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A Flood Forecasting Model for the River Padma

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Abstract- Flood constitute one of the critical problems faced by Bangladesh. Due to the unique graphical situation of Bangladesh in the delta of three great rivers, namely the Brahmaputra, the Padma and the Meghna, which drains a vast catchment, flood in this country is usually complex. The problem is gigantic and becomes more complicated with the passage of time. The flood in 1998 sever flood is the highest record. Analysis of water level data of two stations shows that the forecasting model is a linear equation of the type Y= a+bX. Data of the nine hydrologic years have been analyzed in this paper. In most cases values of co-efficient “a” varies from 0.3112 to 1.558 and “b” from 1.047 to 11.91. The general equation for the flood forecasting for the GoalundoTransi station has been established as Y = 1.283X - 8.351 in this paper. The value of travel time of flood wave from base station to forecasting station according to historical method andMutreja’s method is 2 days for both.

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AFLOODFORECASTINGMODELFORTHERIVERPADMA

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I. Introduction

Flood affected many of the engineering structures such as bridge, embankment, barrage, levees, reservoirs, etc. while designing the proper safeguards must be made for the safe passage of the maximum expected flood. The structure must be sound not only for its own safety but also for the life and property which might be in danger by its failure. The valley then becomes ''flooded". A flood is commonly considered to be an unusually high stage of a river. It is often the stage at which the stream channel becomes filled and starts overflowing its banks. In Webster's new international dictionary, a ''flood" is "a great flow of water especially, a body of water, rising, swelling and overflowing and not usually thus covered a deluge, a freshet, an inundation". A flood problem in Bangladesh is gigantic and becomes more complicated with the passage of time. Every year a large area of this country is more or less affected by the flood. For the unique geographical situation of Bangladesh flood cannot be protected. But damages caused by the flood are lowered by the proper and timely forecasting about flood. Most of the flood studies are made for the flood controlling. Here flood forecasting system is very poor. So attempts have been taken to develop appropriate flood forecasting model. Flood is a serious problem in our country. Every year a large number of hydraulic structures, crops and properties are damaged by the flood.

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The necessity of the study is given below:

1. To ensure the safety of the hydraulic structure (like-Barrage, levees etc.).
2. To take measure for the safety of the crops and properties of the adjacent land.
3. Improvement of the existing channel section for the computed discharge.

Within the Padma basin in Bangladesh the important tributaries are the Punarbhaba and Mahananda from the left which drain Panchagar, Dinajpur and Chapainawabgong districts. They enter southeast zone of Bangladesh covering greater districts of Kustia, Jessore, Faridpur, Khulna and Barishal served by the important distributaries of the Padmaviz the Mathavanga and the Arialkhan are the most important. The lower gigantic delta in Bangladesh has a large area subjected to the tides from the Bay of Bengal. Catchment area of this basin is 53706 km2.

The general objectives of this study are given below:

1. Determine the travel time of flood wave from base station to forecasting station.
2. To determine the correlation between the N-th hour stage of base station and (N+T)-th hour stage of forecasting station.
3. To develop a flood forecasting model for the river Padma.

II. Background

Rahman, M.M., Goel, N.K. and Arya, D.S. (2012) developed flood forecasting system by using MIKE11 river-modeling software modules rainfall-runoff (RR) [or Nedbor-Afstromnings model (NAM)], hydrodynamic (HD), and flood forecasting (FF) for the Jamuneswari river catchment of the northwestern part of Bangladesh. A Chowdhury, M. R. , and Ward, N. (2004) worked on Hydro-meteorological variabilty in the greater Ganges-Brahmaputra-Meghna basins. Rahman, M. M. ,Arya, D. S. , Goel, N. K. , and Dhamy, A. P. (2011a) have carried out their research for design flow and stage computation in the Teesta river.The statistical model uses the multiple correlation technique. Basically, only gauge of base stations and forecasting stations are utilized in different forms in developing these models.

III. Methodology

Statistical method has been used in this paper to develop the forecasting model.

a) Outline of Statistical Method

Daily water level of base station X has been used to develop a multiple correlation model for predicting water level Y, at the forecasting station. The model is Y = a + bX.

Where, Y is a dependent variable and is the water level at the forecasting station at time, t(MSL), X is a independent variable and is the water level at the base station at time (t-T) with T as the travel time between this station and the forecasting station, a, b are multiple correlations co-efficient.

It should be noted that the advanced time for the forecast at the forecasting station is the least of the travel times. The procedures involved in the development of the model are:

- Identifying flood forecasting stations;
- Identifying potential base stations;
- Preparation of data base;
- Estimation of travel time; and
- Development of flood forecasting model

b) Estimation of Travel Time To estimate the travel time the approaches used in this paper are:

- Historical Method
- Mutreja's method

i. *Historical Method*

In this method the travel time is considered as the time difference between the peak water level of the base station and forecasting station.

ii. *Mutreja's Method*

This method consists in collecting the water level data of flood at base station for the Nth hour and at the forecasting station for the (N+T)-th hour in a tabular form. By taking different values of T different data tables are prepared such that each data table corresponding to one of assumed T. To compute the cross correlation of the water level data of these two stations at different legs the cross correlation of the data on each table is computed. The value of T corresponding to the data table the maximum correlation is travel time of the reach.

c) Necessary Data

In this study the following three types of data have been collected:

- Daily water level data
- Daily discharge data
- Danger level data

All these data used in this study were collected from the surface water hydrology– II of Bangladesh Water Development Board (BWDB).

i. *Discharge Level Data*

The BWDB in this the primary source of discharge data. The mean daily discharge data during a water year is published by hydrology directorate of the BWDB. Data sheet for daily discharge also contains the annual maximum and minimum discharge. Daily discharge data of Hardinge Bridge and GoalundoTransi station of the river Padma are collected for the purpose of this study.

ii. *Water Level Data*

The BWDB is also the primary source of water level data. The water level of the river is measured 5 times a day, at 6.00, 9.00, 12.00, 15.00 and 18.00 hour on stuff gauges. The mean of the 5 measurements is published as mean daily water level by the hydrology directorate of BWDB of Dhaka. Data sheets containing the mean daily water level at Hardinge Bridge and Goalundo Transi station of the river Padma during a water year (July to October) are given in Appendix-A. The data sheet also contains the annual maximum water level data of the monsoon period has been used for this study.

iii. *Danger Level*

Danger level data for two stations Hardinge Bridge and GoalundoTransi has been collected from the BWDB, Dhaka. The danger level of Padma at the selected river at the selected stations is given below:

Table 1 : The Danger Level of Padma River

River	Stations	Danger level (m)
Padma	Hardinge Bridge(Base Station)	14.25
	GoalundoTransi(Forecasting Station)	8.65

IV. Results and Discussion

a) Travel Time From Base to Forecasting Station

The travel time from the base station to the forecasting station is given in the following table calculated by two separate methods.

Table 2 : Travel Time from Base to Forecasting Station

Hydrologic year	Travel time (day)	
	Historical method	Mutreja's methods
2004	1	2
2005	1	2
2006	2	2
2007	1	2
2008	2	2
2009	1	2
2010	2	2
2011	1	2
2012	1	2

The accepted travel time by both the methods is 2 days.

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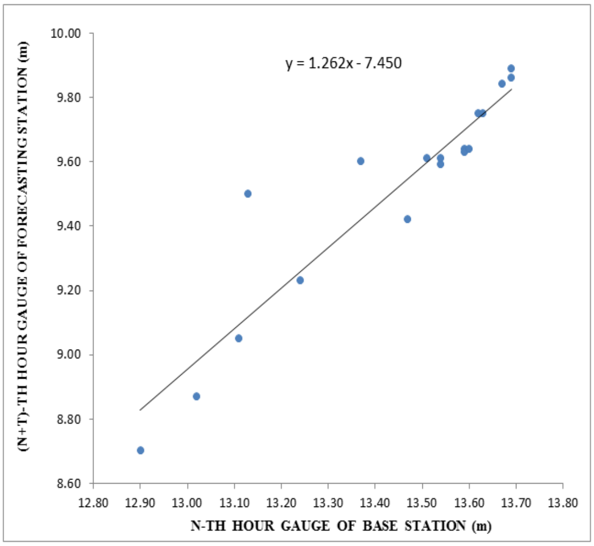
b) Correlations Between Nth hour stage of Base Station and (N+T)th hour Stage of Forecasting Station

The following graphs show the correlation of N-th hour stage of base station with (N+T)-th hour stage of forecasting station. Putting the value of daily water level data at X axis (base station) and daily water level data at Y axis (forecasting station) after the travel time T and finally get a linear equation.



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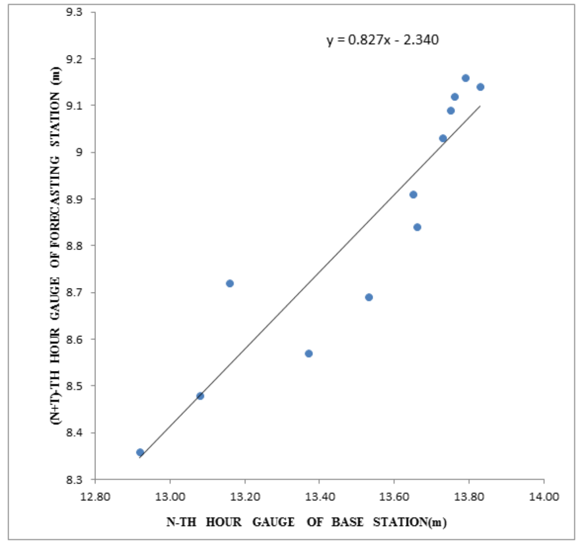

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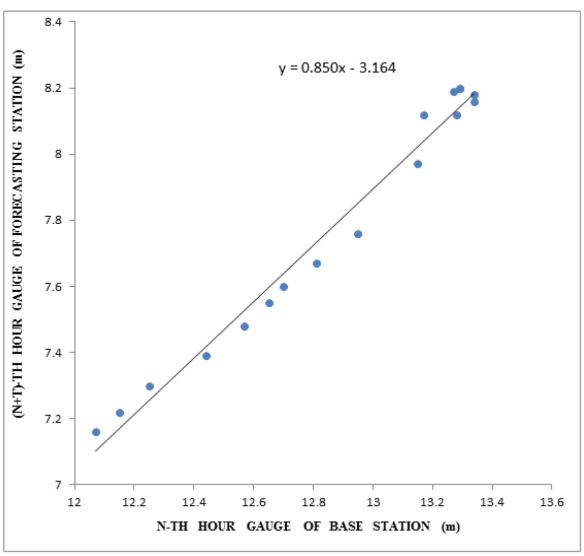
Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2004 and 2005



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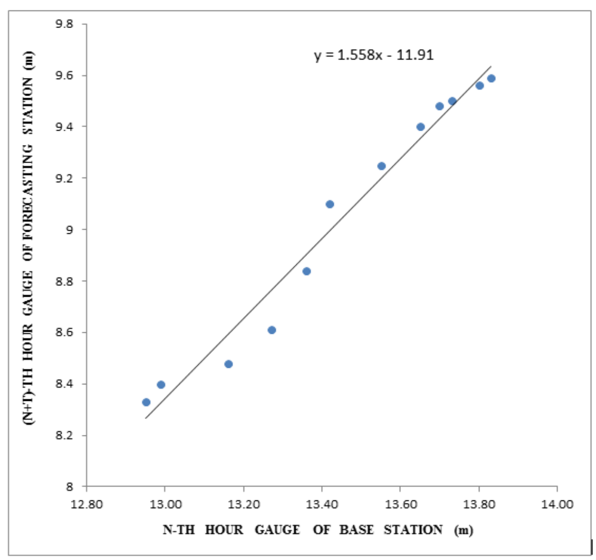

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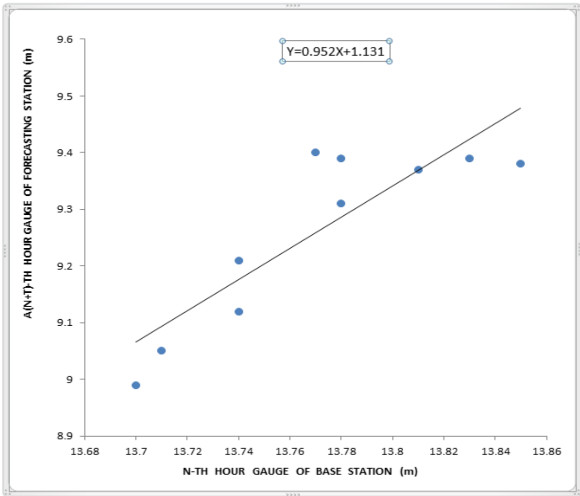

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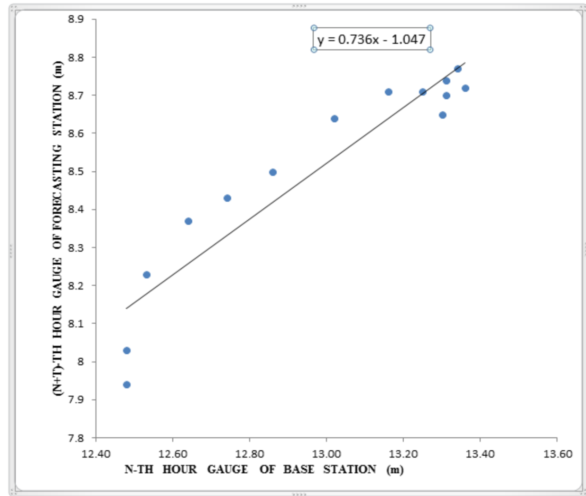

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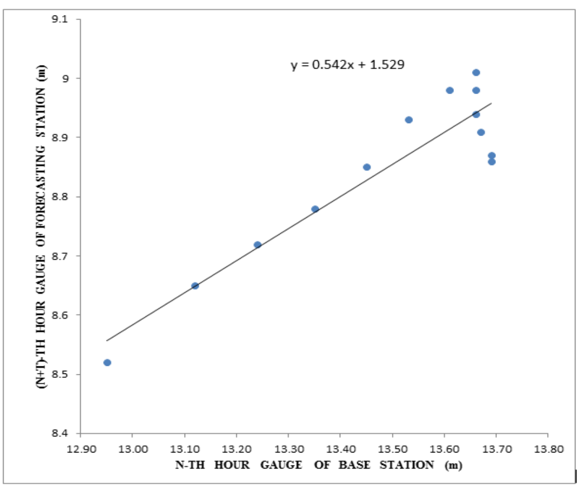
Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2006, 2007, 2008 and 2009



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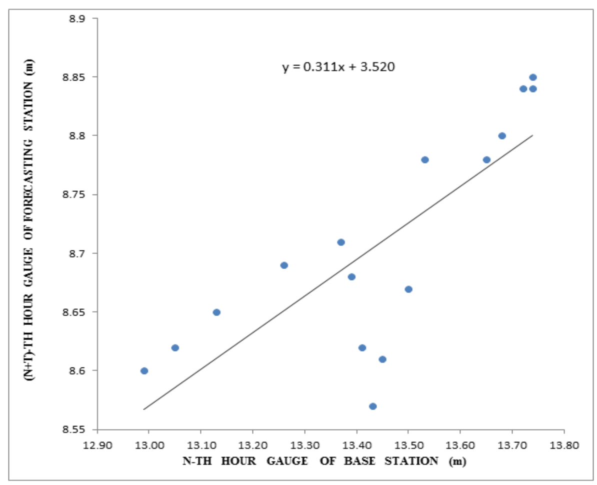

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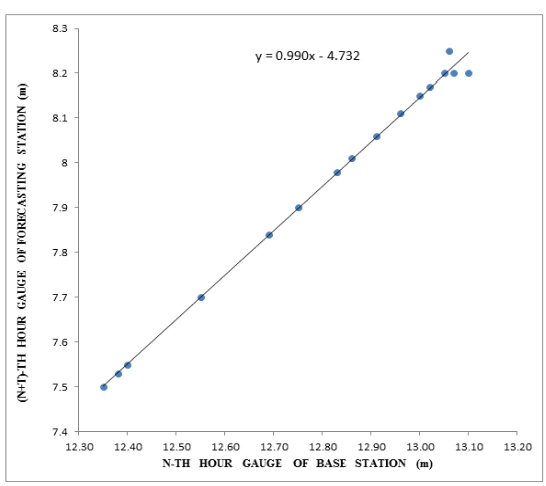

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Figure : Correlation of Nth hour stage of base station with (N+T)th hour stage of forecasting station for 2010, 2011 and 2012

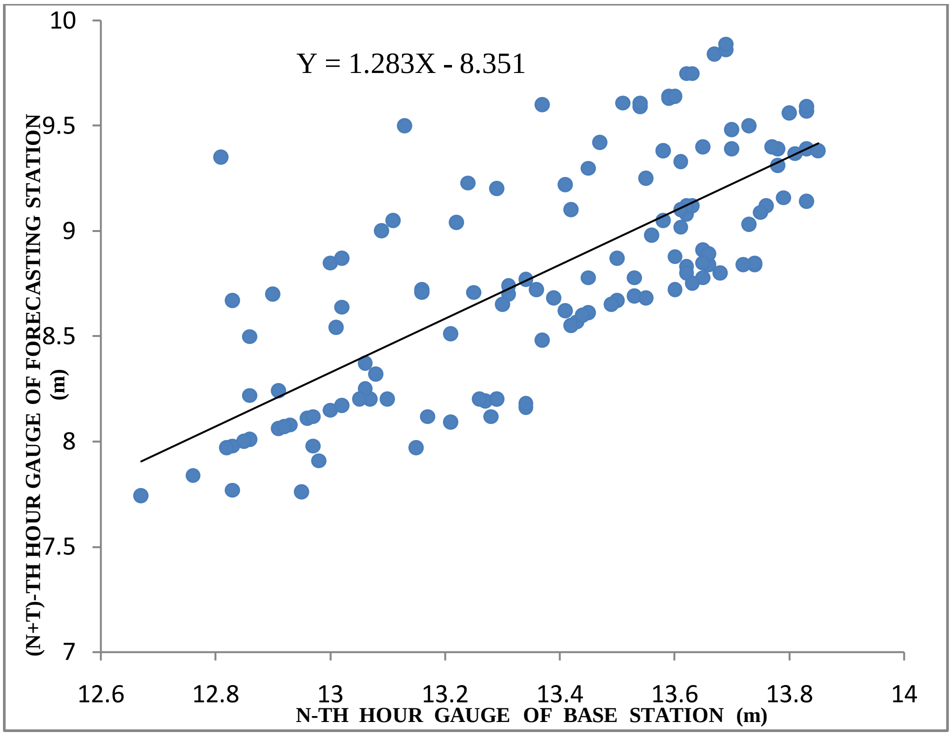

Figure 10 : Combined co-relation of N-th hour stage of base station with (N+T)th hour stage of forecasting station

V. Development of Flood Forecasting Model

From the correlation of different years daily water level data different flood forecasting model Y = a+bX are established. If X is replaced by the highest water level data of the corresponding year then the value of Y can be calculated. If the value of Y exceeds 8.65 m (which is the danger level of forecasting station) then flood will occur. If the value of Y does not exceed 8.65 m then flood will not occur. The following table shows the flood condition for different years.

X=Water level at base station

Y=Water level at forecasting station

Table 3 : Development of Flood Forecasting Model

Hydrological year	Flood Period (day)	Forecasting model Y= a+bX	Nature of the curve	Remarks
2004	23	Y = 1.262X-7.450	Linear Variation	Flood Occurred
2005	22	Y = 0.827X-2.340	Linear Variation	Flood Occurred
2006	19	Y = 0.850X-3.164	Linear Variation	No Flood
2007	20	Y = 1.558X-11.91	Linear Variation	Flood Occurred
2008	16	Y = 0.952X+1.131	Linear Variation	Flood Occurred
2009	19	Y = 0.736X-1.047	Linear Variation	No Flood
2010	28	Y = 0.452X+1.529	Linear Variation	Flood Occurred
2011	22	Y = 0.311X+3.52	Linear Variation	No Flood
2012	24	Y = 0.99X-4.732	Linear Variation	Flood Occurred

The general equation for the flood forecasting for the Goalundo Transi station is Y = 1.283X - 8.351.

VI. Conclusions

The following conclusions can be drawn from the above analysis:

- The accepted value of travel time from Hardinge Bridge to Goalundo Transi is 2 days.
- Combined co-relation of N-th hour stage of base station with (N+T)th hour stage of forecasting station has been established as a linear equation.
- The general equation for the flood forecasting for the GoalundoTransi station is Y = 1.283X - 8.351.

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