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Flood damage and management modelling using satellite remote sensing data with GIS: case study of Bangladesh

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Abstract Physiographic divisions, geological divisions, land cover categories and drainage network data were used as GIS components. Flood frequency and floodwater depth were estimated using NOAA AVHRR data for the development of a flood hazard map. The flood hazard map provides information for the development of counter measures and preparation of high risk areas, on a priority basis, against flood damage. It is concluded that the flood hazard map, which was developed by considering the interaction of floodwater depth and flood frequency, gives good results for other events.

Key words elevation height; flood affected frequency; flood hazard map; floodwater depth; geological division; hazard rank; land cover classification; physiographic division; ranking matrix

INTRODUCTION

Flood is a common environmental disaster in Bangladesh and high magnitude floods occur on a regular basis in the three rivers basin of the Ganges, Brahmaputra and Meghna rivers in Bangladesh and in the Indian peninsular, because of the passage of depression and cyclone storms during the monsoon (Kale & Pramod, 1997). This study focuses on the 1988 flood which was the most devastating environmental hazard in the memorable history of Bangladesh.

ANALYSIS OF FLOODWATER DEPTH AND FLOOD FREQUENCY

Flood depths were classified as shallow, medium and deep by using a maximum likelihood method of supervised classification. Training areas for shallow, medium and deep flood depth were assigned on the NOAA AVHRR images of 18 and 24 September and 8 October 1988, according to the differences of colours and grey scales for different depths. These differences were recognised after superimposing the NOAA images onto a digital elevation image of Bangladesh. Priority was given to the greatest degree of depth among the three classes floodwater depths for three images.

Flood affected frequency within the 1988 event was estimated by using the same images: inundated water not appearing in any of the above mentioned three images was considered to be a non hazard area; the inundated water that appeared in a single

image was considered to be a low hazard area; the common inundated water that appeared in two images was considered to be a medium hazard; and common inundated water that appeared in all three images was considered to be a high hazard area.

HAZARD ASSESSMENT

A weighted score was estimated by

$$\text{Weighted score} = 0.0 \times class1 + 1.0 \times class2 + 3.0 \times class3 + 5.0 \times class4$$

where *class*1, *class*2, *class*3 and *class*4 are area percentages acquired by no-flooding, shallow, medium and deep depth or non hazard, low, medium and high hazard areas for land cover categories, physiographic divisions and geological divisions.

The area percentage obtained for each class number for the physiographic divisions (31 divisions), geological divisions (28 divisions), land cover classification categories (9 categories) and elevation height intervals (9 intervals) were estimated on the basis of flood frequency and flood depth which were considered as hydraulic factors. Only the estimated results of land cover classification categories for the flood frequency are shown in Table 1 with counted scores, allocated points and hazard ranks. In order to quantify the flood hazard, the three ranking was obtained from the allocated point, and finally interactive effects of the physiography, geology and land cover classification were considered on the flood hazard assessment. Hazard ranks ranged from 1 to 27 for floodwater depth and flood frequency, respectively, which were estimated by the ranking matrix of three dimensional multiplication mode (hazard rank for physiography, HR: 1–3, geology, HR: 1–3, and land cover, HR: 1–3) for the combination of physiographic division, geological division and land cover classification. Finally, a higher hazard rank was assigned for a pixel between the two hazard ranks which were developed by considering the depth and frequency for that pixel. The study shows that 92.15% and 89.94% areas for the 1995 and 1998 floods, respectively, did not exceed the risk ranks of the hazard map developed, which is shown

Table 1 Hazard rank for land cover classification by flood frequency (ID: land cover classification categories, HR: hazard rank).

ID	*Class*1	*Class*2	*Class*3	*Class*4	Score	Point*†	HR 1~3
1	47.44	20.87	17.23	14.46	144.86	63.96	2
2	38.87	12.66	14.25	34.22	226.50	100.00	3
3	43.78	18.47	15.60	22.15	176.00	77.70	3
4	66.58	15.85	9.25	8.32	85.19	37.61	2
5	58.93	16.51	14.21	10.35	110.88	48.95	2
6	76.04	12.87	6.17	4.92	55.98	24.72	1
7	80.90	9.26	5.12	4.72	48.24	21.30	1
8	68.72	15.18	7.65	8.46	80.40	35.50	2
9	33.07	25.42	21.96	19.56	189.07	83.47	3

*Points 0 to 100 are linear corresponding to minimum score (0) to maximum score (226.50).
†Points 0~33 is HR 1, 33~66 is HR 2 and 66~100 is HR 3.

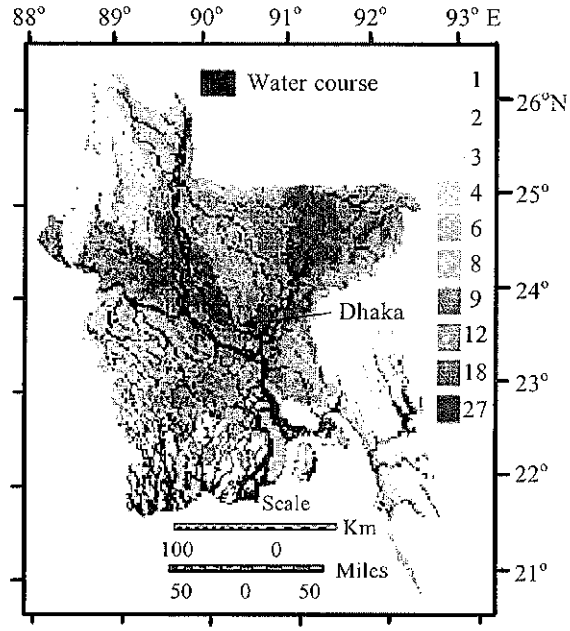

Fig. 1 Flood hazard map.

in Fig. 1. Therefore, the hazard map will give more safety for the flood counter measure compared with our previous developed hazard maps (Islam & Sado, 2000) because the pixels belonging to higher degrees were increased due to the consideration of higher degrees of ranks.

CONCLUSIONS

A flood hazard map was developed on the basis of the interactive effect of floodwater depth and flood frequency on land cover categories, physiographic and geological divisions. This hazard map will provide helpful information for flood countermeasures and preparation of aid and relief operations for high risk areas during future flood events.

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