Journal of Nepal Geological Society, 1996, Vol. 13, pp. 139-142

Erosion and sedimentation processes and river training works in Nepal

S.B. Upadhyay
MULTI Disciplinary Consultants (P) Ltd., Kupundol, P.O. Box 5720, Kathmandu, Nepal

ABSTRACT

This paper attempts to present an overview of erosion and sedimentation processes in Nepal. The rivers that flow through the Nepalese territory originate not only from different altitudes of the country but also have catchment areas lying in India and Tibetan region of the People's Republic of China, too. All the rivers ultimately join the Ganges. GLOF and erosion of the upper reaches of the catchment area are the major processes of sediment production. Depositional areas are mainly the foot hills and wide river channels. The author also tries to demonstrate the impact of erosion and sedimentation on the geo-environment in Nepal. Finally, mitigative measures and importance of river training works are highlighted.

INTRODUCTION

In Nepal there are more than 6000 rivers, streams and rivulets stretching between the Higher Himalaya and the Gangetic plain. The major river systems are the Koshi in the east, the Gandaki in the west and the Karnali in the far west of the country. The total drainage area of these three river systems before entering into India is around 139,000 km^2. The figure also includes the drainage area of about 40,000 km^2 located in the Tibetan region of the People's Republic of China. All the rivers ultimately join the Ganges in India. The drainage density is about 0.3 km per km^2.

The perennial high discharge rivers like the Sapta Koshi, Gandaki, Karnali and Mahakali originate from the Higher Himalaya while the other large perennial rivers like the west Rapti, Babai, Tinau, Bagmati, Kamala and Kankai originate in the Mahabharat Range. The third type, which are ephemeral and often dry out during dry season, originate from the Siwalik hills.

The runoff of the Sapta Koshi, Gandaki and Karnali is inclusive of the flows from the catchments located in Tibet. The catchment area of the Mahakali River lies in Nepal, India and Tibet. The other rivers originate within the Nepalese territory. It is estimated that the annual average runoff only inside the Nepalese territory is in the order of 165 km^3, however, the total runoff inclusive of contribution form the territory in Tibet accounts for 200 km^3 (WECS, 1986).

During the wet season (June-September) the discharge of rivers is about 80% of the average annual discharge. In the upper reaches, the rivers and streams have steep slope and the flow velocity is higher and they pickup the sediments which are transported to the lower reaches. The transported coarse sediments are mostly deposited just at the foot-hills and wider channels (Carson, 1985).

EROSION AND SEDIMENTATION

Erosion of watershed, in general, is found to be most intense in the upper reaches while sediment deposition is observed at the lower reaches. The main sources of sediment are hill erosion, tributary degradation, gully erosion, flood plain erosion, channel erosion such as river degradation, river bank erosion, landslide, etc. The erosion process is also influenced by the glacier lake outburst floods which causes debris flow, landslide, erosion of river banks generally resulting in huge sediment production. A large amount of sediment are deposited especially when the rivers flow through broad valleys.

Shifting of River Course In Terai Area

The increased bed load that exceeds the carrying capacity of a river is deposited along its course. In this situation, the original course of the river is blocked by sediment deposition and the river changes to new course. This phenomenon is repeated and the rivers oscilate in its flood plains. It is a continuous process, which devastates the cultivated area by drifting river course like a pendulum, swinging to and fro in that area. This is seen, for example, in the Koshi River. The Koshi River has shifted about 120 km from the Rangeli market at the east to the Hanuman Nagar market at the west since 1736 in a period of 250 years. Similarly, a large quantity of sediment was deposited by the Lothar Khola near the Mahendra Highway (Fig. 1).

LANDSLIDE AND SEDIMENTATION

Surge from glacier lake outburst, rainfall and earthquake are the main triggering factors for natural landslides. Three fourths of the sediment from landslide are from natural sources. Most of the landslides are caused by (a) the toe erosion during floods (b) high pore water pressure (c) seismic activity (d) damming of rivers and (e) weathered and fractured nature of rocks.

In Nepal the proceses of mass wasting are accelerated by the construction of irrigation canals in unstable hill slopes. After providing irrigation to agriculture land on hill slopes, the soil will have increased pore water pressure, and the angle of repose of soil decreases. So ultimately slope fails producing landslide.

Similarly, the construction of a high dam has a dominant effect on the stability of watershed slope. The base of unstable slopes of the valley will be affected by impounding water resulting in landslides and consequently reduce the reservoir capacity. Even after a long period of relative stability of slopes, the filling and emptying of reservoir increases the pore pressure within the slope following a rapid drawdown that may be enough to set such a slope into a phase of further active sliding. Simultaneously, bed level of the river, at downstream of a structure across the river, will be changed. Sediment concentration in river water remains minimum. Due to increased river bed cutting, the side slope of the river could be destabilized accelerating degradation of the river.

GLACIER LAKES AND THEIR CONTRIBUTION TO SEDIMENTATION

The glacier lakes are broadly classified into three categories based upon the damming material (WECS, 1986).

Fig. 1: Down stream view of Lothar river showing bio-engineering works on right embankment and series of short sloping spurs.

(i) Moraine dammed lakes
(ii) Glacier ice-dammed lake
(iii) Ice-core moraine dammed lake

Glacier lakes dammed by ice have been classified based upon their location. Three distinct lake types are (a) lakes dammed in tributary valleys, (b) lakes dammed by ice fall, and (c) lakes occupying pro-glacial, super-glacial, and sub-glacial positions.

The bursting of glacial lakes owes mainly to the sudden removal of a portion of the dam materials. The erosion of dammed materials is caused due to spilling over the dam. Adjacent landslide, rock fall, ice fall, wind ice calving, etc. also cause the bursting of lake. Piping through the dammed material, intensive precipitation, etc. are other reasons of bursting of lakes

The surges from moraine-dammed lakes are more devastative than those resulting from ice-dammed lakes. The peak discharge from ice-dammed bursting takes place in a day to weeks but the bursting of moraine dammed lakes is sudden; the peak discharge is achieved within minutes and the lake is usually emptied within a few hours. Huge quantity of sediment obtained from glacial lake bursting is deposited in the river bed. So sudden deposition of sediment increases the river bed level as well as ground level of the valley. Study of Bhote Koshi reflected that the volume of materials eroded from the moraine was of about 1,000,000 m^3.

RIVER TRAINING

In the Terai area as well as in some valleys of Nepal, river changes its course and thus devastates the good cultivated area. So for its protection, river training works have to be done in such a way that river flow may be confined to certain channel.

The events which have already been experienced should be analyzed in detail. From these case studies the problems are to be clearly understood and its solution can be identified. In Nepal, geology, topography, density of drainage, climate, slope, soil texture etc. are variable and hence at any time unforseen problems may come up, which are to be solved in an effective way. To study the problems and identify its solution, proper training is needed for the specialists who are involved in these works. The problems of mass wasting, erosion and sedimentation are all spread up in the whole country.

For the river training works details of catchment area like, drainage pattern, gully formation, slopes, soil nature, occurrence of landslides in the drainage system, main river channel flow location, high flood level, deepest bed level etc. are also to be incorporated in its study. For control measures such as fixation of waterway, flood height at different return period, estimation of Manning's rugosity co-efficient, scour depth, silt factor, spacing of the spurs etc.should be incorporated in the study.

Embankment construction restricts the deposition of sediment in the bed. Hence raising of embankment should be done time to time according to the change of high flood level (Fig. 2).

As an example, in the Bagmati River all the sediment brought by the river from the mountain area is finally deposited at the foot hill. The river creates various problems like aggradation and flooding in Terai area. The magnitude of the loss of property caused by the rivers has increased year after year. The river creates devastation in a number of villages and washes land every year downstream of the Mahendra Highway. The protection work is done by constructing embankment on both side with number of long spurs (about 300m length) upstream of Gour.

CONCLUSIONS AND RECOMMENDATIONS

Erosion is especially intensive at the upper reaches of catchment areas. The erosion process is also influenced by the glacier lake outburst floods which cause landslide and bank undercutting. Numerous rivers and rivulets flowing through the Nepalese territory transport the sediments and deposit them on the foot hills and wide river valleys. Shifting of river course in the Terai area has been devastating the cultivated land in a large scale.

The human-made activities such as construction and maintenance of road, creation of irrigation and other water resources development facilities etc. contribute only a small increase to the enormous magnitude of mass wasting and that also affects the cost of economic development of the country.

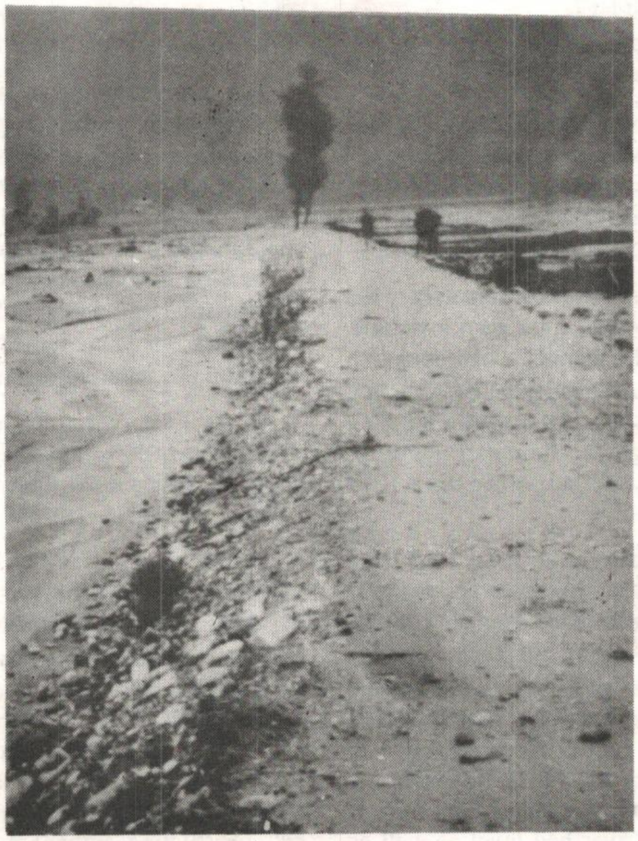

Fig. 2: Sediment deposit at the river bed due to the flood of 1993.

Alignment of roads should be planned in such a way that it creates less problems. Avoiding potential slide areas, providing appropriate drainage works, minimizing cuts from unstable slopes of hills, etc. can greatly help to minimize the problem. These actions can greatly reduce mass movement from the hill.

For minimizing the harmful effects of such flood, protective measures like reduction of the volume of water, blasting masses of loose rocks, construction of an outlet control structure and tunnel, control of breaches by blasting etc. may be undertaken.

REFERENCES

Carson, B., 1985, Erosion and sedimentation processes in the Nepalese Himalaya. ICIMOD, Occasional paper no. 1, Kathmandu, Nepal.

WECS, 1986, Preliminary study of glacier lake outburst floods (GLOFs) in the Nepal Himalaya: Phase 1. Interim report, report no. 4/1/200587/1/1, Seq. 252, Water and Energy Commission Secretariat, Kathmandu, Nepal.