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Sediment management of the Kosi River basin in Nepal

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Abstract The Kosi River is one of the biggest in south Asia. It accounts for about 25% of the county's total river runoff and causes soil erosion equivalent to nearly 50% of Nepal's total sediment loss. Meandering of this river has caused shifting of the channel from east to west of over 110 km spreading devastation and laying waste an area of about 770 km^2. The Sunkosi storage dam at Kurule would possibly store about 50% of the Kosi sediment and nearly 40% of its flood flow. The Tamor-I storage dam would also hold about 20% of the Kosi sediment. Altogether 70% of the Kosi sediments will be stored and the remaining 30% will probably be required to sustain the turbidity of the Kosi River flow. These two storage dams would control 60% of the Kosi flood flow.

INTRODUCTION

The Kosi River with a length of 720 km is one of the biggest in south Asia, and its drainage area of 92 538 km^2 lies in Tibet, Nepal and India. The Kosi River has three main tributaries, comprising the Sunkosi, Arun and Tamor Rivers, which meet at Tribeni 5 km upstream of Barahkshetra. After this confluence, the river is called "Spat Kosi" or Kosi. The hydrological characteristics of the Kosi River and its tributaries (Thapa, 1993) are given in Table 1.

It is quite clear that the flood flow of the Kosi River during the monsoon season historically has been creating serious problems of widespread destruction and devastation. Cities and villages have been ruined, along with damage to agricultural land in Nepal as well as India. Chitale *et al.* (1966) have commented on the meandering nature of the Kosi River: "The Kosi is known as the river of sorrow of north Bihar...the Kosi has shifted from east to west over 70 miles in the last 200 years, spreading devastation and laying an area of approximately 3000 square miles bare with sand deposit". Further they note: "The flood embankments cannot prevent the shifting tendency of the river (Kosi) course ...". The runoff of the Sunkosi, Arun, Tamor and Sapakosi rivers, comprising 22.4, 18.0, 10.0 and 50.9 m^3 $\times$ 10^9 respectively, causes soil erosion with the result that about 180 million tonnes of surface fertile soil is lost annually from the Kosi River basin, while the country as a whole loses about 380 million tonnes annually (Nayak, 1993b). The Kosi River, which is the most sediment laden river of Nepal, has an average suspended concentration of 10 g l^{-1}, compared with the predicted mean concentration of 2.69 g l^{-1} for the Mahabharat region (Nayak, 1992).

Even though the investment in water resources development has been increasing significantly over the years, the performance of agriculture, irrigation, water supply and

Table 1 Hydrological characteristics of Kosi River and its tributaries.

River name	Gauging station	River length (km)	Drainage area (km^2)	Mean monthly maximum flood flow ($m^3\ s^{-1}$)	Annual suspended load ($m^3 \times 10^6\ year^{-1}$)
Sunkosi	Kampughat	330	19 000	2 890	54
Arun	Tumlingtar	510	36 000	1 481	35
Tamor	Mulghat	190	6 000	1 407	30
Sapakosi	Barahkshetra	720	61 000	6 981	119

hydropower, along with environmental degradation, have not been satisfactory. For example, Nepal was a net exporter of food grains in the 1980s, but the country has been facing a deficit of about 25% of food grain production in recent years (Thapa, 1993) which is widening due to irrational utilization of the country's available resources. Taking into account the complex regional character of water resources development of the Kosi River basin and the poverty of Nepal, a rational concept of "INTEGRATED" planning and management, involving sediment control together with water resources development, is therefore clearly required to facilitate energy supply, food grain sufficiency, water supply and ecological balance not only for Nepal but also especially for the neighbouring state of Bihar in India.

CONCEPT OF RESOURCE MANAGEMENT

The complexity of planning, organization and management for sustainable sediment control, including water resources development, has been increasing due to many factors. These are the *ad hoc* basis of previous political and social systems, the obsolete scientific and technical mechanisms, the ever increasing volume of the works to be done, the ambiguity of technical solutions to be adopted on the basis of advanced science, technology and practice, the lack of specialized knowledge in Governmental staffs and the decentralization of power to all levels in the country.

Resource management on a scientific basis, decentralization, unity of political and technical resources, planning at all levels within the system, stimulation on the basis of moral and material judgements, and improved appointment of suitable specialists, directors and officers has flowed as a consequence of democracy (Nayak, 1993b). Democratic decentralization actually provides a decentralized management which fosters initiative and self-dependence in the producer organizations. Effectiveness of management is principally determined by the rational utilization of resources and stimulation of integrity among the executive, as well as the collective, of the work force.

WATER RESOURCE MANAGEMENT

In order to protect Bihar from damage by the Kosi flood flow, Dr A. N. Khosla developed a comprehensive survey of the Kosi River basin, which finally resulted in construction of storage dams in Kosi basin for sediment and flood control. The second

purpose of regulating flow in the Kosi basin was to allow irrigation in Bihar (India) and in Nepal through construction of a major canal, extending to Birgung. However, the construction of this major canal has not been possible due to topographical and cross-drainage conditions.

Analysis of various water resource projects in the Kosi basin (Thapa, 1993), has identified only three multipurpose projects. These are the Kosi High Dam at Barahkshetra and the Tamor-I and Sunkosi Kamala Diversion projects. They are obviously of great importance from the point of view of economic effectiveness for both Nepal and India. The natural topography and discharge capacity of the Kosi River at Barahkshetra would allow construction of a large dam of about 260 m in height with a power production of about 6.5 million kilowatts (Pokhrel *et al.*, 1994). In addition, short-term studies on the Sunkosi-Kamala Diversion project (UNDP/FAO, 1972) have identified a potential power production of about 2.15 million kilowatts with an irrigation provision of 0.2 million hectares in Nepal's Terai and 0.25 million hectares in Bihar of India. All these projects will have to function for flood and sediment control and hydropower generation, as well as partially for irrigation.

SEDIMENT MANAGEMENT

Considering the reservoir projects to be built in the Arun River and others also for checking sediment flow downstream, the Sunkosi storage dam at Kurule would possibly store about 50% of the Kosi sediments and nearly 40% of its flood flow. In addition, the Tamor-I storage dam would also hold about 20% each of the Kosi sediment and flood flow. Altogether 70 and 60% of the Kosi sediment and flood flow, respectively will be stored upstream, and the remaining 30% of the sediment transport might be essential to maintain turbidity at required levels in the Kosi River. The remaining 40% of the total flow would be controlled in time (Nayak, 1993a).

In place of the low height barrage at Chatra proposed by the Government of India for flow diversion and regulation, it would be better to build a medium head storage dam which would not affect the proposed Kosi High Dam at Barahkshetra. The medium head storage dam at Chatra would not only be a feasible independent power project, but also certainly provide amelioration of remaining sediment problems in the Chatra and Kosi canals. The latter would be achieved by diverting flows from this headwork into these canals through construction of a link canal and development of island navigation involving extension of the Chatra-Birpur link canal up to the Ganges River. This, in turn, could be very useful for transportation of the large and heavy hydroelectro-mechanical equipment required for construction of the Kosi High Dam storage project.

CONCLUSION

The question may be asked as to what will be the consequences of the completion of these projects for future generations in eastern and central Terai and in north Bihar? From a scientific perspective, the answer to this question is a positive effect on every aspect of the life of future generations. Not only will life expectancy be improved through the creation of a more healthy environment, but also water will be available for

irrigation of land throughout the year, which in turn will increase agricultural production. Provision of cheap electrical energy, essential for agricultural intensification and small/medium scale industrialization, should also make commodity prices cheaper for the people of these areas.

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