

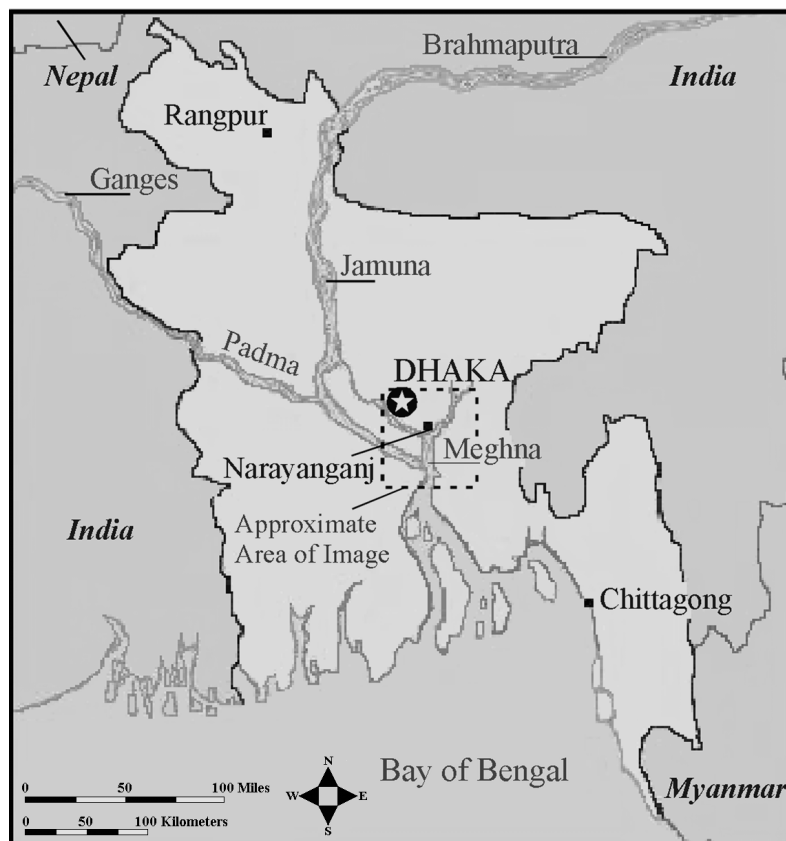
Physiographic and Human Responses to Flooding in the Lower Meghna River Region of Bangladesh

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Introduction

The annual rhythm of flooding in Bangladesh is natural, necessary, and welcome. Water molds the culture, shapes the land and sustains all life; yet, it may also bring death. Like any other summer monsoon day in Bangladesh, it was hot and humid. A brief but torrential down pouring of rain was expected to arrive shortly after 4:00 pm. Except, on this day in June 1985, a severe tropical storm gathered force as it was funneled into the Bay of Bengal. It swept inland and left 20,000 people dead in a wake of flooding. In 1991, 30 million people in Bangladesh were forced into homelessness following yet another heavy flood event. Many were left with no option to rebuild, as the land beneath their homes and fields simply disappeared. With little time to recover, severe floods were repeated in 1998, 1999, and 2000.



Bangladesh is a country with scarce relief, large riparian floodplains, and extensive coastal lowlands (see Figure 7.2). It is a land of water that fosters a culture that is both susceptible to and reliant upon flooding. Many physical and human features in a flood prone region can be best studied by viewing them holistically from a distance. Remotely sensed space imaging of Bangladesh's Meghna River region provides a synoptic look into a unique landscape frequented by "normal"(annual) and catastrophic floods (see Figure 7.3).

Figure 7.2 Map of Bangladesh



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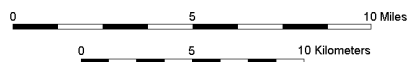
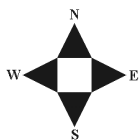


Figure 7.3 Satellite Image of the Lower Meghna River During the Wet Monsoon



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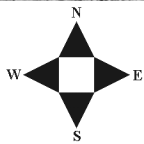


Figure 7.4 Satellite Image of the Lower Meghna River During the Dry Monsoon

Monsoon Climate

The people of Bangladesh anxiously await monsoonal flooding. Little concern is provoked as familiar landmarks, fields, and villages are engulfed by rising floodwaters; however, a weak monsoon and the absence of flooding are cause for considerable alarm. If the rains are late or weak, drought, crop failure and famine result. When the first drop of rainfall signals the onset of the monsoon season, both land and people welcome it. Bangladesh is a land of water. From their headwaters in the Himalayas, two of the world's great rivers – the Ganges and Brahmaputra – flow and eventually merge in Bangladesh, forming the Earth's largest delta. During the dry season, these rivers and their tributaries and distributaries comprise 30 percent of Bangladesh's landscape; yet during the wet season, up to 70 percent is completely submerged (Novak 1993).

The South Asian monsoon is a disturbance in the Earth's general circulation pattern. The trade winds, aptly named because their persistence assured reliable transport and commerce, experience an unusually large latitudinal migration. The Southeast trades and Northeast trades are each seasonally the prevailing wind of southern Asia. The word "monsoon" is derived from Arabic meaning "season", reflecting the seasonal reversal of Southeast and Northeast Trades. Subsequently, the people of Bangladesh recognize three distinct seasons. The most important season is the summer wet monsoon that begins in late May. The first burst of rain signaling the start of this season causes a stir of celebrations. Figure 7.3 shows a largely inundated region during the end of the summer wet monsoon. Light gray represent flowing water with a high sediment content, and black portrays standing and deep water. By November, the winter monsoon arrives, marked by cooler temperatures and persistently dry conditions. Figure 7.4 is characteristic of the winter dry monsoon. Light color, highly reflective features represent dry non-vegetated land made up of recently deposited sediment or exposed soil. The last and shortest season is the hot period that arrives in March. Heat, humidity, and aridity build until May, when the cycle begins anew, and the eagerly anticipated wet monsoon brings relief to people and land alike.

Dhaka, Bangladesh's largest city and capital, is located in the northwest corner of the two main images. Peak precipitation for the Dhaka region occurs in July during the summer wet monsoon, when it receives 15.7 inches (39.89 centimeters). The least amount of rain occurs in December and January, coinciding with the winter dry monsoon core (see Figure 7.5). December and January experience 0.2 inches (.51 centimeters) and 0.3 inches (.80 centimeters) of rain respectively. Total average annual precipitation for Dhaka is 78.6 inches (199.64 centimeters). For a frame of reference, consider the total annual precipitation for three well known cities: Seattle (33.1 inches or 84.7 centimeters), New York City (44.4 inches or 112.77 centimeters), and London (23.2 inches or 58.93 centimeters). Temperatures fluctuate minimally between a high in May at 84.4° Fahrenheit (29.1° Celsius) and a low in January at 64.9° Fahrenheit (18.3° Celsius).

The seasonal reversal of wind that conveys the wet and dry monsoons is produced by differing thermal characteristics between continents and oceans. During the summer monsoon, Asia's large landmass is strongly heated by the Sun. Surficial land features release heat energy to the atmosphere quickly, causing overlying air to expand and rise, producing a thermal low pressure

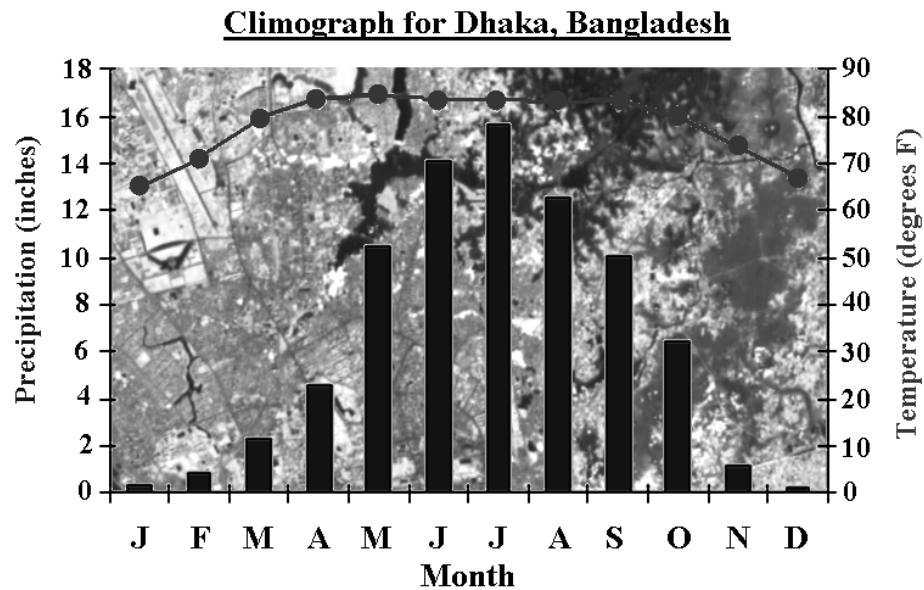


Figure 7.5 Climograph for Dhaka, Bangladesh

area. This continental low pressure attracts moist oceanic air onshore from areas of higher pressure. Much like air escaping from a flat tire, air flows from a high pressure to a low pressure. Rapidly rising humid air in the low pressure system will condense, and very heavy rainfall will ensue over Bangladesh and southern India (see Figure 7.6). The reverse of this process occurs during the winter dry monsoon. Land and the air above it become cooler than the adjacent heat-retaining ocean. A stable continental high pressure forms, causing a dry outward flow of wind to proceed over South Asia, as air is forced offshore to lower pressures (see Figure 7.7).

The summer monsoon movement is well plotted in Figure 7.8, which was generated using data collected from a Geostationary Operational Environmental Satellite (GOES). GOES satellites are weather satellites that remain essentially “fixed” in orbit above the equator. Its very high orbital path allows the satellite to view approximately one-fourth of the Earth’s surface. The figure shows a 3-D perspective of flow during the South Asian wet monsoon in June 1988. Arrows indicate near surface winds. The Himalayan Mountains and surrounding foothills impede and concentrate the northward flow of humid air and produce torrential orographic precipitation. Low lying hills along the northern and eastern borders receive the greatest amounts of rainfall, as moist monsoonal air is uplifted and rapidly cooled. Cherrapunji is situated near the northern boarder of Bangladesh in India. It is the second rainiest location on Earth, after Mt. Waialeale, Hawaii. Cherrapunji receives 428 inches (1,087 centimeters) of rain per year and, amazingly, it experienced a world record 1,042 inches (2,645 centimeters) of rain in 1860. Runoff from orographic precipitation in the areas surrounding Bangladesh contributes to longstanding inundation in the lowland Meghna River region.

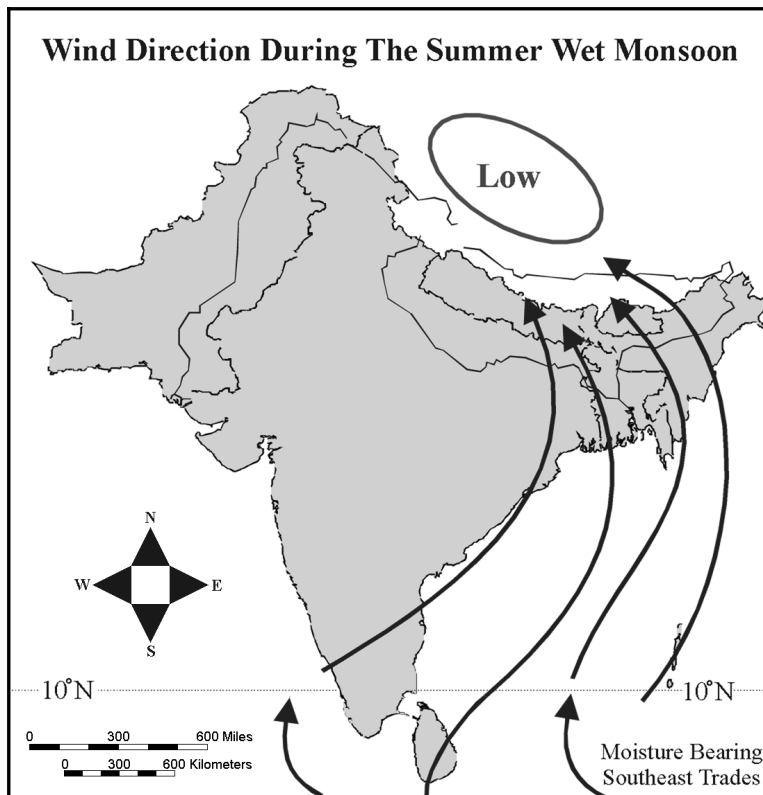


Figure 7.6 Wet Monsoon

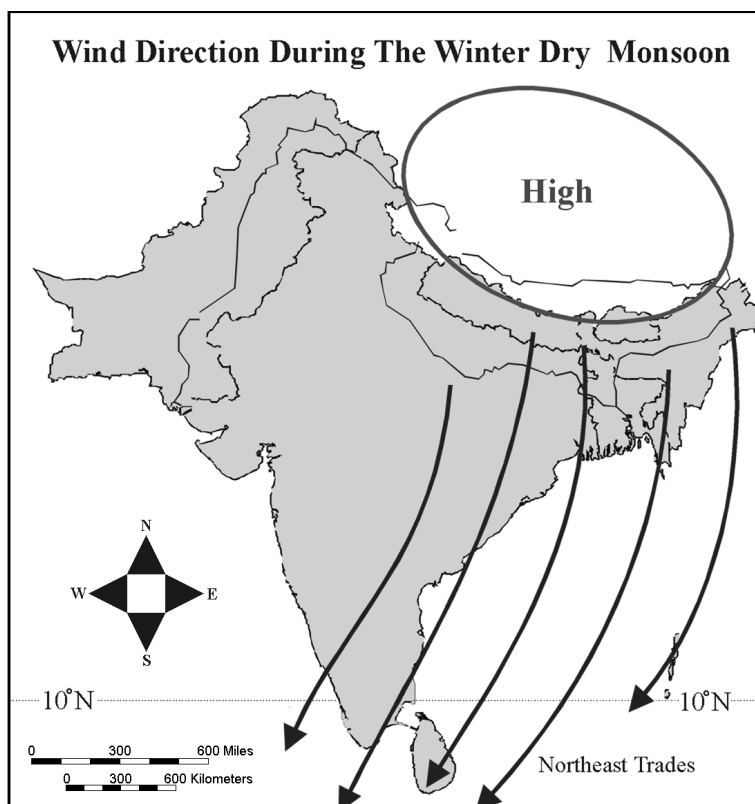


Figure 7.7 Dry Monsoon

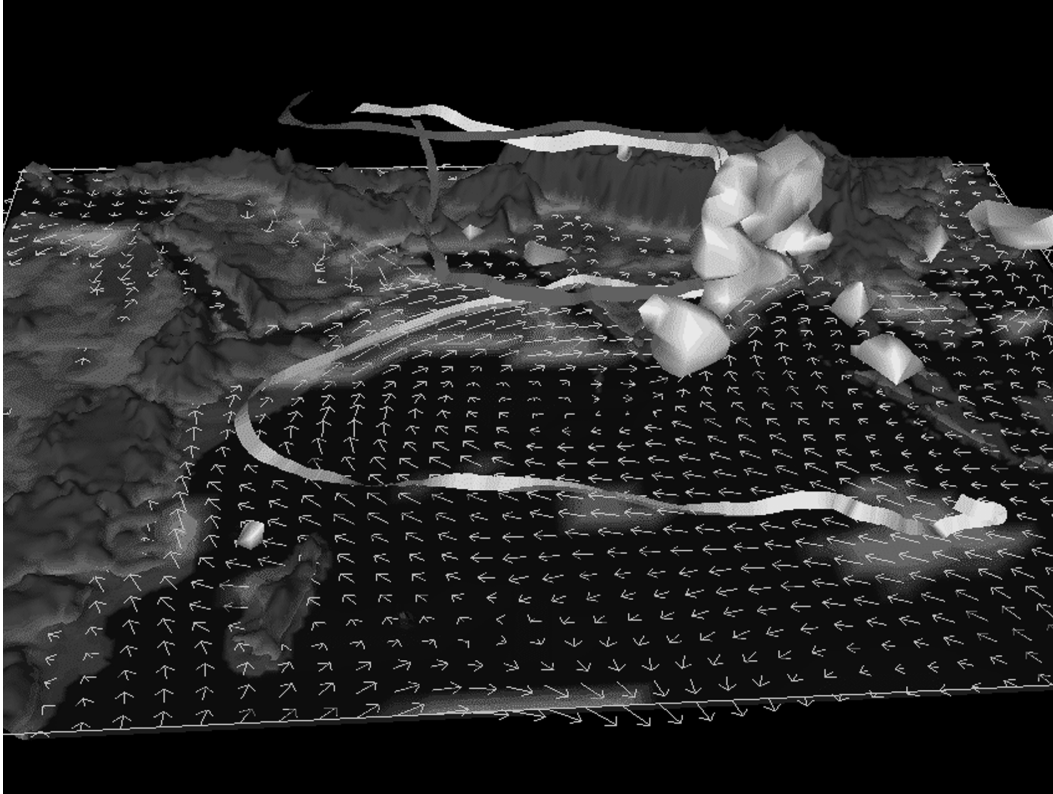


Figure 7.8 Wet Monsoon Wind Flow Patterns Source: NASA, 2000
http://dao.gsfc.nasa.gov/experiments/assim54A/sample_results/monsoon88.html

A Flood Prone Landscape

With the arrival of the monsoon season, Bangladesh is subject to widespread flooding that shapes the region's physiography and influences human activity. Bangladesh's physical landscape is dominated by a vast alluvial plain, where features built by the flux of river sediments, such as islands and terraces, are not permanent; rather, they are subject to the power of high water. The human landscape, while impossible to separate from the physical, is marked by structures designed to keep water out and, curiously, by additional development contrived to contain water.

The Lower Meghna River region is downstream from the confluence of the powerful Ganges and Brahmaputra Rivers (this section is called Padma River in Bangladesh). The Padma and Meghna Rivers merge, flowing 145 kilometers to the Bay of Bengal (see Figure 7.2). The smaller Meghna is the namesake for this section. The Lower Meghna River forms an extensive floodplain and contributes sediment to the world's largest delta. The reason that the floodplain is difficult to discern in the images is because the entire image is situated within the active and historic floodplain. This mighty network of rivers culminates in Bangladesh and, in total, drains 1.5 million square kilometers.

Numerous shifting channels and subchannel features combine to form an extensive submerged zone in Figure 7.2. An analysis comparing the monsoon flood image (Figure 7.2) and the dry

monsoon image (Figure 7.3) revealed that 40% of the land inundated with water returns to dry land. The total area covered by water in Figure 7.2 is 53%, and the total area covered by water in Figure 7.3 is 13%. When the water recedes, numerous subchannels and slack water areas are exposed. Such features are identifiable on Figure 7.3 as barren sediment accumulation zones. The Padma/Meghna Rivers are notorious for their alluvial islands, called chars. Chars are formed and reworked during each year of flooding. People move onto the chars and take advantage of the fertile soils; however, the shifting nature and disappearance of these formations often lead to disastrous consequences. No permanent settlement can exist along the banks of these islands.

Perhaps there is no place on Earth where the immediate relationship between culture and environment is more strongly evident than in Bangladesh. Bangladesh is a developing country with a large population of 130 million people. Population pressures drive desperate farmers into known hazardous areas, putting millions at risk. Because land near the river's edge is highly productive - even during annual flooding - the risks to settle far outweigh the potential dangers of severe flooding. Unfortunately, this risk will only increase, as the country's population is expected to double in 38 years, thereby forcing greater numbers into even more marginal lands.

During the dry season, newly deposited nutrient-rich alluvial soils attract farmers to settle. Farmers locate "high" ground upon which they construct their dwellings and use the surrounding areas for crops. Lots are small but exceptionally productive. In the Lower Meghna River, high patches are generally unavailable. Farmers adapt by digging drainage ditches around their settlement site and use the excavated earth to build mounds. Houses on bamboo stilts are centered upon the elevated ground. Additional sources of "high" ground may come from digging tanks or ponds. The tanks serve as a permanent source of water and will be used for drinking, bathing, washing, and waste disposal. During the dry season, tanks provide an important source of stored water for irrigation. Farmers must practice intensive successive cropping to sustain their families. To meet this demand, large quantities of water need to be available on a year-round basis. Most farmers along the Lower Meghna practice triple-cropping. Common to the region is one crop of rice during flood stage, a second crop of rice with partial irrigation, and a third winter crop that is dependent upon irrigation. Water is so critical that most of the arable land along the Meghna is cultivated during the wet monsoon, despite the potential for severe flooding. Severe flooding devastates agricultural productivity.

Figure 7.2 portrays flooded agricultural land at the confluence of Meghna and Padma rivers. Light colored geometrical lines encircling entire islands are dikes. Dikes are designed to protect the densely packed fields from severe flood by diverting high flows. However, during annual floods, the dikes function to reduce flow velocities and retain water, making the land suitable for rice and jute production.

Catastrophic Flooding

The many rivers of Bangladesh are the country's preeminent resource and greatest hazard. Floods occur when a river overflows its natural and human made drainage system due to excessive runoff. Despite constant flood conditions during the wet monsoon season, Bangladeshis recognize different types of floods. Annual flooding is known as "barsha", while high magnitude, low frequency floods associated with cyclones are called "bonna". To an outside observer "barsha" floods are severe and "bonna" floods are catastrophic. Cyclones in Bangladesh are strong tropical storms comparable in force to hurricanes. Unlike annual flooding, cyclonic floods bring extensive devastation and death.

Catastrophic flooding is a consequence of three major factors: 1) cyclones, 2) land use practices, and 3) timing. Tropical cyclones, simply called cyclones in Bangladesh, are known by various names, depending upon different locations. In the United States they are referred to as hurricanes; while in the western Pacific, they are called typhoons. Irregardless of the name, these storms bring torrential amounts of rain and are destructive. Cyclones form in the Indian Ocean and generally migrate northward with prevailing winds. The frequency of cyclones in Bangladesh is magnified because the Indian Subcontinent and the Southeast Asian mainland constrict lateral migrations and effectively funnel storms toward coastal Bangladesh. The magnitude and intensity of annual and cyclonic flooding is dependent upon land-use practices within each river's drainage basin. Floods are intensified by poor land use practices. Rampant urbanization, deforestation, and agricultural clearing increase peak flows, creating favorable conditions for heightened flooding. Vegetation naturally impedes and absorbs runoff, thus reduce peak flood flows. Less than 10% of the forest cover remains in Bangladesh today (Khalequazzaman 1999). The final factor contributing to catastrophic flooding is timing. The occurrence of cyclones corresponds with the wet monsoon season. Most seem to occur near the end of the wet season, when inundation is already at its peak.

Despite long-standing attempts to structurally control major flood events in Bangladesh, the discharge rate, extent, and severity of successive cyclonic flood is increasing. Following the 1998 cyclonic flood, nearly 70% of Bangladesh was under water. The cyclonic magnitude causing the 1999 and 2000 floods was weaker than other recorded major storm events in Bangladesh; yet, comparatively, inundation was excessively high. Low-lying river and deltaic regions, including the Lower Meghna Region, were almost completely submerged. After each major flood, Bangladesh tries to recover and rebuild. However, relief and rehabilitation are short-term tasks, as cyclonic flooding soon returns. The country's immense efforts at flood control have largely failed. Bangladesh currently spends 20% of its budget on water development projects (Islam 2000). Regardless of such expenditures, economic damage caused by recent floods continues to worsen; thus, Bangladesh must seriously rethink its long-term strategy regarding flood control.

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