The 18 August 2008 Kosi river breach: an evaluation

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In the Himalayan terrain, the Kosi river is formed by the confluence of seven smaller streams, viz. Indravati, Sun Kosi, Tama Kosi, Likhu Kosi, Dudh Kosi, Arun Kosi and Tamar Kosi at different places in China, Tibet and Nepal, before its entry into the Indian state of Bihar (Figure 1). In India, the Kosi river merges with the mighty Ganges near Kursela village, Katihar District, Bihar. Kamla, Baghmati (Kareh) and Budhi Gandak are the major tributaries of Kosi in India, besides many minor tributaries like Bhutahi Balan. The river travels a distance of 729 km from its source to the confluence with the Ganga, and drains a total area of about 69,300 km^2.

The Holocene Kosi river mega fan in Bihar is ~180 km long and 150 km wide, and is believed to be one of the largest river-built alluvial fans in the world[1]. This alluvial cone preserved the evidences of lateral channel shifting of the Kosi river in the form of many distinct palaeochannels, suggesting a dynamic river system. Through the first maps prepared by British surveyor, C. C. English (1779), the Kosi course could be traced since AD 1731. These maps indicated that in the 18th century Kosi flowed near Purnea town and then gradually moved westward, shifting its course from east of Purnea to west of Supaul, i.e. a shift of about 120 km in about 275 years.

The river cuts across the Himalayas and the Shiwalik ranges carrying huge quantities of sediment. High rainfall (mean 1451.8 mm/yr) leads to extensive soil erosion and landslides in its upper catchment. The silt load of the river is one of the highest in the Indian sub-continent, to the tune of 80 million tonnes/yr. On reaching the plains, high aggradations of river bed and sediment bed load offer enough resistance to the water, forcing the river to find alternate paths, resulting in lateral shift of the river course. Though shifting of a river is part of its natural evolution process, other factors inducing this phenomenon could be earthquakes, landslides and neotectonic activity[1]. The Kosi flood plains are constantly being influenced by the compressive tectonic regime resulting from the collision of the Indian and Eurasian plates. Besides, the presence of various active subsurface structures like East Patna fault, Begusarai fault, Monghyr-Saharsa ridge, Bhawanipur fault, Malda-Kishanganj fault, Madhubani graben with sediment thickness of about 6 km and the shallow Purnea depression underneath the vicinity of Kosi and north Bihar flood plains may result in uplift/subsidence of the surface, causing changes in the river course[1]. Of late, climate change is also being thought to be responsible for escalating frequency and intensity of floods.

The Kosi river is responsible for many floods in Bihar. Due to the devastation caused by the Kosi floods in 1954, the Government of India (GOI) entered into an agreement with Nepal under which a barrage was built about 5 km inside the Nepal territory at Bhimnagar and was inaugurated in 1963–64. The barrage construction was aimed at taming the river floods and using the water for irrigation purpose. A 1149 m length barrage was constructed along with 46 gates (each gate is 18.288 m × 6.44 m). Two canals (Eastern and Western Kosi canals) were later constructed on either side of the barrage with six gates for left under sluice and four gates for right under sluice. The design discharge of the Eastern Kosi canal is 15,000 cusec. The gross command area under the Eastern canal is 7.45 lakh hectares and the cultivable command area is 4.4 lakh hectares. The Western canal is under various stages of completion. Afflux bunds were made along 12 km in the west and along 32 km in the east. To channelize the river flow in the downstream side, 125 km long eastern embankment and a 101 km long western embankment were constructed. The building up of embankments on either side of the river confined the river channel to some extent. The Kosi river has an average discharge of 55,000 cusec, which increases 18 to 20 times during peak floods. The highest flood recorded in recent history of the river is reported to be 850,000 cusec on 24 August 1954. Therefore, the Kosi barrage has been designed for a peak flood discharge of ~950,000 cusec. However, several floods have also been recorded in this area during 1963, 1971, 1984, 1987, 1991, 1995, apart from the present flood in 2008, after construction of the barrage.

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On 18 August 2008, the eastern embankment of Kosi was breached near Kusaha village, Nepal, about 12 km upstream of the barrage. At the time of breach the river flow was below average, considering the same time-period in different years. The water inundated the adjoining villages of Kusha and Haripur (Nepal) immediately and reached Bhimnagar, Birpur (India) within a few hours. In Birpur, flood water rose alarmingly to a height of 5–6 ft within a short time after the breach. Subsequently, the flood water

Figure 1. Regional map showing the course of the Kosi river (old – pre-18 August 2008, and new) and areas affected by the 18 August 2008 floods.

spread over a great extent covering Supaul, Saharsa, Madhepura, Araria and Purnea districts, causing severe damage to life and property. In fact, after the 18 August breach, the Kosi river has altogether taken a new course, that of the 1930s, as reported by local residents near Muraliganj.

To get first-hand information, assess the present situation and suggest possible scientific studies/steps to be taken to mitigate future floods, we visited the affected area including the breach point during the 12–16 September 2008. As mentioned by several workers earlier, since the river is flowing from the high-altitude mountains, due to its high gradient, it carries heavy bed load. Once it reaches the plains its velocity reduces to a great extent and the river is not able to carry its load. Apart from that, the river in the downstream of the barrage till its confluence with the Ganga (at Kursela) is flowing about 250 km length in a semi-circular way with a low hydraulic gradient (1 : 5000 m). Due to this, the river is not able to carry its suspended load even after the barrage. The river deposits its load wherever possible and changes its course to lower levels. After the barrage construction, due to its channelized flow, the river started building up the stream bed, resulting in considerable elevation difference between the stream bed and the surrounding areas (in particular in the east). Presently as the river is flowing close to the eastern afflux bund and the material used to construct the embankment is local sandy soil, which makes it easy to breach the embankment as well as to spread the breach up to 2 km within no time. The topographic low in the eastern side of the embankment facilitated the river to select one of its older courses making its route almost like a straight line from Kusaha (at the breaching point) to Phulaut (meeting with Kosi) in about a 120 km stretch.

Now the dilemma is whether to plug the breach or leave it as such. The chances of plugging the more than 2 km breach near Kusaha are bleak, till the water recedes enormously. Even if this is done, chances of breaching at the same point or at any other are high as the river bed is a few metres higher than the surrounding area.

The advantage of allowing the newly formed course is that it is a straight and shortened new river course with hydraulic gradient nearly double that of the earlier course, hence having more sediment-carrying capacity. The newly formed course is likely to be more stable and hence flood risk can be reduced at least for a few tens of years.

The new course necessitates rehabilitation of the population from the entire stretch of the new course and more importantly, the existing barrage and canal system will become defunct. Further, a new embankment has to be constructed along the new course.

However, if we make a balance between the old and new courses and make use of both of them, the flood risk and expenditure may be minimized. Though this area has good groundwater potential, because of availability of surface water, groundwater exploitation is minimum. Waterlogging is a natural phenomenon in the north Bihar plain because of high rainfall and lesser topographic gradient. The groundwater table in these areas is shallow (3–4 m below ground level in general) as the aquifers always remain saturated. The Kosi fan area has substantial groundwater resource. Replenishable resource of the five districts (Araria, Madhepura, Purnea, Saharsa and Supaul), where major part of the fan falls, is 3.94 billion m^3/yr, with a stage of development being 35%. If the groundwater exploitation is maximized, volume of the desaturated zone would increase prior to the onset of monsoon. This will in turn help absorb a part of the flood water during monsoon. Groundwater development also helps in tackling waterlogging problem in low-lying areas. A detailed groundwater investigation, including surface water and groundwater interaction may help assess the groundwater recharge potential in detail.

This area requires close interval (0.5 m) topographic mapping, which would enable the flood management authorities to quickly assess and identify probable areas susceptible to inundation, and accordingly take necessary remedial measures.

In order to understand the problem from different angles, besides monitoring the surface hydrological data, structures present beneath the flood plains, and the tectonic movements should be measured precisely with the help of sub-surface geophysical mapping. Identification and delineation of active structures are also essential to understand the river shift. The past is the key to the future. The past lateral movements of the Kosi should also be reconstructed making use of OSL dating to give an idea about any such movement in future.

1. Aggrawal, R. P. and Bhoj, R., *Int. J. Remote Sensing*, 1992, **13**, 1891–1901.

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