Use of Southern Oscillation Index for the Prediction of Flood and Drought in Bangladesh

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Abstract

Bangladesh is the heart of the Monsoon system. Analysis of rainfall and flood data from 1940-1990 have shown that severe flooding in Bangladesh occurs during La Niña period and severe drought occurs during El Niño period. This result has been used in the real forecast of floods and droughts since 1997. This has enabled the Government in formulating appropriate crop policy and averting major natural disasters saving many lives and a lot a property. This paper gives the necessary illustrations.

Advance Prediction of Climate of a country/region is desirable from various economic considerations especially in the field of Agriculture as the farmers can take appropriate measures to plan and protect their crops in the light of advance information on climate. The research conducted by the author while he was an Associate of the Abdus Salam International Centre for Theoretical Physics (ICTP) has made it possible in the case of Bangladesh. The results were presented by the author under the title Bangladesh Floods, Cyclones and ENSO in the International Conference on Monsoon Variability and Prediction held at the Abdus Salam ICTP during 9-13, May, 1994 sponsored by ICTP and WMO. The proceedings have been published as WCRP-84 and WMO/TD-No. 619 (1994)[(1)]. The paper found a strong correlation between the Southern Oscillation Index (SOI) and the Bangladesh rainfall. Southern Oscillation Index (SOI) is a measure of the pressure difference between the eastern Pacific Ocean and the western Pacific Ocean and actually pressure anomaly difference between Tahiti Island in the Eastern Pacific and Darwin city of Australia is taken in the Western Pacific for its actual measurement. Fig 1 shows the Southern Oscillation Index (SOI) for the years 1951-1991. When SOI is strongly negative, the situation is known as El Niño and when the SOI is strongly positive, the situation is known as La-Nina. The paper has shown by taking hydrological data of Bangladesh rivers and the SOI index from 1951-1991 that and El Niño situation favours less rainfall in Bangladesh with the chances of drought and strong La-Nina could herald devastating floods. This is shown in Fig 2 and Fig 3. This follows from the findings of Sir Gilbert Walker who was the Director General of India

Meteorological Department in the beginning of the twentieth century that when pressure is high in the Pacific Ocean, it tends to be low in the Indian Ocean from Africa to Australia[2]. This circulation has been named after him as the Walker Circulation. A schematic diagram of the ENSO circulation is shown in Fig-4. El Niño and SOI are sometime jointly called ENSO because of their interconnection. Fig 5 shows SOI values for the years 1997-2002.

In the Pacific ocean the highest temperature region shifts with the SOI values. When the SOI value is very high (LaNiña condition) the highest temperature region stays close to the Asian continent and when SOI value is highly negative (El Niño condition) the highest temperature region shifts close to the South American continent. These two contrasting situations are shown in figures 6 and 7 respectively. The highest temperature zones are shown in red colour in these figures.

Actually the term El Niño which means the young Christ in the Spanish Language originated in Peru. The Peruvians observed that in every few years during the Christmas time, there is sudden rise in the sea temperature near the coast of Peru resulting in serious loss of their fish industry. As a result of rise in the coastal sea surface temperature, the wind direction reverses and upwelling of sea water stops and there is thus no supply of nutrients in the surface water. The fishes deprived of the nutrients either die or migrate elsewhere. This is the cause of loss in the fish industry.

There are a few different methods of how to calculate the SOI. The method used by the Australian Bureau of Meteorology is the Troup SOI which is the standardised anomaly of the Mean Sea Level Pressure difference between Tahiti and Darwin. It is calculated as follows:

$$SOI = 10 \, \frac{[\,Pdiff - Pdiffav\,]}{SD(Pdiff)}$$

where

Pdiff = (average Tahiti MSLP for the month) - (average Darwin MSLP for the month),

Pdiffav = long term average of Pdiff for the month in question, and

SD(Pdiff) = long term standard deviation of Pdiff for the month in question.

A study taking the rainfall data for the years 1950-1992 showed that there is a significant reduction of rainfall in all the seasons in Bangladesh during El Niño years, which is statistically significant[3]. Some interesting features have come out with regard to a connection between ENSO and floods in Bangladesh. The most catastrophic floods in recent years in Bangladesh occurred in 1954, 1955, 1974, 1987, 1988, 1998 and 2004. The years 1954, 1955 and 1988 are years with highly positive ENSO index whereas 1974 and 1987 are years of continuing El-Nino years, the main El Nino occurred in the previous years and in these years negative anomaly were not that strong. Let us note the major El Nino years in this period. These are 1951, 1957, 1972, 1976, 1982, 1986 and 2006. In these years, there was no catastrophic flooding in Bangladesh. Thus we can conclude that during major El Nino years at least during the first year of El Nino, Bangladesh can be spared from catastrophic floods. The years 1963, 1965 and 1969 were moderate or weak El Nino years and in those years there were moderate floods in Bangladesh. Thus we conclude that during highly positive or weak ENSO (positive and negative) years, Bangladesh can be a victim of flood. The year when SOI index is usually highly positive during monsoon months, floods can be severe whereas when SOI index is strongly negative there can be scarcity of rainfall and even drought.

Taking the research results into practical applications, the author had successfully made early prediction of the climate in Bangladesh during 1997-2001 and the research results have been vindicated. For example, the devastating monsoon floods in Bangladesh in 1998 was predicted by the author well in advance, which enabled the Govt. to take appropriate measures and tackle the situation[4]. During 1998 the SOI started rising sharply from a highly negative value to a highly positive value starting from May 1998 and continued to maintain very high positive value all through the monsoon and the author used this information in his prediction. The year 1997 was an El Niño year and the author has used this information to predict drought in that year which was again materialised and accordingly the Govt. advised the farmers to use irrigation instead of depending on rainfall[5]. This averted great crops loss which otherwise could have caused a famine. It may be mentioned that the years 1769 and 1943 were El Niño Years when millions of people died in the great famines in the then undivided Bengal. There could have been serious crop losses due to drought in those El Niño years.

During the years 1999-2000, SOI maintained moderate values during monsoon and there was normal weather during these years in Bangladesh though during Sept. – Oct., 2000, SOI rose sharply and there was some flooding in West Bengal of India and south-western Bangladesh.

This is how research conducted by the author is being used to advise Bangladesh Govt. in its various policy issues specially in achieving food security and saving millions of human lives. It may be mentioned that from a food deficit country, Bangladesh has assumed self sufficiency in food recently and the method developed by the author to make advanced prediction of Climate in Bangladesh has definitely contributed in this. An evaluation of this situation has been given in the News from International Centre for Theoretical Physics (ICTP) # 99 Winter 2002[6].

An Interesting study[7] was carried out in the case of Bangladesh showing the relation of Percentage Growth Rate of GDP and natural hazards. Table 1 shows the percentage growth rate of GDP at constant market price. Table 2 shows the years of lesser growth rate and disaster associations. It is shown that the lesser growth rate is in general associated with Flood or Drought or El Niño/ LaNiña Phenomena. As El Niño is associated with drought and LaNiña is associated with floods in Bangladesh, it is likely that either of these extreme values of SOI will cause a lesser growth rate in Bangladesh.

The streamlines sketched at 200 mb level[8] (Fig-8) shows that there is a strong divergence of motion at a point close to the Bangladesh coast indicating that there must be a convergence of motion at the same place at the lower atmosphere. This may explain why there is a strong correlation of Bangladesh rainfall with ENSO phenomenon.

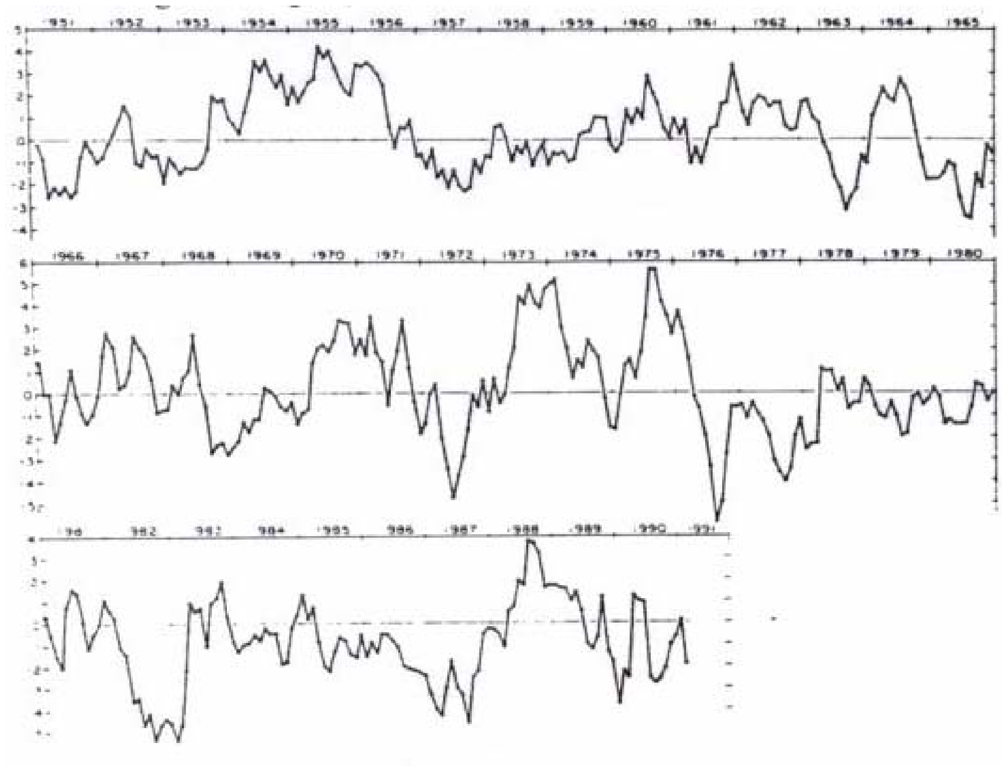

Fig. 1: Diagram showing the Southern Oscillation Index (SOI) for the years 1950-1991

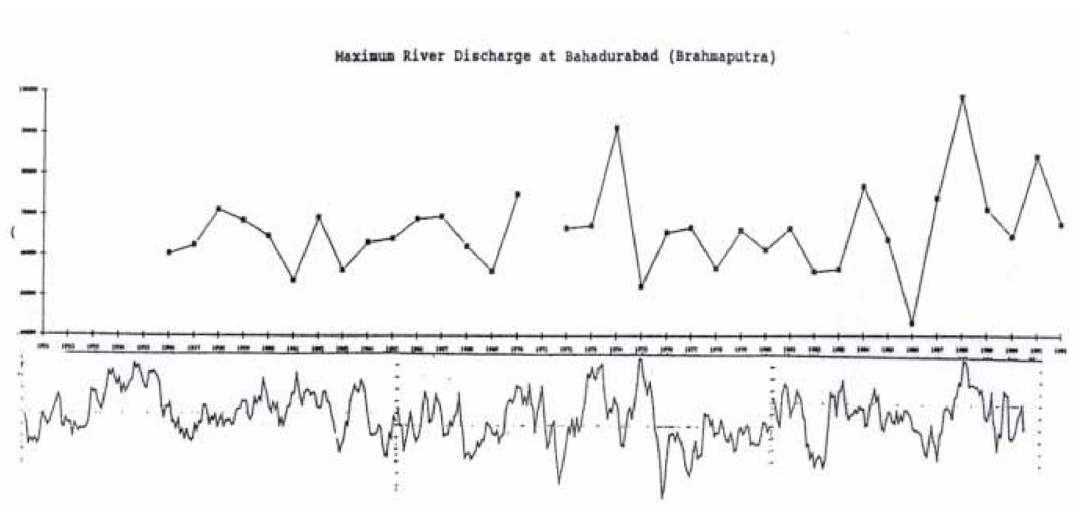

Fig. 2: The diagram showing the correlation of the maximum discharge at Bahadurabad (Brahmaputra river) with SOI for the period 1951-1991.

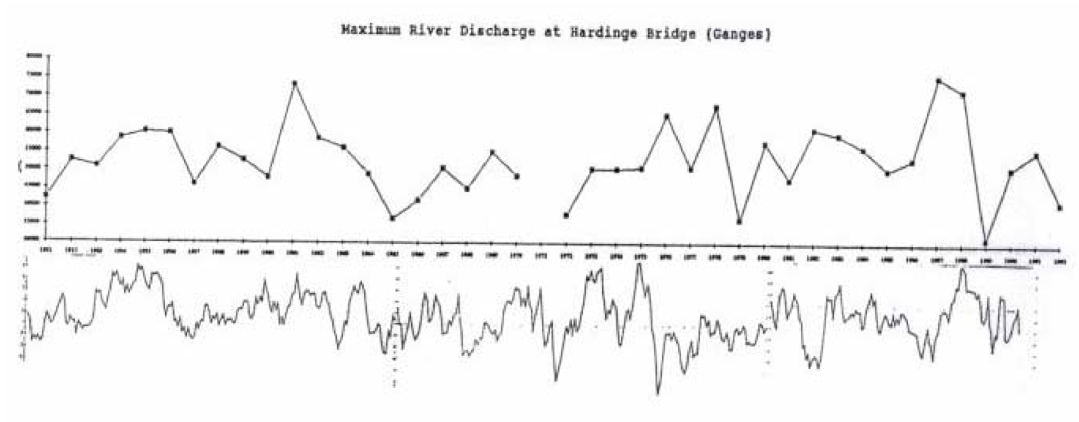

Fig. 3. The diagram showing the correlation between the maximum discharge at Hardinge Bridge (Ganges river) for the period 1951-1991.

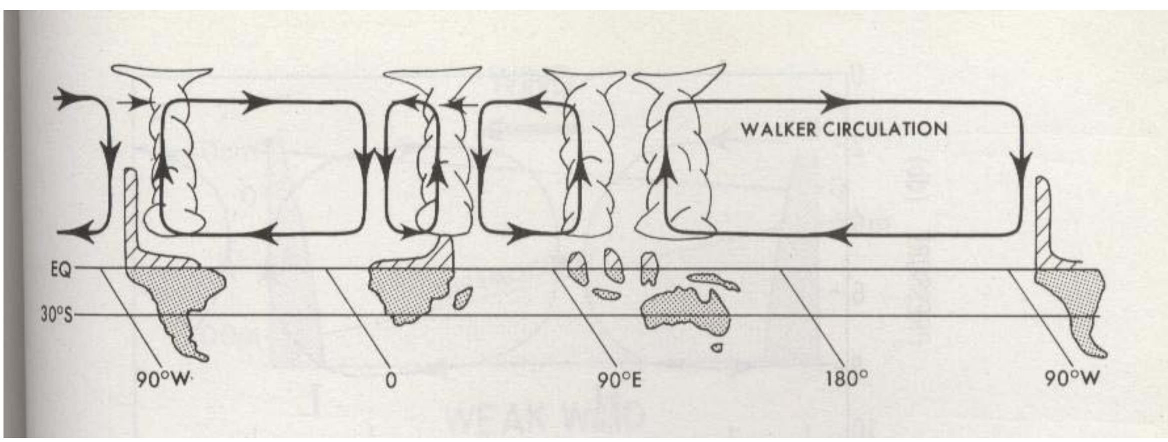

Fig-4: Schematic diagram of the normal Walker circulation along the equator during LANINA condition. Rising are and heavy rains tend to occur over Indonesia and the western Pacific and extends upto Bangladesh. During an El-Nino condition, the Walker circulation is weakened and rainfall over our region diminishes.

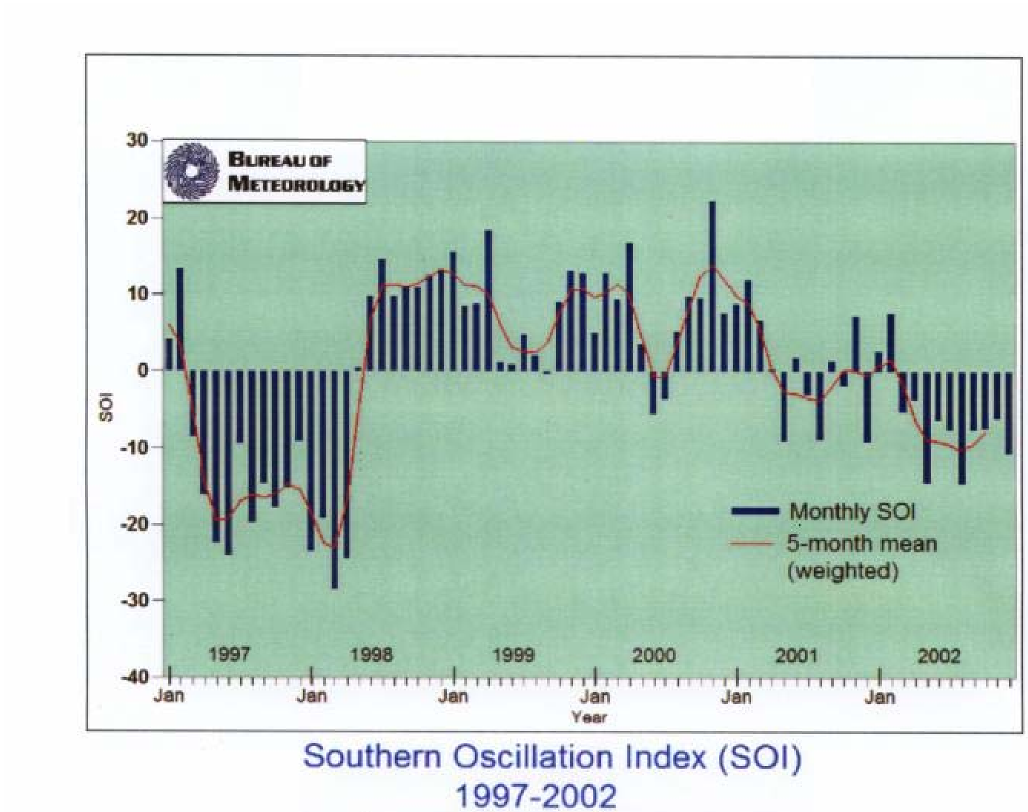

Fig 5

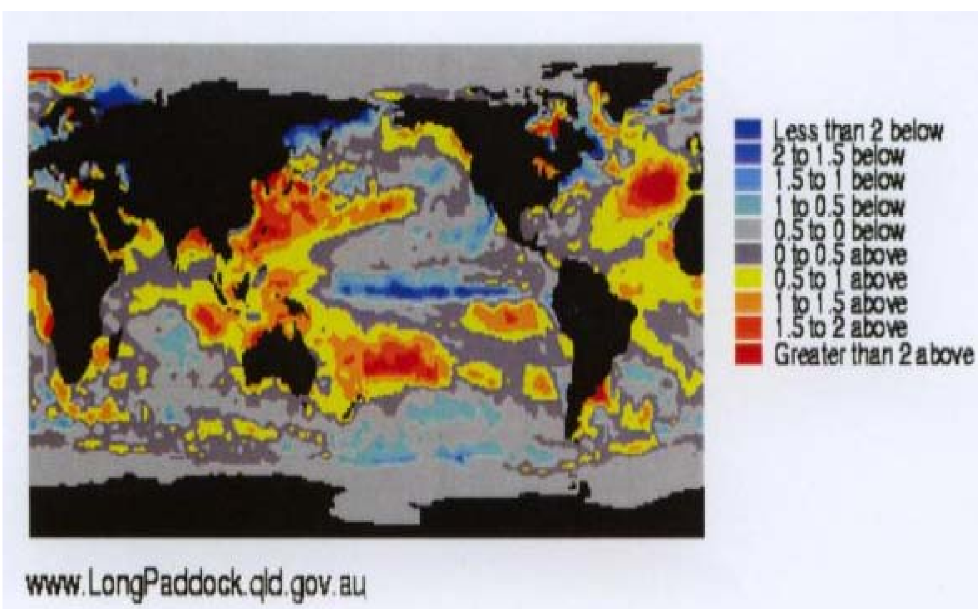

Fig 6 : Variation of Sea-surface Temperature from Average of November 1998

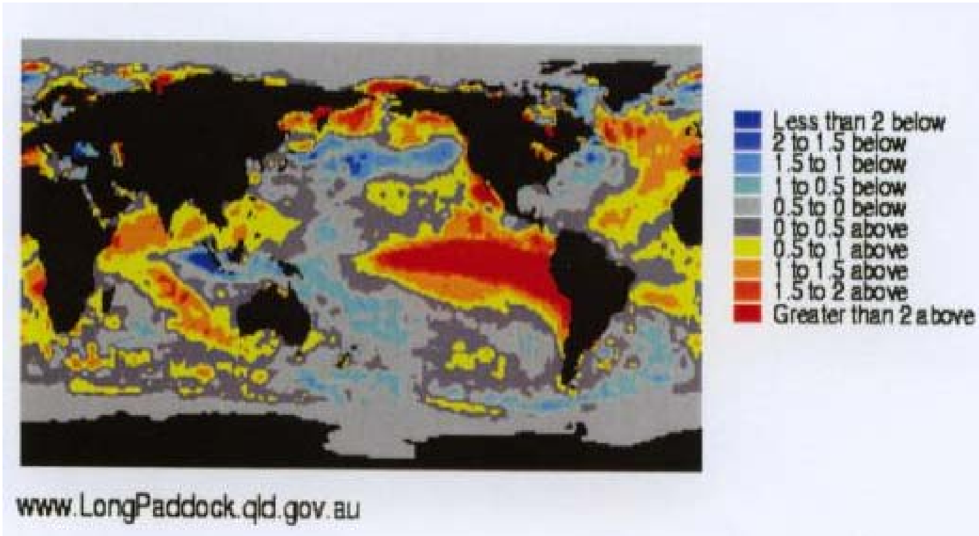

Fig 7: Variation of Sea-surface Temperature from Average of October 1997

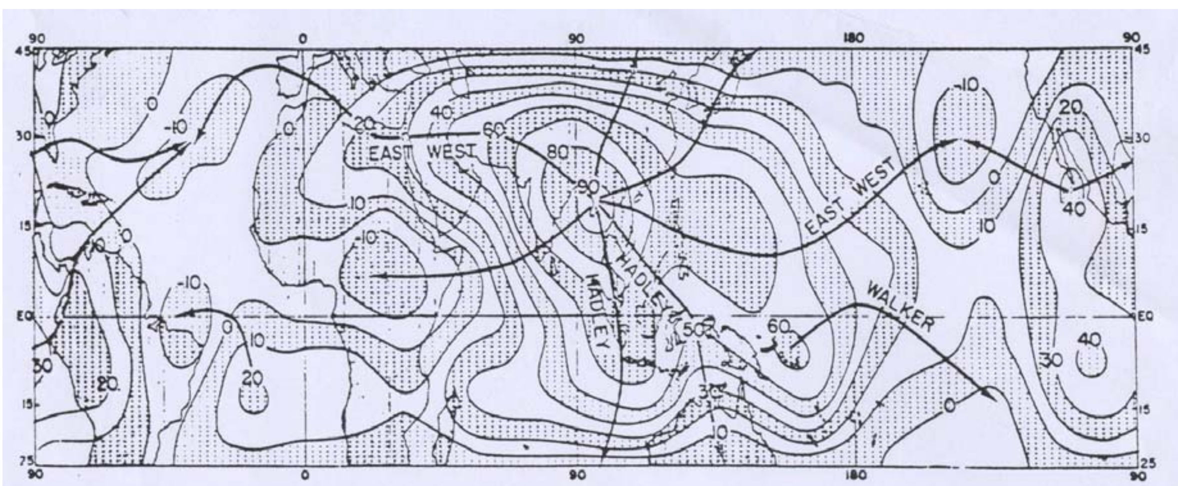

Fig 8 : The streamlines sketched indicate the direction of the mean divergence motions

Table-1

Year	Percentage Growth Rate of GDP at Constant Market Price
1973-1974	11.6
1974-1975	3.5
1975-1976	9.6
1976-1977	1.6
1977-1978	6.9
1978-1979	4.3
1979-1980	1.2
1980-1981	6.2
1981-1982	1.4
1982-1983	3.4
1983-1984	4.2
1984-1985	3.9
1985-1986	4.4
1986-1987	3.9
1987-1988	2.9
1988-1989	2.5
1989-1990	6.6
1990-1991	3.4
1991-1992	4.2
1992-1993	4.5
1993-1994	4.6

Table-2

Years of Lesser Growth Rate and Disaster Associations

Year	Growth Rate	Disaster
1974-1975	3.5	Flood
1976-1977	1.6	Elnino
1979-1980	1.2	Drought
1981-1982	1.4	Elnino
1984-1985	3.9	Flood
1987-1988	2.9	Elnino/Flood
1988-1989	2.5	Lanina/Flood/Drought
1990-1991	3.4	Cyclone

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