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A Note on Kopchey Landslides, Namchi Block, Sikkim Himalayas

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Abstract: *Two debris slides, measuring about 200 m² and 5,278 m², developed on the Kopchey–Namchi road, are studied. Developed on phylite mica-schist and granite-gneiss terrains, both of the slides initated in 2007. Caused primarily by high rainfall on deeply weathered hill slopes, the slides are reactivated in almost every monsoons. Human activities like boulder mining, road construction, drainage alignment, and deforestation also played significant role in their formation.*

Introduction

During the monsoon and post monsoon periods every year, landslides cause significant loss of human life and property in the eastern Himalaya (Mukharjee and Mitra, 2001). In Sikkim, they severely affect the roads, the only mode of communication in the region, and bring about economic crisis. Many roads in this area were constructed in the past without following proper slope stabilisation process and modern engineering techniques, which make them especially vulnerable to landslides (Rawat *et al*., 2012).

In this work, two landslides near the Kopchey village in Namchi Block of South District of Sikkim are selected for investigation. The slides are located on Kopchey–Namchi road about 10 km from the Namchi town. Namchi is the headquarter of the South District, the second most populated district of Sikkim (Fig. 1). The sites are identified here as Kopchey Slide #1 (27°09'03"N, 88°21'19"E) and Kopchey Slide #2 (27°09'07"N, 88°21' 26"E).

The objective of the study is to determine the physical parameters of the landslides and to determine the main reasons of their occurrence in the Kopchey region.

Methods

The digital terrain map and slope profile of the slides are extracted from SRTM data

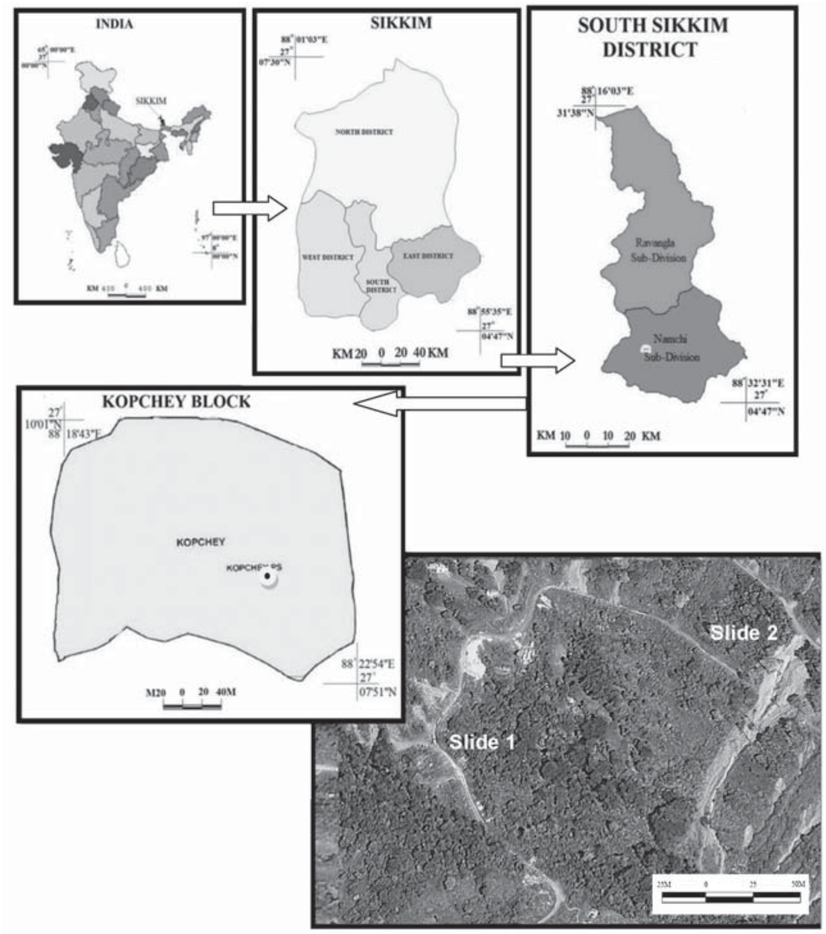

Figure 1. Location map of the study area

and Google Earth images and verified through fieldwork. Google Earth images of 2010, 2011 and 2013 are also used for identification of the temporal changes. Elevations, lengths, slopes, break points and other physical parameters of the slides are measured with the help of transit theodolite and a clinometer. Location and altitude of different points on and around the landslides are recorded using a GNSS receiver. Textural analysis of soil samples are made. Besides this, the local inhabitants are interviewed for verifying the pre-slide conditions. Finally, contoured elevation maps and others diagrams are prepared on the basis of primary and secondary data, mainly using ArcGIS and MS Excel.

Result and Discussion

Kopchey Slide #1

This area of the slide is composed of fragile phylite and mica-schist with varying surface gradient of 30°–60°. The rock structure is brittle and unconsolidated owing to deep weathering.

This slide initiated in 2007 due to heavy shower in the late monsoon period. As the hillslope got exposed, people started to remove loose boulders from toe of the slide

Table 1. Characteristics of Kopchey landslides

Particulars	Kopchey Slide #1	Kopchey Slide #2
Pre-slide conditions		
Rocks	Phyllite and mica schist, deeply weathered	Granite-gneiss with some weathering
Altitude	1096 – 1074 m	1127 – 1031 m
Slope	Convex (35°– 85°)	Convex
Natural vegetation	Scattered bushes with some deciduous trees	Grass and thin cover of bushes
Rainfall	Range of average monthly rainfall: 48 – 918 mm in monsoons (2007-2010)	As in the left
Landuse	Degraded grassland / forest; boulder mining prevalent	Grassland with some settlements close to the slide
Soil color	*Top*: yellowish to reddish; *Base*: Reddish brown	*Top*: light greyish, *Base*: light yellowish
Post-slide conditions		
Type of slide	Debris slide	Debris slide
Length of scar	22.6 m	45 m
Width of scar	20 m	13.9 – 61.4 m
Shape of scar	Triangular	Elongated
Total area affected	200.2 m^2	5,277.6 m^2.
Processes primarily responsible	Slope becomes unstable due to collection of boulders on the hill slope. Penetration of water through the loose particles due to heavy rainfall. Road construction by excavating toe slope.	2007: Two gullies formed due to heavy downpour, initiating instability 2011: An earthquake triggered major reactivation of the slide 2013: Heavy downpour in March greatly reactivated the slide
Modified slope	Concave and irregular (45°–60°)	Concave
Notable features	Resembles a hollow in the hill slope. Large, embedded boulders jut out from the mid-portion of the slide A small gully is formed at the middle of the spur. Continuous seepage of water is seen	Two gullies drain the landslide scar. Seepage of water is noticed close to the bottom the slide.
Remarks	Construction of a ground wall with proper drainage outlets are recommended to prevent damage to the road	Due to seepage of water and unscientific method of constructing road and retention wall, chance of reactivation remains in the future

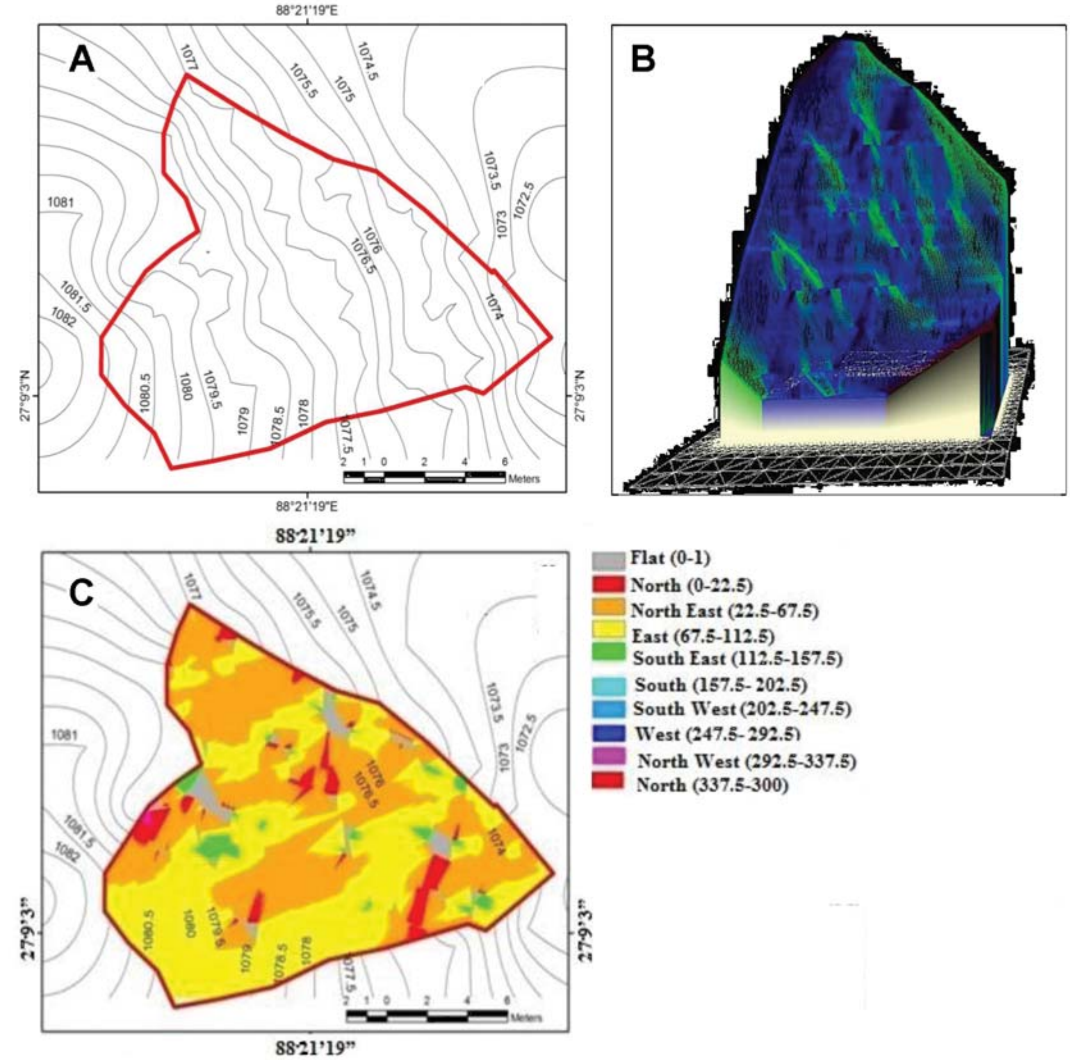

Figure 2. Kopchey Landslide #1. (A) Contour map, (B) Elevation model, (C) Slope aspect map.

for selling, leaving the slope unstable and susceptible to further landslides during the following monsoons. A part of the eastern portion of the slide got stabilised due to a safe angle of repose and growth of vegetation. The base of the landslide was excavated vertically by the Public Works Department for road construction in 2003, after which the landslide reactivated and extended downward by about 100 m, subsiding the road.

The slide extends between 1,096 m and 1,074 m, is triangular in shape with the general inclination of 35°–85° (Plate 1A). From the crest, the debris material came down almost vertically for about 3 m., after that a facet of 6.5 m is formed having a slope of about 35°. Loose materials roll down from its break of slope for about 8.6 m and get deposited at the on the foot of the slope, continuing for about 16 m. The middle part of

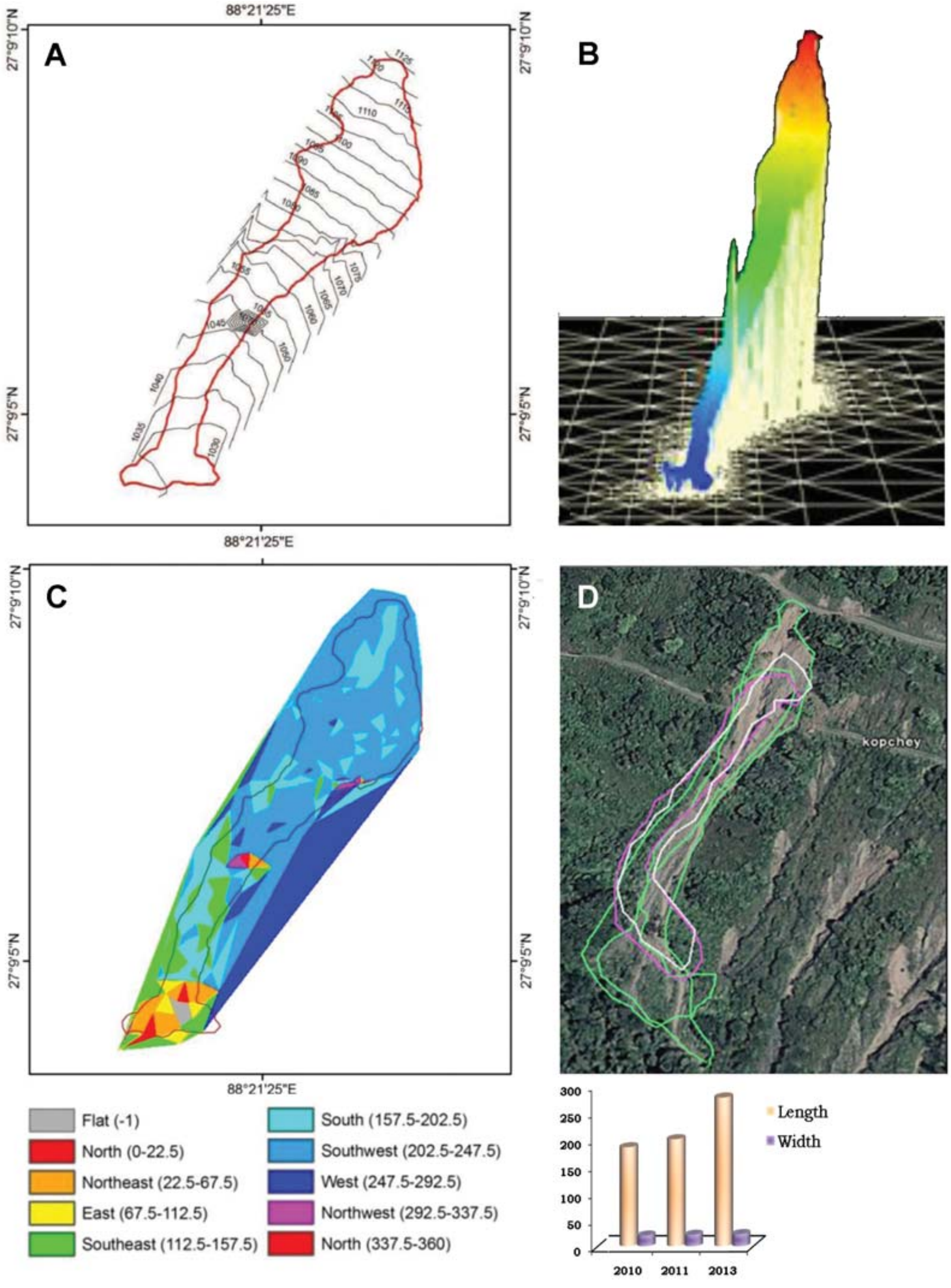

Figure 3. Kopchey Landslide #2. (A) Contour map, (B) Elevation model, (C) Slope aspect map, (D) Changes in outline of the slide extracted from Google Earth images. Values are in m.

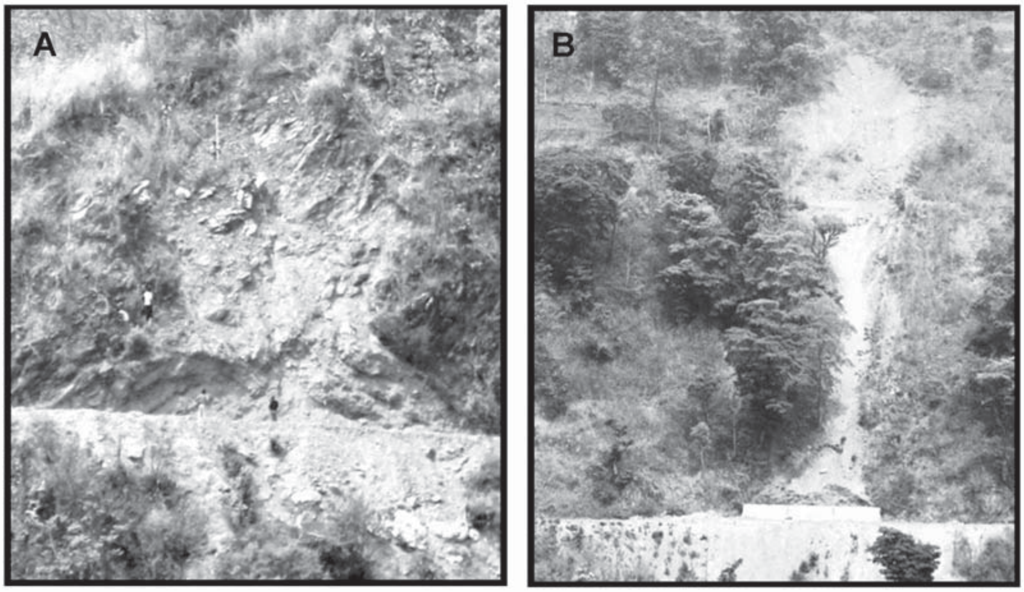

Plate 1. The Kopchey landslides (A) #1 and (B) #2

the slide resembles an arm chair. Oozing water from the bottom of the middle portion of the slide is collected by the local people digging small pit along the periphery. This further re-activates the slide.

As indicated by Google Earth images, its 2011 length and width were 20.6 m and 10 m. A couple of years later these enlarged to 22.6 m and 20 m, respectively. The expansion in width compared to length occurred due to absence of vegetation and mining of boulders from both sides.

The principal physical parameters of the slide are shown in Table 1 and in Fig 2. From the slope aspect map (Fig. 2 C), it is found that more than 65 per cent of the slope is inclined eastward and about 20 per cent of slope is inclined towards northeast while about 7 per cent of slope is tilled towards the north.

Kopchey Slide #2

The region around the slide is composed of granite-gneiss rocks. Analysis of soil samples indicated that the top layer (0–10 cm depth) as well as the bottom layer (40–80 cm depth) are composed of silt and clay, which are prone to volume expansion when wet. The middle layer is comparatively coarse textured, having lower water retention capacity. This renders differences in shear strength of the soil, and makes it conducive to downslope movement under wet conditions (De *et al*., 2009)

Enquiry in the region revealed that two gullies developed in upper part of the slope and induced continuous water penetration. This caused the upper layers of the slope to become unstable, resulting in a massive debris slide. In the year 2007, when the landslide occurred for the first time, road communication between Namchi and Kopchey was disrupted for days. Although the intensity and duration of rainfall was very high in 2010, the slide remained stable due to increase of vegetation cover on both of its sides and construction of a retaining wall at

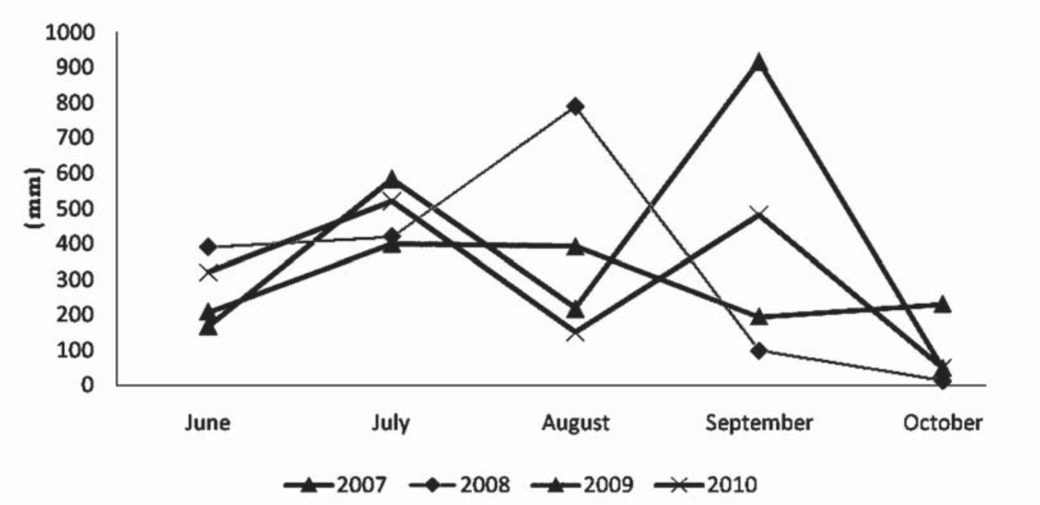

Figure 4. Variation in monsoon rainfall during 2007–2010. (Source: Namthang Weater Station)

its base (Plate 1B). However, following an earthquake in 2011, the slide reactivated in a major way, and huge debris fall took place from the crest. This earthquake occurred on 19 Septmebr 2011 and is known to trigger a number of slides throughout Sikkim (Chakraborty *et al*., 2012) A heavy downpour in March 2013 caused the next major reactivation. At present, the slide continues to move almost every year (Fig. 9). The gullies are still there and play a key role in development of the slide.

Currently, the face of the landslide is covered with large boulders and huge amount of debris. The middle part of the scar is oval shaped having steep slope on both sides towards the gully. The upper middle elevated part of the slide is gradually being covered with grasses and thin bushes. Seepage of water, close to the bottom of the slide, is also noticed.

The main physical parameters of the slide are shown in Table 1 and in Fig 3. The slope aspect map (Fig. 3C) indicates that almost 50 per cent of its slope is southwestward and 20 per cent of slope is towards south. Some 17 per cent of the slope face west.

Conclusions

According to field investigations and available information, 75 per cent landslides in the Kopchey region occurred in rainy season. Consequently, it seems that heavy rainfall or rainstorm occurring during the monsoons (Fig. 4) is one of the most important factors that induce landslides among various external dynamics apart from the deeply weathered metamorphics. Slope mass increases when rainwater flows through slope, sliding surface is soaked and softened and the shear resistant strength of slope decreases with rainfall and percolating groundwater. Dry and wet alternations causes rock and soil masses to rupture resulting in large number of joints and fractures, which increase pore water pressure and cause the slope to be in equilibrium state to slide (Ding *et al.*, 2006). In the two studied landslides, most movements coincided with high rainfall event.

Besides the above, several instances of human interference with the natural system is seen in the Kopchey region that have augmented chances of landslides. These include boulder mining from hillslopes, toe slope excavation for road and building construction, construction of inappropriate drainage systems and deforestation. In the slides close to the Namchi–Kopchey road, vibrations from movement of heavy vehicles may also work as triggering mechanism.

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References

Chakraborty, I., Ghosh, S., Bhattacharya, D. and Bora, A. (2012) *Earthquake induced landslides in the Sikkim-Darjeeling Himalayas – An aftermath of the 18th September 2011 Sikkim earthquake.* Geological Survey of India (Engineering Geology Division), Eastern region, Kolkata; http://www.portal.gsi.gov.in/gsiDoc/pub/report_portal_final_20102011.pdf/ (retrieved on 2013-10-14)

De, S.K., Jamatia, M., Bandyopadhyay, S. (2009) A Geo-technical investigation of Mirik Landslide, Darjiling Himalayas. In Sharma, H.S. and Kale, V.S. (ed) *Geomorphology in India*, Prayag Pustak Bhawan, Allahabad: 207–216.

Ding, Y.H., Ren, G.Y., and Shi, G. (2006) National assessment report of climate change (I): climate change in China and its future trend. *Advances in Climate Change Research*, 2: 3–8.

Mukharjee, A. and Mitra, A. (2001) Geotechnical study of mass movement along the Kalimpong approach road in the Eastern Himalaya. *Indian Journal of Geology*, 73(4): 271–279.

Rawat, M.S., Rawat, B.S., Joshi, V. and Kimothi, M.M., (2012) Statistical analysis of landslide in South district, Sikkim, India: using Remote Sensing and GIS. *IOSR Journal of Environmental Science*, 2(3): 47–61.

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