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Flooding in Bangladesh: A Geographical Advantage & Disadvantage of Times

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Bangladesh

Abstract

Bangladesh is prone to flooding due to being situated on the Ganges Delta and the many distributaries flowing into the Bay of Bengal. Coastal flooding, combined with the bursting of river banks is common, and severely affects the landscape and society of Bangladesh. 80% of Bangladesh is floodplain, and it has an extensive sea coastline, rendering the nation very much at risk of periodic widespread damage. Whilst more permanent defenses, strengthened with reinforced concrete, are being built, many embankments are composed purely of soil and turf and made by local farmers. Flooding normally occurs during the monsoon season from June to September. The convectional rainfall of the monsoon is added to by relief rainfall caused by the Himalayas. Melt water from the Himalayas is also a significant input.

Keywords: Flood; Bangladesh; Advantage of Flood; Disadvantage of Flood; Periodical Overview.

1. Introduction

In late summer 2002, heavy monsoon rains led to massive flooding in eastern India, Nepal, and Bangladesh, killing over 500 people and leaving millions homeless. This true-color image, acquired by the Moderate Resolution Imaging Spectroradiometer (MODIS) aboard NASA's Terra spacecraft begins on August 5, 2002, shows the extent of this flooding. In the upper right-hand corner of the image, the swollen Brahmaputra River runs east to west through the Indian state of Assam. Normally, the river and its tributaries would resemble a tangle of thin lines. Moving to the upper left-hand corner, flooding can be seen along the Ganges River in the state of Bihar, India.

Each year in Bangladesh about 26,000 km2 (around 18% of the country) is flooded, killing over 5,000 people and destroying more than seven million homes. During severe floods the affected area may exceed 75% of the country, as was seen in 1998. This volume is 95% of the total annual inflow. By comparison, only about 187,000 million m3 of stream flow is generated by rainfall inside the country during the same period. The floods have caused devastation in Bangladesh throughout history, especially in 1966, 1987, 1988 and 1998. The 2007 South Asian floods also affected a large portion of Bangladesh.

2. Benefits of Flooding

Small scale flooding in Bangladesh is required to sustain the agricultural industry, as sediment deposited by floodwaters fertilizes fields. The water is required to grow rice, so natural flooding replaces the requirement of artificial irrigation, which is time consuming and costly to build. Salt deposited on fields from high rates of evaporation is removed during floods, preventing the land from becoming infertile. The benefits of flooding are clear in El Niño years when the monsoon is interrupted. As El Niño becomes increasingly frequent, and flood events appear to become more extreme, the previously reliable monsoon may be succeeded by years of drought or devastating floods.

3. Types of Floods

While the issue of flooding and the ongoing efforts to limit its damages are prevalent throughout the entire country, there are several types of floods that have recently occurred regularly, affecting different areas in their own distinct way. These flood types include:

- Flash floods in hilly areas
- Monsoon floods during monsoon season
- Normal bank floods from the major rivers, Brahmaputra, Ganges and Meghna
- Rain-fed flood

Dozens of villages were inundated when rain pushed the rivers of northwestern Bangladesh over their banks in early October 2005. The Moderate Resolution Imaging Spectroradiometer (MODIS) on NASA's Terra satellite captured the top image of the flooded Ghaghat and Atrai Rivers on October 12, 2005. The deep blue of the rivers is spread across the countryside in the flood image.

4. Flood in Dhaka, Bangladesh

In the 19th century, six major floods were recorded: 1842, 1858, 1871, 1875, 1885 and 1892. Eighteen major floods occurred in the 20th century. Those of 1987, 1988 and 1951 were of catastrophic consequence. More recent floods include 2004 and 2010.

The catastrophic floods of 1987 occurred throughout July and August and affected 57,300 km2 of land, (about 40% of the total area of the country) and was estimated as a once in 30-70-year event. The seriously affected regions were on the western side of the Brahmaputra, the area below the confluence of the Ganges and the Brahmaputra and considerable areas north of Khulna.

The flood of 1988, which was also of catastrophic consequence, occurred throughout August and September. The waters inundated about 82,000 km2 of land, (about 60% of the area) and its return period was estimated at 50–100 years. Rainfall together with synchronization of very high flows of all the three major rivers of the country in only three days aggravated the flood. Dhaka, the capital of Bangladesh, was severely affected. The flood lasted 15 to 20 days.

In 1998, over 75% of the total area of the country was flooded, including half of Dhaka. It was similar to the catastrophic flood of 1988 in terms of the extent of the flooding. A combination of heavy rainfall within and outside the country and synchronization of peak flows of the major rivers contributed to the river. 30 million people were made homeless and the death toll reached over a thousand. The flooding caused contamination of crops and animals and unclean water resulted in cholera and typhoid outbreaks. Few hospitals were functional because of damage from the flooding, and those that were open had too many patients, resulting in everyday injuries becoming fatal due to lack of treatment. 700,000 hectares of crops were destroyed, 400 factories were forced to close, and there was a 20% decrease in economic production. Communication within the country also became difficult.

The 1999 floods, although not as serious as the 1998 floods, were still very dangerous and costly. The floods occurred between July and September, causing many deaths, and many people were left homeless. The extensive damage had to be paid for with foreign assistance. The entire flood lasted approximately 65 days.

The 2004 flood was very similar to the 1988 and 1998 floods with two thirds of the country under water.

In early October 2005, dozens of villages were inundated when rain caused the rivers of northwestern Bangladesh to burst their banks.

5. Climate Variability

From March to September in a typical year, the citizens of Bangladesh are the most susceptible to major flooding, as a mixture of the monsoon seasons and the rising of major rivers and their tributaries reach their peak as the snow starts to melt and the rain starts to pour.

Widespread flooding in Bangladesh, as seen in 1988, 1998 and 1991 has caused widespread destruction in one of the least developed countries in the world. With three of the world's mightiest river systems and being situated in the world's largest delta, river bank erosion is taking away precious land from the small nation with a growing population every year. The economic development of the rural sphere is largely intertwined, as every year the populace loses property and livelihood. South Asian people, 70 percent of whom lives in rural areas also account for 75 percent of the poor, most of whom rely on agriculture for their livelihood. Each year they are disproportionately affected by the effects of climate change. Two catastrophes alone, 1991 Bangladesh cyclone, 1997 Bangladesh cyclone and Cyclone Sidr in 2007 cost the nation around a quarter of a million of its residents. There needs to be serious considerations to mitigate the effects of climate change and invest in capacity building of each system component to secure the future of this country.

This global change is likely to have a more dramatic effect on the global agriculture than previously predicted meaning that the world hunger situation and Bangladesh's food security issues will only get worse. The difference between historical and projected average temperatures each season throughout the world has revealed that harvests from major staple crops could drop by 40 percent by the end of the 21st century due to high temperatures in the growing seasons. A research study predicted this by using the patterns and characteristics of 23 global climate models. Not only are the harvests affected, the grain yield is also predicted to decrease anywhere from 3 to 15 percent.

6. The Overall Damage

- Half of the districts were affected
- 100,000sq km (66%) of the country was overwhelmed
- 1,050 deaths reported
- 30 million people affected
- 25 million people left homeless
- 26,000 livestock lost
- 20,000 education facilities damaged

- 300,000 wells damaged
- 16,000 km of roads flooded
- 4,500 km of river embankments destroyed
- 32 percent of the total population affected

What is most unfortunate about Bangladesh's flood catastrophe is the fact that its people are largely blameless for the rise of global warming, yet they experience the worst of its escalating effects.

7. Flood Preparation

Yearly flooding during monsoon season and other forms of inclement weather have forced the people of Bangladesh to adjust their lifestyle in order to prepare for the worst. One thing that people are doing to avoid the effects of the flooding is building elevated houses and roads. The raised houses are built on platforms raised above the typical water level a flood can reach. In many cases, neighborhoods of people build these raised homes and roads, creating a "cluster village" which is essentially a village that is all raised above flood level. This has proven to be very effective at avoiding the immediate effects of flooding.

Additionally, several organizations, such as the Global Fund for Children and the Bill & Melinda Gates Foundation, have taken the initiative of helping kids rebuild their lives after natural disasters by building schools that function on boats themselves. "Floating schools", as these classrooms are known, help provide an education for children whose lives were drastically affected by the effects of constant flooding. Furthermore, children who even prior to a natural disaster did not receive proper schooling benefited from the opening of floating schools, making these communities into beneficial learning spots.

However, there are some effects from flooding that cannot be avoided simply by raising houses above flood level. Water contamination, for example, is very difficult to cope with during floods. Because of this, many people in Bangladesh use a called a tube well, which is a well with a top that is raised high enough that contaminated flood water from a flood cannot enter it. Many cities also have flood shelters, which are large raised platforms where people can find refuge from the effects of the on-rushing flood. As a result of several demanding summer floods, in 2004, the government of Bangladesh made the step of seeking foreign aid rather than try to assist the millions of homeless people on their own. Nearly all the 147 million people living in Bangladesh at the time were forced to adapt to intense rainfall and water-borne disease exposed conditions. An increase of salinity, a lack of food distributors, and the effects of seeing slum dwellers survive on flood water were just the initial blows to a monumental flood season that summer, extending beyond Bangladesh's borders and affecting India, China, Nepal, and Vietnam as well.

These may all be great solutions to the problem of flooding, but some cities do not have raised houses or flood shelters. These cities typically have rescue boats that can search for people who were unable to get above flood level and help them get out of the water. These boats are very important; they rescue over a thousand people over the course of multiple years.

8. Coverage of Inundation and Deaths in Major Floods, 1954-1998

Year	**Flooded Area(sq. km)**	**Percentage of Total Area**	**Number of deaths**
1954	36920	25	112
1955	50700	34	129
1956	35620	24	
1962	37404	25	117
1963	43180	29	
1968	37300	25	126
1970	42640	28	87
1971	36475	24	120
1974	52720	35	1987
1984	28314	19	513
1987	57491	38	1657
1988	77700	52	2379
1998	100000	68	1050

9. Table of flood damage in Bangladesh (1953-1998)

Year	**Crop Damage(million tons)**	**Total Financial Loss(million tk)**
1953	0.6	
1954	0.7	1500
1956	0.5	1580
1962	1.2	1500
1966	1.0	600
1968	1.1	1200
1969	1.0	1100
1970	1.2	1000
1974	1.4	20000
1980	0.4	4000
1984	0.7	4500
1987	1.5	35000
1988	3.2	40000
1998	4.5	142160

10. Developing Flood Forecasting Services

Bangladesh Water Development Board (the Board) is responsible for flood management through structural and non-structural measures. It also provides hydrological services in Bangladesh. As part of non-structural measures, the Board has been providing flood forecasting and warning services through its Flood Forecasting and Warning Centre (FFWC), established in 1972. Since then, the development of flood forecasting and warning services has made stepwise progress, which can be divided into three stages.

Initial stage (1972–1988) initially, 11-gauge points were used for real-time flood monitoring and forecast purposes. In this early phase, gauge-to-gauge statistical correlation and Muskingum–Cunge methods were used for predicting water levels. In 1981, WMO and the United Nations Development Programme provided technical assistance for computerization of the hydrological database. Computer programs were also developed to carry out operations that had previously been performed manually. During devastating floods in 1987 and 1988, flood forecasts of the major river systems proved to be fairly accurate.

Second stage (1989–1999) after the 1987 and 1988 floods, an initiative was launched to develop a flood forecasting system based on a numerical model. WMO engaged the Danish Hydraulic Institute (DHI) to create a flood forecasting model for Bangladesh. During 1989–1991, the national flood forecasting model was developed using a MIKE 11 modeling system. From 1991, additional deterministic flood forecasting efforts were pursued, resulting in forecast lead times being increased to 48 hours. The number of real-time forecasting stations was increased to 16. From 1995 to 1999, the flood forecasting model was further upgraded to improve its forecast accuracy, under the Bangladesh Flood Action Plan. A geographic information system (GIS) module was added to the flood forecasting model, and the number of stations used to support forecast modeling was increased from 16 to 30.

Bangladesh again experienced severe flooding in 1998, for which the flood forecasting and warning services yielded productive and successful results. An internal analysis of the 1998 flood concluded that flood forecasting and warning services should be extended to all flood-prone areas of the country. In addition, the need for dissemination of flood information to vulnerable communities became very evident.

Third stage (2000 to date) Many lessons were learned from the 1998 floods. Foremost was that the people of vulnerable communities require flood information with a greater lead time. Further, they wish to know when their homesteads are going to be inundated and for how long. This showed that people were demanding area-specific flood forecasts. Moreover, field-level flood and water-related disaster managers also expressed their eagerness to receive timely flood forecasting information. In this third stage, FFWC received support to improve the accuracy and extend the lead time of flood forecasts, expand the provision of flood forecasting services to all flood-prone areas of the country, improve flood information dissemination at the vulnerable community level and build a sustainable institution.

FFWC efforts focused on improving the forecast lead time. It started to use ensemble precipitation forecasts from the European Centre for Medium-Range Weather Forecasts to provide medium-range flood forecasts. Since 2004, FFWC has provided deterministic flood forecasts to 3 days and medium-range probabilistic forecasts to 10 days. FFWC also started to develop its basin model in 2012.

11. Development of the Basin Model

The concept for the basin model was introduced under the Comprehensive Disaster Management Program Phase-II to increase forecast lead time. As Bangladesh is located downstream of three big river basins, an integrated basin model was needed to effectively increase the forecast lead time for Bangladesh. Fundamental to this was using the advances that have been made in numerical weather modeling and ensemble forecasting.

FFWC uses the Weather Research Forecast (WRF) model for precipitation forecasting. A typical WRF over the region and the three basins is shown below. The basin model, which is currently used for flood forecasting purposes in Bangladesh, uses quantitative precipitation WRFs for establishing a deterministic flood forecast with a lead time extended from 3 to 5 days.

12. Flood Forecasting and Warning Activities

Flood forecasting and warning activities run from April to October every year in Bangladesh. In this period, the field-level hydrological measurements division works closely with the flood forecasting center to provide observed data. FFWC remains open 24 hours a day, 7 days a week during this period.

13. Data Collection and Transmission

Today, the hydrology division of the Board has an extensive network of 60 rain gauges and 90 hydrological stations where water level, discharge, sediment or water quality are measured. Network design reflects the need for field data based on requirements of the flood forecasting model. Daily operational requirements of the flood forecast model are for real-time water level and rainfall data. Water level gauge readers for the 90 stations send data to FFWC twice daily. Data are usually collected from 6 a.m. to 6 p.m. at 3 hourly intervals every day. Rainfall records are available for 24 hour periods for the 60 gauges all over the country.

Data are now transmitted from the field using a mobile SMS system. Prior to this development, hydrological data had been orally transmitted using landline telephones. The Board piloted automatic collection of water level data using a radar level sensor as part of another project.

14. Operation of the Flood Forecast Model

The flood forecast basin model is based on the DHI MIKE 11 hydrodynamic modeling system. The computational core of the hydrological forecasting system is the DHI MIKE 11 software, which contains two modeling components:

1. A hydrodynamic model and
2. A hydrological model (NAM; a rainfall-runoff model).

The hydrodynamic module contains an implicit finite-difference computation of unsteady flows in the rivers based on St Venant equations. The flood forecasting model is customized with the Flood Watch database, which uses a GIS. The MIKE GIS module is also integrated with the digital elevation model (DEM) of Bangladesh to generate an inundation model.

Quality checked, processed data are used in the model to generate 5-day deterministic forecasts. The operational flood forecasting system is based on real-time data received from available stations in Bangladesh, relevant online data received from riparian countries (based on an existing data-sharing protocol), and quantitative precipitation forecasts from numerical weather prediction models provided by the Bangladesh Meteorological Department and the Indian Meteorological Department. FFWC also uses satellite-based observation data for flood forecasting purposes.

15. Conclusion

Bangladesh is located downstream of three large river basins: The Ganges, Brahmaputra and Meghna river basins. The total catchment area of these basins is 1.72 million km^2, with almost 93% of the catchment area situated outside the territories of Bangladesh – in Bhutan, China, India and Nepal. The topography, location and discharge from each of these three basins shape the annual hydrological cycle of the country.

Over the course of a year, Bangladesh experiences periods of extreme water availability – too much and too little water. Monsoon precipitation from June to September is the main source of water, and the country has less water available outside of this season, termed the "dry period." Heavy rainfall during the monsoon period is the main cause of flooding; this occurs almost every year, with a devastating flood every 5–8 years (FFWC, 2004). Such flooding causes severe damage to agriculture and infrastructure and the loss of human lives.

Bangladesh has implemented flood control and drainage projects since the 1960s. However, structural measures alone cannot totally protect the people and infrastructure from floods. Complete flood control in a country like Bangladesh is neither possible nor feasible. With this understanding, Bangladesh started developing flood forecasting and warning systems (non-structural measures) for flood management. The objectives were to enable and persuade people, communities, agencies and organizations to be prepared for floods and take action to increase safety and reduce damage. The goal was to alert people on the eve of a flood event.

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