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Remote Sensing and GIS for Estimation of Denudation and Consequences of Flood Hazard in a Siwalik Watershed of Central Nepal (II)

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1. INTRODUCTION

Wide spread damages due to floods is one of the very common water induced natural disasters in Nepal that account for heavy losses during the monsoon period every year. Rivers that flow through Siwalik area transport heavy sediments loads than rivers located in other areas during rainy season due to very fragile nature of the soils in Siwalik Hills. As a consequence, high sediment depositions are observed in the border of the Siwalik and Terai regions where the rugged terrain of Siwalik Hills change to relatively flat floodplain. This causes heavy losses during flood events in this areas due to overflow of river banks and planform changes of rivers. Proper countermeasures for flood prevention or mitigation are hardly carried out even though the disasters occur in time to time. This is partly due to the lack of understanding of flood hazards, hazard prone areas, causes of events, and consequences, as hardly any studies are carried out focusing on these factors.

This research project was aimed at studying the sedimentation in the riverbed of the watershed and in the floodplain using remotely sensed data. The analysis was focused on the process of accumulation, river channel aggradation, degradation, and formation of new channels as a consequence of heavy sediment unloading in the monsoon period of the Siwalik originate rivers. Flood prevention and controlling works that have been carried out in the past were investigated to identify their effectiveness.

2. OUTLINE OF THE STUDY AREA

Present study was carried out in the Siwalik area where the sediment transport is very high depositing enormous amount in the Terai plain. Sub-streams are comparatively short in length with higher gradient, and very flat riverbed is typical to the rivers originate in the Siwalik hills. The dendritic drainage pattern develops towards the upper stream of the rivers, and the gradient of the riverbed gradually increases. Ratu watershed selected for the study belongs to the Siwalik area located in the South of Sun Koshi and west of Kamala river. This river originates at an altitude of 708 meters, south of Sindhulimadi, and flow in the direction of north-south from Siwalik Hills to the Terai region. The East-West Highway (hereinafter EWH) could be considered as the turning point of this river system dividing the watershed and floodplain, Figure 1. The length of the river in the upper stream up to EWH is about 35 km , and average gradient of the riverbed is about 1/100. Width of the river changes dramatically below the EWH. Above the EWH the width is about 600 meters decreasing towards up-stream, and below the EWH the width has been extended to 2 to 3 km decreasing the riverbed along the down-stream.

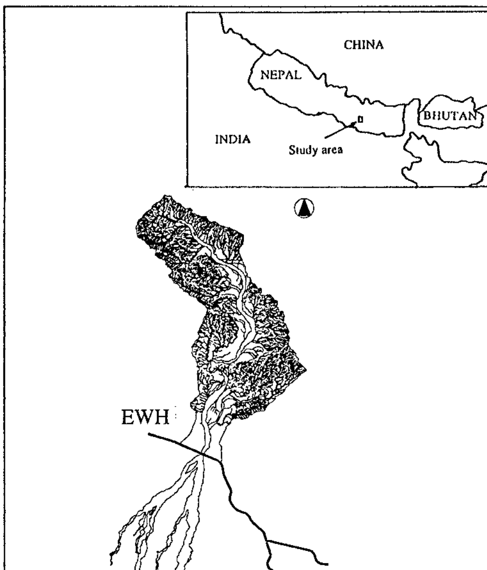

Figure 1 Study Area

3. ACQUISITION OF DATA

Landsat MSS (1973.03.14 and 1977.03.20), TM (1993.03.16 and 1995.03.22), and IRS-LISS-II (1995.03.15) data for the period of 1973-95 was acquired, together with conventional maps, and aerial photographs. These multi-source and multi-date data were integrated in a GIS database with relevant digitization, rectification and transformations. Further, field investigation and helicopter photography was carried out in 1996 January, and these information also incorporated in the current GIS database. A detailed discussion of the method of the field survey, obtained information, and the detail discussion of the soil erosion phenomenon, and its transportation is found in JICA, 1996.

Keyword: Sedimentation, Floods, Remote Sensing, GIS

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4. RESULTS AND DISCUSSION

4.1 Spectral Characteristics of Riverbed Materials

Riverbed in dry season appears very bright on aerial photographs, and on the conventional photographs indicating very high reflectance in the visible spectral region of the electromagnetic spectrum. Further, some form of different gradation was observed in the old deposits and newly deposited areas. It was attempted to observe these characteristic properties on the radiance values observed by satellite sensors to establish the best suitable spectral band or the combination of bands for delineating deposited materials, and assessing the change in the planform of river channels. With reference to photographs, reference areas were established and corresponding digital counts for dominated cover classes, forest, crop lands and river sediments covering most of the study area were extracted and spectral response patterns were investigated. It was found that band 1, band 3, band 5 and band 7 of TM, Band 4, Band 5, band 6 of MSS, band 1, band 2 and band3 of LISS-II are highly suitable for classification of riverbed changes, sedimentation, and planform changes.

4.2 Channel Changes and Sedimentation in the Ratu Watershed

Table 1 Extent of the river bed in the upper watershed in sq.km.

MSS - 1973	MSS - 1977	TM - 1993	TM - 1995	LISS - 1995
5.18	5.23	5.48	5.45	5.53

Using the statistical parameters of the samples of interested cover classes explained above, satellite datasets were classified into sediment deposited and non-deposited areas. Comparison was carried out with the classified images to identify surface changes of riverbed within the watershed. The riverbed extents obtained from these classifications for the watershed are shown in the Table 1. There was no appreciable change was found in the extents of the riverbed area of the up-stream except for some minute differences. Further, attempt was made to identify the spatial distribution of the changes by overlaying classified images. Appreciable sedimentation or riverbed changes were not observable in the river course within the watershed.

4.3 Channel Changes and Sedimentation in the Ratu Floodplain

Table 2 Floodplain deposition of sediment and its change in sq. km.

MSS - 1973	MSS - 1977	TM - 1993	TM - 1995	LISS - 1995
9.20	11.6	9.1	9.6	10.0

Sediment deposition and its change was estimated for the Ratu floodplain using spectral data described earlier. The extents of the sediment deposition in the floodplain for the five dates sets are shown in Table 2. The figures given in the table represent the whole deposited area, including the riverbed below the EWH along the downstream until the satellite sensor can discern the sediment from its surrounding. The estimated extents shows that the sediment deposited area is increasing gradually, except for a significant increase in the time span between 1973- 77. This increase could be a consequence of the comparatively high precipitation prevailed in the period of 1974 to 75, where the total annual precipitation was over 6000 mm. The classification accuracy of LISS shows that LISS data can be used in lieu of TM data in sediment deposition estimations.

Spatial distribution of the changes shown in Table 2 could reveal the changes in planform of the river, which is a valuable information in flood disaster mitigation. Therefore, a set of three images were produced by integrating two classified dataset at a time to investigate the planform changes in the periods 73-77, 77-93 and 93-95. It was found that the extent of the sediment area remains same just below the EWH. Significant river course changes were observed few kilometers below the EWH. This could be mainly due to river bed aggradation near the EWH due to gentle gradient and marginal river flow during dry season. It was observed that the river course has dramatically changed during 77-93 period as a result of a bank erosion dike built just above the EWH. Similar phenomenon was visible in the vicinity of a flood protection dike erected in downstream, forcing the river to flow in a new direction causing damage in unprotected area. The spatial changes showed that the planform deviation of the river was much active during the 73-79 period than the latter, and the potential of planform changing activity is increasing in the east of the floodplain due to continuos deposition and aggradation in the west side of the Ratu riverbed just below the EWH. No much difference were observed between 1993-95 within the floodplain.

5. CONCLUSION

Potential of multi-temporal remote sensing data acquired from different sensors can satisfactorily be used in investigating and assessing the form of riverbed sedimentation, and the planform deviation of river channels. Historical satellite information are invaluable in evaluating the efficiency of flood protection measures carried out in the past, and their consequences that could be useful in future flood management strategies. Also the present trend of the channel formation, spatial distribution of sedimentation observed by satellite data may infer the current sedimentation activities and future channel developments that could be used as an ancillary information in flood disaster mitigation.

REFERENCE

JICA: *Research report on the investigation of landslides and soil erosion in Nepal using remote sensing* March 1996