Flood Monitoring (2007) in Bangladesh Using Terra MODIS Satellite Imageries

M. Mahmudur RAHMAN[1] and Josaphat Tetuko Sri SUMANTYO[2]

[1, 2] Microwave Remote Sensing Laboratory, Center for Environmental Remote Sensing, Chiba University

1-33, Yayoi, Inage, Chiba 263-8522 Japan

E-mail: [1]mahmud@restaff.chiba-u.jp (Corresponding author)

Abstract

Bangladesh, a low-lying delta is located in the South-Asian Monsoon System. The intense monsoon rain often creates flooding in the country. Moderate Resolution Imaging Spectrometer (MODIS) on NASA's Terra satellite image on the 5th August 2007 image was classified to prepare flood map and administrative boundary was overlaid to create the statistics. The result shows nine districts of the country were severely affected (more than 50% of area remained under water). Overall, this investigation found that about 22% of the country was under water though cloud coverage (about 22%) obscured part of the country to create accurate statistics.

1. Introduction

Bangladesh is located at the confluences of Bhramaputra, Meghna and Ganges Rivers. The rivers are the part of the Himalayan drainage systems and empty into the Bay of Bengal through the largest river delta in the world. The annual discharge through these rivers is the second largest after the Amazon in the world. Normal flooding during the monsoon periods is a common phenomenon in Bangladesh. Floods make the cultivable land fertile, but excessive flooding sometimes becomes catastrophic evens. Floods have created devastation in Bangladesh throughout the history, especially during the recent years: 1987, 1988, 1998, 2004 and 2007. The flatland within the country is very fertile and criss-crossed by many rivers. All the river-plains are densely populated. As a consequence catastrophic flooding in any region of the flood-plains creates severe impact to many people.

Since the inception of remote sensing, the technology has been using for flood detection, monitoring, damage assessment and forecasting. Several studies have been carried out in many parts of the world using both the optical and microwave sensor data. The flooding events have been investigated in the many parts of the world., i.e. Senegal River Valley in West Africa (Sandholt *et al.* 2003), Limpopo Basin in southern Africa (Asante *et al.* 2007), Mackenzie River Basin in Canada (Temimi *et al.* 2005), Yellow River Basin in China (Liu and Yan 2005), Ganges-Bhramaputra Delta in Bangladesh (Rasid and Pramanik 1990, Rasid and Pramanik 1993).

The objective of this research was to (i) delineate the extent of flooding in the Ganges-Bhramaputra Delta in Bangladesh during July-August 2007 and (ii) generate flood statistics for each district (local administrative units) of the country.

2. Study Area and Remote Sensing Data

The study area is located in the lower Ganges-Bhramaputra basin covering the administrative boundary of Bangladesh. It covers from 22^0 to 26^0N latitude and 89^0 to 92^0 E longitudes. The area enjoys a sub-tropical monsoon climate with three distinct seasons per year: the pre-monsoon hot season from March to May, rainy season June to October and cool dry season from November to February. The average annual rainfall varies from a maximum of 5690mm in the northeast of the country to minimum of 1110 mm in the west. Most rainfall is concentrated in the monsoon season (about 80%).

The research used Moderate Resolution Imaging Spectrometer (MODIS) satellite imagery of 2nd May and 5th August, 2007, Shuttle Radar Topographic Mission (SRTM) elevation data and administrative (districts) boundaries of Bangladesh. Satellite imageries were downloaded from http://rapidfire.sci.gsfc.nasa.gov/ website. Processed image of 2nd May in jpg format was only available on the website and used in this study for display. Geo-rectified three-bands (1, 2 and 7) were available in tiff format and were downloaded (detailed band descriptions in Table 1). SRTM data was downloaded from Global Land Cover Facility (GLCF). Administrative boundaries were used from Bangladesh Space Research & Remote Sensing Organization (SPARRSO) archive.

Table 1. Terra MODIS selected band descriptions

Primary use	Band	Bandwidth (nm)	Resolution (m)
Land/Cloud/Aerosols Boundaries	1	620-670 (Visible red)	250
	2	841-876 (Near-infrared: NIR)	250
Land/Cloud/Aerosols Properties	7	2105-2155 (Mid-infrared)	500

3. Methodology

Terra MODIS satellite image of 5th August was visualized on computer screen; three bands 1, 2, and 7 into red-green and blue color. Clear water appears in dark blue and water with sediments in light blue. Bare-soil or

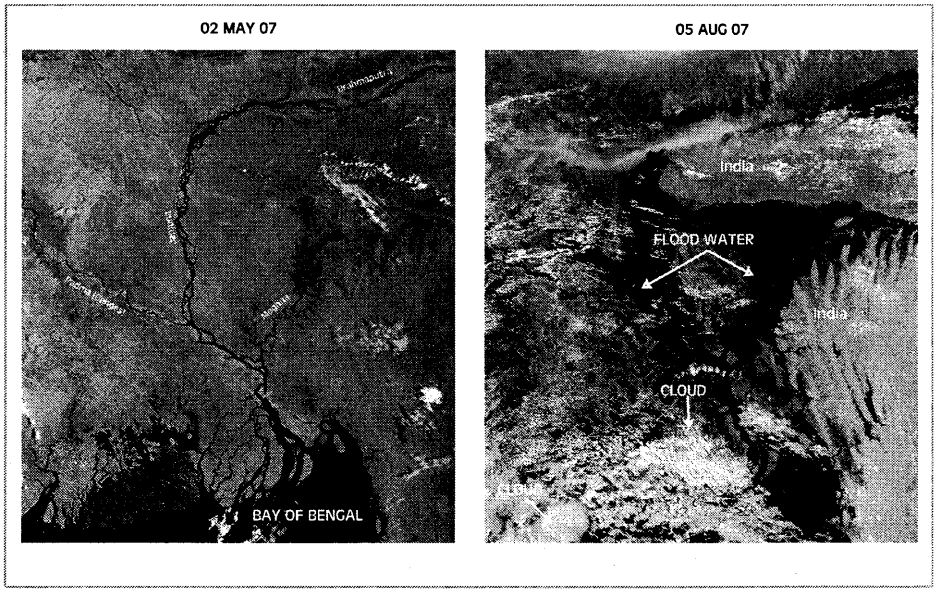

Figure 1. Comparison of inundation level (left image before monsoon and right image during flooding

lightly vegetated area appears as tan, vegetation as bright green, cloud as white (with pink and blue tone). The image was classified using supervised method. First training samples were collected from seven classes: water, vegetation and cloud- two categories in each class and exposed soil class. Care was taken to collect only the homogenous pixels as training samples. In the second step all these seven classes were merged to water, land and cloud. Maximum likelihood algorithm was used in classification. The classification accuracy was computed from training set of pixels and presented in an error matrix. The local administrative unit (district) boundaries were overlaid on the classified imagery to assess the extents of flooding in each district.

4. Results and Discussion

4.1 Monsoon Flooding 2007

Before the on-set of monsoon the rivers and the water bodies in Bangladesh are in the dry months' inundation level and the course of each river is clearly defined on the satellite image (Figure 1, left image). Due to the intense monsoon rain in these regions as well as in the upper catchments the rivers and water bodies were filled with water, over-flowed and submerged many low-lying areas, agricultural fields, villages and cities and created catastrophic flooding. The swollen water-level is shown in Figure 1 (right image).

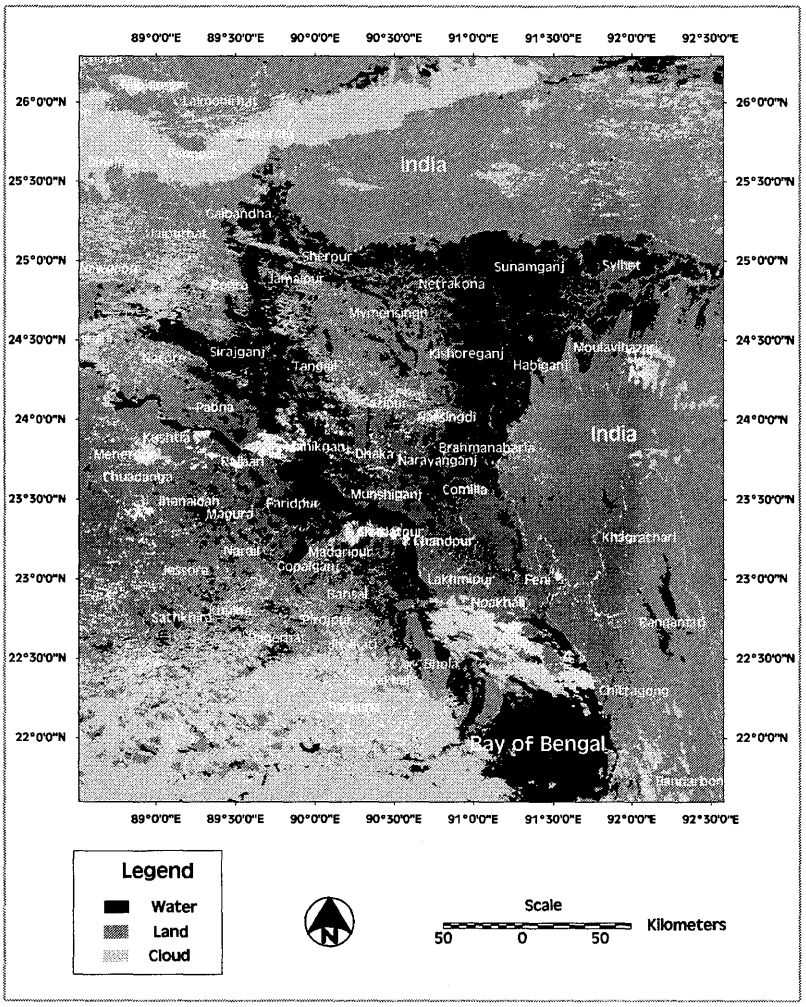

Figure 2. Flood map of Bangladesh (05 August 2007)

Flood map shows that the central and northern region is the most affected part of Bangladesh (Figure 2). Among the 64 districts of the country, nine districts (Sunamganj, Sirajganj, Brahmanabaria, Kishoreganj, Netrakona, Faridpur, Habiganj, Manikganj and Sylhet) were most affected (more than 50%, Table 2). Overall 22% of the country is inundated by 2007 (July-August) flood though cloud coverage (22%) obscures to compute for an accurate statistics and 56% of the country were not affected.

Table 2. Flood water inundation in different districts of Bangladesh (5th August 2007)

Flood Damage	District	Coverage (%)			Area (ha)		
		Water	Land	Cloud	Water	Land	Cloud
>50%	Sunamganj	85	15	-	311 558	54 956	122
	Sirajganj	77	18	5	187 619	43 305	12 813
	Brahmanabaria	75	23	2	144 488	43 230	4 211
	Kishoreganj	71	29	-	179 900	72 177	110
	Netrakona	70	30	-	202 778	85 977	215
	Faridpur	62	38	-	126 680	79 234	12
	Habiganj	58	42	-	150 041	107 734	-
	Manikganj	52	32	15	73 031	44 705	21 444
	Sylhet	50	50	-	174 743	171 554	105
30-50%	Shariatpur	46	39	16	57 971	48 852	19 724
	Jamalpur	43	42	15	88 196	86 547	29 761
	Madaripur	40	50	9	44 368	55 491	10 199
	Munshiganj	40	60	-	37 666	55 915	6
	Sherpur	36	62	2	48 492	82 341	2 294
	Comilla	33	67	-	103 367	209 365	732
	Tangail	33	51	16	113 107	176 932	53 800
	Dhaka	32	59	9	47 801	89 590	13 266
	Chandpur	31	68	2	51 919	115 262	2 840
10-30%	Narayanganj	29	68	3	23 128	53 533	2 132
	Pabna	29	64	7	69 227	155 192	16 582
	Barisal	29	64	8	65 992	147 264	17 471
	Narsingdi	28	59	13	32 607	69 471	15 281
	Mymensingh	26	72	2	110 470	306 209	7 911
	Gaibandha	26	60	14	56 310	131 658	29 755
	Natore	25	57	17	48 759	110 319	33 431
	Gopalganj	25	72	3	39 112	110 999	4 490
	Magura	22	77	-	23 494	81 145	412
	Moulavibazar	20	76	3	55 502	207 436	9 078
	Rajbari	20	66	14	22 129	73 850	15 821
	Bogra	19	51	30	55 833	149 640	86 064
	Narail	11	84	6	10 600	81 917	5 512
	Kushtia	10	74	16	17 238	123 649	27 164

The overall effect of flooding in 2007 is lower than 1955, 1987 and 1988 floods, when 37%, 40% and 57% of the country were affected by flooding respectively (BWDB 1987, Rashid and Pramanik 1990). Considering the elevation gradient from the northern Himalayan Mountain to the southern Bay of Bengal two depressed pockets are vivid in the north-eastern and north-western part of the country (Figure 3). These pockets often become inundated during the monsoon season and results normal flooding every year. But excessive rain in addition to the melting of the Himalayan snow sometimes creates catastrophic flooding and inundates vast areas of northern and central parts of the country, where the elevation is often lower than 20m above mean sea level.

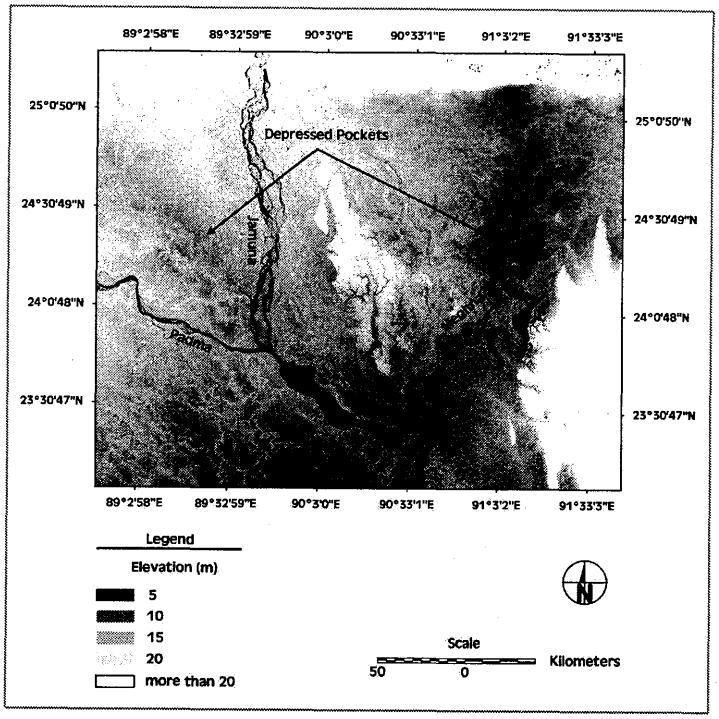

Figure 3. Elevation map of the flood affected region (2007) of Bangladesh

Table 3. Classification error matrix for flood mapping using Terra MODIS satellite imagery

		Training Pixels			
		Water	**Land**	**Cloud**	**Total (classified)**
Classified Pixels	Water	38 437	0	0	38 437
	Land	19	12 410	0	12 429
	Cloud	1	0	28 025	28 026
	Total (training)	38 457	12 410	28 025	78 892

4.2 Classification Accuracy

The overall accuracy of classification computed from the training pixel-sets is almost 100%. This happens because of the large difference of the optical properties between water, land and cloud in bands 1, 2 and 7. The columns and rows of the error matrix show the training and classified pixel-sets respectively (Table 3). The training pixel sets those are accurately classified are located along the diagonal of the error matrix (running from upper left to the lower right). The upper-right cell of the diagonal represents the

commission errors and the lower-right cells the omission errors. Omission errors mean this category has been omitted from the class and commission error is the opposite.

5. Conclusion

This investigation concludes that (i) about 22% of the country was affected by this flooding event though cloud coverage on the image (22%) obscures to compute for an accurate country-level statistics (ii) nine districts among the 64 districts of the country were severely affected (more than 50% inundated). In recent decades catastrophic floods in Bangladesh are becoming common within a few years' interval. Intense rainfall is one of the main reasons of flooding. Further studies should be carried out to investigate whether climate change is affecting the South Asian Monsoon System and rainfall patterns, and often creating catastrophic flooding in this region. The result of this study will be useful for the policy makers to make plan for the post-flood agricultural and reconstruction activities.

Acknowledgement

Terra MODIS satellite imageries and SRTM data were downloaded from http:// rapidfire. sci. gsfc. nasa. gov/ and http: //glcf.umiacs.umd.edu/index.shtml websites respectively.

Administrative boundaries are used from SPARRSO database.

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