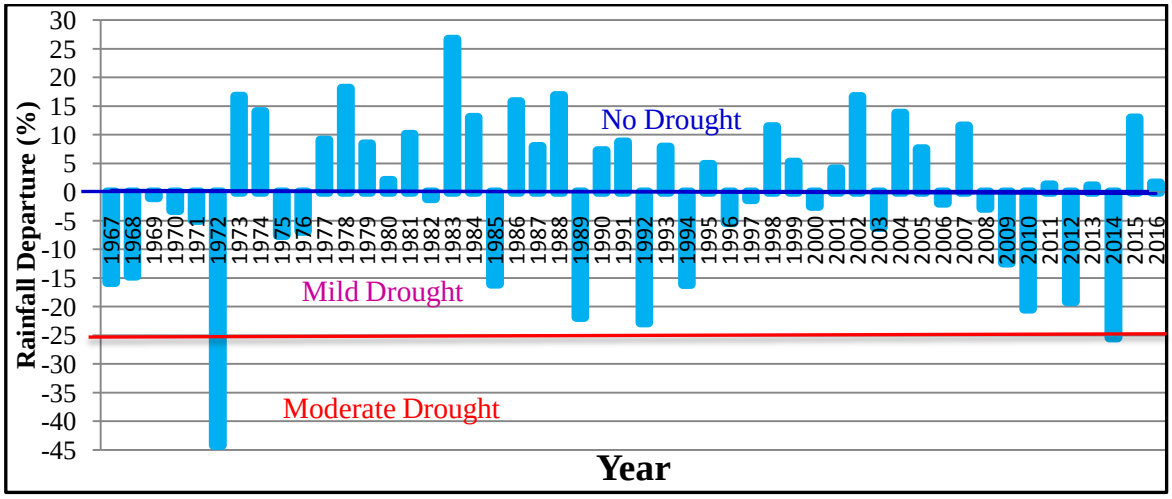

Figure 2: Drought situation on South West region in Bangladesh

3.3 Drought Situation on Central Region

The drought situations on CR are presented in figure 3. In this region found that 25 years were negative departure and 25 years were positive departure. It was observed that the drought situations of this region of fifty percent years were facing no and mild drought respectively. Among last fifty years, the drought situations were faced moderate only one year 1992, mildly faced in the years 1967, 1968, 1972, 1975, 1976, 1978, 1979, 1980, 1985, 1989, 1992, 1994, 1996, 1997, 2001, 2003, 2006, 2008, 2009, 2010, 2011, 2012, 2013, 2014 and 2016. The trends of normal to mild drought situations were found 1967, 1969, 1976, 1980, 1985, 1996, 1997, 2001, 2008 and 2016 years, whereas, mild to moderate drought situations were found 1972, 1975, 1978, 1979, 1989, 1992, 1994, 2003, 2006, 2009, 2010, 2012, 2013, 2014 and 2016 years.

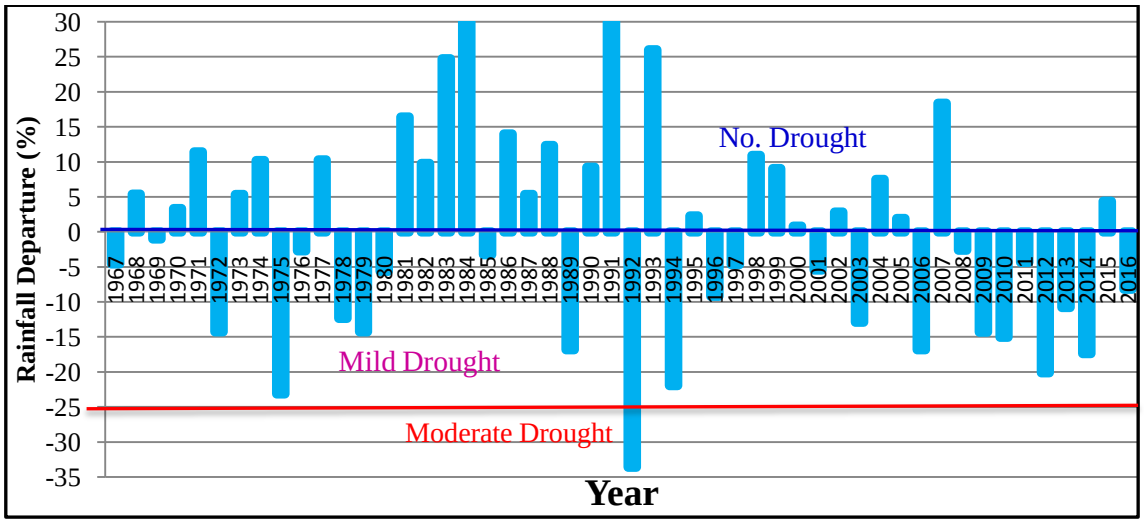

Figure 3: Drought situation on central region in Bangladesh.

3.4 Drought Situation on East Region

The actual drought assessment on ER is shown in figure 4. It was found 22 years were negative departure, 27 years were positive departure and 1 year was neutral. The analyses reveal that the drought situations of majority years were facing normal. The year 1979 and 1980 faced moderately drought situation. The statistics also show that in the years 1967, 1971, 1972, 1975, 1977, 1978, 1981, 1982, 1984, 1985, 1986, 1989, 1992, 1995, 1997,

2005, 2006, 2010, 2014, and 2016 suffered mild drought. The annual drought situation in this region tended from mild to moderate drought in the years 1972, 1985, 1989, 1992, 1994, 1995 and 2014.

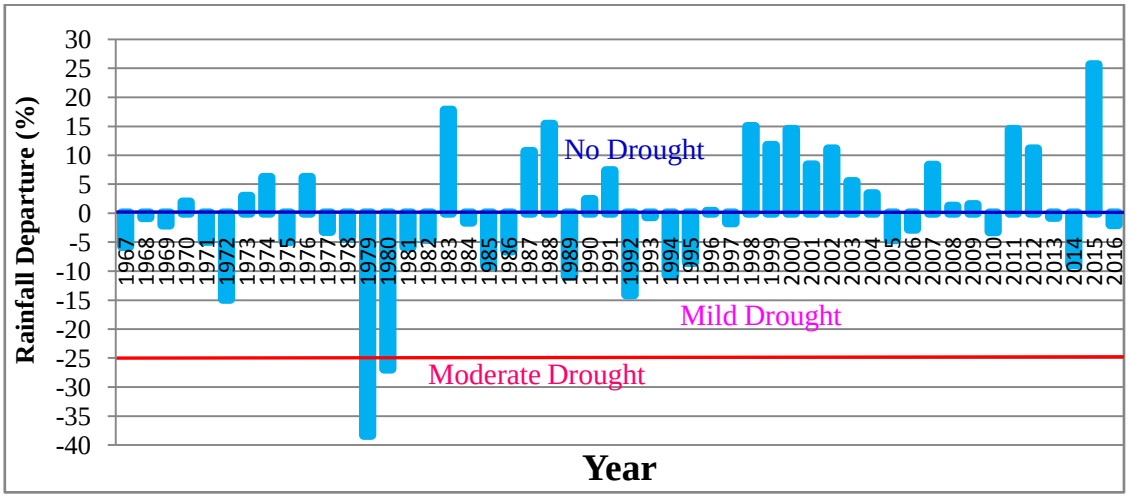

Figure 4: Drought situation of East region in Bangladesh.

3.5 Drought Situation all over Bangladesh

The drought situations all over Bangladesh are presented in figure 5. The drought situations all over country were found 24 years negative departure, 25 years positive departure and 1 year neutral.

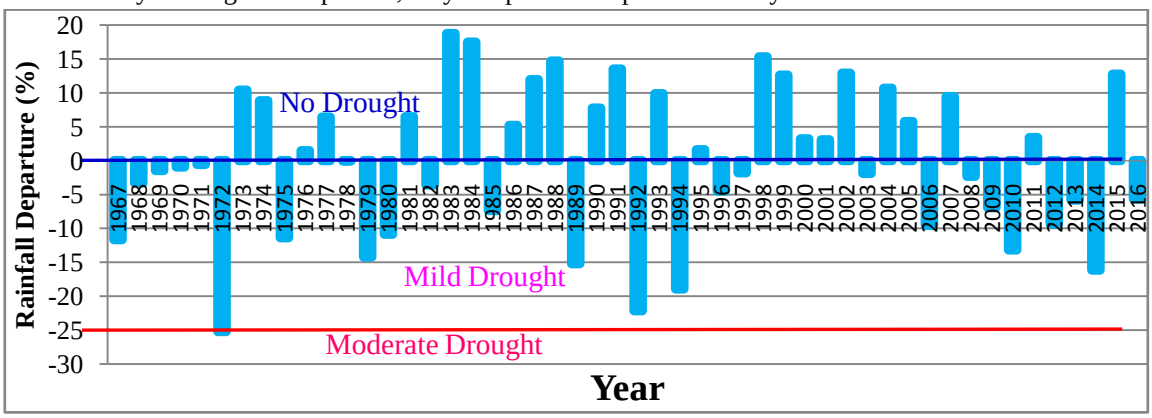

Figure 5: Drought situation of all over Bangladesh.

It was observed that the drought situations of majority years were facing a trend from normal. Among last fifty years, the annual and monsoon faced 1967, 1968, 1969, 1970, 1971, 1975, 1979, 1980, 1982, 1985, 1989, 1992, 1994, 1996, 1997, 2003, 2006, 2008, 2009, 2010, 2012, 2013, 2014 and 2016 mild drought situation; and 1972 faced moderate drought situation. The analysis also shows that the years 1967, 1975, 1979, 1980, 1985, 1989, 1992, 1994, 2006, 2009, 2010, 2012, 2013, 2014 and 2016 suffered from normal to mild drought condition.

4. Discussion and Conclusion

This paper managed to make an appraisal of the meteorological drought for 34 rain gauge stations in Bangladesh for the period 1967–2016 to evaluate the drought cataloguing according to IMD method for this period. The yearly intensity of drought was also determined using the criteria suggested by IMD which is based on the percentage deviation of rainfall from its long term mean. To estimated the drought classification as the percentage departure of rainfall from normal for this period. The lowest percentage departure of rainfall for NWR are found -36 and -33 in the year 1972 and 1994, SWR are found -44 and -25 in the year 1972 and 2014, ER are found -38 and -27 in the year 1979 and 1980 respectively and CR found -34 in the year 1992. Whereas, the IMD values for all over Bangladesh is found -25 in the year 1972. It is observed from this study the mild and moderate drought are occurs most of the station. It is expected that the findings of the study will support drought monitoring and the results indicate lesser precipitation in future over all Bangladesh.

Acknowledgements

We thank the Bangladesh Meteorological Department (BMD) for providing the data which is the authorized government organization for meteorological activities of Bangladesh.

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