Mausam, (1996), **47**, 2, 157-162

551.513.7 : 551.526.6 : 551.577.3 (549.3)

El-Nino southern oscillation and rainfall variation over Bangladesh

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(Received 28 December 1994, Modified 10 July 1995)

सार — बांग्लादेश में वर्षा में परिवर्तिता की जाँच करने तथा एल नीनो दक्षिणावर्त दोलन (इ०एन०एस०ओ०) के साथ संभाव्य सहसंबंध का पता लगाने का इस अध्ययन में प्रयास किया गया है। इस उद्देश्य के लिए चार भिन्न जलवायु क्षेत्रों से चार केन्द्र, नामतः, जैसोर, ढाका, बारीसाल और श्रीमंगल लिए गए हैं। क्षेत्रों का वर्गीकरण वार्षिक वर्षा की मात्रा के अनुसार किया गया है। इसमें वर्षा के 43 वर्षों (1950-92) के आँकड़ों का विश्लेषण किया गया है। एनसो घटना के साथ वार्षिक औसत वर्षा को सुस्पष्ट नकारात्मक (ह्रासमान) प्रवृत्ति का पता चलता है। वर्षा ऋतु की वर्षा का विश्लेषण कुछ बेहतर सहसंबंध दर्शाता है।

ABSTRACT. In the present study, an attempt has been made to examine the variations of rainfall over Bangladesh and to find possible correlation with El-Nino/Southern Oscillation (ENSO). Four stations have been chosen from four different climatic regions of Bangladesh for this purpose, namely; Jessore, Dhaka, Barisal and Srimangal. The regions have been classified according to annual rainfall amounts. The rainfall data for forty three years (1950-1992) have been analysed. The yearly mean rainfall shows a distinct negative (decreasing) tendency with the occurrence of ENSO. The seasonal rainfall analysis shows a somewhat better correlation.

Key words — El-Nino Southern Oscillation, Rainfall variation, Decreasing tendency, Negative correlation, Tropical cyclones, Bay of Bengal, Standard deviation.

1. Introduction

The oceanographic phenomenon of El-Nino which comprises mainly of a large catastrophic flux of warm water of most eastern and central tropical Pacific and south American coast and the Southern Oscillation, an atmospheric event of a sea-saw of surface pressure between the southeast Pacific high pressure zone and the north Australian-Indonesian low pressure zone, have been known quite early in the century (Walker and Bliss 1932). These two inter-related events are now termed El-Nino Southern Oscillation (ENSO) and a considerable amount of work has been done on the theories [Barnet (1977), Cane (1983), Philander (1983)] to fit the events which are essentially modelled on a coupling between the atmosphere and the oceans. ENSO is the most important of short term fluctuations of the tropical circulation and various meteorological variables in the tropics would possibly have correlation with this phenomenon. Different workers have been working on the basis of this assumption.

Gray (1984), working on hurricane activity in the north Atlantic found a significant reduction of hurricane activities during the year following El-Nino events in both areas. This idea was modified by Dong (1988) who suggested that typhoon activity is suppressed by the ENSO event. Similar results were found in the Australian region cyclones by Nichols (1979a, 1984).

Sikka (1980) was the first to suggest that during El-Nino years Indian monsoon performs below

normal. Mandal (1989) found a negative correlation with tropical cyclones over the Bay of Bengal and a correlation of the ENSO events with rainfall deficit over India and Bangladesh during 1951-87. Gupta and Mathuchami (1991) studied the tracks of Bay of Bengal cyclones during post-monsoon seasons during 1902-87 and found a reduction of storm numbers and also a strong tendency of recurvature of the cyclone tracks south of 17°N during El-Nino years.

Choudhury (1992) proposed that a study of the ENSO phenomenon might lead to do a way of predicting the trend of weather and climate over Bangladesh. Chowdhury *et al.* (1992) also indicated a relation of ENSO with deficit rain over Bangladesh.

In the present work a detailed study of rainfall for a period of forty-three years (1950-92) over different climatological regions of Bangladesh have been made in order to find possible correlations with the occurrence of ENSO.

2. Source of data

The rainfall over different stations of Bangladesh from 1950-92 were collected from Bangladesh Meteorological Department, Dhaka. The years of occurrence of El-Nino upto 1987 have been taken from Mandal (1989) and indications of recent events were obtained from the Monthly Ocean Reports, El-Nino Monitoring Centre, Japan Meteorological Agency.

3. Method of analysis

The work has been done in two phases. At first, four stations have been selected from four climatic zones of Bangladesh, classified according to total annual rainfall as follows.

(*i*) Lowest rainfall (<1200 mm) — Jessore, Rajshahi etc.

(*ii*) 1200-1500 mm rainfall — Dhaka, Mymensingh etc.

(*iii*) 1500-1800 mm rainfall — Barisal, Comilla etc.

(*iv*) >1800 mm rainfall — Srimangal, Sylhet etc.

The stations selected were respectively (*i*) Jessore, (*ii*) Dhaka, (*iii*) Barisal, and (*iv*) Srimangal for

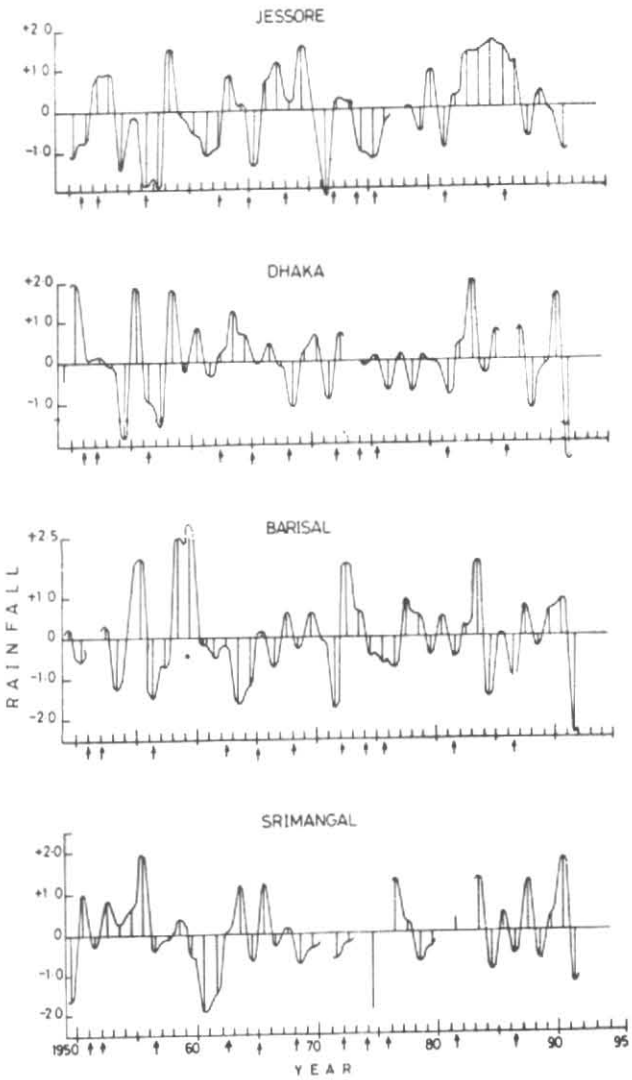

Fig. 1. Time series plots of yearly rainfall

TABLE 1

The study of yearly rainfall

Name of station	No. of El-Nino years accounted (1950-92)	Negative* or decreasing tendency events	Positive* or increasing tendency events	Zero or* small variation tendency events
Jessore	10	70	30	0
Dhaka	9	67	22	11
Barisal	9	67	22	11
Srimangal	9	67	22	11

* % of total El-Nino years.

TABLE 2

The study of seasonal rainfall

Name of station	No. of El-Nino years (1950-92)	Negative* or decreasing tendency events	Positive* or increasing tendency events	Zero or* small variation tendency events
		Pre-monsoon rainfall variation		
Jessore	10	50	30	20
Dhaka	9	78	22	0
Barisal	10	60	30	10
Srimangal	10	70	20	10
		Monsoon rainfall variation		
Jessore	10	80	30	20
Dhaka	8	38	50	13
Barisal	10	60	40	0
Srimangal	9	67	33	0
		Post-monsoon rainfall variation		
Jessore	10	60	40	0
Dhaka	9	78	22	0
Barisal	10	70	30	0
Srimangal	10	80	10	10
		Winter rainfall variation		
Jessore	10	80	20	0
Dhaka	9	67	22	11
Barisal	10	90	10	0
Srimangal	9	56	44	0

* % of total El-Nino years.

having the best relatively continuous set of data.

In the first phase, the total yearly rainfall data of these stations have been examined in a time series plot (Fig. 1). In the second phase the rainfall of the above four sub zones have been studied by season by season, *e.g.*, pre-monsoon (March-May), monsoon (June-September), post-monsoon (October-November) and winter (December-February) taking the mean of the various seasons separately for every year and making the time series plot.

In the time series analysis all the data are converted into normlized form. The mean values for 43 years (1950-1992) of the different stations are first determined and the standard deviations are calculted. The deviation from the mean of each reading divided by the standard deviation (σ) is taken as the normalized value. This is then plotted with respect to give time series graph. The year where data for several months are missing is omitted from the yearly graph.

4. Results and discussion

The time series graph of yearly rainfall (Fig. 1) of four stations for the 43 years period (1950-92) showed negative or decreasing tendency during ENSO events for 70% of the events at Jessore and for 67% of the events at Dhaka, Barisal and Srimangal. There is an increasing tendency for 30% of the events at Jessore and for 22% of the events at Dhaka, Barisal & Srimangal (Table 1).

In a similar fashion, the time series graphs of mean rainfall of the different seasons, namely, pre-monsoon, monsoon, post-monsoon and winter of the four stations have been also separately studied.

(*i*) *Pre-monsoon period*--There is a decreasing (negative) tendency at Jessore, Dhaka, Barisal and Srimangal respectively for 50%, 78%, 60% and 70% of the events and positive variations for 30%, 22%, 30% and 20% of the events.

(*ii*) *Monsoon period*—There is a negative (decreasing) tendency for Jessore, Dhaka, Barisal and Srimangal respectively for 80%, 38%, 60% and 67% of the time and positive variations are 20%, 50%, 40% and 33% of the time.

(*iii*) *Post-monsoon period*--There are decreases in rainfall for Jessore, Dhaka, Barisal and Srimangal respectively for 60%, 78%, 70% and 80% of the time and positive variations for 40%, 22%, 30% & 10% of the time.

(*iv*) *Winter period*—During this low rainfall period, the mean rainfall at Jessore, Dhaka, Barisal & Srimangal respectively showed a decrease for 80%, 67%, 90% & 56% of the time with El-Nino and increase for 20%, 22%, 10% & 44% of the time. All these have been summarized in Table 2.

TABLE 3 (a)

Study of mean rainfall anomaly

(a) Yearly rainfall

El-Nino year (−1)	Yearly rainfall anomaly				El-Nino year	Yearly rainfall anomaly				El-Nino year (−1)	Yearly rainfall anomaly			
	Jessore	Dhaka	Barisal	Sri-mangal		Jessore	Dhaka	Barisal	Sri-mangal		Jessore	Dhaka	Barisal	Sri-mangal
1950	73.46	—	101.93	−485.66	1951	−315.54	—	−238.07	355.33	1952	−190.54	—	—	−62.66
1952	−190.54	—	—	−62.66	1953	315.46	−147.27	122.93	312.33	1954	333.46	251.73	−554.07	119.33
1956	13.46	411.73	864.93	678.33	1957	−566.54	−527.27	−632.07	−90.66	1958	−615.54	−710.27	−333.07	15.33
1962	−324.54	−295.27	−200.07	−434.66	1963	−258.54	−109.27	−79.07	42.33	1964	349.46	229.73	−719.07	425.33
1964	309.46	229.73	−719.07	425.33	1965	94.46	35.73	−492.07	−189.66	1966	−393.54	−166.27	60.93	447.33
1968	449.46	−186.27	290.93	71.33	1969	115.46	−541.27	−73.07	−225.66	1970	562.46	−86.27	278.93	−90.66
1971	—	391.73	21.93	—	1972	657.54	−273.27	−725.07	−422.60	1973	135.46	387.73	739.93	−147.60
1974	94.46	—	237.93	—	1975	−302.54	63.73	−234.07	−884.66	1976	−366.54	156.73	−290.07	1026.33
1975	−302.54	63.73	−234.07	−884.60	1976	−366.54	156.73	−290.07	—	1977	−45.54	−220.27	−280.07	415.33
1981	206.46	87.73	184.33	−53.66	1982	−268.54	−272.27	−274.07	−35.66	1983	126.46	283.73	48.93	601.33
1986	553.46	397.73	−27.67	122.33	1987	513.46	104.73	−487.07	−358.66	1988	259.46	396.73	226.93	494.33
Mean	92.26	137.60	52.23	19.14		−34.70	−150.90	−309.30	−42.84		10.46	52.33	−82.07	294.87

TABLE 3 (b)

(b) Mean yearly rainfall anomalies for 4 stations

El-Nino year (−1)	Mean of rainfall anomalies for 4 stations	El-Nino year	Mean of rainfall anomalies for 4 stations	El-Nino year (−1)	Mean of rainfall anomalies for 4 stations
1950	−103.42	1951	−66.09	1952	−126.60
1952	−126.60	1953	150.86	1954	37.61
1956	492.11	1957	−454.13	1958	−407.05
1962	−313.63	1963	−101.13	1964	71.36
1964	61.36	1965	−137.88	1966	−12.88
1968	156.36	1969	−181.13	1970	166.11
1971	206.83	1972	−190.85	1973	278.88
1974	166.19	1975	−339.38	1976	131.60
1975	−339.37	1976	−166.62	1977	−32.63
1981	106.21	1982	−212.63	1983	265.11
1986	261.61	1987	−56.88	1988	344.30

TABLE 3 (c)

Seasonal rainfall anomaly during El-Nino years

Station	Pre-monsoon			Monsoon			Post-monsoon			Winter		
	Y(−1)	Y	Y(+1)	Y(−1)	Y	Y(+1)	Y(−1)	Y	Y(+1)	Y(−1)	Y	Y(+1)
Jessore	19.15	−69.66	48.87	64.37	−29.62	−48.46	53.55	−54.40	24.04	−6.14	−5.40	−3.67
Dhaka	18.82	−56.56	76.53	100.10	−0.82	−91.12	49.77	−64.00	67.70	−2.78	0.38	3.52
Barisal	27.82	−59.04	−7.38	−2.57	−107.40	−111.40	29.86	−83.43	25.44	−3.50	−5.11	−1.48
Srimangal	−124.50	−94.26	7.47	−15.54	−12.60	232.75	42.01	−24.24	57.70	−7.85	−5.51	3.33

TABLE 3 (d)

El-Nino years under study

El-Nino year (−1) Y(−1)	El-Nino year Y	El-Nino year (+1) Y(+1)
1950	1951 (m)	1952
1952	1953 (m)	1954
1956	1957 (s)	1958
1962	1963 (m)	1964
1964	1965 (m)	1966
1968	1969 (m)	1970
1971	1972 (s)	1973
1974	1975 (m)	1976
1975	1976 (m)	1977
1981	1982 (s)	1983
1986	1987 (m)	1988

The mean rainfall anomaly of the annual and seasonal rainfall for the ENSO years (11 events) ENSO (+1) years and ENSO (−1) years are shown in Tables 3 (a-d).

The negative anomaly during ENSO years comes out to be large compared to the years before and after ENSO.

The data of the year of the severe El-Nino (1982-83), where other meteorological phenomena have been known to exhibit large perturbations, were examined carefully, but do not show any excessive variation compared to other El-Nino years.

The yearly pressure and temperature data did not show any particular variations with El-Nino.

Tests of significance have been performed for the variations. These showed that the anomaly of rainfall in El-Nino years throughout the country is significant.

5. Conclusions

In conclusion we may summarize as follows :

(*i*) In events of El-Nino Southern Oscillation have been found to have an important modulating effect on tropical phenomena. A study of the rainfall pattern over Bangladesh for a period of 43 years seems to support this. There is a definite correlation of ENSO with deficit rainfall in this area.

(*ii*) The yearly rainfall at four stations of different climatological areas shows decreasing tendency for most of the ENSO events (66%-70% of the time).

(*iii*) The time series graphs of the mean rainfall during different seasons, namely; pre-monsoon, monsoon, post-monsoon and winter, studied separately for the four stations again showed a negative correlation with ENSO events, varying from 60%-80% of the time, except for Dhaka where the yearly graph shows a more clear decrease.

(*iv*) The mean rainfall anomaly of the annual and seasonal rainfall for the ENSO years as

compared to ENSO (+1) and ENSO (−1) years show a definite negative value.

(v) Other parameters of the monsoon circulation need to be examined to get a better understanding of the modulating effect of ENSO.

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