COMPARISION OF STANDARDIZE PRECIPITATION INDEX WITH DIFFERENT TIME SCALES IN BANGLADESH

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Abstract— Drought, which is the major issues of today's world have several inverse impacts on economy, society and ecology. The severity of the drought is related to main usage of water and can be expressed in different indexes. These indexes could give different information for the drought analysis and one of them is the Standardized Precipitation Index (SPI).The SPI is the most widely used drought index to provide good estimations about the intensity, enormity and spatial scope of droughts. In this study, the analysis of drought events has been carried out by applying the SPI. The daily rainfall data of 34 different rain gauge stations from different locations of Bangladesh have been selected for the SPI analysis. The data ranges are varied from the year 1948 to 2007. Total monthly rainfalls for all stations are calculated from the daily rainfall data. From monthly precipitation data, the SPI is calculated by using the software 'SPI_SL_6' of National Drought Mitigation Center, Zimbabwe for different time scales. Based on the SPI values, the intensity of drought category is estimated for total data and two periods (1968~1987 and 1988~2007) in different locations of Bangladesh. The investigation has been carried out for diverse cumulative months as 3, 6, 9, 12 and 24. SPI patterns were found to be changed due to change of time scales for available rainfall data. It is observed that with increasing the time scales, the numbers of fluctuating cycles are decreased but the duration of each fluctuating cycle is increased. The numbers of drought events were found higher for mild drought, and the drought numbers were gradually decreased with the severity. The least number of droughts were found to be occurred in extreme category. With decreasing the SPI time scales, the difference in number of drought events between two periods are decreased. The mild and moderate droughts have been increased from period 1 (1968~1987) to period 2 (1988~2007) but extreme droughts are decreased. The total numbers of drought events have been increased in period 2 compared to period 1 in different locations of Bangladesh. It is found that in a station where 30 years rainfall data is not available, 20 years rainfall data can be used for calculating the SPI values to characterize a drought.

Index Terms Drought, extreme droughts, rainfall data, Standardized Precipitation Index.

1 INTRODUCTION

THE Standardized Precipitation Index (SPI) is a tool which was developed primarily for monitoring and defining drought. It allow an analyst to determine the scarcity of a drought at a given time scale (temporal resolution) of interest for any rainfall station with significant data. Standard deviation is often described as the value along a distribution at which the cumulative probability of an event happening is 0.1578. In a like mode, the cumulative probability of any SPI value can be established, and this will be equivalent to the cumulative probability of the corresponding rainfall event. [4] Defined categories of SPI for the drought severity definition is given in Table 1.

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TABLE 1 DROUGHT CATEGORIZATION VALUES

SPI Values	Drought Category
0 to -0.99	Mild Drought
-1.00 to -1.49	Moderate Drought
-1.50 to -1.99	Severe Drought
< -2.00	Extreme Drought

Droughts are one of the world's most severe and collectively affective natural disasters that cause an average $6-8 billion in global damages yearly [9]. The usable water sources consist of soil moisture, groundwater, snow pack, and runoff and reservoir storage. Any drought is directly related with the one or more of these five sources of supply. Some uncertainty has been cast on the effectiveness of solar disinfection the antimicrobial properties of sunlight have been known for a long time but it is only recently that solar radiation has been seriously proposed as a means for decontaminating water. The time scale over which precipitation deficits accumulate becomes extremely important and functionally separates different types of drought. Agricultural (soil moisture) droughts, for example, typically have a much shorter time scale than hydrologic (groundwater, runoff and reservoir storage) droughts [4].The term hydrological drought is applied to less than normal amounts of water in the different types of water bodies, and represented by low water levels in streams, reservoirs, and lakes, as well as groundwater aquifers. Several different indices have been developed to define types of droughts.

These indices have been presented in different studies [2] where most of them (Standardized Precipitation Index (SPI), Standardized Runoff Index (SRI), Surface Humidity Index (SHI)) are separate indices and define one of the previously defined drought types. Among the indices, SPI is the most used one for defining the meteorological drought by using the precipitation data. Low cost, simple and easy to use household treatment methods are suitable for treating water for rural communities. Boiling, chlorination, filtration through granular media and solar disinfection are some of the systems developed for treating water at household level. Boiling and chlorination may not be suitable in rural households due to practical difficulties. Although a lot of works have done on Solar Disinfection throughout the out the world but in Bangladesh very few studies have been done. So, more studies are required on this method to judge its suitability and applicability in Bangladesh the water quality will definitely of Bangladesh will definitely vary with other countries of the world.They concluded that 'using the SPI as a drought monitoring tool will improve the timely identification of emerging drought conditions that can trigger appropriate state and federal actions'. Researchers also compared the monitoring capabilities between the Palmer drought severity index (PDSI) and 3 and 12 month SPIs for the drought of 1983 that occurred in south-eastern Hungary. It was demonstrated that the SPI, with several time scales, is a enhanced tool for detecting the start and end of a drought event [8].[3] compared the SPI calculated at a 0.5° grid across the whole of Europe over time scales of 3 to 24 months with the PDSI. The SPI, in addition, was used for real-time monitoring or retrospective analysis of drought/flood in Argentina [7] Canada[1], Korea [5] and South Africa [6] After evaluating 14 well-known drought indices by using a weighted set of six evaluation criteria, [2]found that the SPI is a valuable estimator of drought brutality. Like other developing countries in Bangladesh providing safe water specially in the southern part of the country is a great challenge. So, solar disinfection can play an important role to meet this challenge-In this study, SPI is worn for the investigation of drought pattern change in different locations of Bangladesh. The goal of this study is to determine the variation of SPI with respect to different time scales (3, 6, 9, 12 and 24-month) and compare the variation in number of drought events with different SPI time scales. Therefore, it is to be expected that researchers would choose to keep the length of precipitation data used in the SPI calculation as long as possible for the station of interest.

2 Procedure for Paper Submission

The daily rainfall data of 34 different rain gauge stations from different location of Bangladesh have been selected for the SPI analysis. The SPI program used in this study (SPI_SL_6) is relatively easy to operate. An input file is prepared with all data for one station in the following format.

Header

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

yyyy mm pppp

etc.

Where Header = a string which describes the file, or something concerning the position, etc

yyyy = year

mm = month (in digit format 1,2,3 etc)

pppp = precipitation multiplied by 100

"etc" is not put in the input file, but more like entries.

The yyyy, mm and pppp may either be separated by space or commas. Missing values are denoted by -9900. Name of this input file is stdin and it is put in the same directory as the SPI agenda. Output would be written to the file stdout (in the same directory) and any error messages would be written to the file sadder. The program runs correctly and there should be nothing written to the sadder file. Some possible causes of error which may cause the program not to be run properly. The precipitation values entered contain decimals after multiplying by 100. The real input precipitation values ought to be integers (after multiplying by 100, that is), so the actual precipitation should not be contained more than 2 decimal places. The input file contains too little values. There should be at least a least amount number of precipitation values for each month. The output of the program is in the following format.

Header

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

yyyy mm spi3 spi6 spi9 spi12 spi24

etc.

Where yyyy and mm are as before

spi3 = SPI for a 3 month rainfall total

spi6 = SPI for a 6 month rainfall total

spi9 = SPI for a 9 month rainfall total

spi12 = SPI for a 12 month rainfall total

spi24 = SPI for a 24 month rainfall total

The program allows calculating SPI for rainfall totals of different time periods. Namely, 3 month, 6 month, 9 month, 12 month and 24 month rainfall total. This allows the forecaster to revise time rainfall events at dissimilar time scales. The time scales are, regrettably stiff coded into the program so they cannot be changed to time scales which we are more familiar with, such as one decade, or one month. The daily rainfall data of 34 different rain gauge stations from different location of Bangladesh have been selected for the SPI analysis. The data ranges were varied from the year 1948 to 2007. Total monthly rainfalls for all stations are calculated from the daily rainfall data. From monthly precipitation data, the SPI was calculated by using the software 'SPI_SL_6' of National Drought Mitigation Center, Zimbabwe for different time scales. From the graphical representation of SPI, the intensity of drought category is calculated for total data and two periods (1968~1987 and 1988~2007) in different locations of Bangladesh. The steps of the methodology are shown in the flow chart given in Figure 1

Figure 1 Flow chart showing the steps of the works

3RESULTS & DISCUSSIONS

Normally, 1-3 month(s) SPI values show the effect on agricultural applications; 6-12 months SPI show the drought on reservoirs' levels and on river discharges; and 12-24 months SPI generally shows the effect on groundwater table and groundwater recharge. Fig. 2 shows the 3-months SPI pattern for the Rajshahi station for precipitation data 1964-2007. It can be seen that the dry and wet periods generally continue from 3 to 4 months and after that the graph goes to the inverse direction. In some years, the fluctuation continues up to 10-12 months. From the graphical representation of SPI, it is clear that different category droughts have occurred in various years.

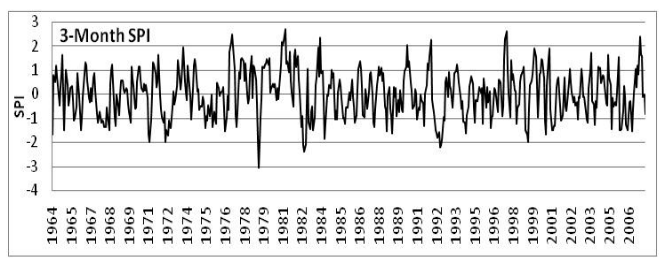

Fig. 2 Variation of SPI values for 3-month time scales for total period (Rajshahi station)

Frequencies of different category droughts are shown in figure [2&3] for different time scales of 3, 6, 9, 12 and 24 months SPI respectively for different rain gauge stations of Bangladesh. The maximum drought events are found to be occurred in Faridpur (362 events) for 3 month SPI. Other top 4 drought affected areas in descending order are Bogra, Jossore, Khulna and Satkhira. Analysis shows that in Faridpur, drought events are occured on an average 6.14 months per year. Among 362 total drought events, 67% are found mild drought, 23% moderate drought, 7% severe drought and 3% extreme drought. From these tables it can be seen that mild droughts occur more times than other category of droughts and extreme drought occurs in least numbers. That means, the severity of drought is in reverse order with number of drought events.

Similar phenomenon is also observed for other stations as

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well.

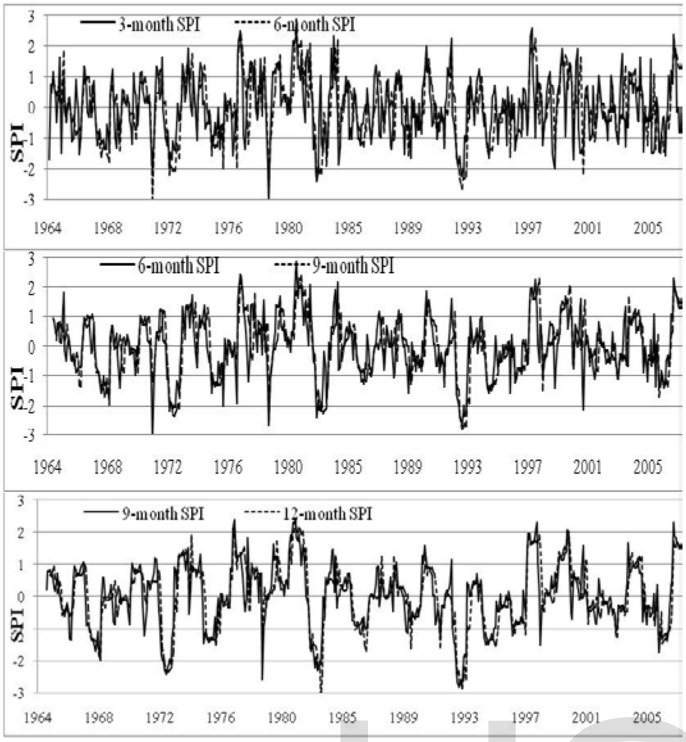

Fig. 3 Variation of SPI pattern with different time scales for total period in Rajshahi station.

Comparison of different category droughts for 6-month SPI in different stations of Bangladesh for two periods is shown below as bar chart (Figures 4 to 8). From these figures, it can be seen that the number of mild and moderate droughts are increased both in 74% station, severe droughts are increased in 82% stations, and total droughts are increased in 78% stations from period 1(1968~1987) to period 2 (1988~2007). However, extreme droughts are found to be decreased in 74% station. Although droughts in different categories are increased, the extreme droughts are found to be decreased in period 2. On the whole, it can be concluded that the total number of drought events has been increased in period 2 compared to period 1 in most of the locations of Bangladesh.

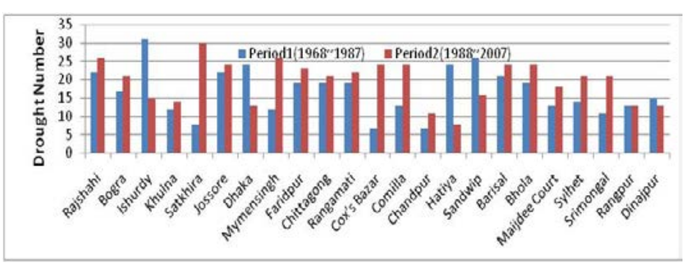

Figure 4: Comparison of number of mild droughts (6-month SPI) in different station for two periods

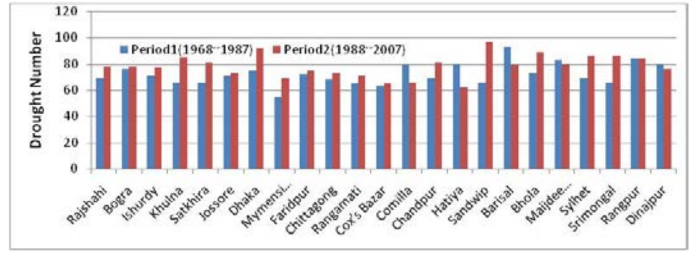

Figure 5: Comparison of number of moderate droughts (6-month SPI) in different station for two periods

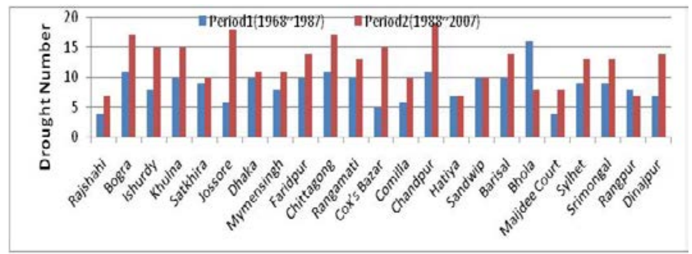

Figure 6: Comparison of number of severe droughts (6-month SPI) in different station for two periods

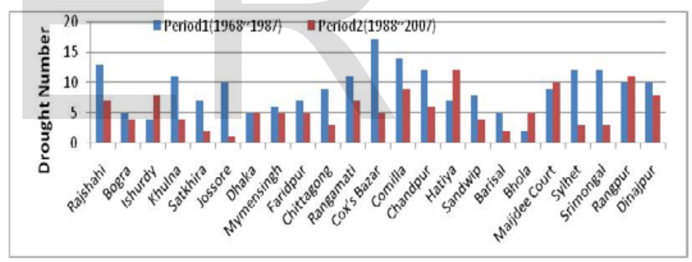

Figure 7: Comparison of number of extreme droughts (6-month SPI) in different station for two periods

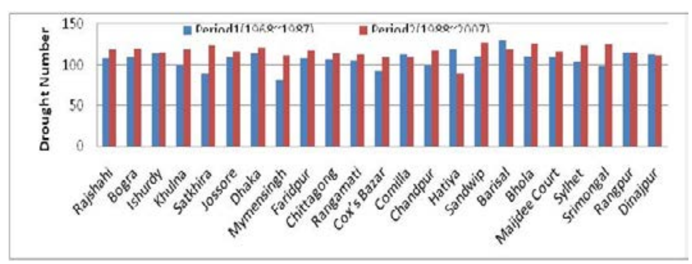

Figure 8: Comparison of number of total droughts (6-month SPI) in different station for two periods

4 CONCLUSIONS AND RECOMMENDATIONS

In this study, meteorological drought analysis has been carried out with monthly precipitation data for the period of 1948-2007. The period was divided into two separate periods as

1968~1987 and 1988-2007. The change in drought pattern between two periods was identified. Based on the analysis, following conclusions can be made.SPI pattern were found to be changed due to change of time scales for available rainfall data. It is observed that with increasing the time scales, the numbers of fluctuating cycles are decreased but the duration of each fluctuating cycle is increased. The numbers of drought events were found higher for mild drought and the drought numbers were gradually decreased with the severity. With decreasing the SPI time scales, the difference in number of drought events between two periods are decreased. The mild and moderate droughts have been increased from period 1(1968~1987) to period 2 (1988~2007) but extreme droughts are decreased. The total numbers of drought events have been increased in period 2 compared to period 1 in different locations of Bangladesh.In a station where 30 years rainfall data is not available, 20 years rainfall data can be used for calculating the SPI values to characterize a drought. The calculated SPI pattern can be compared with the ground water table fluctuations and the applicability of SPI in predicting ground water fluctuation can be examined.

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