SOIL EROSION AND NUTRIENT DYNAMICS IN A MIDDLE MOUNTAIN WATERSHED

H. SCHREIER, M. CARVER AND S. BROWN
Resource Management and Environmental Studies,
University of British Columbia, Vancouver, B.C. V6T 1Z2, Canada
P.B. SHAH, G. NAKARMI AND B. SHRESTHA
Mountain Resource Management, International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal

Stream flow, soil nutrients and sediment dynamics were examined in the Jhikhu *Khola* Watershed, a 1100ha basin located 35km east of Kathmandu. A set of 5 automated hydrometric stations, five tipping bucket raingauges, and five erosion plots were installed in the watershed in 1991 and a detailed monitoring programme was carried out from 1992 to 1994. The focus of the research was to determine the dynamics and impact of major storms on soil erosion, nutrient losses, and sediment transport over the annual hydrological cycle. To link the hydrological regime with land use, soil surface conditions, land-use activities, and nutrient contents in soils were determined using field surveys, sample analyses, and aerial photo interpretations. A digital topographic map on a scale of 1:5000 was drawn and this provided the basemap for evaluating the soil-sediment-nutrient relationships and dynamics using Geographic Information Systems (GIS) techniques. The carbon and phosphorus content and major cations were determined in 200 field sites under irrigated and rainfed agriculture, forests, as well as grazing lands. The sediment quantity and phosphorus and carbon content of 250 sediment samples originating from three erosion plots and five hydrometric monitoring stations were also determined. The sediment samples from the stream stations and the erosion plots covered most of the major storms which occurred over the 1992-1994 period.

As shown by Carver et al. (1995), premonsoon storms produced sediment rating curves that were significantly different from those obtained during the monsoon season. The regression line intercept of the premonsoon sediment rating curve was significantly higher and the slope significantly less steep than the monsoon regression line. This trend was consistent in all

stations and in all three years. The implications of these findings are that soil and nutrient losses are more severe at low flow during the premonsoon season but approach the same level at peak stream flow. In addition, 75% of the annual losses of soil and nutrients usually occur in two or three storm events. The impact of storms, during the premonsoon season, is most critical because they occur at a time when the plant cover of soils is minimal and when the fields are prepared for cultivation and planting of the most productive crop in the annual cycle of double and triple-crop rotations. It is also a time when nutrients in the form of compost are incorporated into the soils. The impact of these premonsoon storms on sediment generation and nutrient dynamics is clearly evident when analysing samples from the erosion plots located in rainfed agricultural fields in the upper parts of the watershed and the sediments collected at two hydrometric stations below the plots. The quantity of sediments and the sediment phosphorus content both show the same differences between the premonsoon and monsoon periods.

The factors that play important roles in controlling the nutrient variability in soils are soil type and land use. The soil and land use maps were combined with the soil fertility conditions which are based on data from 200 reference sites. With GIS overlay techniques, it was possible to produce soil fertility maps that can be used as a basis for initiating conservation measures. Phosphorus was found to be a good indicator for monitoring nutrient dynamics because it is tied up in the soil and sediment materials and has low solubility. The GIS analysis enabled us to produce a digital phosphorus map of the watershed which forms the basis for conservation management. Available phosphorus, as shown by Schreier et al. (1995), is usually the most limiting nutrient for agriculture in this part of Nepal and based on the GIS map, the areas where early vegetation cover would prevent key losses of phosphorus can easily be identified. The timing of these early pre-monsoon storms are difficult to predict, and to establish a vegetation cover during the dry period is difficult because of water shortages. Establishing an intercropping or relay system could enable farmers to maintain some vegetation cover in their best fields during this critical period and thus prevent significant soil and nutrient losses. Exchangeable cations (Ca and Mg) are also lost in significant amounts during the pre-monsoon season, and continuous leaching during the remainder of the monsoon season leads to soil acidification. With the help of the GIS overlay technique, exchangeable cation, base saturation, and pH maps were produced. These can be used as tools to indicate locations where lime application would benefit crop production and reduce soil acidity. Given the high annual cropping intensity and the inherently low soil pH, these cation and acidity maps can be used to

determine where selective soil management could reduce soil and nutrient losses. The link between soil fertility, soil loss, sediment transport, and sediment redistribution is a key to sustainable management of rainfed agriculture fields in the Middle Mountains of Nepal. The results of this research provide a better understanding of the dynamics and dominant processes that govern the nutrient cycles in steeply-sloping agricultural terraces in the Middle Mountains of Nepal.

REFERENCES

Carver, M.; Schreier, H.; Nakarmi, G.; and Pathak, A.R.,1995. 'Land use Effects On Stream Suspended Sediments in the Middle Mountains of Nepal'. In Guy, B.T. and Barnard, J. (eds), *Mountain Hydrology, Peaks and Valleys in Research and Applications* (pp73-78). Proceeding of the CSHS and SCSH Conference, Canadian Water Resource Association.

Schreier, H.; Shah, P.B.; Lavkulich, L.M.; and Brown, S., 1995. 'Maintaining Soil Fertility Under Increasing Land Use Pressure in the Middle Mountains of Nepal'. In *Soil Use and Management*, Vol. 10 (pp137-142).