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HAZARD CHARACTERISTICS OF NATURAL FLOOD: A CASE STUDY OF PADMA RIVER

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ABSTRACT

Flood in river Padma is one of the very complex hydrologic processes. The present study aimed at understanding flood hazard characteristics in the river Padma. To obtain this objective, secondary data about water level and discharge in river Ganges have been collected and analyzed. Flood frequency analysis was done. Very vulnerable flood with more than 70000cumec water discharge occurred five times during the year 1960 to 2010 and the flood frequency is >4.23. Havoc flood with a water discharge of 50001-60000cumec occurs 22 times during the year 1960 to 2010 and the flood frequency is 1.13 to 2.01. The return period of the extreme flood event (with highest discharge) is 10 years. The return period of the flood with second highest discharge is 8 years. Analyzing the water level data it is clear that during the year 1960-2010 water level crossed the danger level for 21 times.

KEYWORDS: Padma River, Water Discharge, Flood Frequency and Danger Level

INTRODUCTION

Padma River the downstream of the Ganges, more specifically, the combined flow of the Ganges and the Jamuna after their confluence at Goalandaghat. The Ganges is one of world's biggest trans-boundary river systems flowing through India and Bangladesh (Abbas, 1982; Haroun, 1998; Chowdhury, 2003; Hossain et al., 2005). In Bangladesh the Ganges is popularly known as the Padma (Islam, 2011) from its point of entrance at Manakosa and Durlabhpur unions of Shibganj upazila, Nawabganj district. Flood in river Padma is one of the very complex hydrologic processes. Number of sorrows and sufferings are caused by flood. Repetition of flood hazard can solely increase people's vulnerability to flood hazard. According to Subramanya (1997), the hydrograph of flood peaks of extreme floods and stages provide important information for the purposes of hydrologic design.

Flood-peaks vary from year to year at a given location of a river and their magnitude constitutes a hydrologic series which is able to assign a frequency to a given flood-peak vary from year to year at a given location of a river and their magnitude constitutes a hydrologic series which is able to assign a frequency to a given flood-peak value and that frequency (i.e. 1 in 100 years) is useful for all hydraulic structure's design (Subramanya, 1997). Usually in the Gangetic flood occurs when water level cross the danger level. In the present research, it is necessary to analyze how many times water level crossed a danger level in a given period of time. Flood causes annual deaths of 25,000, homelessness, disaster induced disease, and crop and livestock damage and other serious harm (UNU, 2004)... In a "normal" year approximately 20 percent of the country is affected by overflowing rivers caused by heavy rainfall (Bhuiyan and Baky, 2014). Flooding cause damages crops, infrastructure, island settlements and communication network (Mafizuddin, 1992).

The main objective of this study was to understand flood hazard characteristics in the river Padma. To fulfill this objective flood frequency and water level data were analyzed. The results from this study explain how frequently and severely flood occurs in the present study area.

METHODOLOGY

Study Area

Ganges-Padma River System is one of the three major river systems of Bangladesh (Figure 1). Total length of Ganges is about 2,600 km and approximately 907,000 sq km of catchment area. Within Bangladesh, the Ganges is divided into two sections - first, the Ganges (258 km long) starting from the western border with India to its confluence with the Jamuna at Goalandaghat, some 72 km west of Dhaka. Second one is the Padma, about 120 km long, running from the Goalandaghat confluence to chandpur where it joins the Meghna. The total drainage area of the Ganges is about 1,087,400 sq km, of which about 46,300 km^2 lies within Bangladesh. The present study was conducted to understand Padma river flood hazard characteristics. To fulfill this purpose water discharge data were collected from hardinge bridge hydrological station and Water level data were collected from the hydrological station in Rajshahi city along the river Padma. The main reason of flooding in this study area is the trans-boundary flow from upstream catchment carried by river Ganges.

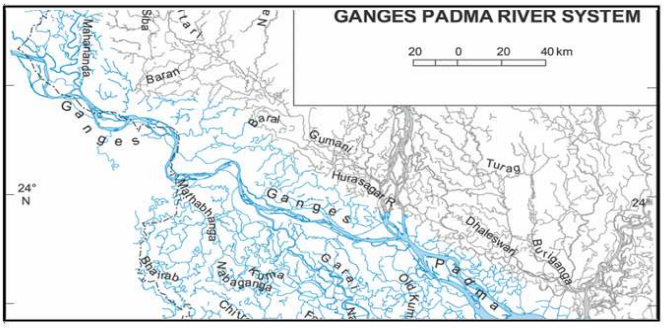

Figure 1: Ganges- Padma River System, Banglapedia

Methods to Estimate the Magnitude of Flood Hazard

Different approaches are applied to estimate flood peak. There are seven leading methods to estimate the magnitude of flood peak. The methods are:

- Physical indicators of past flood-flood marks and local enquiry
- Empirical formulae and curves
- Concentration time method
- Overland flow hydrograph
- Rational method
- Unit hydrograph
- Flood frequency analysis

RESULTS AND DISCUSSIONS

Flood Frequency Analysis

The magnitude of an extreme event is inversely related to its frequency of occurrence, very severe events occurring less frequently then more moderate events. The purpose of frequency analysis of hydrologic data is to relate the magnitude of extreme events to their frequency of occurrence through the use of probability distributions (Maiti, 2007).

Some of commonly used frequency distribution functions for the predictions of extreme flood values are given below.

- Weilbul method
- Gumbel's theory of extreme values
- Log-Pearson Type III distribution and
- Log normal distribution

Only the second method is dealt with in this study.

Gumbel's Method

The purpose of these method is to develop the relation between the probability of occurrence (return period) of a certain event, and its magnitude. Floods or rainfall are the heavy events in hydrology. As discussed earlier that probability of event with a certain magnitude is called hazard. There are two aspects of a hazard: i.e. magnitude and frequency. Frequency is how often an event of a given magnitude may be expected to occur in long-run average. Magnitude is interrelated to the amount of energy released during the disaster event, or it can refer to the size of the disaster (Maiti, 2007).

Disasters generally follow the magnitude-frequency relation that means the events with a smaller magnitude and high frequency happen more frequently than events with large magnitudes and low frequency. Probability is a measure of the degree of certainty. This measure has a value between 0(impossibility) to 100(certainty).

Data Preparation for the Gumbel's Method

The annual peak discharge data of the river Ganges (1960-2010) at hardinge bridge station are selected for flood frequency analysis. Then the given annual flood peaks are arranged in descending order of magnitude and assigned an order number m.

The yearly peak discharged values are ranked from high to low. So assign rank 1 to the highest data value and assign the highest rank N to the lowest data value. For example, for the first entry m=1, for the second entry m=2 and so on till the last event for which m = N = Number of years of record.

The probability P for each observation equaled or exceeded is given by the following formula:

$$P = 1 - e^{-e^{-y}} \quad (1)$$

Where e = base of natural logarithm

y = a reduced variate given by

$y = \frac{1}{0.78\sigma}(x-\bar{x} + 0.45\sigma)$ *for n > 50*

x = flood magnitude with the probability of occurrence, *P*

$\bar{x}$ = arithmetic mean of all the floods in the series

Recurrence interval of the event of magnitude *x*

$$T = \frac{1}{1 - e^{-e^{-y}}} \quad (2)$$

Where, T = Recurrence interval

And Percent probability (P) is calculated by the following formula

$$P = \frac{1}{T} \times 100 \quad (3)$$

Table 1: Flood Frequency and Probability Analysis of the River Ganges, 1960-2010

Year	Peak Discharge in cumec	Rank(m)	Peak Discharge in Cumec (Descending)	Reduced Variate (y)	Recurrence Interval $T = \frac{1}{1 - e^{-e^{-y}}}$	Percent Probability $P = \frac{1}{T} \times 100$
1960	48000	1	76000	2.28	10	10
1961	73200	2	73200	1.95	7.5	13.3
1962	58700	3	73200	1.95	7.5	13.3
1963	56100	4	73200	1.95	7.5	13.3
1964	49000	5	73091.4	1.93	7.40	13.5
1965	36800	6	67900	1.31	4.23	23.6
1966	41900	7	65400	1.01	3.28	30.5
1967	50800	8	61600	0.55	2.28	43.9
1968	45200	9	61122.7	0.50	2.19	45.6
1969	55200	10	60000	0.37	2.01	49.8
1970	48700	11	59875.7	0.35	1.97	50.0
1971	44300	12	59100	0.25	1.85	50.1
1972	38200	13	58700	0.21	1.80	55.6
1973	50700	14	57800	0.10	1.67	59.9
1974	50700	15	56500	-0.06	1.52	65.8
1975	73200	16	56100	-0.10	1.49	67.1
1976	51100	17	56000	-0.12	1.48	67.6
1977	65400	18	55200	-0.21	1.41	70.9
1978	51100	19	54487.8	-0.29	1.36	73.5
1979	67900	20	54216.8	-0.33	1.33	75.2
1980	36900	21	53500	-0.42	1.28	78.2
1981	57800	22	53407.7	-0.43	1.27	78.7
1982	47900	23	52538.9	-0.53	1.22	81.9
1983	61600	24	51300	-0.68	1.16	86.2
1984	60000	25	51100	-0.70	1.15	86.9
1985	56500	26	51100	-0.70	1.15	86.9
1986	50600	27	50800	-0.74	1.14	87.7
1987	53500	28	50700	-0.75	1.14	87.7
1988	76000	29	50700	-0.75	1.14	87.7
1989	73200	30	50600	-0.76	1.13	88.5
1990	31600	31	50562.3	-0.77	1.13	88.5

Table 1: Contd.,						
1991	51300	32	49000	-0.95	1.08	92.6
1992	56000	33	48700	-0.99	1.07	93.4
1993	41900	34	48000	-1.07	1.05	95.2
1994	44800	35	47900	-1.09	1.04	96.2
1995	46100	36	46100	-1.30	1.026	97.4
1996	59100	37	45200	-1.41	1.017	98.3
1997	54487.8	38	44800	-1.46	1.013	98.7
1998	42465.2	39	44300	-1.52	1.010	99.0
1999	73091.4	40	43620	-1.60	1.007	99.3
2000	61122.7	41	42465.2	-1.74	1.003	99.7
2001	52538.9	42	41900	-1.81	1.002	99.8
2002	53407.7	43	41900	-1.81	1.002	99.8
2003	40980	44	40980	-1.92	1.001	99.9
2004	59875.7	45	38600.8	-2.20	1.0001	99.9
2005	37259.3	46	38200	-2.25	1.00008	100
2006	43620	47	37259.3	-2.36	1.00003	100
2007	37254.3	48	37254.3	-2.37	1.00002	100
2008	54216.8	49	36900	-2.41	1.00002	100
2009	50562.3	50	36800	-2.42	1.00001	100
2010	38600.8	51	31600	-2.98	1	100

Source: Bangladesh Water Development Board, Surface Water Hydrology Department, Dhaka.

Return period as well as probability of occurrence of the annual peak floods of the river Ganges has been calculated using the above formula. The probability of occurrence of the highest flood peak is once in 10 year (percent probability 10). The return period of second highest flood peak is 7.5 years (percent probability 13.3) and the third highest flood peak is 7 years (percent probability 13.5; Table 1).

Due peak water Discharges Island has been affected by flood every year. Devastating flood occurs during the month of July, August and September. The peak water discharge of the river Ganges has been classified in the discharge range of 30001-40000cumec that has been called as Normal Flood (Table 2) and the frequency has been observed 1-1.0001 and that has been occurred seven times between the years 1960 to 2010. The second classified range is 40001-50000cumec that has been called moderate flood and the frequency has been observed 1.001-1.08 and this type of flood has been occurred thirteen times in 51 years. The next classification is called havoc flood and the discharge ranges from 50001-60000cumec. The frequency of this range is 1.13-2.01. In Gangetic delta this type of flood occurred twenty two times between the years 1960 to 2010.

Table 2: Flood Frequency of the River Ganges, 1960-2010

Flood Year	Flood Type	Water Discharge Class Cumec	Flood Frequency
7	Normal Flood	30001-40000	1-1.0001
13	Moderate Flood	40001-50000	1.001-1.08
22	Havoc Flood	50001-60000	1.13-2.01
4	Great Havoc Flood	60001-70000	2.19-4.23
5	Very Vulnerable flood	>70000	>4.23
Mean	2.70		

Criteria of Assessment				
1	2	3	4	5
Normal Flood	Moderate Flood	Havoc Flood	Great Havoc Flood	Very Vulnerable flood

Source: Bangladesh Water Development Board, Surface Water Hydrology Department2, Dhaka

The peak water discharge in the river Ganges has been classified into the discharge range of 60001-70000cumec and this flood type has been called Great Havoc Flood and the flood frequency of this type of flood is observed (Table 1

and 2) 2.19-4.23. Great Havoc flood occurred four times in Gangetic delta, Bangladesh. The peak discharge in the river Ganges has been classified in the discharge range of >70000cumec that has been called as Very Vulnerable Flood and flood frequency has been observed >4.23 and this type of flood has been observed five times in the present study area. For preparing flood disaster risk index all these types of flood have been score 1 to 5 considering their severity. Finally a mean score representing over all condition flood frequency has been calculated.

Water Level

From the year 1960 to 2010 there are so many ups and downs in the water level of the river Ganges. In the river Ganges water level crossed the danger level in this 51 years. In the year, 1961, 1971, 1974, 1976, 1978, 1980, 1982, 1983, 1984 1985, 1986, 1987, 1988, 1991, 1994, 1995, 1996, 1998, 1999, 2000, 2003 the danger level was crossed. So in these years flood occurs in Gangetic delta. In the year 1998 the water level reached the highest peak. In this year 1,00,000 sq. km area was gone under water (UNDP/MEF(GOB), NAPA, 2005).

In the year 1983 and 2006 the minimum water level was very low almost 7 meters (Figure 1). Usually in the month of August and September the water level reaches its highest peak and in the month of April and May the water level reaches its lowest peak. The annual maximum water level is becoming lower day by day. The present study area is an Island so that normal water level brings flood there and causes adversities every year. In the year 1998 maximum water level shows the highest value during 1951-2010 in this year (Figure 2) water level was highest in the river Ganges. Similarly in 1987 the level of water represents the second highest value and 1999 shows the third highest value. In the year 1987, 1988 and 1998 the level of water was so high that more than 90% of the study area was gone under water.

Flood disaster is directly related to water level. The higher is the level of water the higher is the level of flood risk. When water level crossed the danger level the situation becomes worst there. In Rajshahi station danger level is 18.50 m-pwd. In July, august and September peoples become more susceptible to flood because of higher water level.

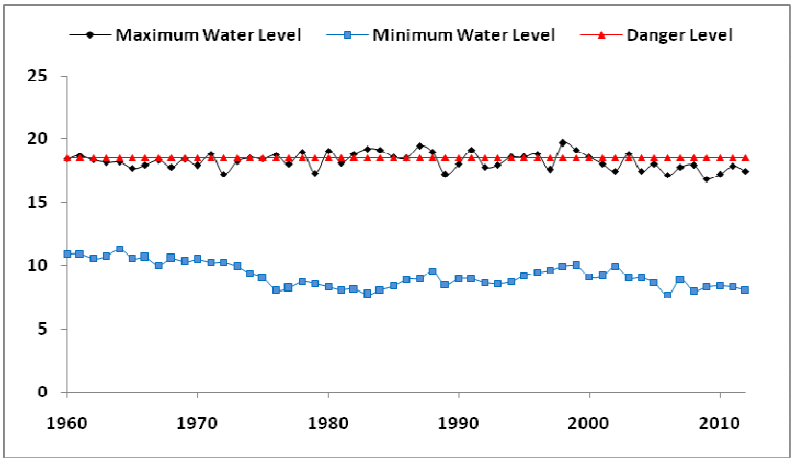

Figure 2: Water Level Crossing Danger Level

CONCLUSIONS

Flood in river Padma is one of the very complex hydrologic processes. Very vulnerable flood that means flood with more than 70000cumec water discharge occurred five times during the year 1960 to 2010 and the flood frequency is >4.23. Havoc flood with a water discharge of 50001-60000cumec occurs 22 times during the year 1960 to 2010 and the

flood frequency is 1.13 to 2.01. The return period of the extreme flood event (with highest discharge) is 10 years. The return period of the flood with second highest discharge is 8 years. Analyzing the water level data it is clear that during the year 1960-2010 water level crossed the danger level for 21 times. The higher is the level of water the higher is the level of flood risk.

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