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CRITICALITY IN THE HIMALAYAN MIDDLE HILLS, NEPAL

Thomas L. Millette, Amulya R. Tuladhar, Roger E. Kasperson, Narpat S. Jodha, Sugandha Shrestha and B. L. Turner II

Abstract

Researchers at The George Perkins Marsh Institute of Clark University, in cooperation with local research teams, have been analyzing environmental degradation in nine "critical" regions of the world where the claim has been made that environmental degradation is directly tied to a decline in human or social well being. This work has been extended in cooperation with ICIMOD to a more specialized project on the contested notion of the Himalayan environment "in crisis" with two interrelated aims: (i) to determine the utility of analysis of satellite imagery for assessment of both environmental and social change; and (ii) to understand the salient trajectories of land-use change, particularly in the face of population change, and its environmental impacts. Both aims are tackled through the study of three small villages in three micro-watersheds located in the Middle Hills of Nepal, each site situated differently along the gradients of environmental degradation and economic transformation for the country.

The remote sensing component of the project is supported by a grant from NASA with specific objectives to explore the extent to which satellite imagery can provide indicators of change that will permit assessments of environmental criticality as defined above. Examples of indicators of change are the presence and extent of cash crops such as vegetables and paddy, subsistence crops such as maize and millet, degraded forest and pasture lands, land slips, sloping terraces and rehabilitated slope features, and agroforestry. Landsat Thematic Mapper satellite imagery for the study sites were produced for January of 1989 and 1991, as well as the following supplementary data bases: (i) black and white panchromatic aerial photos for 1992 and 1978 at scales of 1:50,000 and 1:40,000 respectively; (ii) land capability and land cover maps based on 1978 aerial photos at 1:50,000 scale; and (iii) topographic maps at 1:50,000 prepared by the Survey of India in 1954/55.

The satellite images were analyzed with the IDRISI geographic analysis system. Exploratory image analysis for indicators of criticality revealed a number of sources of confounding variation [noise]. The

source of this noise included: (a) topographic relief causing shadowing and variable spectral response at different aspects and slope angles; (b) sub-pixel (less than 30 m by 30 m) environmental variation in the landscape; and (c) a significant amount of agricultural land cover without biomass in the winter season. The analysis of the images was also limited by the absence of digital elevation models and accurately geocoded control points for image registration.

The case study portion of the study is associated with the UNU project on Population, Land Management and Environmental Change (PLEC). Reconstructions of the trajectories of environmental and socio-economic involve: (i) intensive interviews of key agents from within the micro-watershed; (ii) in-situ monitoring of change by local observers; (iii) historical reconstructions from in-depth profiles of the study villages and areas from recent ICIMOD studies; and (iv) review of relevant "grey" literature, including local project and government documents. Based on these preliminary reconstructions for the first two years of the project, each village site/micro-watershed was found to reveal complex skeins of environmental and economic trajectories of change. The village of Tauthali northeast of Kathmandu, representing the most environmentally degraded and economically undeveloped area based on the ICIMOD study, shows how an isolated mountain settlement distant from modern transport invested in management and landesque capital, such as the protection of degraded forests, plantations, and rehabilitation of land slips, without external support. The Khani Khola micro-watershed of Macchegaon in Naubise represented the most economically transformed area, having shifted its agriculture from subsistence crops of paddy and maize to cash crops of paddy and vegetables. This transformation was facilitated by the site's proximity to Kathmandu (26 km to the east), and its immediate access to a major highway and irrigation water. Here, land-use change has not been associated with major perceptions of environmental degradation. The Murli-Bhanjyang micro-watershed in Dhading-besi, selected as a case intermediary between Naubise and Tauthali, is located about an hour walking-distance from the district head-quarters of Dhading. Its development was impeded in the past by the lack of motorable means across the Trisuli River to Prithvi Highway leading to Kathmandu. The placement of a barge-ferry across the river has released market driven land-use changes in Murli-Bhanjyang; once forested landscapes are being transformed to horticulture and rain-fed agriculture with significant fodder trees on the terraces. Here, too, environmental degradation has not been perceived by the local people.

In addition to the ICIMOD work in each site area, the villages were briefly observed in 1993. Ground truthing was done in January 1994 with the help of Global Positioning Satellites (GPS) and geodetic control points to geocode indicators of criticality in the three study areas. This information will be used to georeference accurately the satellite images and geocode field data to support a supervised approach to image classification of the land covers in the three study areas. Indicators of criticality will be refined by including ancillary information of crop phenology, altitudinal zonation, and farmers input from the field within the GIS domain. This research is already beginning to demonstrate how integral use of satellite imagery from remote sensing, GIS, GPS, and geographic concepts of criticality can enhance understanding of environmental change in the Himalayas.