

**COMPARISONS OF STORM SURGE DISASTERS IN ASIA
----CASES OF CYCLONES SIDR IN 2007 AND NARGIS IN 2008----**

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Field surveys were performed in the southwest of Bangladesh after cyclone Sidr in 2007 and in Yangon River Basin after Cyclone Nargis in Myanmar in 2008 in order to learn lessons out of severe disasters due to storm surges. Spatial distributions of inundation heights were measured around the most damaged areas. Both Bangladesh and Myanmar were severely damaged, but the preparedness against storm surge and the experiences were different. The resultant total losses in these two countries were significantly different. In Bangladesh, many people witnessed that storm surges inundated with bore-like waves. Counter measured against storm surges should account for the physical mechanisms for the development of such bore-like waves and possible damages due to such waves. Embankment showed significant roles to minimize the damage. Development of riverbanks especially around the river mouth is one of most essential counter-measures to be carried out in Bangladesh. Shelter functioned well to save significant number of lives in Bangladesh. But in Myanmar, there were few experiences on storm surge and no countermeasures such as shelters. These differences results the difference of losses. They were 4,234 including deaths and unknowns in Bangladesh but 138,366 in Myanmar.

Keywords: storm surge; Bangladesh; Myanmar

INTRODUCTION

Field surveys were performed in the southwest of Bangladesh after cyclone Sidr in 2007 and in Yangon River Basin after Cyclone Nargis in Myanmar in 2008 in order to learn lessons out of severe disasters due to cyclones. Spatial distributions of inundation heights were measured in around the most damaged areas. Both Bangladesh and Myanmar were severely damaged, but the preparedness against storm surges and the experiences were different. In the following parts, general reports of the surveys are described

A CASE OF CYCLONE SIDR IN BANGLADESH
(Shibayama et al., 2009a)

The basic method of survey was to detect flood height and to measure distances by using laser distance meters and to measure locations by using GPS. Fig. 1 shows the survey route and distribution of measured storm surge heights in meters.

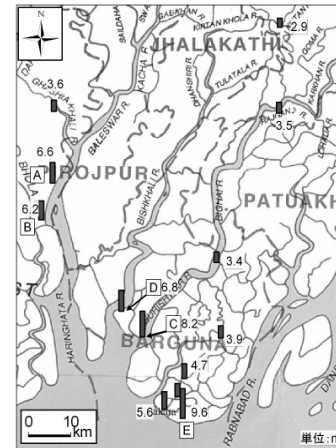
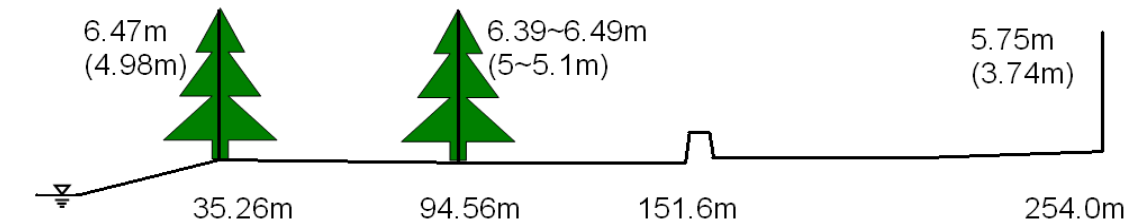


Figure 1. Survey route and measured storm surge height. (Shibayama et al., 2009a)

(1) Southkhali

The measurement result of a cross section is shown in Fig. 2. River banks were built around thirty



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Figure 2. Measurement result of a cross section in Southkhali. Distances are from the river shore and inundation height from the river water level (numbers in parenthesis is from the ground level). (Shibayama et al., 2009a)

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Figure 3: River bank erosion in Southkhari.



Figure 4: Cyclone shelter in Southkhari.

years ago but they were broken due to erosion before Sidr attacked them. Though newer banks had been built recently about 150 m inside from these older banks, the high tide due to Sidr flowed over their tops of about 2.5 m over the river water at the measurement time. These newer banks are shown in Fig. 2 around $x = 151.6$ m and their photo in Fig. 3. The river depth decreases every year due to erosion, resulting in wider width of the river.

According to our hearing, the first wave of the high tide came to the newer bank at x is about 150 m, after which the second wave flowed over the newer bank. The third wave of the high tide advanced on the shelter (Fig. 4). The wave period of these bores was around one minute. The high tide continued about fifteen minutes. Women and children took mainly refuge in the second level of the shelter, where the inundation depth was 0.59 m over the floor, whose height was 2.99 m over the basement surface of the shelter. Some water entered through windows, the lower edges of which were of 3.8 m height over the basement surface of the shelter. When the water came into the second level, the refugees were frightened and wanted to go outside but they could not open doors because of strong winds. Some traces were left when they forced themselves to open the doors. Around one thousand people evacuated on the shelter top, where they felt the space was not enough.

Many people were flowed before they reached this shelter, including a child flowed about 3 km. Several children caught trees to be spared. In this area about 300 people were died. In regard to evacuation, the following points are important: 1) education of residents on disaster prevention, 2) certain communication channel of evacuation information (e.g. speaker for Alcoran), 3) construction of shelters considering adequate evacuation distance and enough capacity.

(2) Royenda Bazar, Sarankhola

In a bank of the Baleshwar River in Royenda Bazar, the measurement of inundation were performed. The traverse line was extended upward, where a lot of collaborative people gave us in-depth information. The measurement result of a cross section is shown in Fig. 5. Inundation at a depth of 2.5 - 3.0 m over the ground surface was shown in several places.

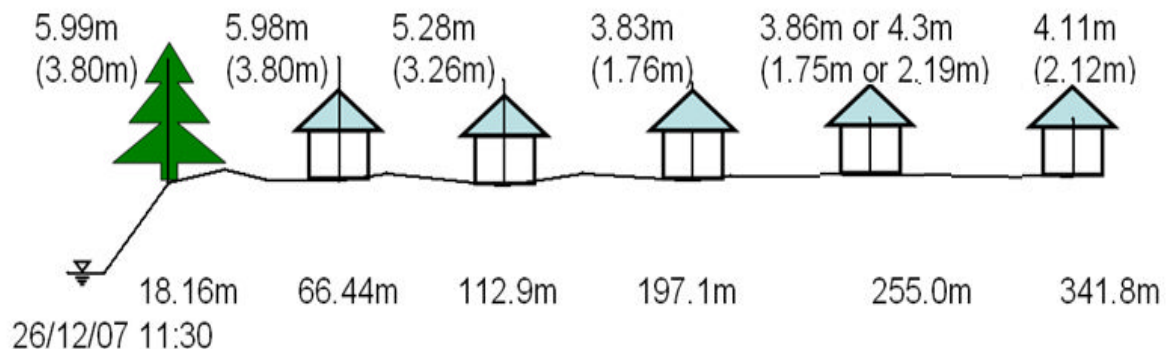


Figure 5: Measurement result of a cross section in Royenda Bazar. (Shibayama et al., 2009a)

In Fig. 5, the inundation level at $x = 18.16$ m was shown on a palm tree. Several people, who climbed upcountry palm trees during the high tide, watched the riverside trees having a soak of water. Eight people were died at $x = 66.44$ m. At $x = 255.0$ m, one person said the inundation depth was 1.75 m over the ground surface, while another person said the water depth was 2.19 m covering the top of a house door. At $x = 341.8$ m, the inundation depth was 2.12 m inside a house. Outside this house, three different values of inundated water depth were shown by three persons of a family, one of which was 1.54 m; these three values possess lower reliability.

(3) Somboniya

Somboniya is the south-west of Barguna, where the survey team accessed finally by motorcycle. One side of the embankment on the access road was collapse at many points. As the hollows on the surface of the road were repaired simply by use of bricks, the height of embankment may be lower than the initial high. Palm trees stood on slope of the embankment were uprooted completely with foundation and fell down to the direction of downstream of storm surge.

The survey on water level of storm surge was started from the surface water of Burishwar River, where riverbank had eroded into 50m in shape of a semicircle (Fig. 6 and Fig. 7). The old location of riverbank before storm surge was 500m forward. The erosion area was all over a few kilometer of river line.

The high water level 7.2 m at one high palm tree nearest the river was based on two witnesses of inhabitants. The one, 7.6 m is that some people watched water level on the palm tree from trees on the embankment during the storm surges. The other is that some people climbed the palm tree and checked the trace of water line on the next day of storm surge. There was other witness about water level at other palm tree on the embankment. This water height was almost same as height of the palm trees on embankment based on information of another inhabitant who had survived at other tree. Both water levels were almost same and the levels were agreed in almost of the inhabitants so that the height is confidence.

Situations of storm surge and evacuation told by inhabitant are as follows. Strong wind had blown since daytime. At river, water level had suddenly sank, inhabitants had thought something had happened. After about 5 minutes, inundation had started. At that time, the people had understood a storm surge had been coming and had evacuated. High water level had marked 15minutes after flood had started. Storm surge wave came only one time. Many people, especially woman and children had flushed away and had not come back. One elder person had caught floating box or driftwood and had survived while being flushed away for 3 km distance by the storm surge.



Figure 6: River shore erosion in Sombonia.



Figure 7: Erosion behind bank in Sombonia.

(4) Kuakata

Characteristic features observed in Kuakata are outlined as follows. Fig. 8 overviews observed features in Kuakata. Since the distance from the shoreline to the embankment was relatively long, $L = 690$ m, and various plants were vegetated on the mild slope to the embankment, storm surge did not overtop the embankment. Before the storm, 1.5m-high sand dune was developed (dune A in Fig. 8) and restaurant house was built on the dune. Storm surge completely washed both the house and the sand dune although the surface of the dune was fully vegetated. Estimated volume of the washed sand dune is about 8000m^3 . A part of sand dunes (dune B in Fig. 8) was also washed away. The width and height of

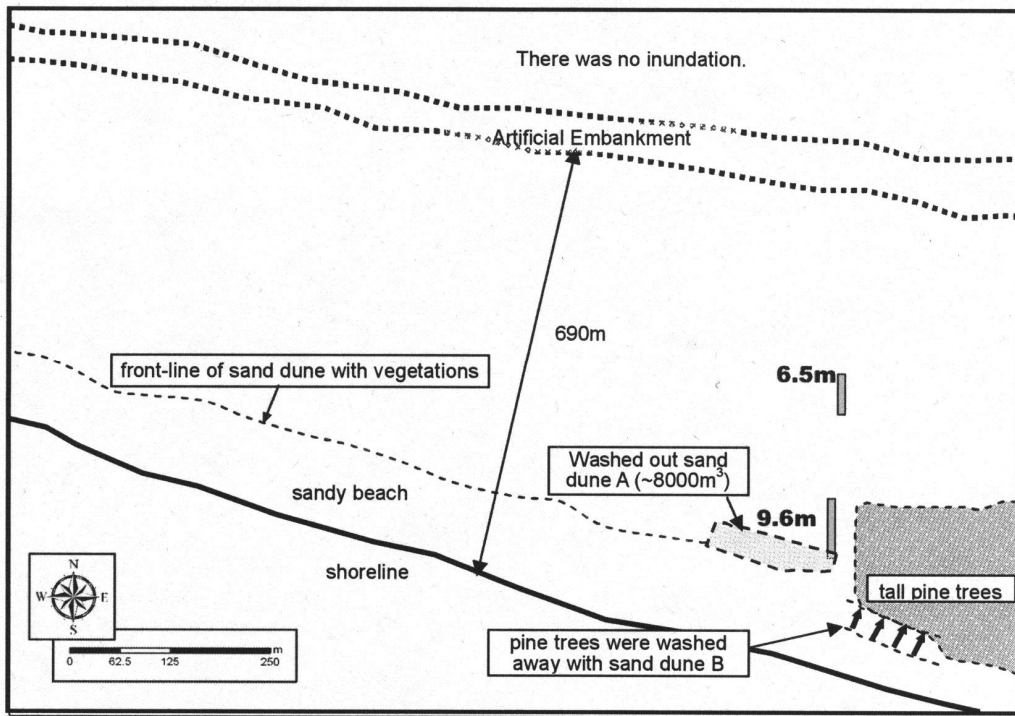


Figure 8. Overview of observed damages around Kuakata. (Shibayama et al., 2009a)

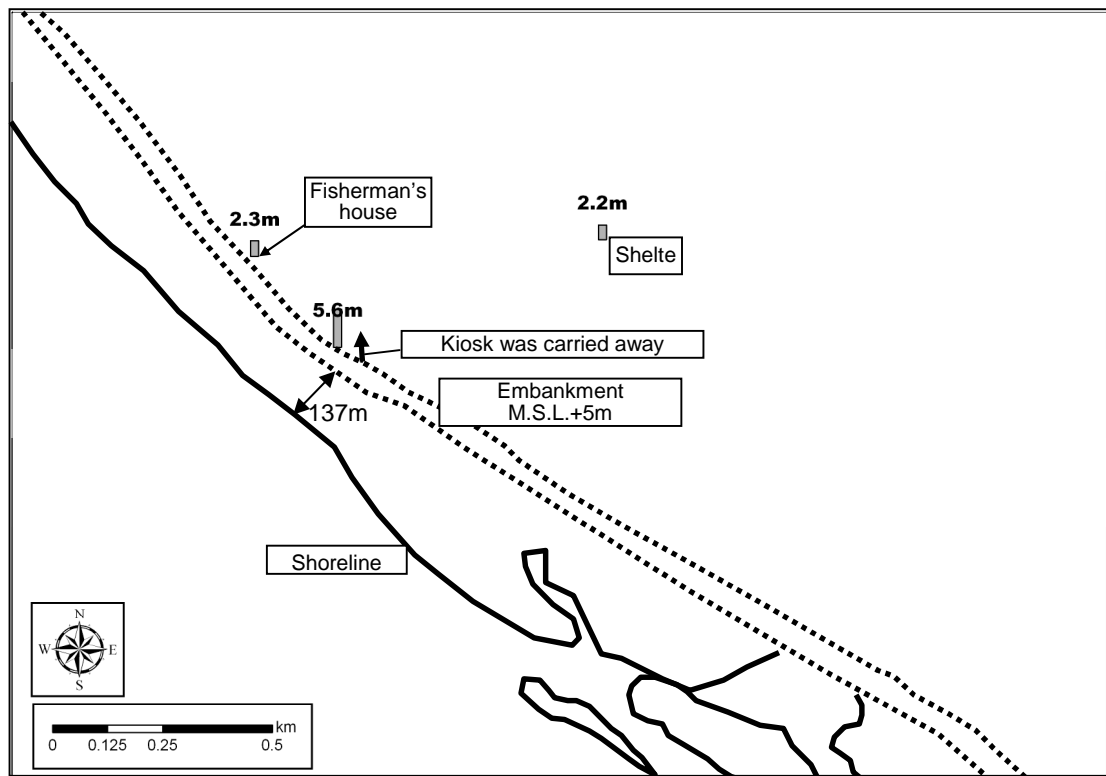


Figure 9: Overview of observed features in West Kuakata. (Shibayama et al., 2009a)

the washed sand dune were about 30m and 1m, respectively.

(5) West Kuakata

Figure 9 shows overview of West Kuakata. Characteristics features observed in West Kuakata are as follows. Height and width of the embankment were 5m above the mean water level and 12m, respectively. Depth of the flooding water on the embankment was about 60cm. Kiosk built on the embankment was washed in the northward and reached around 55m behind the embankment (Figure 9). The storm surge overtopped the embankment for 10 to 15 minutes. Front slope of the embankment was about 1:2. Sandbags were placed where the front surface was severely eroded due to stormy waves. Many houses, built on the seaside of the embankment before the storm, were all washed away. Backside slope of the embankment is 3:10. Several scours were observed behind the crest of embankment. Inundation depth at fisherman's house just behind the embankment was 72cm. This house was not settled on the foundation and was washed around 1m without suffering structural damages. Stormy waves were witnessed although their heights and periods were unknown. Most of residents took a shelter while some survived by tie themselves to a tree. Inundation depth around the shelter was about 1m. The shelter was built beside school since the school provided the land for the shelter.

(6) Summary of Bangladesh case.

Inundation heights along the Baleshwar river and the Burishwar river were relatively high compared to those observed on the coast of Kuakata although these sites are far from the coast. Embankments along the river had been eroded before the storm while dikes on the coast significantly functioned to reduce the damages of the coastal area behind. Many people witnessed that storm surges inundated with bore-like waves. Counter measured against storm surges should account for the physical mechanisms for the development of such bore-like waves and possible damages due to such waves. As observed in Kuakata and Somboniya, embankment showed significant roles to minimize the damage. Development of riverbanks especially around the river mouth is one of most essential countermeasures to be carried out in Bangladesh. Shelter functioned to save significant number of lives although the numbers of shelter still needs to be increased to match the number of residents.

CASE OF CYCLONE NARGIS IN MYANMAR (Shibayama et al., 2009b)

The cyclone 'Nargis' hit the southern part of Myanmar on May 2nd and 3rd 2008. Figure 10 shows the track of Nargis and the contour map of southern part of Myanmar coast. This strong cyclone caused more than 130 thousands of loss of lives, enormous number of casualties as well as fatal damages to houses and paddy fields. Particularly both the downstream areas of the Irrawaddy and Yangon River basins were seriously damaged. In the present field survey, the activities were limited to the area near Yangon city due to strong governmental restrictions. As results of field survey through interviews to residents and measurements by using the laser type distant meter, it was found that the tide due to the storm surge was probably up to 2m and more and came up to around 50 kilometers upstream of the river mouth of Yangon River. In the followings, some of the survey results are summarized and described. In figure 11, the survey results are summarized.

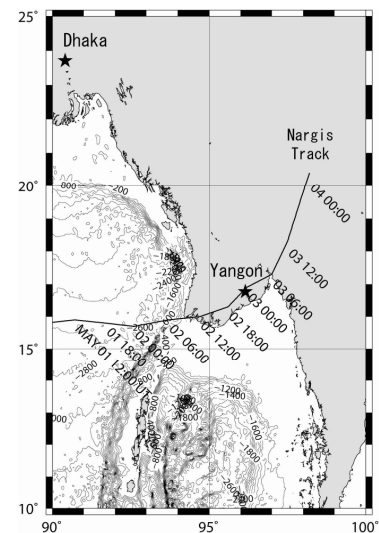


Figure 10: Track of Cyclone Nargis (Data from UNISIS and U. of Alaska). (Shibayama et al., 2009b)

(1) Yangon Port (location A in Fig. 11: N16deg. 46min. 5.2sec., E96deg. 9min.43.5sec)

Figure 12 shows one example of flooded height in Yangon area. The storm surge height was around 1.2 m above the bank. The water flooded over port area and many boats are damaged to sink. The high water continued for around four days.

(2) Left Bank of Bago River (location G: N16deg. 46min. 58.84sec, E96deg. 14min. 01.61sec)

Large numbers of boats were moved and were left in land after the storm. A large scale local scour

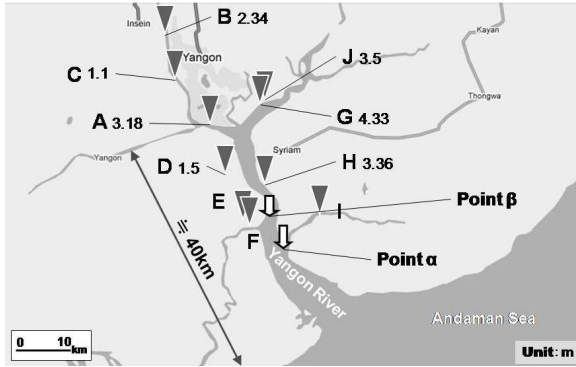


Figure 11: Survey route and measured storm surge height. (Shibayama et al., 2009b)



Figure 12: Yangon Ferry



Figure 13: Left bank of Bago River



Figure 14: Flood at Rakhine Chaing Village.

due to return flow of flooded water was observed as shown in the Figure 13.

(3) Rakhine Chaing Village (location D: N16deg. 39min. 37.5sec, E96deg. 11min. 11.6 sec.)

Storm surge came to paddy area with height of around 1.5 m through irrigational channels (see Fig. 14). According to interviews with the local residents, it appears that significant flooding took place at inland areas as a result of the upsurge through the tributaries or channels from the main river.

Even though the situation was catastrophic, it seems that most residents had not evacuated. One of the reasons for this could be related to the fact that the cyclone passed through the area investigated in the late night May 2nd to the early morning of May 3rd. Another reason might be because of an underestimation or the lack of perception of the threat of storm surge.

(4) Comparison with past cyclones

Apart from the investigation, the tracks for the present and past cyclones (1945-2007) (see references UNISIS, University of Alaska, JTWC and Chu et. al) have been analyzed based on a string of best track data as shown in Fig. 15. The results reveal that quite a small number of cyclone (roughly 2 times on average every 10years) have hit the southern coast of Myanmar compared to the number of cyclones that hit the coast of Bangladesh, and that the route that Nargis traced is rather unique. Since the residents have few experiences of storm surge, they didn't get any image of the possible disasters when the storm surge came.

Years1945–1959

Years1960–1969



Years1970–1979

Years1980–1989



Years1990–1999

Years2000–2007



Figure 15: Historical paths of cyclones in the vicinity of Myanmar. (data from JTWC and Chu and Sampson, 2002) (Shibayama et al., 2009b)

CONCLUSIONS

In Bangladesh, many people witnessed that storm surges inundated with bore-like waves. A general image of storm surge is gradual elevation of water level but in some cases the behavior of water body is more violent one. Therefore the counter measured against storm surges should account for the physical mechanisms for the development of such bore-like waves and possible damages due to such violent waves. River and coastal embankment showed important function to minimize the water level, momentum and resultant damage. Development of riverbanks especially around the river mouth is one of important counter-measures to be carried out in Bangladesh. Cyclone shelters functioned well to save a gib number of lives in Bangladesh. But in Myanmar, there were few experiences on storm surge and no countermeasures againt storm surge including such as shelters. These differences results the difference of losses. They were 4,234 including deaths and unknowns in Bangladesh but 138,366 in Myanmar.

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