CS-225

Determining of Flood Hazard Areas in Bangladesh Using NOAA AVHR Images with Digital Elevation Data

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1. INTRODUCTION

The whole Bangladesh is an immense river basin criss-crossed three mighty rivers the Ganges, the Brahmaputra and the Meghna with their innumerable tributaries which ripped the country. Bangladesh faces flood every year during the monsoon, while normal monsoon floods are beneficial for the country, sever one damage to property, agriculture, life, economy and infrastructure. The flood of 1988 in Bangladesh was the most terrible cataclysm and set 100 years new record. To prevent the further flooding and making the land planning decision, it is necessary to understand the water amount in dry and flood season and flood hazard areas for the construction of embankment, dam and dikes which delineate the flood endangered areas.

2. DADA ACQUSITION AND PREPARATION

Four available NOAA AVHRR images data which contained low cloud amount were considered for this study, one for dry season (Jan. 20, 1988) and three for flood season (Sep. 18, Sep. 24 and Oct. 8, 1988). Whole area of Bangladesh was captured in each single image. After geometric corrections sub scenes were extracted from the full scenes by using vector layer for Bangladesh. Vector data for the boundary of Bangladesh were prepared by ARC/INFO software.

3. METHOD AND ANALYSES RESULTS

In the year of 1988 flood existed for long time in Bangladesh. Therefore, interpretation among the images those as much as could be taken during the flood give more accurate results of flood hazard areas. Owing to that we classified three images for flood and one image for dry season. Land cover classification were carried out by using unsupervised (ISO-DATA clustering) and supervised landcover classification. Initially each image clustered into hundred categories and finally divided into two groups of water and non-water areas. Parametric and non-parametric signature were used in supervised landcover classification. Initially each image classified into fifty categories and finally divided into two groups of water and non-water areas using parametric rule as maximum likelihood, Mahalanobis and minimum distance, and non-parametric rule as parallelepiped and none. When both parametric and non-parametric signature are used to classify an image, one would be able to better analyze and visualize the class definition than either type of signature to be provided independently.

Normally flood occurs in Bangladesh during rainy season. Cloud covered pixels were interpreted by cloud free pixels for different images during the same flooding after the classification of raw images. Cloud covered pixels those were could not be interpreted among the images, were replaced by classes' pixels of dry seasons image or interpreted by the pixels of same image with the help of elevation data, land slope and land cover maps.

To differentiate among normal water, flooded areas and land, and for the estimation of flood hazard area's elevation, a model was constructed by using model maker of ERDAS IMAGINE software. Classified image data; one for flood and another one for dry season, and digital elevation data were considered as input files. Each image yielded 145,919 pixels on the display monitor after geometric correction, and each pixel covered 1.1km × 1.1km on ground surface. So, each image covered 176,562 km^2 but land area of Bangladesh is 143,998 km^2 remaining area were included from the Bay of Bengal, which is considered as normal water areas with normal water (river, lake, etc.) inside the country.

The estimation results of inundated, land and normal water areas are shown in Table 1 and 2. Table1 and 2 show the results which were calculated from unsupervised landcover classification (ISO-DATA clustering) and supervised landcover classification. The elements those represent the water and non-water area both during the flood and dry season are considered as normal water (river, lake, sea, pond, etc.) in dry season and land area during the flood, respectively. On the other hand the element that represents the water area during the flood but non-water area for dry season is considered as inundated area, and the element that represents the non-water area during the flood but water area during dry season is considered as error pixels. Therefore, flooded area percentage can be estimated by the following equation:

$$Flooded\ area\ percentage = \frac{a}{b+a} \qquad (1)$$

Where, a= inundated area (non-water area for dry season but water area during the flood), b= non-water area both during the flood and dry season.

1. *Flood event as seen by unsupervised landcover classification (ISO-DATA clustering)*: Table 1 shows 36.77%, 40.84% and 21.51% are inundated, land and normal water and 0.88% is the error pixels. So, flooded area percentage is 47.38%.

Table 1. Inundated, land and normal water areas (%) calculated from unsupervised landcover classification (ISO-DATA clustering)

		Dry season (%)		
		Water area	Non-Water area	Total
Flood season (%)	Water area	21.51	36.77	58.28
	Non-Water area	0.88	40.84	41.72
	Total	22.39	77.61	100.00

Keyword: NOAA AVHRR image, digital elevation data, flooded area, ISO-DATA clustering.
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Table 2. Inundated, land and normal water areas (%) calculated from supervised landcover classification

(a) Non-parametric rule: Parallelepiped, Overlap rule: Parametric and Unclassified rule: Parametric

		Dry season (%)								
		Maximum likelihood			Mahalanobis distance			Minimum distance		
		Water area	Non-water area	Total	Water area	Non-water area	Total	Water area	Non-water area	Total
Flood season (%)	Water area	23.65	37.46	61.11	22.53	35.97	58.50	22.86	37.73	60.59
	Non-water area	1.73	37.16	38.89	1.37	40.13	41.50	0.94	38.47	39.41
	Total	25.38	74.62	100.00	23.90	76.10	100.00	23.80	76.20	100.00

(a) Non-parametric rule: None, Overlap rule: Parametric and Unclassified rule: Parametric

		Dry season (%)								
		Maximum likelihood			Mahalanobis distance			Minimum distance		
		Water area	Non-water area	Total	Water area	Non-water area	Total	Water area	Non-water area	Total
Flood season (%)	Water area	26.18	35.14	61.32	22.97	35.23	58.20	23.00	37.83	60.83
	Non-water area	3.14	35.54	38.68	1.78	40.02	41.80	1.36	37.81	39.17
	Total	29.32	70.68	100.00	24.75	75.25	100.00	24.36	75.64	100.00

Table 3. Flooded area (%) with their elevation (Flooded area calculated from ISO-DATA clustering)

Elevation (m)	0 ~ 4	4 ~ 8	8 ~ 12	12 ~ 16	16 ~ 20	20 ~ 40	40 ~ 60	60 ~ 80	80 ~ 100	100 ~	data not
Flooded area (%)	23.40	25.63	17.55	10.00	4.92	5.81	1.07	0.11	0.109	0.001	11.40

2. *Flood event as seen by supervised landcover classification,* (a). *Non-parametric rule is Parallelepiped*: Table 2(a) shows the inundated area are 37.46%, 35.97% and 37.73% and error pixels area are 1.73%, 1.37% and 0.94% when parametric rule are Maximum likelihood, Mahalanobis and Minimum distance, respectively. According to eq. 1, flooded areas percentage for maximum likelihood, Mahalanobis and minimum distance are 50.20%, 47.27% and 49.51%, respectively.

(b). *Non-parametric rule is None*: Table 2(b) shows the inundated area are 35.14%, 35.23% and 37.83 and error pixels area are 3.14%, 1.78% and 1.36% when parametric rule are maximum likelihood, Mahalanobis and minimum distance, respectively. According to eq. 1, flooded area percentage for maximum likelihood, Mahalanobis and minimum distance are 49.72%, 46.82% and 50.01%.

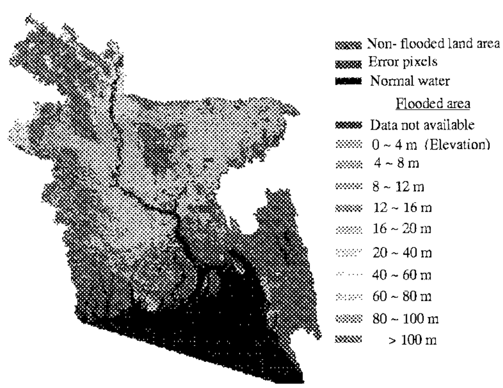

Fig. 1. Flood hazard map of 1988

3. *Flood event as seen through digital elevation*: Flooded hazard area has been observed by combining with digital elevation data, revealing that certain lower lying areas did not look flooded though higher elevation areas were flooded. Table 3 shows the flooded areas corresponding with elevation. Maximum flooded area (25.63%) lies between the elevation from 4 to less than 8m then followed by 0 to less than 4m (23.40%) and 8 to less than 12m (17.55%). Therefore, elevation 0 to 12m is high risk of flooding areas, and every year lower land area is being flooded due to the high rainfall and over bank flow of rivers. Fig. 1 is flood hazard map which was constructed from ISO-DATA clustering represents non-flooded land and normal water and flooded areas with different elevations.

4. CONCLUSION

Remote sensing data can provide a wide range of flood related information. At a flood prevention level, flood hazard and flood prone areas can be determined by remote sensing with digital elevation data.

Results calculated by unsupervised and supervised classifications are very resemble. Table 1 and 2 show that maximum flooded area is 50.02% and minimum flooded area is 46.82%. Maximum error is 3.14 and minimum error is 0.88. Elevation of maximum flooded areas ranges from 0 to 12m.