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EDITORIAL

Sediment management of the Himalayan rivers: a challenge for river managers

A river transfers both water and sediments through its journey from its source to sink, and the form and processes in a river channel are strongly influenced by the balance of these two fluxes. In case of the Himalayan rivers, sediment delivery from the tectonically active hinterland is exceptionally high compared to rivers draining from the peninsular India. Monsoonal rainfall in the Himalayan hinterland further helps to bring these sediments down into the alluvial reaches of the rivers where lower slopes and wider channels encourage natural deposition of sediments. Traditionally, our river management strategies are mainly focused on the water flows, including flood management, and these have resulted in various interventions such as dams, barrages, canals and embankments. These structures are primarily designed to regulate or store water and then divert it for irrigation and other purposes. However, these interventions not only interrupt the flow, but also disturb the natural balance of water and sediment fluxes. They act as a barrier to sediment flows, particularly the coarser fragments, and result into aggradation of channel beds. Water extraction and diversion further reduce the flows downstream and therefore the sediment-carrying capacity, and this again results in accumulation of sediments. As a result, several Himalayan rivers are choked with sediments, their bed levels have risen above the general floodplain river, and the flood risks have increased manifold. Most of these interventions have had very little consideration for sediment transfer and even if they did, they were generally defunct within a few years of their operations either due to improper design or inadequate maintenance. A long-term sediment management strategy has never been a part of any protocol of river management, not just in India, but in several other parts of the world. A nation like India hosting several large rivers originating in the Himalaya, the world's highest and most active mountain belt and hence a huge sediment production factory, needs a sediment management framework more than any other country.

Conceptually, any such framework should be based the following questions: (a) Where is the sediment coming from and where is this getting deposited? (b) How much sediments are getting deposited in the channel? (c) How do we manage excessive sedimentation in channels? (d) What can be done with excess silt/sediments? These questions not only require a strong process-based understanding of the rivers to identify the 'hotspots' of siltation, but also require first-order estimate of sediment fluxes and volumes accumulated within the channel belt over historical timescales. Removing large volumes of sediment accumulated in the channel belt to improve the channel conveyance poses a great challenge on its own, but a bigger challenge lies in the disposal of the excavated silt that is possible only through commercial utilization of this resource.

The lower stretch of the Ganga river draining through Bihar and West Bengal is a classic case where sediment management is urgently needed. Three highly sediment-charged Himalayan rivers flowing from the north, namely the Ghaghra, Gandak and Kosi fall into the Ganga in this stretch, and they significantly add to the sediment budget of the Ganga. The problem is further compounded by the fact that all these tributaries are transboundary rivers and their hinterlands are located in Nepal. Therefore, any effective sediment management strategy would require meaningful cooperation between India and Nepal. A very high sediment flux from the tributaries is compounded by the regulation of the non-monsoon flows upstream and disruption of the longitudinal connectivity by the Farakka barrage further downstream. As a consequence, several stretches of the lower Ganga are completely filled with sediments, resulting in major morphological changes, migration of rivers and flooding in unexpected areas and at unexpected times. The situation has become grim in recent years around several important towns such as Patna, Bhagalpur and Farakka, where the river has shifted several kilometres north leaving the banks of these cities high and dry. In several reaches acute drainage congestion exists because the longitudinal connectivity of the river has been seriously impacted due to siltation. There has also been a demand from certain section for decommissioning of the Farakka barrage. Moreover, the proposed inland waterways project of the Government of India (GoI) has also become a matter of concern, and there are apprehensions that this may further fragment the river into several parts due to the construction of a series of barrages.

While it is agreed that some urgent action is needed to remedy this situation, it is not clear yet if the Farakka is the sole reason for these problems or if the decommissioning of the barrage would solve the problem or not create additional problems. In particular, several issues need to be resolved before planning any mitigation measure for alleviating the region from the recurring problems of siltation and associated flooding.

First, there is still no good estimate of the total sediment flux and silt accumulated within the river channel. This poses a serious problem in planning any mitigation measures such as dredging of river channels. However, such estimates require a comprehensive dataset in terms of close-interval sediment measurements, repetitive cross-sections and modelling studies. Very little data are available for the Ganga in spite of the fact that siltation in the river is recognized as the most serious problems for decades. Second, the overall impact of the Farakka barrage on the morphodynamics of the Ganga and siltation problem in this stretch of the river need to be assessed properly. In addition to the morphological changes, it may also be useful to assess the ecological impacts due to this intervention. Further, an overall cost–benefit analysis of the various interventions in this region (including those on the tributaries) accrued so far should also be done as soon as possible. Third, while a detailed study may be necessary to assess the situation fully, it is understandable that it may take long and some immediate steps may be necessary.

As an example of the first-order sediment budgeting, data from the Kosi river, one of the most sediment-charged tributaries of the Ganga draining through Nepal and north Bihar, may be illustrative. Our estimates suggest that the total mass of sediments accumulated between Chatra and Birpur (reach upstream of the barrage) during the last 54 years (post-embankment period) is ~1082 million tonnes, which translates to 408 million m^3 in volume of sediments accumulated at a rate of 5.33 cm/yr. This is attributed to the relatively smaller area of sediment accommodation within the channel belt, i.e. ~142 km^2 between the two stations. Between Birpur and Baltara (reach downstream of the barrage), the available depositional area is almost five times that between the Chatra and Birpur stretch. As a result, sedimentation rate in this stretch is lower (2.83 cm/yr), but the total sediment accumulation is very high, ~2053 million tonnes, that translates to 774 million m^3 of sediments. Similar estimates are urgently needed for the Ganga and all its major tributaries.

A sediment management framework should therefore consist of the following components:

(i) Problem identification: Process understanding of sediment dynamics, causes and problems associated with siltation, both natural and anthropogenic.
(ii) Measurements: Sediment load and rating curves, empirical equations and Artificial Neural Network (ANN) models, cross-sections and isotopic measurements.
(iii) Management practices: Three Rs - Reduce sediment production, Route sediments and Remove sediments, each requiring an assessment of suitable methods based on the terrain, hydrology and engineering intervention.
(iv) Benefit/cost (B/C) analysis: Critical assessment of benefits related to agriculture, filling material, fisheries, etc. to the costs or losses related to operation, silt removal and ecological losses.

It is amply clear that sediment management must form an important component of management strategies for the Himalayan rivers. The Ministry of Water Resources, River Development and Ganga Rejuvenation, New Delhi has recently circulated a draft policy on sediment management. The draft policy document has put forward several important suggestions and has also proposed a set of useful guidelines, which if implemented, can bring phenomenal change in the health of the rivers. However, the policy is heavily tilted towards promoting navigation rather than focusing on improving river health, so much so that the navigation requirements can overrule several guidelines.

Instead, sediment management plans must be based on a strong understanding of sediment dynamics aimed at improving river health for which detailed studies may have to be initiated, wherever needed. Sediment management plans should also be linked to river health assessment and habitat suitability. Several planform characteristics define the ecological habitats, including longitudinal connectivity in the river that is severely affected by excessive aggradation. Also, several tributaries of the Ganga are trans-boundary rivers, and therefore, it is important to engage Nepal and Tibet in designing long-term sediment management strategies, particularly those related to soil erosion and mass wasting processes in the hinterland which are major sources of sediment flux in the river. It is equally important to involve and train the local community not only for reducing soil and bank erosion processes, but also to encourage utilization of silt for agricultural and other applications. Finally, a strong capacity-building programme on sediment management is recommended for field engineers who are ultimately responsible for implementing sediment management plans. Until a full understanding of sediment dynamics is available, the ‘precautionary principle’ should be applied on the basis of perceived threats as described above.

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