

Study of landuse and stream planform dynamics using aerial photographs: A case study in Siwalik Hills of Nepal

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Abstract

This study is based on analysis of historical aerial photographs for assessing landuse and stream planform changes in eastern Siwalik Hill of Nepal from period between 1964 and 2003. Khajuri Khola watershed of about 27 sq km in area was selected for the study. Overlay of rectified photographs indicates that from 1964 to 1978, rapid deforestation took place mainly to expand agricultural land. However, the rate decreased in the subsequent periods. The study also indicates that the streams are constantly enlarging their sections. Main cause of changes is the occurrence of intense cloudbursts. Based on the study, three types of geomorphic hazards are recognized: bank erosion in the terraces, stream widening in the floodplains and, widening and course shifting in the area of confluence. The findings would be useful for making bank erosion and flood hazard mapping in the Siwalik streams.

Introduction

In Siwalik Hill region which is the southernmost hill range of Nepal Himalaya, floods of small streams become the panic for local residents in the monsoonal rainy season every year. There could be two principle implications of floods from Siwalik stream systems. First, agricultural land in the terraces and flood plain area are damaged by bank erosion and inundation. Second, these streams inflict loss of lives and properties, and frequent havoc to infrastructures like roads. In this context, two types of geomorphic processes are important: bank cutting in the terraces, and course widening and sometimes course shifting in the floodplains.

The Siwalik Hills exhibit a young geology containing weak and fragile landscapes. Over the last two-three decades, population of the Dun valleys has been raising rapidly exerting an undue pressure on the forest resources which has led to the ecological degradation in the region. In view of such degradation and increasing geomorphic hazards from the Siwalik streams, this paper attempts to document historical change pattern of land use and stream planform over the last four decades and to identify type and process of geomorphic hazards induced by the streams.

Study area

The research site called Khajuri stream is located in Trijuga river basin in Udayapur district in eastern Nepal (Figure 1). The study area covers an area of 26.5 sq km. It consists of three small watersheds and stream systems, which drain into Trijuga River. Many streams emerge from a huge network of drainage channels in the hillslope. The hillslope is subjected to many instabilities such as landslides, gullies and slope failures which are the principle sources of sediment which the stream systems transport downstream (Ghimire, 1998). Most part of the headwaters is covered by natural vegetation i.e. forest and shrubs, while terraces and flood plain are used for cultivation.

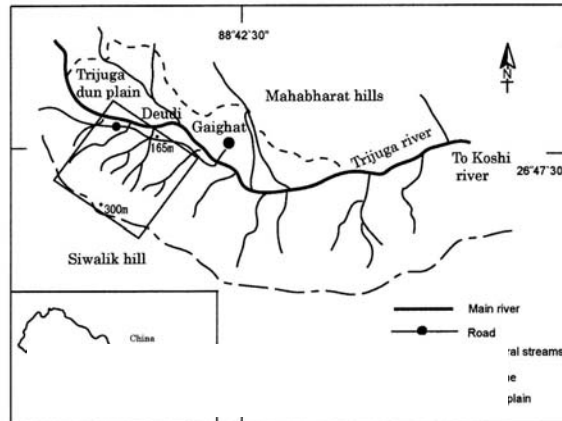


Fig. 1 Location map of study area

Methodology

The study is mainly based on the use of computer-assisted interpretation of multi-temporal aerial photographs and satellite image (1964, 1978, 1992 and 2003-satellite image). They were rectified using software called ERDAS Imagine and overlay technique was applied using software- Adobe Illustrator. Interpretation and analysis of the rectified images was done based on field observation and verification.

Results

Changes in land use

Overlay of the land use categories indicated that during the period between 1964 and 1978, rapid deforestation occurred for expanding agricultural land (Figures 2 and 3). Forest land decreased by 28% (21% of total study area) and agricultural land increased by 82% (15% of total study area). In the period between 1978 and 1992, both forest area and agricultural land decreased (7.5 and 11 % respectively) because of remarkable increase in settlements. In the period between 1992 and 2003, a slight decrease (5.8%) in forest area was noticed. More importantly stream channels kept on increasing (23%).

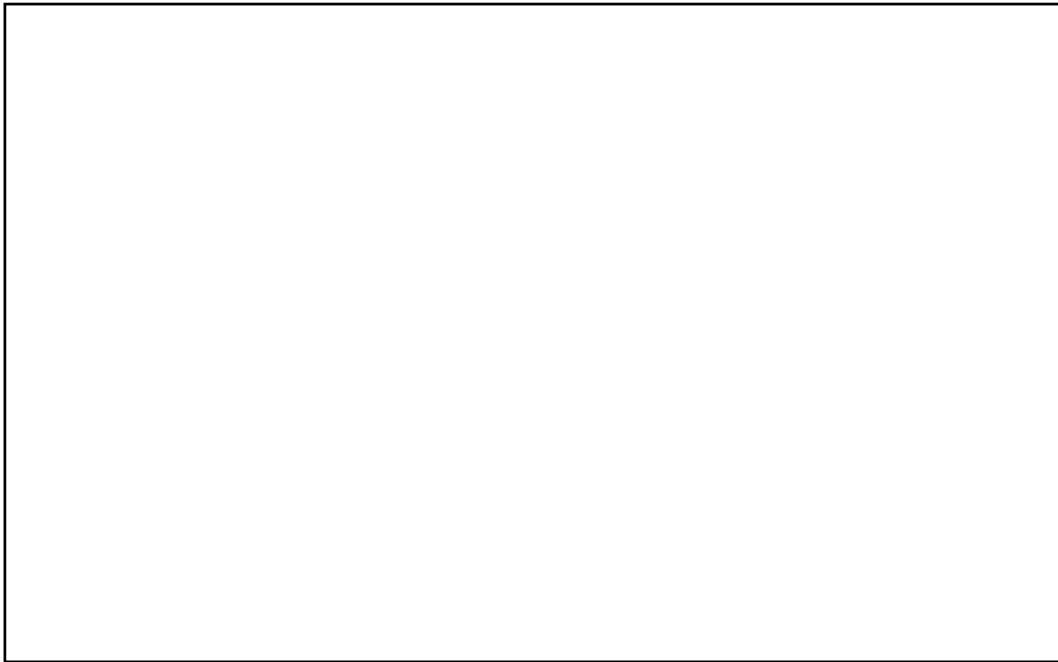


Figure 2 Delineation of Land use change from 1964 to 2003 overlaying aerial photographs

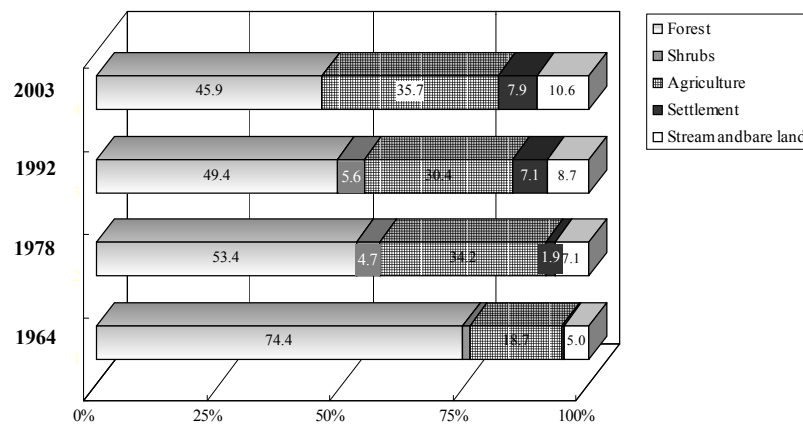


Figure 3 Land use change computation from 1964 to 2003

Changes in stream plan form

In view of the different planform change patterns in different stream reaches, the streams were divided into three segments: hillslope, flood plain and confluence area (floodplain area near the confluence of main stream- Trijuga). Planform change during the period between 1964 and 2003 is shown in Figure 4. The figure indicates remarkable spatial variation in stream planform change. In the hillslope zone, gradual increase of stream width was noticed, mainly by the process of bank scouring. Similarly stream courses gradually widened in the floodplain zone. Overbank flow during the intense rainstorms cause the inundation of the floodplains. In the confluence reach, not only stream widening is persistent but also there is frequent stream course shifting phenomena.

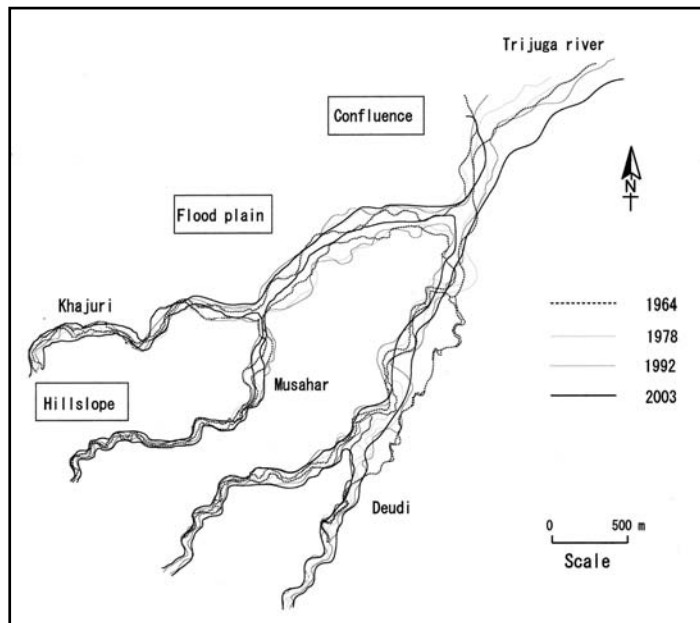


Figure 4 Delineation of stream planform changes from 1964 to 2003 by aerial photo overlay.

It is important to note that in 2003, decrease in stream width is noticed predominantly in flood plain area of Khajuri and Musahar streams. This is mainly due to the bank protection measures such as streamside earthen embankments carried out by Water Induced Disaster Prevention Technical Centre (DPTC) in 1998.

Conclusions

This study documents changes in landuse and stream planform in an area of Siwalik region using multi-temporal aerial photographs. It was found that in the period between 1964 and 1972, massive deforestation occurred to expand agricultural land, mainly in the floodplain and terraces. However, rate of deforestation decreased since then probably due to unsuitability of Siwalik soil in the hillslopes for agriculture. It was also revealed that Siwalik streams have undergone significant changes in cross-section, mostly they are broadening and the extent of change is more pronounced in flood plain and confluence areas. As a result, they induce geomorphic hazards such as bank cutting in the terraces, floodplain inundation and stream course change. The findings of this study could be important for making bank erosion and flood hazard maps of Siwalik streams.

References

- Ghimire, S.K., 1998. Planning of countermeasures against sediment disasters in Khajuri watershed of Udayapur district, Nepal. Unpublished report. Dept. of Water Induced Disaster Prevention (DWIDP), Katmandu.
- DPTC, Water Induced Disaster Prevention Technical Centre, 1998. Landslides and Erosion Study in Khajuri Watershed, Udayapur district. Unpublished report.