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Importance of Making More Water Dams and Construction of Concretes River Embankment in Bangladesh to Protect Flood

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Abstract
Water is Bangladesh's blessing and a curse. For nearly half the year, the monsoon rains cause the country's four major rivers, the Jamuna, Padma, Brahmaputra and Meghna, and their tributaries to swell. Devastating floods are often the consequence. During the rest of the year, the dry season brings almost no rainfall, and droughts threaten the livelihoods of people and the health of the natural environment. Frequent and widespread flooding is a major problem in Bangladesh, which is a Rangpur, Bogra, Shirajganj, Rajbari Region. The problem is caused mainly by the Jamuna River and sudden coming floodwater from India through Brahmaputra whose erratic riverbank erosion has been leading to the general widening of channels and large-scale instability of riverbanks. Both the flooding and erosion in the river valley can be tackled only through an adaptive response that includes the use of structural protection systems such as making water dams and strong river embankment. A practicability study in this paper was led for riverbank protection works and an increasing number of dams are also discussed.

Keyword: *Embankment, Erosion, Flood, Dam, Slope Stability*.

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I. Introduction

Bangladesh lies roughly somewhere in the range of 20°30' and 26°40' north latitude and 88°03' and 92°40' east longitude. It is one of the greatest dynamic deltas on the planet with a territory of around 1, 47,570 sq.-km. The nation is under a sub-tropical storm atmosphere, the yearly average precipitation is 2,300 mm, differing from 1,200 mm in the north-west to more than 5,000 mm in the north-east. India borders the nation in the west, north and most piece of the east. The Bay of Bengal is in the south, Myanmar borders part of the south-eastern zone. It has 405 rivers including 57 transboundary rivers, among them 54 started from India including three significant streams the Ganges, the Brahmaputra and the Meghna according to Bangladesh Water Development Board (BWDB, August 2011). Three streams are begun from Myanmar. Rainstorm flood immersion of about 20% to 25% territory of the nation is accepted useful for corps, ecology, and environment. But, flood more than that making immediate and roundabout harms and extensive bothers the population.

The country comprises of the flood plains of the Ganges, the Brahmaputra and the Meghna rivers and their various tributaries and distributaries. The Ganges and the Brahmaputra combine at Aricha-Goalundo and is known as the Padma River. The river Meghna joining the Padma closes Chandpur Rivers to the Bay of Bengal as the Meghna River.

During the time of March to June, Bangladesh has sweltering summers described by extremely high evapotranspiration and periodic heavy precipitation. This is trailed by a hot and sticky storm season (from June to October) including substantial precipitation (80 % of the normal precipitation happens during this season). The third season is moderately cooler and drier (from November to March).

The significant rivers have a length of 500 to 2500 km and the width ranges from 1 km to 20 km, with level slopes. Bangladesh by and large experiences four kinds of floods which are (1) flash floods, (2) rain-fed floods, (3) river floods (generally normal) and (4) storm surge floods. On account of significant cyclones, the whole coastal belt is overflowed, once in a while causing incredible loss of lives. During the last 50 years, in any event, eight extreme flood occasions happened affected half of the land zone. Two of these extreme floods were the flood of 1988 and the flood after the devastating cyclone of 1991.

The Ganga and Brahmaputra River is the main cause of flooding in the north region of Bangladesh. The problem of flooding in the river basin is basically linked with the monsoon, sudden water reduction from

the Indian River. Further, insufficient water dams are also responsible for extreme floods. This means that both the flooding and erosion in the river valley can be tackled only through an adaptive response, by managing the consequences of the ever-changing river environment in an integrated manner. While high dam's square measure counseled for control, it'll be necessary to continue dependence on the present network of embankments with correct periodic maintenance.

II. Data

The information on time series of historical floods in Bangladesh with immersion territory is gathered from Bangladesh Flood Forecasting and Warning Center (FFWC). Most of these data are found in their Annual Flood Reports published on the website www.ffwc.gov.bd. The Bangladesh tide table and rise in Sea level during 1998 flood are collected from Bangladesh Inland Water and Transport Authority (BIWTA), Dhaka.
Soil properties data are collected from SRDI (Soil Resources Development Institute) [6] and BBS (Bangladesh Bureau of Statistics (2009) [5]

III. Analysis and Discussion

3.1. RIVER SYSTEM OF BANGLADESH

The Ganges, Brahmaputra and Meghna river systems together, drain the tremendous spillover produced from an enormous region with the most elevated precipitation regions on the planet. Their all-out catchment region is around 1.6 million sq.-km of which pretty much 7.5% lies in Bangladesh and the rest, 92.5% lies outside the Bangladesh. It is assumed that the normal flow of 1,009,000 Million cubic meters goes through these waterway systems during the monsoon season. The majority of the rivers are described by having sandy bottoms, flat slopes, substantial meandering, banks powerless to erosion and channel shifting.

The Old Brahmaputra is the primary left-bank distributaries of the Brahmaputra River directly known as the Jamuna. Inside Bangladesh, the Brahmaputra gets four significant Right Bank tributaries - the Dudkumar, the Dharla, the Teesta and the Hurasagar. The initial three are flashy rivers, ascending in steep catchments on the southern side of the Himalayan among Darjeeling and Bhutan. The Hurasagar River is the outlet to the Karatoya-Atrai stream river, which contains a great part of the inside drainage of northwest Bangladesh.

The Jamuna at Goalondo, the river, known as the Padma, streams in a wide and straight. At Chandpur, the Padma is joined to the Meghna from where it streams to the ocean with tidal impact.

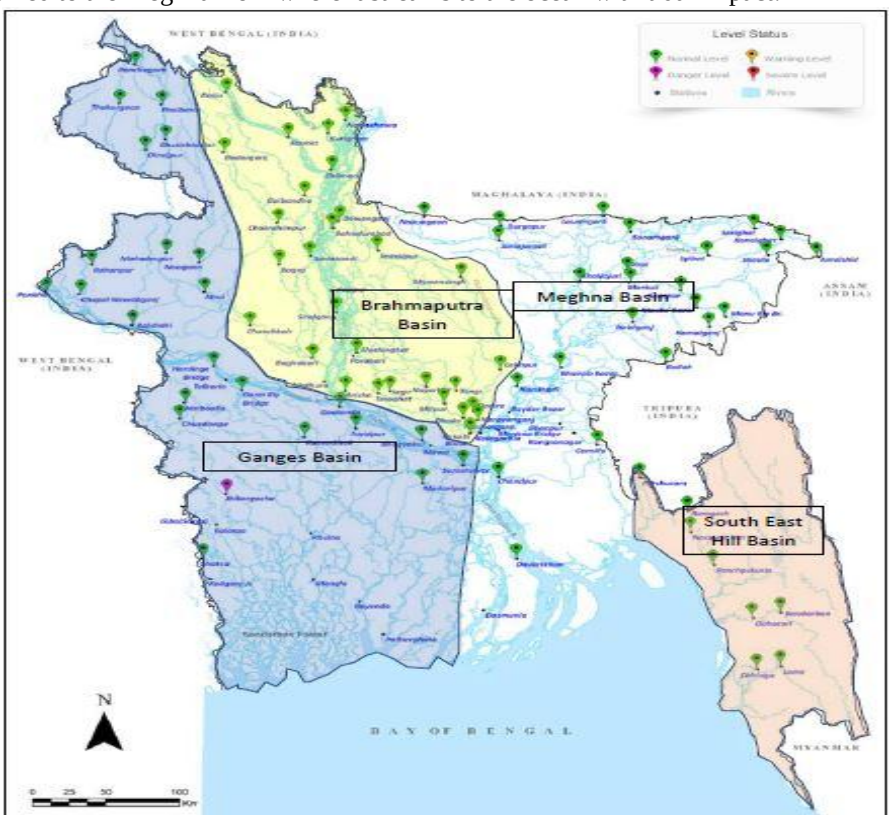

Fig. 1. Basin Map of Bangladesh with Water Level Gauge Stations (BWDB).

Fig. 1 represent the picture of the Basin map of Bangladesh and this map surveying by the Bangladesh Water Development Board (BWDB).

Fig. 1 shows that the Meghna River system begins in the slopes of Shillong and Meghalaya of India. The primary source is the Barak River, which has an extensive catchment in the edge and valley territory of eastern Assam bordering Myanmar. On arriving at the border side with Bangladesh at Amalshid in the Sylhet region, it bifurcates into Surma and the Kushiyara waterways. The Surma river streaming on the north of the Sylhet basin.

So, it's clear that all the rivers main source of water is coming from India. During raining season India release excess river water which is very dangerous for Bangladesh.

3.2. RIVERBANK EROSION

Riverbank Erosion an endemic and intermittent regular danger in Bangladesh. At the point when streams enter the development stage (as for the situation with the three compelling rivers, Ganges, Brahmaputra, and Meghna) they become sluggish and meander or twist. These motions cause gigantic riverbank erosion shows in Fig. 2&Fig. 3. Consistently, a huge number of individuals are influenced by erosion that devastates standing crops, farmland and property land. According to M R Rahman [2] [3], it is estimated that about 5% of the total floodplain of Bangladesh is directly affected by erosion. A few scientists have revealed that bank erosion is occurring in around 94 out of 489 Upazilas of the nation. A couple of different specialists have recognized 56 Upazilas with an occurrence of erosion. At present, bank erosion and flood risks in about 100 Upazilas have become right around an ordinary situation. Of these, 35 are seriously severely affected. For instance, a newspaper report expressed that more than 25,000 families were rendered homeless in June 1993 by riverbank erosion in 16 regions. A few drivers cause erosion in large scale and high recurrence because of their unstable character. These rivers accept an interlaced example comprising of a few channels isolated by little islands in their courses. During the most recent 200 years or somewhere in the nation, the channels have been swinging between the main valley walls.

There are few causes of failure known were a breach of the river embankment, cutting by the general public, overflow, erosion, seepage, and sliding. moreover, Furthermore, supervising throughout construction leads to poor-quality earthworks with the utilization of inappropriate soil materials, too little or no clod breaking, inadequate compaction and or no too little parturition of dirt layers, the utilization of inferior materials, inadequate maintenance, stream migration and cutting by the general public. Among several reasons, the improper style methodology and construction procedure square measure prime and one in all the foremost vital causes of river embankment failure.

Fig. 2. River Embankment Broken Shirajganj Area (Jamuna River Side).

Fig. 3. Food Breaks River Embankment Which Is Made by Only Concrete Block and Soil.

During the rainstorm, extensive over bank spills, bank erosion and bank line shifts are typical. The slow relocation or moving of channels of the significant rivers in Bangladesh add up to anyplace between 60m to 1,600m every year. In a typical year, around 2,400 km of the bank line encounters significant erosion. The unpredictable moving conduct of the rivers and their infringements influence the country's floodplain population as well as urban development places and foundations.

According to (Md.Wasif Zaman et al., 2016) [1] recent river embankment breach in Bangladesh shown in

Table 1.

From the table it's visible that it was too dangerous during 2014, 30 villages flooded and 2 crore takas damaged.

Table 1.Recent Embankments Breach in Bangladesh.

Region/District	River	Name of Embankments	Date of Breach	Damages
Faridpur	Padma	Faridpur city protection embankment	May 18, 2015	20 meters bolder collapsed
Sirajganj, Dhekuria	Jamuna	Dhekuria embankment	March 29, 2015	10 houses destroyed
Bogra; Jamalpur; Sirajganj;	Jamuna	Flood protection embankments	August 30, 2014	150 villages flooded in Bogra; 20 villages flooded in Jamalpur; 600 families shelter less in Sirajganj
Rajshahi	Padma	Rajshahi city protection	August 07, 2014	Soil moved and damaged
Feni, Fulgaji	Muhuri	Muhuri river embankment	June 22, 2014	30 villages flooded
Pabna, Sathiya	Ichamoti	Ichamoti river embankment	May 20, 2014	Crops and fisheries worth 2 crore damaged

3.4. EMBANKMENT SOIL CHARACTERISTICS OF JAMUNA AND PADMA RIVER SIDE

A normal 256.1 ha and 622.2 ha of a complete land region of Gaibandha and Sirajganj individually were eroded including embankments every year during the time of 1973-2009 according to (Rahman M.R., 2010) [2] During this period, the study areas i.e. Lohajang and Kazipur observed 3.82 ha and 6.89 ha erosion per year respectively [CEGIS 2005]. Throughout June 2015, major bank erosions were estimated to take place at 48 places along a 210 km stretch of the Brahmaputra-Jamuna, Ganges and Meghna riverbank [CEGIS 2005]. The government has constructed 1,209 km of river embankment and has fixed 15,358 km of embankments in the 2014-15 financial years (April to March).

For research purposes, the soil research development institute took soil samples from different locations which are the flood-affected areas in Bangladesh and found different properties of soil which as seen in

Table 2.

Table 2.Embankment Soil Characteristics at Four Specific Areas.

Location	Lohajang, Munshiganj	Kazipur, Sirajganj
Soil sample	Ganges sandy soil	Brahmaputra's alluvial soil
Texture	Sandy loam	Loam
OM (%)	1.37	0.8
Type	Non-calcareous grey	Non-calcareous alluvium
Sand (%)	0	27
Alluvium (%)	17	72
Clay (%)	83	1
Percolation rate	Poor	Medium

Soil properties collected from SRDI (Soil Resources Development Institute) [6] and BBS (Bangladesh Bureau of Statistics (2009) [5] as shown in

Table 2.

3.5. SLOPE STABILITY ANALYSIS OF JAMUNA AND PADMA RIVER EMBANKMENT

Table 3 shows that the Stability of the Jamuna and Padma river embankment was checked in terms of Factor of Safety (FS) values.

Table 3.Slope Stability Analyses for the Failed Sections of Jamuna and Padma Flood Control Embankment According to (Hossain M.Z. et al., 2008) [9]

Embankment failed	Jamuna		Padma	
Type of analyses	Effective stress analysis		Effective stress analysis	
Water storage condition	With-out water storage	With water storage	With-out water storage	With water storage
Factor of safety	1.45	1.27	1.55	1.35
Deviation (%)	14.17		14.8	
Recommended F.S. (without EQ)	1.5	1.5	1.5	1.5

The results from Table 3 show that the factor of safety is overestimated about 14-15% in the case without water storage. Moreover, without water storage condition does not satisfy the recommended factor of safety.

After affected with some biggest flood and embankment erosion, the water development board made some good qualities embankment last year 2019 shows in Fig. 4. This is very effective for riverside people to project their live and agricultural land.

Now these river embankments have a slope stability factor of safety more than 1.5 which is enough strong to protect flood as shown in Fig. 4.

Fig. 4. Newly developed Jamuna and Padma river embankment maintaining proper slope stability factor of safety.

But this type of embankment slope stability factor of safety value is not available in all river embankments in Bangladesh.

3.6. STATISTICS OF FLOOD IN BANGLADESH

According to (Paul et al., 2010) [12], Bangladesh has encountered 28 significant floods in the previous 42 years (1954–1996), of which 11 were delegated "devastating" and five as "most devastating". Outlining all distributed flood data in the few articles, 30 significant floods were seen during 1962–2017.

Numerous parts of Asia during rainstorm frequently experience the dangerous effects of extreme floods. A few parts of India and Bangladesh experience floods pretty much consistently with extensive damages. The floods of 1954, 1955, 1974, 1987, 1988, 1998, 2004, 2007 and 2017 all caused heavy damages to properties and considerable loss of life. During monsoon 2018, the flood was a normal one and stayed for a short duration. However, the Moulvibazar region was hit by serious flash flooding because of the stream Manu during the beginning of the rainstorm in June. 23% of the nation got flood influenced in 2018. During 2019 there was no big flood in Bangladesh aside from hardly any water basin flood.

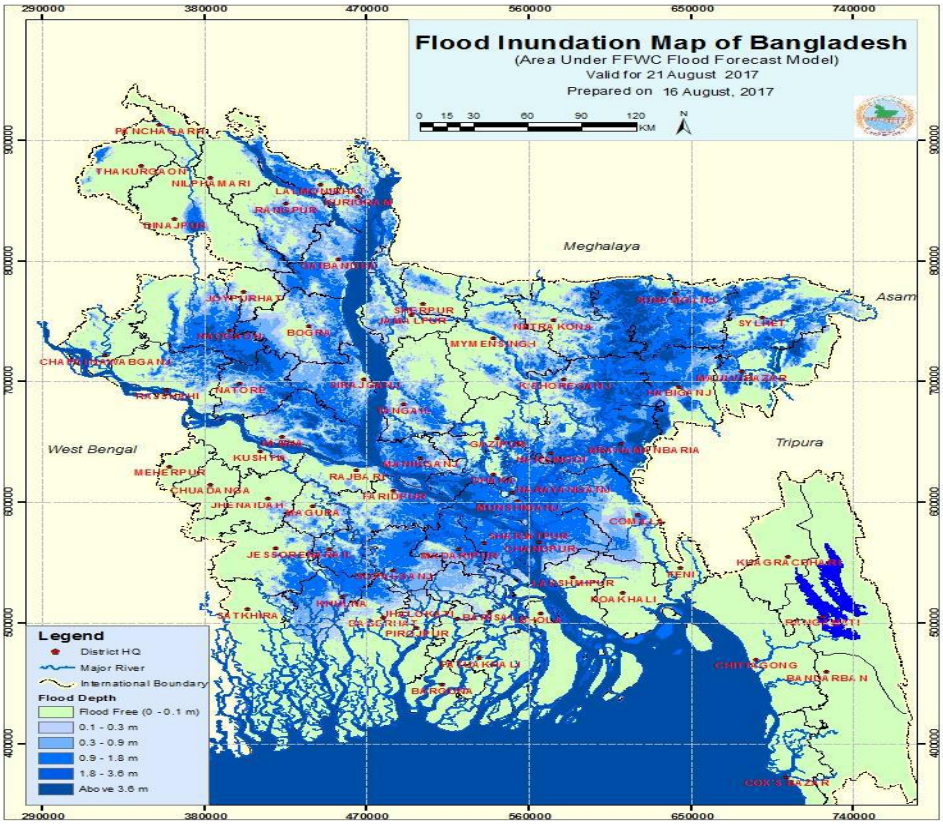

Fig. 5. Flood Inundation Map of Bangladesh (120hr Forecast Based on 16 August 2017-BWDB)

Fig. 5 flood inundation map shows that during the monsoon season the north part and middle areas of Bangladesh affecting highly due to excessive water in the river which occurred flood the near city and villages.

Table 4. Year-wise Flood Affected Area in Bangladesh.

Year	Flood Affected area		Year	Flood Affected area		Year	Flood Affected area	
	Sq-Km	%		Sq-Km	%		Sq-Km	%
1954	**36,800**	**25**	1977	12,500	8	2000	35,700	24
1955	**50,500**	**34**	1978	10,800	7	2001	4,000	2.8
1956	35,400	24	1980	33,000	22	2002	15,000	10
1960	28,400	19	1982	3,140	2	2003	21,500	14
1961	28,800	20	1983	11,100	7.5	**2004**	**55,000**	**38**
1962	37,200	25	1984	28,200	19	2005	17,850	12
1963	43,100	29	1985	11,400	8	2006	16,175	11
1964	31,000	21	1986	6,600	4	**2007**	**62,300**	**42**
1965	28,400	19	**1987**	**57,300**	**39**	2008	33,655	23
1966	33,400	23	**1988**	**89,970**	**61**	2009	28,593	19
1967	25,700	17	1989	6,100	4	2010	26,530	18
1968	37,200	25	1990	3,500	2.4	2011	29,800	20
1969	41,400	28	1991	28,600	19	2012	17,700	12
1970	42,400	29	1992	2,000	1.4	2013	15,650	10.6
1971	36,300	25	1993	28,742	20	2014	36,895	25
1972	20,800	14	1994	419	0.2	2015	47,200	32
1973	29,800	20	1995	32,000	22	2016	48,675	33
1974	**52,600**	**36**	1996	35,800	24	**2017**	**61,979**	**42**
1975	16,600	11	**1998**	**1,00,250**	**68**	2018	33,941	23
1976	28,300	19	1999	32,000	22			

Percentages of the total area of Bangladesh affected by flood available since 1954 are presented in

Table 4.

3.7. THE LAST MONSOON FLOOD 2019 SITUATIINS IN BANGLADESH

According to National Disaster Response Coordination Center (NDRCC), 21 districts of northern, north-eastern and south-eastern Bangladesh are most affected due to week-long monsoon rains in the upstream regions and throughout the country (BDRCS-2019)

The overall flooding scenario represents the following impacts according to the Flood Forecasting and Warning Center (FFWC) and National Disaster Response Coordination Center (NDRCC):

- The water level all things considered of the significant rivers in Bangladesh encountering a decrease of water level while just Jamuna and Padma (Ganges) despite everything demonstrating a rising inclination. However, the water level may begin diminishing in Jamuna within the following 24 hours. Be that as it may, the water level of Padma will continue ascending until the following 48 hours. There is no forecast about heavy rainfall in Bangladesh and cross border upstream region in the next 24 hours.
- Flooding circumstances in Sirajganj and Tangail may fall apart together with Manikganj, Rajbari, Faridpur, and Munshiganj.
- Flood circumstances may stay consistent or improve in Bogra, Jamalpur, Kurigram, Gaibandha, Netrokona, Sunamganj and Sylhet locale inside the following 24 hours.
- The highest recorded rainfall in the last 24 hours at the Rajshahi division (61mm at Bogra) and at Rangpur division (47mm at Kaunia).
- 25 river stations reported flowing over danger level out of 93 stations.
- Two major river system Jamuna & Teesta recorded highest flood level in last 100 years.

IV. Impacts of Floods in Bangladesh

Floods in developing nations represent a more prominent risk to human life, health, and prosperity than in developing nations. When all is said in done 66% of passing straightforwardly identified with flood events are caused about by suffocating and 33% by physical injury, heart attack, and electric shock [Fitzgerald et al., 2010]. The most vulnerable members of the community are the elderly and the youngest requiring special assistance according to (Dewan et al., in press 2015) [16]. While economic losses are rising, direct deaths from flooding may be declining over time as measures to prevent flooding are increasingly being deployed.

The impact of flooding in Bangladesh was severe in both rural and urban areas affecting the majority of the population, infrastructures, and family assets. The direct impacts are considered in this section.

Table ***5*** below shows information on some of the impacts of floods that were registered during this synthesis from the year 1984-2017.

Table 5. Historical Floods of Bangladesh and Its Impact.

Year	Affected People	People Killed
2017	8,000,000	145
2007	13,771,380	1110
2004	36,000,000	747
1998	15,000,050	1050
1988	45,000,000	2379
1987	29,700,000	2055
1984	30,000,000	1200

Source:

1. https://reliefweb.int/report/bangladesh/monsoon-floods-bangladesh-humanitarian-coordination-task-team-hctt-situation-3
2. http://www.preventionweb.net/english/countries/statistics
3. National Workshop on Options for Flood Risk and Damage Reduction in Bangladesh, September 7-9, 2004; ADB and World Bank Staff estimates.

4.1. IMPACTS ON HUMAN LIFE

In Bangladesh, the significant effect of floods is death, brought about by suffocating, water-borne diseases, diarrhea, and snakebites. During the 2007 storm floods in Bangladesh, snake bites were evaluated to be the second most significant reason for death in the wake of drowning and added to a larger number of deaths than even diarrheal and respiratory sicknesses (ICHARM, 2008).

Other major impacts result from being traumatized by witnessing death, loss of employment and access to basic needs such as getting an adequate supply of fuel required for cooking in urban, semi-urban and rural areas. Fuel such as cow dung, jute stick, wood that are used in rural areas are usually all washed away or become wet, making these unusable while in the urban area, the water harms the gas pipeline prompting the non-accessibility of gas for cooking according to (Dewan et al., in press 2015; Ninno et al., 2001) [16] [17]. In addition, day workers regularly starve to death due to remaining an extensive stretch with no work or, because of the disorder.

From Fig. 6 we can see that people leaving their homes from flood-affected areas to higher areas to stay safely with their family. They will be back to their home again after the flood but till then they lost everything such as home, agricultural land, and crops.

Fig. 6. Flood Water Get Inside of Local Villages and Homes (Newspaper Daily Sun 28/07/2017).

4.2. IMPACTS ON HOUSEHOLDS AND INFRASTRUCTURES

From Fig. 7 shows that the effect of flooding on lodging and family units can be broad. Quick flowing flood waters are fit for washing away entire slums while the gradually rising water-harmed structures. In the country zones of Bangladesh houses with "Mud Walls", "Coconut leaf Walls" and "Tin Walls" breakdown leaving individuals and resources uncovered and helpless. About 32% of the complete populace in Bangladesh lives in the slum according to (Miyan, 2012; Rahman, 2011) [2] and along these lines, an enormous number of individuals are left destitute and abandoned for quite a long time because of flooding.

Fig. 7. People Lost Their Home and Personal Properties During Flood After Breaking River Embankment 2017 (Newspaper Daily Sun 28/07/2017).

Providing both immediate and long-term healthcare and support. It is a typical wonder for Bangladesh to observe unusable and additionally destroyed streets due to flood which makes barriers to drive and move. The city and village waste management system are negatively affected during flood, with garbage scattered all over the clogging drainage system and the polluting environment in both the countries according to (Jha et al., 2012; NAPA, 2005; Dasgupta et al., 2010) [22] [23] [24].

4.3. IMPACTS ON AGRICULTURE AND ANIMALS

Bangladesh has a largely agrarian economy. In Bangladesh agribusiness involves about 18.6% of the nation's GDP and utilizes around 45% of the complete work powers according to (Weisman et al., 2011) [18]. Most of the poor in Bangladesh live in zones of the high danger of floods and landslides and are increasingly dependent on local natural characteristic assets.

Rice is stapling food in Bangladesh. An extraordinary kind of rainfed rice; "Aman" developed in Bangladesh is exceptionally powerless to stream floods and has been influenced in the entire long stretches of flooding according to (Baky et al., 2012) [20]. During the Bangladesh 1998 floods, 69% of "Aush" rice production, 82% of Deepwater "Aman" and 91% of transplanted "Aman" were lost leaving the entire country food insecure according to (Ninno et al., 2001) [19]. Generally, the greater part of the floods happens during the wet monsoon (July–August) and seriously affects the summer vegetable harvests particularly the creeper and climbers, for example, lady's finger, cucumber, and gourd.

Floods in Bangladesh additionally affect little agriculture farms, for example, mushroom industries. The entire mushroom industry was truly affected by the floods of 1998 and 2007 causing immense loss of foreign money according to (IPCC, 2007) [21].

V. Conclusion

The following conclusions can be drawn from the present study:

- The soil which was used for constructing Jamuna, Brahmaputra, Ganges, and Meghna river embankment has been found poorly graded sand with higher silt content. The permeability of the soil is high with lower quality properties. There is no defensive measure on the inclination of slope and simple to be washed off by river and river wave activity.
- Excessive pore water pressure influences the shear quality of bank material which prompts the mass failure of the bank.
- In slope stability analysis of embankment, the factor of safety is found to be overestimated for assumed saturation line.
- Need to develop more water dam and control properly so that water moves to all river equally and decrease flood possibilities.
- Need to make high river embankment with concrete slaps or concrete block so that it can’t be washed out easily by floodwater wave.

VI. Recommendations

The geotechnical properties of the river bank material should be improved by utilizing added substances or reinforcing materials like soil-concrete, normal or geosynthetic fiber, and so on. It is likewise important to ensure the inclination of the slope by confronting materials utilizing geo-bags, concrete composites with reinforcement, and so on. It is likewise recommended to find the free surface inside the embankment by conducting leakage examination preceding behavior slope dependability investigation to acquire an increasingly reliable factor of safety in structuring stable river embankment.

Data Availability Statement

Some data, models used during the study were provided by a third party such as Bangladesh Water Development Board (https://bwdb.gov.bd/), Flood Forecasting and Warning Centre, BWDB, Bangladesh (http://www.ffwc.gov.bd/). Direct requests for these materials may be made to the provider as indicated in the Acknowledgements.

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