The Tehri dam, located in the north of India, was commissioned in 2006 to provide water for electricity generation, irrigation and drinking water. It has a sediment trap efficiency of 95 per cent and was designed to offset 150 years of sedimentation. Watershed management is the principle measure in use for reducing the sediment inflow into the Tehri reservoir.

The Tehri hydroelectric power complex, located in the Himalayan foothills, is owned and operated by the Tehri Hydro Development Corporation, a joint venture by the government of India and the government of Uttar Pradesh. The USD 1 billion complex comprises the 1,000 MW Tehri hydropower plant, the 400 MW Koteshwor plant (commissioned in 2012) and the 1,000 MW Tehri pumped storage plant (expected to be commissioned in 2018). See the hydroelectric complex aerial view in figure 1.

The Tehri reservoir serves multiple purposes besides storing water to produce 6,200 GWh of annual electricity generation. It provides irrigation to an additional area of 270,000 hectares as well as supporting the existing irrigated area of 604,000 hectares. It supplies clean drinking water to about 4 million people in Delhi and 3 million people in Uttar Pradesh and Uttarakhand. And last but not least, the Tehri reservoir has a flood control pool capacity of 219.65 Mm³.

The Tehri dam, a 260.5 m-high earth and rockfill dam, impounds water 44 km along Bhagirathi River and 25 km along Bhilangana River, creating a dead storage of 925 Mm³ and live storage of 2,615 Mm³, making a total storage capacity of 3,540 Mm³. Impoundment commenced in 2005. The Tehri reservoir operates between a 835 masl maximum operating level and a 740 masl minimum operating level. The crest elevation is 815 masl and together the chute spillway (see figure 2) and the four vertical shaft spillways have a discharge capacity of 15,540 m³/s.

The Tehri underground powerhouse hosts four Francis turbines of 250 MW each, which benefit from a gross head of 231.50 m. The power plant has a design power discharge of 584 m³/s.
The catchment tributary to the Tehri dam comprises 7,691 km² and forms part of the Himalayan mountain range, and is characterised by four months of a rainy season called ‘monsoon’. The monsoon lasts from June to September, with July and August considered the peak flow period.

Both the Bhagirathi and the Bhilangana Rivers originate from a glacier. The annual average precipitation varies from 1,016 mm to 2,630 mm during the rainy season, when the 40-60 per cent of annual rainfall occurs.

The Tehri reservoir is designed to store the surplus flow during the monsoon season, resulting in about one-third of the average annual water yield of the Bhagirathi River - about 2,615 Mm³ - being stored in the Tehri dam.

The fragile geology and the topographical features of the catchment, with its steep slope valleys, combined with development activities such as deforestation and terrace cultivation, increased the erosion rate in the area.

The Bhagirathi River transports large amounts of sediment, with a mean annual suspended sediment load of about 6.8 Mt. The river bed material consists of boulders, sand, and silt.

The most significant sediment transport occurs during the rainy season. The specific annual sediment yield in the watershed is 907 t/km². The Brune curve estimates the trap efficiency of the Tehri dam to be 95 per cent.

Sediment problems
In 2008, the study ‘Impacts of Tehri dam lessons learnt’, prepared by the Water for Welfare Secretariat at the Indian Institute of Technology Roorkee found that sedimentation will reduce the water storage capacity of the reservoir, having an impact on all of the benefits it currently provides.

During the planning phase of the Tehri dam back in the 1970s, the design did not include any sediment management strategy to route or remove sediments from the reservoir. It was designed with a traditional approach to offset 150 years of sedimentation. The lack of sediment data prevented accurate estimations of suspended sediment load and sedimentation rate.

The design sediment rate was estimated at 6.08 Mm³ per year. Since commissioning of the dam, two bathymetric surveys, one in 2008 and the latest in 2013, were carried out, and as a result, the sediment rate was estimated at 5 Mm³ per year. Currently, the total storage capacity is 3,506 Mm³.
and the live storage capacity is 2,598 Mm$^3$. According to the results from the bathymetric surveys, the dam could offset up to 185 years of sedimentation without implementing any sediment management strategy under the current climate and land conditions.

In 2011, a study calculated the sedimentation rate in the reservoir based on satellite imagery. The study determined the loss of storage capacity derived from the water-spread area at different elevations and the corresponding original and revised capacities. However, the results only show the loss of capacity from 2006 to 2011 in the study zone between 823 masl and 763 masl.

The average loss rate computed in this live zone is higher than the average sediment rate estimated from the bathymetric surveys to the Tehri reservoir.

**Sediment management strategies**

Following the impact assessment studies, watershed management was the mitigation measure taken to reduce the soil erosion and therefore the sediment inflow into the reservoir.

The Catchment Area Treatment (CAT) plan was applied in areas of high and very high erosion, in total 52,204 hectares including 44,157 hectares of forest land and the 8,047 hectares of agricultural land. The CAT works comprised afforestation, soil conservation, treatment of agriculture land, farm forestry and horticulture.

The soil erosion in the rim area of the reservoir is monitored between 850 masl and 1,050 masl. This monitoring programme aims to protect and regenerate the vegetation in this area to reduce soil erosion and enhance the landscape to support tourism. The relative success of this approach is still to be determined.
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Graphs and figures

Figure 1 - aerial view of the Tehri hydropower project (Google Earth)

Figure 2 - Tehri dam chute spillway

This is part of a series of sediment management case studies collated by International Hydropower Association with support from the South Asia Water Initiative (SAWI), trust funds to the World Bank.  www.hydropower.org/sediment-management