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Floods and hazardous heavy rainfall in India: Comparison between local versus oceanic impact

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ABSTRACT

Generally, during the south-west monsoon season, several severe/ extreme weather systems form over India, leading to heavy rainfall. Such heavy rainfall result in floods for wider region of northern India, and, which, finally, causes loss of agriculture, human and animal's life, outbreak of diseases/ epidemics, and thus affecting national economy. An attempt has therefore, been made to analyze the disastrous events that occurred in the summer monsoon months over different states in India for the period 1981-2000. The analyses included the raining event which were active, but, caused due to- or without the monsoonal-systems that were formed in north Indian Ocean. Results showed that West Bengal was the mostly affected state during monsoon season, where both, local as well as monsoonal systems were equally responsible for heavy rainfall/ flood events. The local atmospheric phenomenon affected highly to Uttar Pradesh, West Bengal, Gujarat, and Maharashtra, whereas for systems that were associated with the north Indian Ocean and Bay of Bengal, the states of West Bengal and Orissa were the mostly affected states. From the study, it may be concluded that all the heavy rainfall related disastrous weather events formed over different states in India was not only due to systems developed over Oceans, rather, local atmospheric phenomena had equally important contributor of similar affects, particularly for northern and western India.

Keywords: Flood, heavy rainfall, hazard, local atmospheric phenomenon, oceanic impact

Among the meteorological hazards, on the global front, Obassi (2001) had estimated loss of ~ US$ 50-100 billion annually together with loss of about 2,50,000 lives. It has also been suggested that these losses might either be due to a real increase in the frequency of the extreme weather events or due to increased vulnerability of cities, towns and the associated infrastructure and installations, which have grown rapidly to meet the needs of a growing population. The meteorological hazards can be summed as snow fall, cold wave, heat wave, drought, squall, gale, dust storm, lightening, thunderstorm, hailstorm, floods and heavy rain/cyclonic storm. The flood, drought and heavy rainfall showed the severe impact over a wider region (De and SinhaRay 2000; De and Mukhopadhyay, 1998; De and Joshi, 1995, 1998; De and Dandekar, 2001; Pandey *et al.*, 2008; Pandey *et al*., 2007). Cyclonic disturbances have been studied extensively by De and Joshi (1995); Pandey *et al*. (2007); Rao *et al*. (2001); and Srivastava *et al.*, (2000). Among these hazards, though the largest meteorological hazards are related with rainfall, not much work has been done so far in this direction in India, although, during the south-west monsoon season (June-September), several severe/ extreme weather systems form over India, leading to heavy rainfall.

Rainfall associated such natural disaster have impact over India on recurring basis. One of the major disaster is landslide (Jamir *et al.*, 2008), others are flood and drought. Flood is associated with access of rainfall and drought with deficit of rainfall. These studies invite further to study such extreme meteorological events to improve the forecast skill and for disaster management. In the present study, the authors analyzed one of the meteorological hazards, the floods/heavy rain, which affected the concerned region. The major objective of the study is to analyze the cases, which are either associated with the systems that are formed over north Indian Ocean or cause due to local atmospheric disturbances. The study is based on the data for the period 1981-2000.

DATA AND METHODOLOGY

The data of the disaster events 'flood/ heavy rain' are taken from the report on Disastrous Weather Events of 1981 to 2000 published by India Meteorological Department. The year-wise frequency of flood affected states during monsoon period (α), state-wise frequency of flood during monsoon period (β), and month-wise frequency of flood of monsoon period (γ) have been computed. For flood-events, which are associated with local atmospheric phenomenon are presented with suffix '1' and those events which are associated with the systems that are influenced from north Indian Ocean, such as due to depression, deep depression, cyclonic storm and severe cyclonic storm have been suffixed with '2' along with the parameters α, β and γ.

Table 1: Frequency of number of states having flood during monsoon period due to local atmospheric phenomenan (α_1) in different years, given in descending order of total frequency.

Year	June	July	August	September	Total
1988	-	6	4	7	17
1998	2	7	3	5	17
2000	3	7	4	2	17
1983	2	4	4	5	15
1990	1	5	6	2	15
1993	-	10	2	3	15
1994	3	5	1	5	14
1984	4	4	1	4	13
1985	2	4	4	2	12
1996	4	4	3	1	12
1997	2	2	7	1	12
1999	2	5	1	4	12
1981	4	4	1	2	11
1986	1	3	6	1	11
1991	2	3	3	3	11
1992	2	2	2	3	9
1995	-	3	2	4	9
1987	1	2	3	2	8
1989	1	6	-	-	7
1982	-	-	5	-	5

Table 2: Frequency of flood affected states in each year during monsoon period (beta α_1) in monsoon months, given in descending order of frequency. These flood-events are caused due to local systems

State	June	July	August	September	Total
Uttar Pradesh	2	9	8	10	29
West Bengal	3	5	5	17	24
Gujarat	5	9	5	2	21
Maharashtra	6	7	5	3	21
Assam	1	12	3	4	20
Bihar	1	5	8	3	17
Himachal Pradesh	-	8	5	3	16
Andhra Pradesh	-	4	5	5	14
Karnataka	3	3	3	2	11
Rajasthan	1	7	3	-	11
Jammu and Kashmir	1	3	3	2	9
Kerala	5	3	1	-	9
Madhya Pradesh	3	2	1	2	8
Arunachal Pradesh	4	1	-	1	6
Orissa	-	1	2	3	6
Punjab	-	3	2	1	6
Meghalaya, Mizoram and Tripura	1	2	2	1	6
Sikkim	1	1	-	2	4
Haryana	-	1	1	1	3
Tamilnadu	-	-	-	-	-

RESULTS AND DISCUSSIONS

Table 1 shows the variation of α_1 in different years, i.e. number of states affected in each year in terms of flood and heavy rainfall during each monsoon month of June, July, August and September as well as during the monsoon season (June to September) due to local atmospheric disturbances. The highest α_1 value of 17 for the years 1988, 1998 and 2000,

Fig. 1: Frequency of flood in each month of monsoon cause due to local atmospheric phenomenon (γ_1) and systems that have originated in the oceans (γ_2)

Table 3: Variation of frequency of flood during monsoon period with due association with north Indian Ocean, (β_2) for different years in descending order of total frequency.

Year	June	July	August	September	Total
1981	2	-	3	3	8
1990	1	-	3	-	4
1991	-	4	-	-	4
1995	-	-	-	-	4
1996	4	-	-	-	4
1999	2	1	1	-	4
1986	-	-	1	2	3
1997	1	-	1	1	3
1982	1	-	-	1	2
1984	-	-	2	-	2
1985	-	-	1	1	2
1988	1	-	1	-	2
1994	-	-	2	-	2
1998	-	-	-	2	2
1983	1	-	-	-	1
1987	-	-	1	-	1
1989	-	1	-	-	1
1992	1	-	-	-	1
2000	1	-	-	-	1
1993	-	-	-	-	-

suggested the worst affected years due to flood and severe rain, followed by years 1983, 1990 and 1993, which had the α_1 value of 15. Years 1982 and 1989 were the years of lowest α_1 value of 5 and 7, respectively. However, for the month of July 1993, 10 states are affected by the heavy rain/flood due to active monsoon for most of the country.

Table 2 shows the variation of β_1 in various states in month of June, July, August and September and also for the monsoon season (June to September). The highest β_1 value of 29 in Uttar Pradesh suggested that Uttar Pradesh was the worst affected state due to flood and heavy rainfall during 1981-2000, followed by West Bengal (β_1 = 24). Other affected states were Assam and Gujarat having β_1 value of 20 and 21, respectively. Arunachal Pradesh, Haryana, Punjab, Sikkim, Orissa were the least affected states. Tamilnadu had no affect of this type of meteorological disaster during the period of study. Table 2 also indicated that Maharashtra has the highest value of 6 disastrous events in the months of June, while during July, Assam experienced maximum events of value 12. However, in the month of August, Bihar and Uttar Pradesh (8), and in September, West Bengal had the highest number of such events (17).

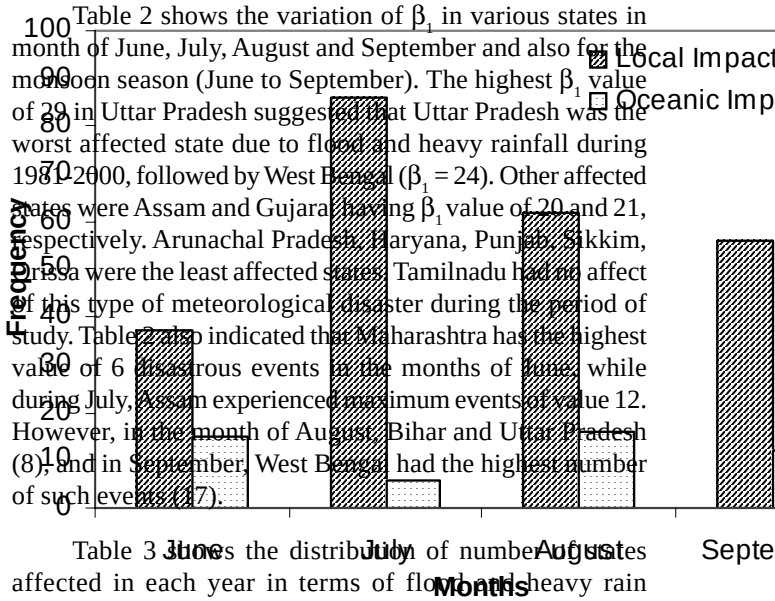

Table 3 shows the distribution of number of states affected in each year in terms of flood and heavy rain associated with systems that are formed in the Indian Ocean (α_2). The highest value of α_2 was found for the year 1981. In this year, 4 deep depressions and 1 cyclonic storm entered in India during the entire summer monsoon season, except the month of July. Other years had less affect, while in year 1993 there was no damage.

Table 4 shows the variation of β_2 during monsoon months. The highest $_2$ value was found in Orissa (β_2 = 14),

Table 4: Frequency of flood affected states in each year during monsoon period (α_2) in monsoon months, given in descending order of frequency. These flood-events are caused due to their association with north Indian Ocean.

State	June	July	August	September	Total
Orissa	4	2	4	4	14
West Bengal	4	-	2	4	10
Andhra Pradesh	2	2	3	1	8
Maharashtra	2	1	2	1	6
Gujarat	2	1	-	1	4
Bihar	-	-	3	-	3
Madhya Pradesh	-	-	2	-	2
Tamil Nadu	1	-	-	-	1
Uttar Pradesh	-	-	-	1	1

followed by West Bengal (β_2 = 10). However, both West Bengal and Orissa had very less impact of disasters in the month of July. It suggested that these two states were the highest affected at the time of onset and peak months of monsoon, followed by the withdrawal time. Other severely affected states were Maharashtra and Andhra Pradesh, however, Tamil Nadu and Uttar Pradesh had less effect.

Fig. 1 shows the total number of states during different month of monsoon season which were affected due to flood and severe caused by local atmospheric phenomenon (γ_1) as well as due to oceanic systems (γ_2). The figure shows the comparison between impact due to local versus impacts due to systems that were formed over ocean and affected the continent. The highest γ_1 value of 86 was in July and the lowest (37) was the month of June. It suggested that the June month had the lowest impact and July month had highest impact caused due to local phenomenon. For the flood/ heavy rain spells caused due to oceanic impact, it was found that June, August and September months had the high value of 15, 16 and 12 respectively, whereas July month had comparatively low value of 6 only. It suggested that the local events had more pronounced than the oceanic events, which were more prevalent during monsoon.

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