

Literature Review

Some Selected Issues in the Field of Fluvial Geomorphology

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Bank Erosion:

Stream bank erosion is a dynamic and natural process as stream meanders across the landscape, however, in many places the rate of bank erosion has increased markedly because of hydraulic and geotechnical process. Stream bank erosion may be considered as either hydraulic or geotechnical process (Rosgen, 2001). Erosion refers to hydraulic process where individual soil particles at the bank edges are carried away by fluid flow, whereas bank erodibility is a function of bank material, bank morphology and bank vegetation (Shrestha and Tamrakar, 2007).

There is involvement of a large number of variables in the process of river bank erosion. The intensity of bank erosion varies widely from river to river as it depends on such characteristics as bank material, water level variations, near bank flow velocities, plan form of the river and the supply of water and sediment into the river. Loosely packed, recently deposited bank materials, consisting of silt and fine sand are highly susceptible to erosion and rapid recession of floods accelerate the rates of bank erosion in such materials (Kotoky et al., 2005).

With fine bank material and the constant change in flow approaches the bank at an angle; sever under cutting takes place resulting in slumping of sediments. Kotoky et al. (2005) observed that slumps are more common along the banks composed of clayey silt and silty clay. Quite often, the highly saturated clayey silt will liquefy and tend to follow towards the channel. As the materials flow, the overlying, less saturated bank sediment tends to slump along well-defined shear planes. Thus, there appear to be two prominent types of slumping which cause the bank line to recede; one operating during flood stage (under cutting), and other during falling stage (flow of highly saturated sediments). However, the intensity of slumping is more acute after the flood stage. The accumulated water level during the flood stage provides additional support to bank materials as the pore spaces of the loosely bound bank materials are occupied by water and act as a continuous system. With the fall in water level, the support diminishes abruptly and the bank materials are subject to different degrees and nature of failure. In some locations, stratified fine sand, quite massive channel sands and silts underline the silting clay of the natural levee deposits. During high stage of the river, water is forced into the strata, raising the pore pressure in the strata. As the water level in the river falls rapidly and the pressure against channel wall is lessened, water moves from the formation back into the river. This causes a lateral flow of sands and silts into the channel, resulting in sub aqueous failure. This normally produces a bowl – shaped shear failure in the overlying cohesive natural levee deposits (Coleman, 1969). These types of failure with semi – circular outlines of different magnitude area abundant along the Brahmaputra River channel.

The geomorphic work accomplished during an extreme storm event by three primary tributaries in the western Manawatu River in New Zealand was assessed by Fuller (2007) using sequential aerial photographs. Areas of flood plain and channel erosion were quantified as a measure of the work accomplished during floods triggered by a “150-Year” storm in February 2004. Of the three rivers studied, the smallest (Kiwitea, 225 km²) accomplished the most geomorphic work, eroding 1.1 km² of flood plain along a 30 km long reach where spatially discontinuous channel transformation was associated with large-scale bank erosion in response to a flood estimated to be more than five times bigger than the mean annual flood. Total energy expenditure in the Kiwitea flood was $\sim 14,900 \times 10^3$ joules. The larger Pohangina (547 km²) and

Oroua (329km²) rivers were less effective, expending $\sim 14,400 \times 10^3$ joules and $\sim 5,300 \times 10^3$ joules and eroding 0.36 and 0.6 km² of flood plain, respectively. The contrasting amount of geomorphic between these tributaries relates to valley floor and channel configurations, which prime discrete reaches for instability, sensitizing them to perturbation by this flood event. In the Kiwitea, greatest erosion occurred where floodwaters were confined by terrace bluffs at bends that locally enhance stream powers. The wider channels of the Pehangina and Oroua Rivers wander across broader gravelly flood –plains, permitting widespread dissipation of flows across the wider active channel and valley floor. Hydrologic, hydraulic and geomorphic variables thus explain the variability in geomorphic work accomplished during the event. Ultimately, diverse channel behaviors reflect varied catchments and reach sensitivity to flood event.

The branching of streams has been largely controlled by geologic structure, lithological characteristics, slopes and rainfall intensity. The different mathematical models of Horton and Strahler related to the drainage network may not be applicable in totality but linear relationship is very much validated and a high relative relief shows a high degree of dissection (Choudhury, 1985). The width, depth and velocity of channel in relation to discharge had similar expressions with rivers of similar environmental situation of the world. The estimated Froude numbers expressed sub-critical situation indicating energy loss in active erosion of the river. The sinuosity indices indicated a meandering course of the river in the plains and sinuous course in the hills. Meandering variables especially meander wave-lengths have a comfortable positive relationship with meander-widths (Gogoi, 2006).

Human occupation and development of alluvial river flood plains are adversely affected by river channel lateral migration. The ecology of riverine corridors is dependent upon the process of erosion and sedimentation, which lead to lateral migration. Multiple uses of floodplains adjacent to active rivers also influence the probability and magnitude of channel movements, with implications for habitat type distribution and ecosystem integrity (Shields et al., 2000)

Flood:

Geomorphologically, it has been proved that the channel response to long duration floods is likely to be significant especially in alluvial reaches in terms of bed and bank erosion as well as coarse sediment transport. The stream power graphs derived from the flood hydrographs, the channel slope and the hydraulic geometry for great and common flood indicated that the power per unit area during flood events is sufficiently high for several tens of hours to produce substantial changes in the alluvial sections of the river (Hire et al., 2006). Goswami (1998) also examined some of the important features of flow regime of the Brahmaputra River using flow data series for the last 40 years in general and the 1971 – 1980 decade in particular. The study also focused on several aspects of the basin environment that had considerable bearing on the flow regime of the river.

The maximum annual average discharge has been observed in moderately forested, cultivated catchment and minimum discharge in the forested catchment. The highest monthly suspended load, amounting to 49.28 % of the total annual load and denudation rate is 8.51 T/sq.km/month observed in September, where as 47.64 % of the total sediment and 4.06 T/sq.km/month being observed in August. In Kolani the highest monthly concentration of suspended load is (63.98%) of the total annual load and denudation rate 2.75 T/sq.km/month being observed in the month of June (Pal, 2000). The study deals with the quantitative measurement of water discharge and sediment budget, comparison of the quantitative data. The discharge and suspended load yield can be computed Based on the morphometric and drainage analysis, rainfall.

Changing Courses:

The change of the Barak River channel was detected (Das et al., 2007) using topographic data and satellite images of different years. This study revealed neck cut off and active shift both towards north and south. Though the river has shown an oscillatory shifting nature yet, it has an overall north ward shift which is probably due to uplift of the southern part of the Barak River valley.

Channel configuration and bank line migration of Brahmaputra River at Dhola-Hatighuli region in Assam (Sarma et al., 2007) reveals the status of the river from Dhola to Dibrugarh and its erosion activity starting from the year 1998 to the post flood season of 2004 based on the analysis of the multi date satellite data and GIS approach. The work highlighted the channel pattern of the river and continuous changes in its channel configuration.

The findings of Ghosh, (2002) and Mishra (1997) reported that the Kosi River is moving westwards and it is predominantly proved that the bank line shifting from 1966 to 1989 showing six consecutive reaches. The studies were based on information carried through hydrographic and field surveys; remote sensing techniques and topographical maps.

Sengupta et al. (2000) studied the changes of stream courses around Maithon Reservoir based on the interpretation of 1996 IRS 1B Satellite Imagery (1, 2 B2, P70 – R51, Band 234, dated 29.2.96) Survey of India toposheets of the study area. The satellite imagery was visually interpreted using standard procedures for the identification of lineaments, stream alignment and vegetation cover and related with the toposheets at 1: 50,000 scale. The author came to a conclusion that lineament controlled drainage pattern and sudden appearance and disappearance of tributaries with perennial to quasi – perennial flow, reveal a complex network of the surface and subsurface water regimes in the study area.

Chandramouli et al., (2004) carried out a detail analysis to study bank line migration and formation of braided pattern with the help of remote sensing data and topographic maps and GIS platform for Brahmaputra River at Dhubri region in Assam. A small tributary of the Brahmaputra, Jinjiram joins the main river in this region. The river island formed between the rivers Brahmaputra and Jinjiram was the focus of the study. The study pointed out the changing course of the river led to tremendous river bank erosion and flood hazard in one hand and non-uniformity of discharge distribution led to development of braided channels in the other.

An attempt had been made by Maurya et al. (2004) to study the channel shifting of one highly sinuous Vishwamitri River in Gujarat. The river follows a slope deviating course and exhibits a narrow, highly sinuous and deeply incised meandering channel. For this river several lines of evidence, including satellite and topographic data, stratigraphic and sedimentological data subsurface structural data were used to study the nature of channel morphology and channel shifting. The study revealed that the course of the Vishwamitri River has shifted towards east in the last 35 years from 1969 to 2003, in response to geotectonic activity.

Larsen and Greco (2002) made an attempt to study channel management impacts on river migration. The work was done taking Woodson Bridge State Recreation Area, Sacramento River, California, USA as a case study. Using a numerical model based on the mechanics of flow and sediment transport in curved river channels, the authors predicted 50 years of channel migration and suggested the planning and ecological implications of that migration for a 6.4 km reach of the Sacramento River near the Woodson Bridge state Recreation Area, California, USA.

The bank line migration of the Brahmaputra River at Palashbari region of Assam was also studied by the same author during the period 1911 to 1988 using Land sat MSS and IRS -1A data and Survey of India Toposheets.

Saif Uddin and Iqbal Uddin (1999) carried out an excellent detail study of migration of Yamuna River from Mahabharata period to the present. The Digital Image Processing using statistical analysis techniques were carried out on IRS -1B LISS II data corresponding to path: row 28:48 of 26th January, 1990 to reconstruct Yamuna River. The image improvement was attempted through different techniques of Digital Image Processing to enhance the Palaeochannel of Yamuna River. The scars of palaeochannels and old meanders of Yamuna were enhanced. The morphology, colour, hue, density and saturation were used as interpretation keys. The study pointed out that the migration of the river from west to east which is probably due to progressive slope mutation of Aravalli block from west to east due to plate accretion in the Indian Ocean and Arabian Sea after the collision tectonics of the Himalayas. Another reason of the migration stated that the capture of Yamuna from Saraswati to Ganga drainage system around 1500BC.

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