GIS-based most influencing parametric classes identification in one of the most landslide prone geology in mid Nepal Himalaya

Key words: GIS, deep-seated landslides, Nepal Himalaya

O K.P. Acharya, N.P. Bhandary, R. Yatabe
(Graduate School of Science and Engineering, Ehime University)

1. Introduction

Phyllite, slate, and schist are the most landslide prone geologies (Gerrard 1994) whereas other geologies come under less-prone category in Himalaya Regions. As phyllite and slate as the most vulnerable geological formation has already been reported elsewhere by the same authors, schist zone is analyzed in this particular study. This paper takes accounts of identification of in-situ most influencing terrain classes/factors in relation to non-uniform occurrence of deep-seated landslides in schist zone of the mid Nepal Himalaya. The slope, relief energy, drainage density, and thrust-faults proximity are the parameters employed. To incorporate non-uniformity in landslide occurrence, unit square kilometer blocks (USKBs) are constructed covering the entire schist area. The comparative influencing role of employed parameters is observed in different high and low zones of landslide density and the most influencing parametric classes/factors are identified. The application of present study includes prediction of the possible sites of failure with use of identified most influencing classes in other similar geological conditions of the Himalaya Region.

2. Study area and geology

The study area covers for about 5075 km^2 in Lesser Himalaya and Siwalik zone of Mid Nepal (Fig. 1). It encompasses sections of Prithvi Highway, Tribhuvan Highway and Narayanghat-Mugling Highway, all of which connect the Capital area of Kathmandu with rest of the nation. Physiographically, the study area lies in Midland group (Upper Precambrian to late Paleozoic). Bedrock geology is composed of 14 main types of lithological units (Fig. 2) (high grade to low weathered metamorphic rocks such as metagabro, limestones, quartzite, gneiss, phyllite, slate, schist etc) that have been folded and faulted (MCT, Main Central Thrust, MBT, Main Boundary Thrust) (Pantha et al. 2008), resulting steep slopes deeply dissected by an actively eroding drainage network.

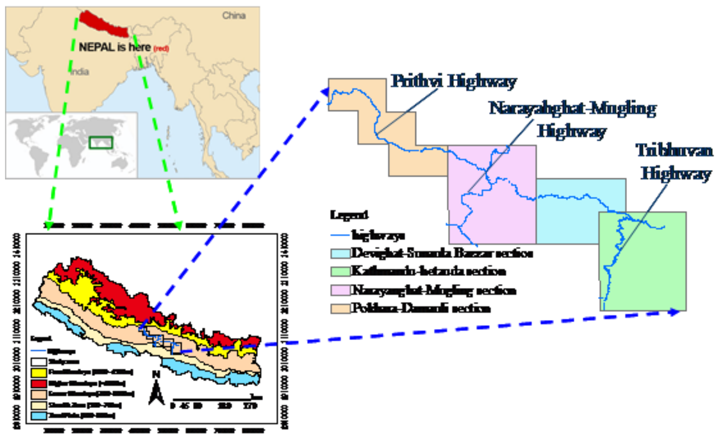

Fig. 1 The study area

3. Methodology

ArcGIS 9.0 is used to produce different layer maps which assist on carrying out whole analysis. The input parameters selected for this particular study include slope, drainage density, relief energy and distance to thrust-faults with 50m resolution whereas rock formation is kept constant. The selected schist area (Fig. 4) is the part of 5075 km^2 study area. Blocks of 1km × 1km (USKB) size are constructed covering the entire schist area (Fig. 5). The total numbers of blocks are 556. The shape file of unit square blocks is crossed with landslide raster employing zonal statistics function of Spatial Analyst Tool in ArcGIS. It gives the number of pixels of landslides occurring in each block. Then, landslide density per block is calculated which varied from 0.0025 to 0.435 km^2/km^2. The resultant landslide density map is classified into four landslide density zones (Fig. 6) by defined interval method of statistics with their density ranges namely none (0 km^2/km^2), low (<0.1 km^2/km^2), medium (0.1 km^2/km^2 - 0.3 km^2/km^2), and high (>0.3 km^2/km^2). High, medium, low, and none landslide density zones occupies 2.32%, 12.41%, 30.56%, and 54.71% schist area respectively. The forth step is to observe the natural occurrence of pixels of employed parameters in different high and low landslide density zones. The percentage of parameter pixels increasing significantly from none to high zones is the basis for determination of most influencing parametric class for this study.

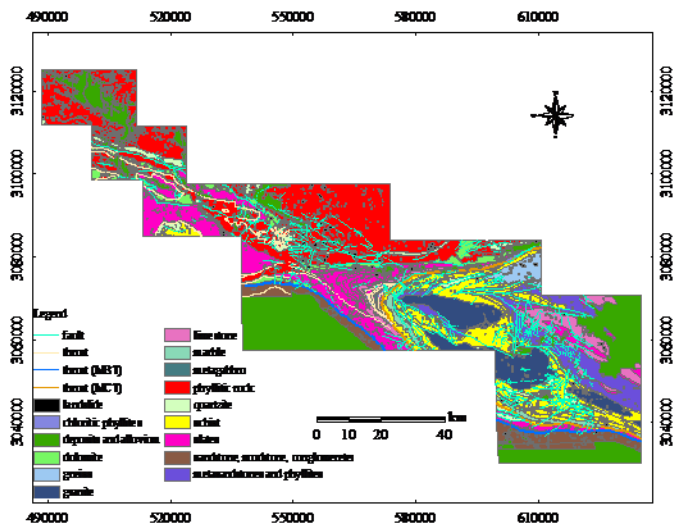

Fig. 2 Geological map of the study area

4. Results and discussion

Fig.7 shows the results of parametric pixel distribution diagram in schist. No distinct increasing trend is found in any slope range. This indicates that slope reserves no influencing character for non-uniform occurrence of landslide. Distance to thrust-faults and relief energy also do not exhibit clear increasing trend towards higher

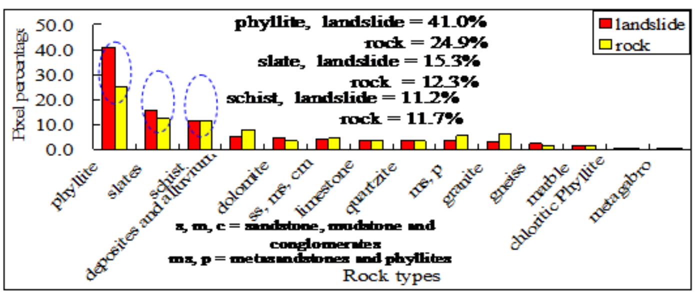

Fig. 3: Landslide and rock type distribution in the study area

zones. The result obtained in case of distance to thrust-faults is suspicious because schist zone is bounded by MCT. Moreover, MCT is totally isolated among other thrust-faults and further statistical analysis is done. The increasing trend of thrust-faults density is different from that of landslide density (Fig. 8a). On the contrary, the increasing trend of 0-0.5 km distance to MCT is similar with landslide density (Fig. 8b). This clearly meant that distance to MCT plays a mild role for spatial occurrence of landslide in schist, but thrust-faults in total is not much influencing. A very clear increasing trend can be seen in 4-6 km/km^2 drainage density class. This range of drainage density is not very high range thus landslides have maximum chances of occurrence of landslide at this range. Thus, it must be the most influencing parametric class.

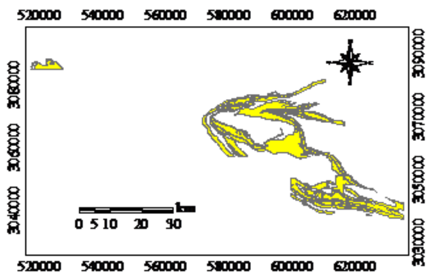

Fig. 4: Delineation of schist

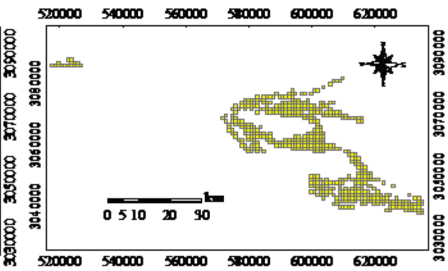

Fig. 5: Rasterization of USKB

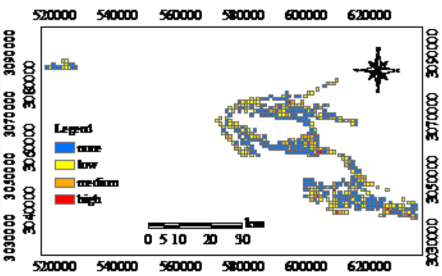

Fig. 6: Landslide density map

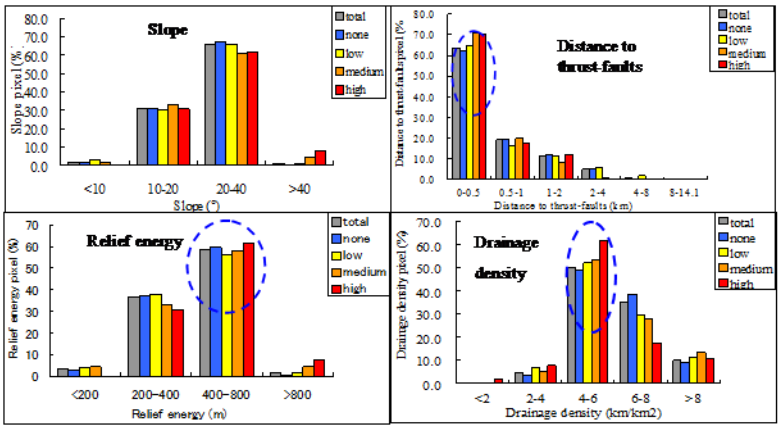

Fig. 7: Results of schist analysis

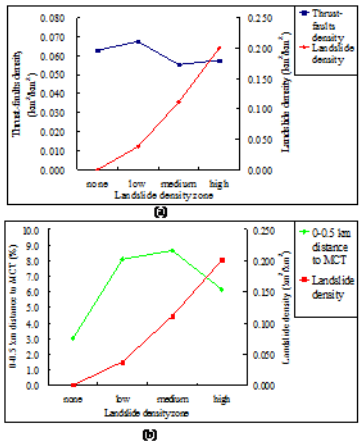

Fig. 8: showing landslide and thrust-faults statatistics

5. Conclusions

In this study, the non-uniform occurrence pattern of large-scale deep-seated landslides is analyzed in schist zone of central Nepal. The analysis is conducted by constructing USKB in whole schist area. The 4-6 km/km^2 drainage density class is found as the most influencing parametric class for non-uniform occurrence of landslides. With finding of the most influencing parameters, it is considered that the further identification of landslides in other similar geologies is possible with few and important data.

References

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