FLOW ANALYSIS OF THE HALDA RIVER TO BE USED AS A TOOL FOR THE REDUCTION OF FLOOD DAMAGES

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ABSTRACT

A flood is an unusually high stage in a river at which it overflows its banks and inundates the adjoining areas. It spreads water over the lands, causing destruction of crops, propertiesand lives. For analyzing the flow, some stations of the Halda river locating in Fatikchhari upazila are choosen for the study purpose. Out of these stations, Narayanhat is the upstream most location where the effects of flooding is not very severe, but erosion occurred at high scale. The other stations like Panchpukuria, Enayethat, Telpari etc are situated at downstream portion where flood mainly occurs. The eroded particles are transported from upstream sites and deposited at this portion decreasing the river depth and consequently flooding occurs. The primary objective of this study is to relate the magnitude of extreme events to their frequencies of occurance by using probability distribution. The main objectives are to determine the most probable flood discharge that may occur and calculate its return periods. Several methods are available to calculate return periods and design discharges using hydrological data. For this project, Log Pearson type III and Gumbel method are used which are commonly used for finding frequency distribution function. This study would help preparing a sound and effective action plan for controling the flood damages by knowing the magnitude and frequency of design flood and at that level of flood what are the destructive effects. From all relevant analyses, it has been found that flood affects the area at least once in five years and its magnitude is around 548.67 cumecs with 10.44 m of highest water level from MSL. With thiese magnitudes, to protect the flood damages in the areas, urgent flood manage measures are suggested to be taken from government and non-government organization and flood control structures are to be constructed with economic consideration at suitable places.

Keywords: *Flood flow, Return period, Gumble method, Log Pearson type 3, Linear regression*

1. INTRODUCTION

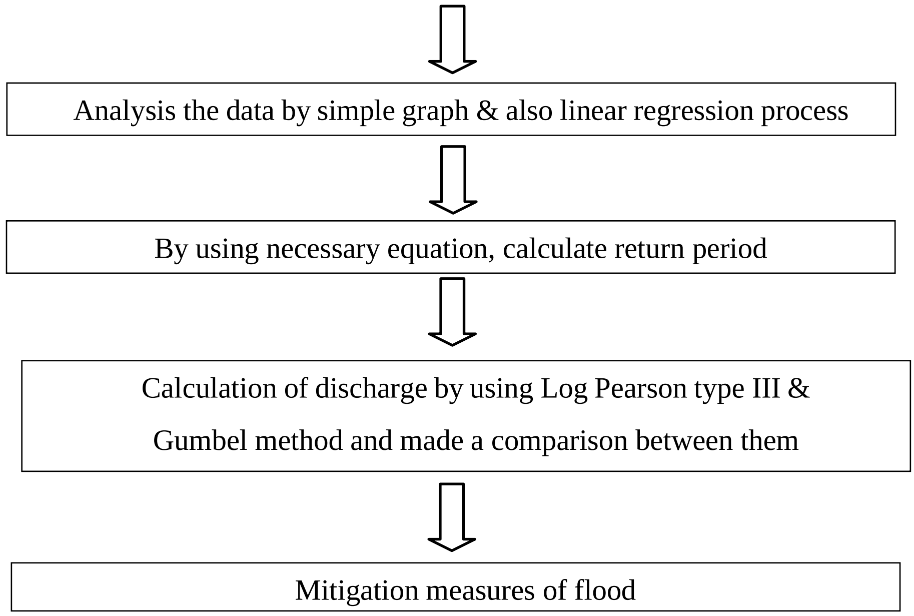
Bangladesh is a riverine country. It is surrounded by many rivers. And the water in the river is very essential element to all life both animal and plant. Without water life is impossible on this earth, but it is destructive when it overflows its banks spreads water all the places due to flood. Bangladesh is a flood prone countries in all over the world due to its geographical position and the surroundings river will enhance the possibilities to flood occur. Flood causes huge damage to life, property and place. Hence it is decided to terminate a project on flood flow and its control. For this case it have selected Halda river. It is located in south-eastern of Bangladesh in Chittagong division. It generates from Badnatali Hill ranges in Ramgarh upazila under Khagrachari district and flows through Fatikchhari upazila, Bhujpur Thana, Hathazari, Roazan upazila and finally falls into Karnaphuli river. It is a river of too much meandering. Because of meandering bank erosion takes place and make people homeless and landless. When the flow overtopping the banks it makes deterioration, severely affected the landscape and society of surroundings. It also causes many fatal diseases like cholera, typhoid and dysentery and breaks up food and sanitation problem.
For this case it has to be decide to make a report on flood flow analysis of Halda and its control later which should use as a guideline for all over the country. Another reason is that it is an important surface water source in Chittagong city. If proper control and manage the water it will reduce thewater supply problem in Chittagong city.
Frequency analysis of flood is very effective area of investigation in static hydrology. Different types of distribution, parameter estimation methods, problems related to regionalization and other related problem are investigated here. And frequency analysis, flood at different return period is a general problem in hydrology. The standard process to examine probabilistic of flood flows consists of adjusting the accomplished stream flow record to definite probability distribution. This process is only available for basins which have long enough stream flow records to standard stream flow records where flood flows are not considerably deflected by reservoir regulation, channel improvements or land use change. Gradual hydraulic simulation is an important tool to determine flood frequencies in unassessed watersheds and assessed watersheds that have short stream flow records or frequently regulated. Since hydrologic simulation models the rainfall runoff relationshipin the basin it can also be used to check the validity of the probability distribution selected for gauge, unregulated watersheds with long stream flow records.
The main objective of the study is Firstly to analyze the historical water level and the discharge data of Halda river.Secondly to analyze the flooded area of the recorded years at the adjoining land of Halda river.Thirdly to determine the return period of flood occurrence.& lastly to recommend the flood mitigation measures of the river.

In our country flood frequency analysis is quite large due to unavailable manpower to collect the hydrological data accurately. From frequency analysis it should relate the magnitude of extreme events, determine the most probable flood and level of flow. Hydrologic simulation can also be used to determine the flood frequency in unassessed streams. The model parameters then fixed to express the physical changes between the calibrated and unassessed watershed. All the available audited meteorological data can be used to create a long stream flow record for unassessed stream which can be used to a statically distribution.

2. METHODOLOGY

2.1 Flow chart of our work procedure:

Collection of necessary data from BWDB like water level, discharge, flooded area, rainfall, temperature & humidity of different station



2.2 Log Pearson Type-iii Method:

The first step is to take the logarithms of the hydrological data. 10 based logarithms are usually used.Then the mean standard deviation and coefficient of skewness C_S are calculated. There is a frequency factor which depends on the return period and the coefficient of skewness.

Variate, Z = log Q and $\bar{Z} = \frac{\sum Z}{N}$

Q = Flood discharge in cumec, N = Number of total data

Standard deviation of the Z variance, $\sigma_Z = \sqrt{\frac{\sum(Z-\bar{Z})^2}{N-1}}$

Coefficient of skew of variance Z, $C_S = \frac{N\sum(Z-\bar{Z})^3}{(N-1)(N-2)\sigma^3}$

2.3 Gamble's Method:

$Q_T = Q + K\sigma_{n-1}$ Where,

Q_T = The magnitude discharge of the T year flood event
K = Frequency factor

$K = \frac{(yt - yn)}{Sn}$

$y_t = -[\ln \ln \frac{T}{T-1}]$

y_n = Reduced mean
S_n = Standard deviation

$T = \frac{N+1}{m} = \frac{21}{m}$

N = 20

m = Rank

$\overline{Q}$ = The mean discharge

σ_{n-1} = Standard deviation of the simple size= $\sqrt{\frac{\sum(Q-Q)^2}{N-1}}$

3. STUDY AREA & DATA COLLECTION:

The Halda river in Chittagong District is prone to flooding, with the most intense impact occurring in the Fatikchhari upazila. This area serves as the main focus for flood analysis, and there are several river stations for studying the effects of flooding. While the upstream level experiences less flooding, the downstream level is significantly affected. Narayanhat station, located upstream, is particularly susceptible to river erosion. On the other hand, Panchpukuria, Nazirhat, Enayethat, and Telpari stations, situated downstream, face higher flood levels. Flood plains, which are the valley floors adjacent to the river channel, can become inundated during periods of high water. These flood plains are primarily formed through the deposition of fine sediments, and organic matter may accumulate in cutoff meander loops. In some cases, the stream can flow at a higher elevation than its flood plain due to deposited sediments and natural levees on the banks. To fully understand the characteristics of flood plains, it is necessary to utilize detailed maps or conduct special field surveys.

In order to analyze the flood flow in the Halda River and to control various essential data are collected from Bangladesh Water Development Board that are given bellow-

Table-3.1: The discharge recorded at Panchpukuria station No &
Name of River: 44, Halda (B.M value: 9.57m & D.L: 9.50m)

No & Name of station: 119/1, Panchpukuria

S.L NO	River	Station	Year	Recorded Discharge (cumec)			
				Yearly Highest		Yearly Lowest	
				Month	Value	Month	Value
1	44, Halda	119/1, Panchpukuria	1998	July	386.954	March	2.103
2			1999	July	548.672	May	8.079
3			2000	August	297.647	October	11.974
4			2001	July	476.225	March	19.873
5			2002	July	482.336	March	8.147
6			2003	July	483.226	March	8.226
7			2004	June	87.124	January	8.079
8			2005	August	145.735	February	52.895
9			2006	February	96.75	November	69.15
10			2007	July	66.161	April	2.228
11			2008	August	188.412	April	0.874
12			2009	October	89.867	March	0.078
13			2010	June	72.683	February	0.870
14			2011	May	32.101	March	0.379
15			2012	August	114.38	March	0.220
16			2013	September	15.422	March	0.147
17			2014	June	162.57	November	2.35
18			2015	September	80.303	February	0.321

19	2016	July	53.868	February	0.208
20	2017	June	164.838	February	1.622

Source: Bangladesh Water Development Board (BWDB), Chittagong

Table-3.2: Areas that have flooded due to overflow

No & Name of River: 44, Halda (B.M value: 9.57m & D.L: 9.50m)No & Name of station: 119/1, Panchpukuria

Year	**Maximum Water Level (m)**	**Maximum Discharge (cumec)**	**Flooded Area (m^2)**
1998	10.44	386.954	299.82
1999	10.10	548.672	295.35
2000	9.26	297.647	403.02
2001	9.19	476.225	262.19
2002	9.41	482.336	372.16
2003	12.50	483.226	374.12
2004	9.39	87.124	372.36
2005	9.40	145.735	112.22
2006	7.32	96.750	170.65
2007	6.09	66.161	130.20
2008	8.99	188.412	112.76
2009	8.15	89.867	233.97
2010	8.72	72.683	145.69
2011	7.74	32.101	125.30
2012	8.44	114.380	74.50
2013	7.28	15.422	226.46
2014	9.10	162.570	34.16
2015	7.33	80.303	320.46
2016	6.12	53.868	174.85
2017	9.70	164.838	106.568

Source: Bangladesh Water Development Board (BWDB), Chittagong

3.1Analysis of data:

Essential data are collected from Bangladesh Water Development Board for flood flow analysis. The table 5.1 is the maximum water level data which is needed for return period calculation. And table 5.5, 5.6 is needed for necessary calculation for Log Pearson Type III and Gumbel method.

Here, Danger Level is 9.50m at Panchpukuria station.

Let "A" be the event that the water level exceeded the danger leval.
From the table-5.1, the number of value that exceeded danger level, n=4
The number of total data, N=20
So the probability that the water level exceeded the danger level,P(A)=$\frac{n}{N}$ = $\frac{4}{20}$ =0.2
The probability that the water will not exceed the danger level in any year=1-0.2=0.8
So the return period, T = $\frac{1}{P(A)}$ = $\frac{1}{0.2}$ = 5 years.

3.1.1.Log Pearson type iii Distribution Method:

First step is to take the logarithms of the hydrological data. 10 based logarithms are usually used. Then the mean standard deviation and coefficient of skewness C_S are calculated. There is a frequency factor which depends on the return period and the coefficient of skewness.

Here, Q = Flood discharge in cumec

Variate,Z= log Q and $\overline{Z}$= $\frac{\sum Z}{N}$

Table-3.1.1: Calculation of variance (Z) and return period for different discharge at Panchpukuria station.

Year	Q (cumec)	Rank, m	Z=log Q	(Z-$\overline{Z}$)	(Z-$\overline{Z}$)^2	(Z-$\overline{Z}$)^3	T= $\frac{N+1}{m}$
1999	548.67	1	2.73	0.61	0.37	0.22	21
2003	483.23	2	2.68	0.55	0.30	0.17	10.5
2002	482.34	3	2.68	0.55	0.30	0.17	7
2001	476.23	4	2.69	0.55	0.31	0.17	5.25
1998	386.95	5	2.59	0.46	0.21	0.09	4.2
2000	297.65	6	2.47	0.34	0.12	0.04	3.5
2008	188.41	7	2.28	0.14	0.02	0.003	3
2017	164.84	8	2.22	0.08	0.007	0.0006	2.63
2014	162.57	9	2.21	0.08	0.006	0.0005	2.33
2005	145.74	10	2.16	0.03	0.0009	0.00003	2.1
2012	114.38	11	2.06	-0.08	0.006	-0.0004	1.91
2006	96.75	12	1.99	-0.15	0.022	-0.003	1.75
2009	89.87	13	1.95	-0.18	0.032	-0.006	1.62
2004	87.12	14	1.94	-0.19	0.037	-0.007	1.50
2015	80.30	15	1.90	-0.23	0.052	-0.012	1.40
2010	72.68	16	1.86	-0.27	0.074	-0.02	1.31
2007	66.16	17	1.82	-0.31	0.10	-0.03	1.24
2016	53.87	18	1.73	-0.40	0.16	-0.065	1.17
2011	32.10	19	1.51	-0.62	0.39	-0.25	1.11
2013	15.42	20	1.19	-0.95	0.89	-0.84	1.05

Sum		42.66	3.407	-0.370

After doing all the caculation Kz value & mazimum flood discharge is presented in tabulated form:

Table-3.1.2: K_Z value and probable maximum flood discharge calculation

Return period T (Year)	Coefficient of skew, C_S	Frequency factor, K_Z	$Z_T = \overline{z} + K_Z\sigma_Z$	Q_T=antilog Z_T (cumec)
5	-0.2864	1.269	2.669	466.66

3.1.2.Gumble method:

The neccesary equations are written below:

$Q_T = Q + K\sigma_{n-1}$ ...... (1)

$K = \frac{(yt - yn)}{Sn}$ ...... (2)

$y_t = -[\ln \ln \frac{T}{T-1}]$ ...... (3)

$T = \frac{N+1}{m} = \frac{21}{m}$

$\overline{Q}$ =Mean discharge

σ_{n-1} = Standard deviation of the simple size = $\frac{\sum(Q-\overline{Q})^2}{N-1}$

Table-3.1.2.1: Calculation of T and σn-1 for different discharge at Panchpukuria station

Year	Q (cumec)	Rank (m)	T	$\overline{Q}$	$(Q-\overline{Q})$	$(Q-\overline{Q})^2$	σn-1
1999	548.67	1	21	202.26	346.41	119999.9	
2003	483.23	2	10.5	202.26	280.97	78944.14	
2002	482.34	3	7	202.26	280.08	78444.81	
2001	476.23	4	5.25	202.26	273.97	75059.56	
1998	386.95	5	4.2	202.26	184.69	34110.4	
2000	297.65	6	3.5	202.26	95.39	9099.252	
2008	188.41	7	3	202.26	-13.85	191.8225	
2017	164.84	8	2.625	202.26	-37.42	1400.256	
2014	162.57	9	2.333	202.26	-39.69	1575.296	
2005	145.74	10	2.1	202.26	-56.52	3194.51	
2012	114.38	11	1.909	202.26	-87.88	7722.894	175.144
2006	96.75	12	1.75	202.26	-105.51	11132.36	
2009	89.87	13	1.615	202.26	-112.39	12631.51	
2004	87.12	14	1.5	202.26	-115.14	13257.22	
2015	80.30	15	1.4	202.26	-121.96	14874.24	
2010	72.68	16	1.312	202.26	-129.58	16790.98	
2007	66.16	17	1.235	202.26	-136.1	18523.21	
2016	53.87	18	1.167	202.26	-148.39	22019.59	
2011	32.10	19	1.105	202.26	-170.16	28954.43	

2013	15.42	20	1.05	202.26	-186.84	34909.19
Sum	4045.28					582835.5

From 3.5 Mean discharge $\overline{Q}$= 202.26 cumec, $\boldsymbol{\sigma}_{n-1}$ =175.144
From table 7.3 & 7.4 (Subramanya 2017-18),
y_n = 0.526 & S_n =1.0628 ,For T=5 years using equation (3) y_t =1.49,using equation (2) K= 0.909 ~1
Finally using euation (1) Q_T= 377.404 cumec

Table-3.1.2.2: Comparison of different results

Methods	Discharge, Q (cumec)
Gumbel's Method	377.404
Log Pearson Type III	466.66
Maximum discharge	548.67 (July, 1999)

From table-5.5, flood discharge difference between Gumbel's method and Log Pearson type III method = 466.66-377.404 = 89.256 cumec.

Avarage=$\frac{\mathbf{377.404+466.66}}{\mathbf{2}}$ =422.032 cumec

3.2.1. ANALYSIS OF DATA BY GRAPHS:

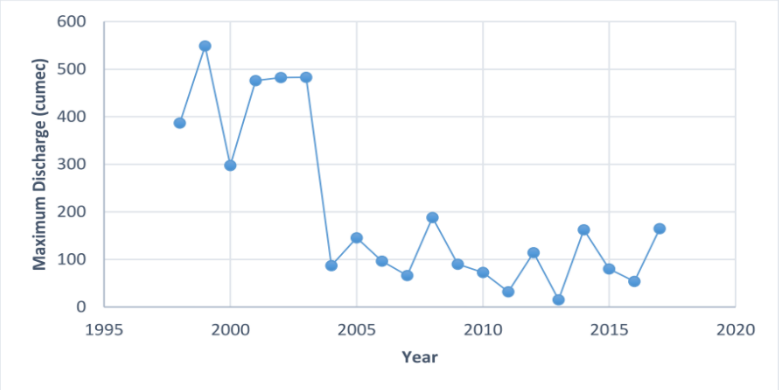
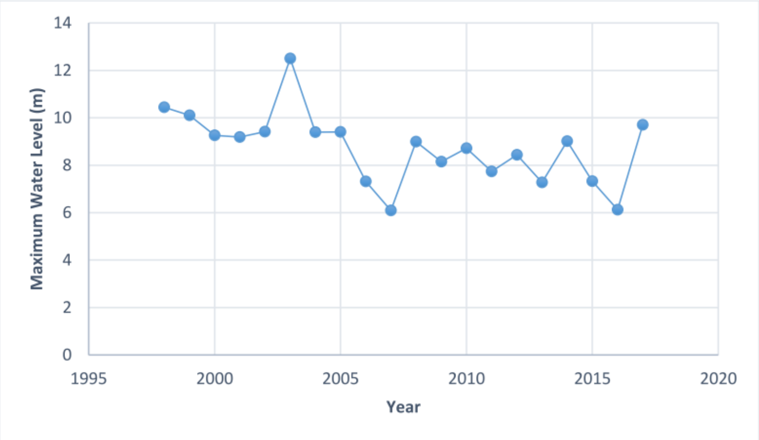


Figure-4.1: Maximum Discharge vs different years at Panchpukuria station
Figure-4.1 represents the values or curve of discharge and year and it almost express the sinusoidal relationship.The heightest value remains in 500 &600.



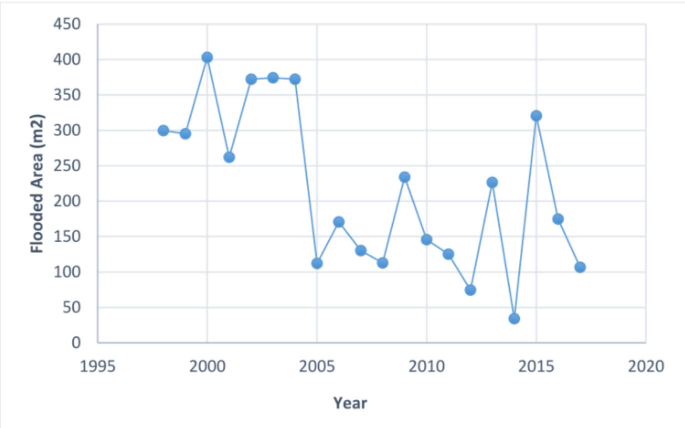


Figure-4.2: Maximum water level vs different years at Panchpukuria station

Figure-4.3: Flooded Area vs different years at Panchpukuria station

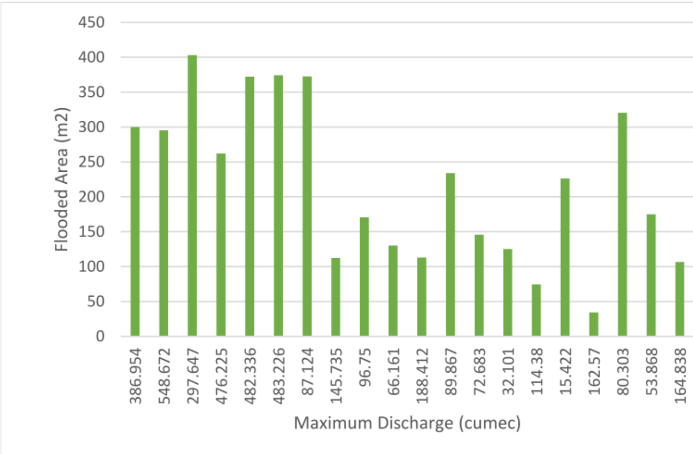


Figure-4.4: Flooded area vs Maximum discharge at Panchpukuria station

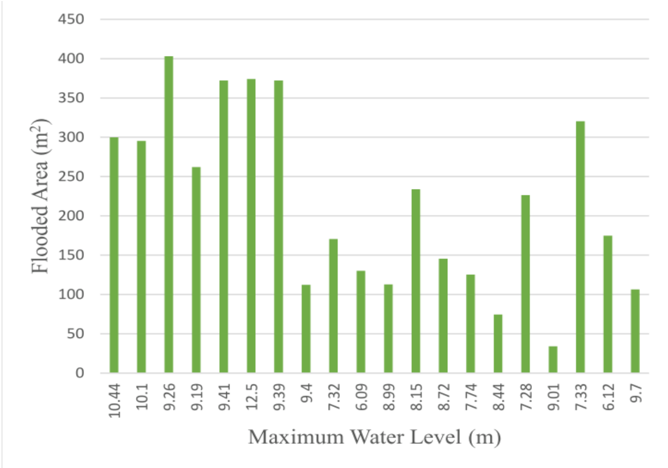


Figure-4.5: Flooded area vs Maximum Water Level at Panchpukuria station

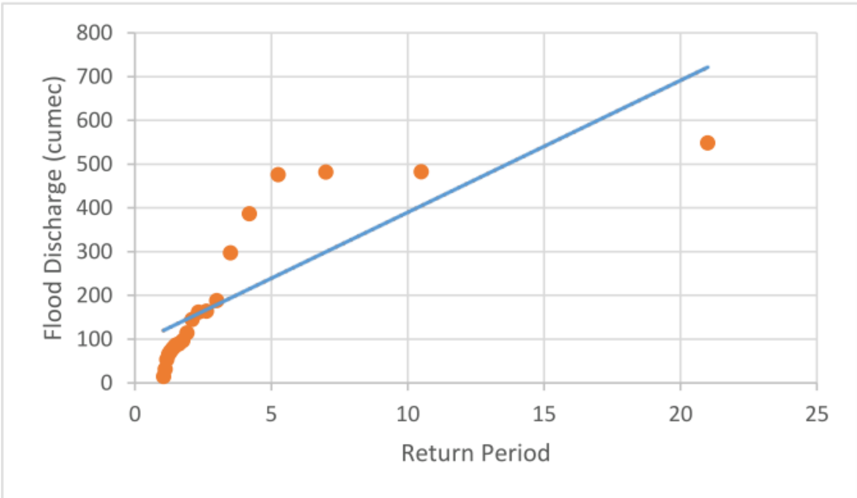


Figure-4.5: Flood frequency plot at Panchpukuria station

Figure-4.2 expresses the maximum water level and different year in Panchpukuria station and the maximum water level shows 12.5m in 2003. Figure-4.3 shows the flooded area v/s year graph in 20 years statically analysis. And the relation is not linear in this case. Fig 4.4 & fig 4.5 dictate the relation or graph of flooded area and maximum discharge& water level. This frequency plot or figure-4.5 represents the relation of flood discharge value and return periodto provide an estimate of the intensity of flood event. It provides a vital role in providing estimation of recurrence of flood which is used for designing the hydraulic structures.

3.2.2 ANALYSIS OF DATA BY LINEAR REGRESSION:

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.726289088							
R Square	0.527495839							
Adjusted R Square	0.501245608							
Standard Error	1.065286669							
Observations	20							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	1	22.80441264	22.80441264	20.09490265	0.000287754			
Residual	18	20.42704236	1.134835687					
Total	19	43.231455						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	7.468306621	0.369323046	20.22161006	7.9629E-14	6.692387693	8.244225548	6.692387693	8.244225548
Q	0.006255168	0.001395391	4.482733836	0.000287754	0.003323559	0.009186776	0.003323559	0.009186776

Figure-5.1: Linear regression between maximum discharge and maximum water level

From Figure-5.1, it can establish an equation between maximum discharge and maximum water level that is given below,

$$WL = 0.006255168 \times Q + 7.468306621$$

Here,WL=Mazimum water level, Q=Mazimum discharge

It will not give accurate value because the month is not same. The month of maximum water level determination and the month of maximum discharge determination is not same. So, the error willbe happened.

SUMMARY OUTPUT								
Regression Statistics								
Multiple R	0.728014581							
R Square	0.53000523							
Adjusted R Square	0.362149955							
Standard Error	90.94090994							
Observations	20							
ANOVA								
	df	*SS*	*MS*	*F*	*Significance F*			
Regression	5	130567.0996	26113.41992	3.157513105	0.040863533			
Residual	14	115783.4874	8270.2491					
Total	19	246350.587						
	Coefficients	*Standard Error*	*t Stat*	*P-value*	*Lower 95%*	*Upper 95%*	*Lower 95.0%*	*Upper 95.0%*
Intercept	369.4985641	216.5847749	1.7060228	0.110079419	-95.0295779	834.026706	-95.0295779	834.026706
R	0.065965081	0.130361594	0.506016217	0.620719294	-0.213632731	0.345562892	-0.213632731	0.345562892
M of R	-53.55898954	22.27324537	-2.404633391	0.030596146	-101.3303497	-5.787629377	-101.3303497	-5.787629377
Q	0.278125655	0.176473085	1.576023082	0.137342371	-0.100371468	0.656622778	-0.100371468	0.656622778
M of Q	17.26947356	12.6273011	1.367629823	0.192982701	-9.813393735	44.35234086	-9.813393735	44.35234086
WL	-4.033616377	23.74122735	-0.169899235	0.86752005	-54.95348476	46.886252	-54.95348476	46.886252

Figure-5.2: Linear regression between maximum total monthly rainfall, month of maximum total monthly rainfall, maximum discharge, month of maximum discharge,maximum water level and the flooded area.

From Figure 5.2, it can establish an equation that is given below,

$$A = 0.069565081 \times R - 53.55898954 \times M_R + 0.278125655 \times Q + 17.26947356 \times MQ - 4.033616377 \times WL + 369.4985641$$

Here,

A=Flooded Area

R=Maximum total monthly rainfall.

M_R = Month of Maximum total monthly rainfall (1-12)

Q = Maximum discharge

M_R = Month of Maximum discharge(1-12)

WL=Maximum water level

3.2.3 MITIGATION MEASURES FOR HALDA RIVER:

Halda is located in south-eastern of Bangladesh in Chittagong division. It originates from Badnatali Hill ranges in Ramgarh upazila under Khagrachari district and flows through Fatikchhari upazila, Bhujpur thana, Hathazari, Roazan upazila and finally falls into Karnaphuli river. Although Nazirhat situated on the downstream zone but it not as much vulnerable for flood occurrence. Because of the topography and the stable soil system the flood could not come here frequently. But in the monsoon due to heavy rainfall flood may visit here. Recently in last year due to heavy rainfall flood visit these area and cause destruction of life and property. The flood water stays two days, and the sufferings of people are beyond description. In Panchpukuria station where the historical water level is high, and flood visit this area frequently. During monsoon due to heavy rainfall the riverbanks are eroded, and the area gets flooded. There is no protection against flood here. The recommended flood mitigation steps like- bank protection by using sandbags, construction of marginal embankment etc should be adopted. Embankment a major structural measure for floods may create negative environment for flood and water logging condition for any floodplain.

4. CONCLUSIONS:

The project on “Flood Flow Analysis of Halda River and Its Mitigation” is done very carefully under sincere supervision. By Log Pearson type 3 Distribution and Gumble methods, the flood discharge is 466.66 cumec and 377.404 cumec. It is observed that from flood frequency plot the area will be flooded at least once in every five years. And the actual maximum flood is found 548.67 cumec in Panchpukuria station. The highest annual maximum water level is 10.44 in observed year for the following station.It is observed from the graphs that in Panchpukuria station the water level is highest comparison to other stations because of topographical position. And the discharge also found very high here. So it is obvious that flood visits the place more than other places. The another cause of flood is this place is bank erosion.

From analysis of graphs it describes that from all the downstream stations the water level is high in Panchpukuria station so flood often visits this area. According to the economical design consideration the value of 377.404 cumec is taken for the design flood. This report also represents some relationships by linear regression between maximum discharge and water level and so on. Sometimes flood occurred at five successive years. So flood control measures should exist every year. The inhabitants of the catchment area should be alert about it. If the preventive measures are taken, then the loss or damage will be minimized. The downstream portion mainly flooded and the reasons of flood of those area mainly heavy rainfall, backwater flow of Karnaphuli, blocking of river by sedimentation or massive landslide. Moreover, the data that have found from BWDB is not totally correct or justified so the variation of result is formed. Overall due to some data limitation the calculation is not fully justified.

5. ACKNOWLEDGEMENT:

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