Photographic Feature

Landslides in the Alaknanda Valley of Garhwal Himalaya, India

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Abstract

The occurrence of landslides is a recurring problem along the hill roads of Himalaya. Roads are often blocked due to landslides, which sometimes also leads to casualties. Identification of such unstable slopes is an imperative task to save life and property. The paper outlines features of major landslides along a National Highway in the Alaknanda valley of Garhwal Himalaya through photo documentation.

Keywords: earthquakes, geomorphology, landslides, risk assessment, slope stability

Landslide occurrences are very common in Himalayas. Though the loss of life and property caused by earthquakes and floods in India are higher than for landslides, some recent landslides have been particularly damaging. A large number of slope failures have affected the main highways in the Himalaya, which are important routes for pilgrims. Many landslides along these highways are triggered during the monsoon season. One such pilgrimage route is the National Highway from Rishikesh to Badrinath where a famous Indian shrine is situated at a height of 3096 m. The total length of the road is about 300 km, along the rivers Ganges and Alaknanda. The up stream part of the Alaknanda valley is very prone to landslides and the road stretch of 100 km from Chamoli to Badrinath particulary so (Fig. 1).

The slope stability in the region is mainly governed by the local geology and geomorphology. The causative factors responsible for inducing instability are weak and weathered rocks, steep slopes, discontinuities, debris overburden on steep slopes, water seepage along discontinuities. These factors may be considered as passive bringing the slopes to a state of marginal stability. However the main triggering factor is the intense rainfall, earthquakes, and anthropogenic activities. The highest rainfall usually occurs during the monsoon period from May to September during which highest incidence of landslides occur. The average annual rainfall in this region is about 500–600 mm. The area falls under seismic zone V of the Seismic Zonation map of India (IS 1893 – 2002). The biggest earthquake in recent years was the 1999 Chamoli earthquake of 6.6 magnitude. There is significant road construction ongoing leading the additional destabilization of slopes.

Geology

In the Alaknanda valley, the Main Central Thrust (MCT) separates the Central Crystalline from the underlying meta-sedimentaries of the Garhwal Group (Srivastava & Ahmad 1979). Besides the MCT there are several faults present in the area. The area is composed of dolomites, slates and quartzites belonging to Garhwal Group and gneiss, schists and metabasics belonging to Central Crystalline Group of high grade metamorphics. These rocks are highly weathered and sheared. Slate units are generally thinly bedded while quartzites for the most part are thickly bedded and highly jointed. Locally, the jointed rock mass are filled by gauge materials as a result of shearing. The gneisses are hard and massive but at few locations these are observed as loose boulders. Average inclination of the beds is about

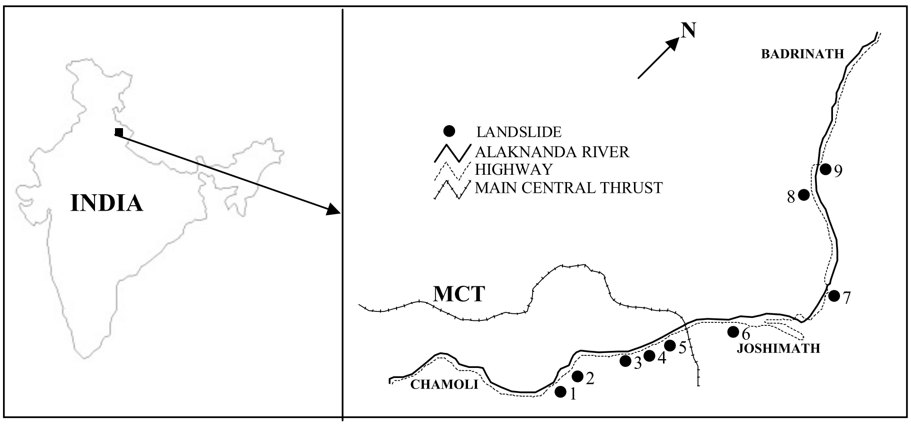

Fig. 1. Study area and locations of landslides.

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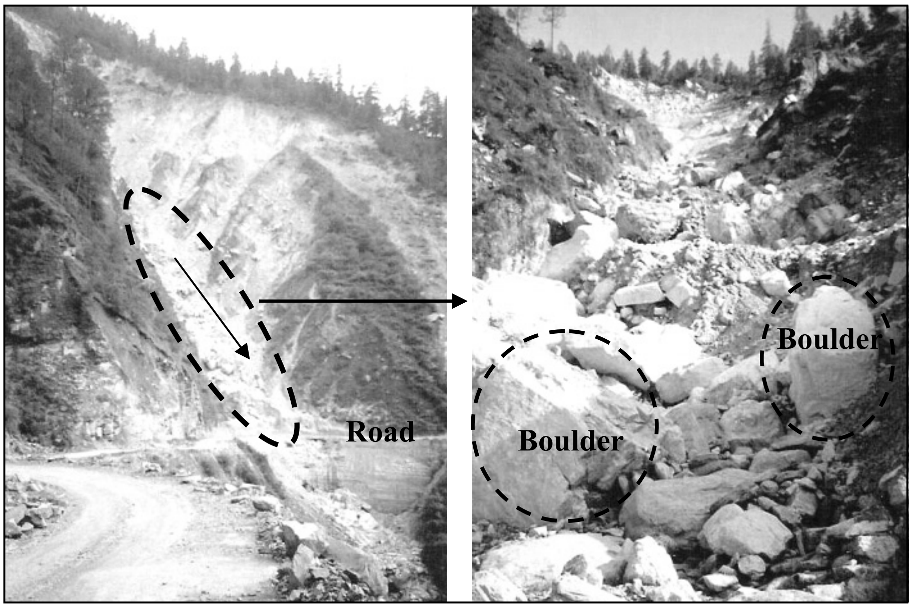

Fig. 2. Debris flow comprising of soil and boulders at landslide 4.

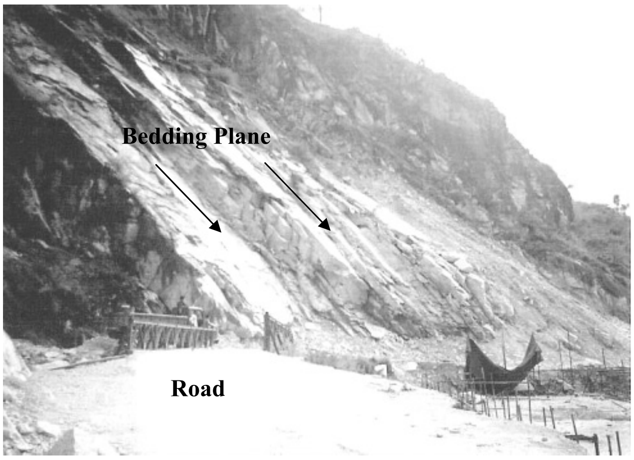

Fig. 3. Planar failure at landslide 3.

30° towards the NE, however, local variations are also observed due to multiple folds.

Landslides

The landslides along Chamoli to Badrinath section of the Rishikesh – Badrinath National Highway are mostly debris slides, debris flows, rock slides and rock falls. Landslide masses are mainly composed of boulders, rock fragments and soil. Debris flows are mostly confined along lines of natural drainage (Fig. 2). Where rock slides have occurred, they are predominantly planar failures along discontinuity that dipping downslope. In such cases sliding takes place as the rock blocks slide along the discontinuity surfaces (Fig. 3).

Landslides along the road occur on slopes that vary from 35^0 to sub vertical. Most of the landslides have fractured and jointed rocks in the main scarp below the crown below which are debris accumulation that extend

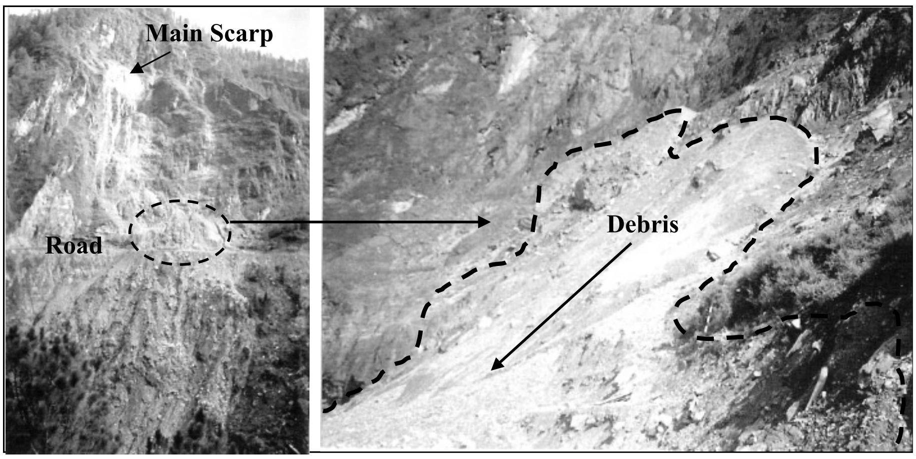

Fig. 4. Landslide 5 on steep of dolomites and slates showing debris accumulation at road level.

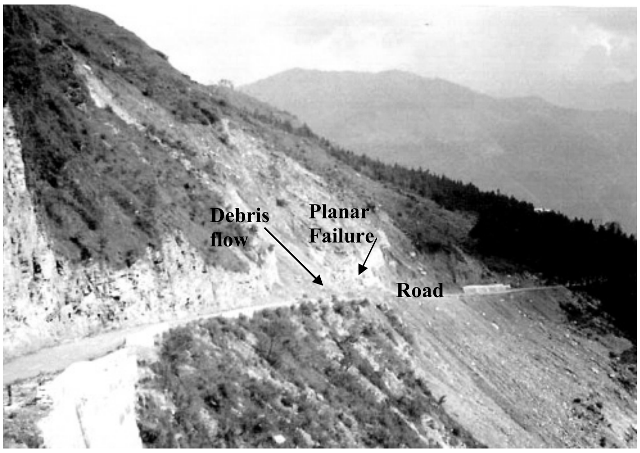

Fig. 5. View of landslide 1 showing multiple failure modes.

to the road level and below (Fig. 4). These materials are often mobilized as debris flows which block the road and sometimes cause fatalities. The volume of the debris on the slope ranges from 5000 to 50000 m^3 as observed in the reported slide areas.

Some of the landslides are complex in nature involving multiple failure modes (Fig. 5). The failure modes for this slide may be attributed to planar failures along discontinuities and debris flow of overburden material. Presence of cracks and subsidence on the road indicate shallow rotational failure at road level (Fig. 6). Rock falls are another failure type, which are often catastrophic causing loss of life to anybody in the vicinity. The impact of sudden rock fall depends on the volume of rock mass and the height from which it falls. On many

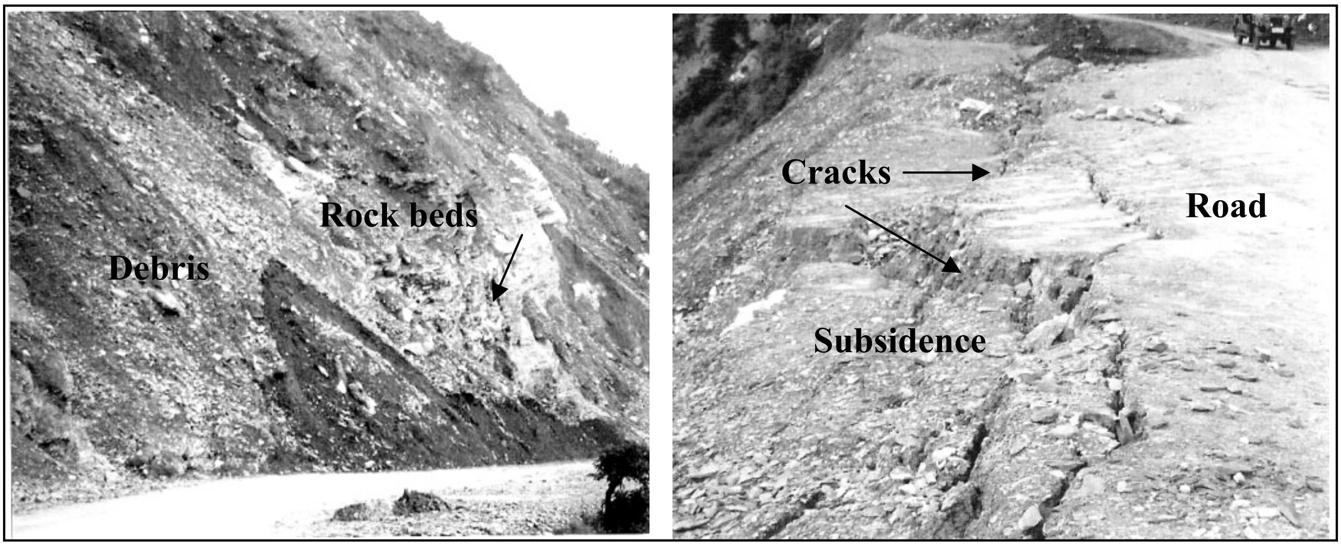

Fig. 6. Debris overburden and road subsidence at landslides 1.

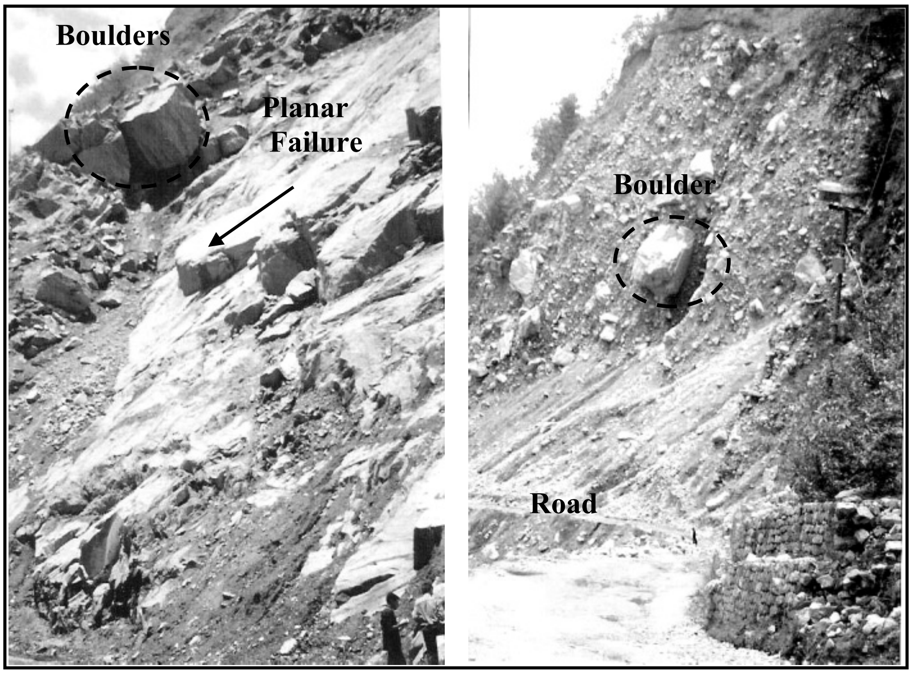

Fig. 7. Risk of risk fall at landslides 7 and 8.

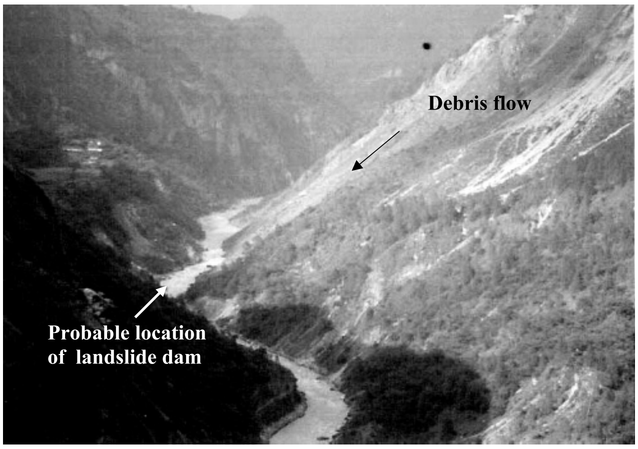

Fig. 8. Potential area for landslide dam.

occasions peoples were injured and killed by rock falls striking vehicles. The identification of areas at risk of rock fall is a major issue (Fig. 7).

Historically, several landslide dams have occurred in the Alaknanda valley causing flash flooding downstream when these dams are breached. Such flooding has claimed many lives. The potential for future events remains as there are many slopes from which debris slides occur directly in to the river that can form dams and associated lakes. One such location is shown in Figure 8 where the narrow width of the river can be blocked to form a landslide dam. Recently a debris flow occurred on the left bank of the river on 26th of September, 2004 triggered by intensive rainfall (Fig. 9). A large volume of debris descended the hill slopes and entered the river partially blocking it for a short time. This resulted in a change to the water course causing the highway on the right bank of the river to be destroyed. Fortunately this occurred during the night and there was no traffic on the highway. The road was blocked for several months and a new road was built to reach the holy shrine of Badrinath.

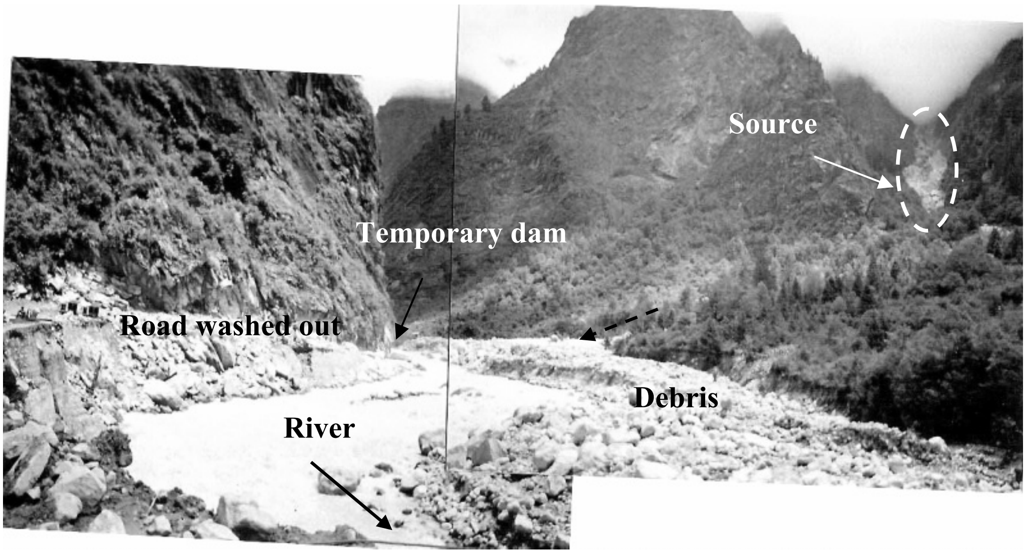

Fig. 9. Massive debris flow at Landslide 9 formed a temporary landslide dam causing change of river course and complete wash out of the road.

Conclusions

There is a high landslide risk along the Alaknanda valley. Given the high volume of traffic using the highway there is a need to identify and map these landslides so that in depth study can be carried out for appropriate solutions to minimize their impact. This also calls for a detailed geomorphological mapping of source zones, probable path of transportation of slided debris and the accumulation zone on a large scale using high resolution remote sensing data and field investigations. Upon completion of the mapping, the hazards and the risk elements must be identified and risks assessed. This will provide relevant data to mitigate landslide hazards.

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