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# Landslide Hazard Zonation Along NH-39 From Kangpokpi To Mao, Manipur, India

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**Abstract.** Due to the prevailing high rainfall and complex nature of terrain, hilly areas of Manipur are vulnerable to instability and mass wasting which have been aggravated by rapid pace of anthropogenic activities and high seismicity. To categorize the land surface into areas and arrange them according to degree of actual or potential hazard from landslide or other mass movements on slopes, an effort is made to prepare landslide hazard zonation map along NH-39 from Kangpokpi to Mao, covering an area of 650km$^2$. Based on the hazardousness to landslide the study area has been divided into four different zones. The major part of the study area about 380km$^2$ (58%) falls under the category of high risk zone, followed by moderate risk zone covering an area of 152km$^2$, low risk zone (115 km$^2$), and very high hazard zone (3 km$^2$). Such zonation maps are useful for identifying and delineating unstable hazard prone areas so that suitable mitigative measures can be adopted to minimize the hazards. It also helps planners to choose the favorable sites for developmental schemes like road and building constructions.

## Introduction

Manipur is a landlocked northeast state of India. Roads are the only means for surface transport and NH 39 is the most important route in the state connecting Nagaland in the north and Myanmar in the south-east. But due to prevailing high rainfall and lithological and structural complexities with the rapid pace of anthropogenic activities and high seismicity, area between Kangpokpi to Mao along NH-39 has witnessed several landslides causing traffic disruption for many days, severe damage to buildings and agricultural lands. In the year 2010 about 10m long stretch of NH-39 was completely damaged near Maram (Fig.1) causing disruption of vehicular movements for several days. Some other major slides occurred in the study area during this decade are Shajouba slide 2007, Phikommei slide 2004, Gopibung mudflow 2004 and Mouzhu slide 2002 etc.

In order to identify and delineate unstable hazard prone area, the present study aims to prepare landslide hazard zonation map along NH-39 from Kangpokpi to Mao, Manipur. The term zonation is applied in a general sense to categorize the land surface into areas and arrange them according to degree of actual or potential hazard from landslide or other mass movements on slopes (Varnes, 1984). Landslide hazard zonation has been carried out by many workers since sixties (Blanc and Cleveland,

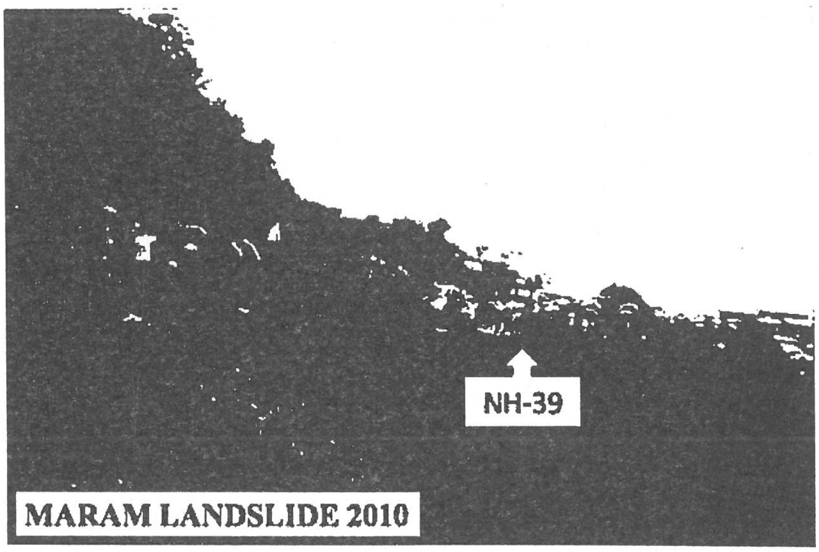


Fig I. Landslide at Maram along NH-39 (25° 25′N:94° 07′E).

1968; Brabb *et al.*, 1972; Carrara, 1983; Hansen, 1984; Anbalagan, 1992; Djamaluddin, 1994; Guzzetti *et al.*, 1999; Lee *et al.*, 2001; Saha *et al.*, 2002; Sarkar and Kanungo, 2004; Ghafoori *et al.*, 2006; Pachauri, 2007; Kumar, 2008; Sharma, 2008).

## Study Area

The present study area between Kangpokpi to Mao, Senapati district, Manipur along NH-39, lies between 25°00′N and 25°35′ N latitude and 93°50′ and 94°10′E longitude covering 650 $km^2$ area (Fig. 2). The entire area is characterized by rugged hilly terrain with an altitude varying from 900 m to 2700 m above mean sea level. Mt Iso (Teñepo), the highest peak of the state with an altitude of about 2994 m is located in the north-western part of Mao. The general trend of the hill ranges is NNE-SSW which frequently varies between N-S and NE-SW. Hill ranges and river valleys are the major landforms in the area. Structural and denudational hills are arranged in parallel to sub parallel covering major part of the area. The entire area is drained by two major river systems- the Barak River and the Imphal River. The area has warm, humid sub tropical monsoon type of climate with a minimum temperature of 3°C to a maximum temperature of 34°C and annual rainfall varies from 671mm to 1454mm.

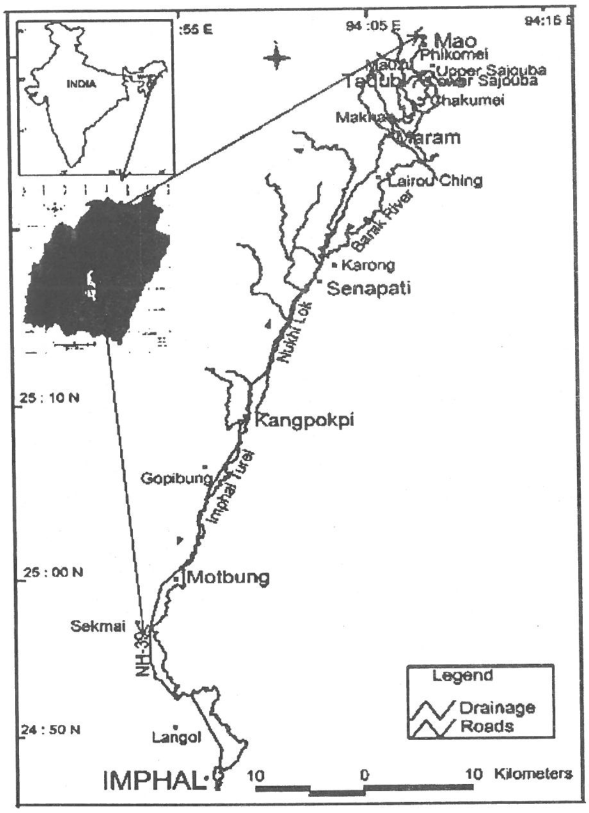


Fig 2. Location map of study area.

## Geologic Setting

The study area occupies the northern part of the arcuate Arakan Yoma-Chin hills, constituting a succession of Disang and Barail group of rocks and Quarternary alluvium. Disangs are dark grey splintery shales intercalated with siltstones and fine grained sandstones, which are tectonically deformed and at places highly weathered. Barails underlain Disangs and are comprised of massive to thick and highly jointed sandstone beds, often interbedded with shales. Thickness of the individual sandstone beds ranges from 60cm to more than a meter, where as shale bed varies between 1 and 2.5cm. There is appreciable increase in the frequency and amount of the arenaceous material towards north. Quaternary deposits are represented by a sequence of alluvium characterized by the dominance of silty and clayey material and at places sandy to pebbly in nature. A simplified stratigraphic succession and litho-character of each unit is presented in Table 1.

## Landslide Hazard Zonation Map

In the present study, guidelines of the LHZ mapping suggested by Anbalagan, (1992) and BIS (1998) with minor modifications have been followed in order to suit the local geological and meteorological conditions. It is a quantitative method based on the landslide hazard evaluation factor (LHEF) rating. This method involves demarcation of slope facets, preparation of various types of thematic maps on 1:50,000 scale for geo-environmental

Table 1. Stratigraphic succession of the study area.

| Litho unit | Age | Description |
|---|---|---|
| Alluvium | Quaternary–Holocene to Pleistocene | Clay, silt, sand, pebble and boulder deposits |
| Unconformity | | |
| Barails | Oligocene to Upper Eocene | Massive to thickly bedded sandstone. Alternations of shale and sandstone. Flysch sediments of turbidite character. |
| Gradational Contact | | |
| Disangs | Eocene to Upper Cretaceous | Dark grey to black, splintery and earthy coloured shales, siltstones and sandstones showing occasionally rythmite characters. |
| Unconformity | | |
| Basement complex: Unseen | | |

factors viz. lithology, structure, slope morphometry, relative relief, drainage frequency, drainage density and land-use/land-cover. LHEF rating for different contributory factors are determined on the basis of their estimated significance in inducing instability. The results are presented in the form of maps (Fig. 3-9). The sum of all causative factors within an individual facet gives the total estimated hazard (TEHD) for that facet. The TEHD value gives an estimate of risk of instability within an individual facet as indicated in Table 2, and this is depicted in landslide hazard zonation map (Fig.10). The study area has been divided into four different zones, namely, low hazard zone, moderate hazard zone, high hazard zone and very high hazard zone. It is observed that the major part of the study area falls under the category of high hazard zone followed by moderate hazard zone, low hazard zone and very high hazard zone.

## Conclusion

Considering the geo-environmental factors viz. lithology, structure, slope morphometry, relative relief, drainage texture and land-use/land-cover landslide hazard zonation map along NH-39 from Kangpokpi to Mao, Manipur covering an area of 650km$^2$ is prepared on macro scale, its based on the hazardousness to landslide. The major part of the study area falls under high hazard zone. Degree of hazardousness increases towards north, particularly from Karong to Mao along NH-39 due to the combination of geo-environmental conditions. It is validated with the distribution of landslides in these areas. To reduce the loss, due to landslide hazards, suitable mitigative measures should be adopted. The state planners should select the favorable sites for developmental schemes like road and building constructions based on the hazardousness.

Table 2. Landslide hazard zonation on the basis of total estimated hazard (TEHD).

| Zone | TEHD value | Description of zones | Area in km$^2$ | Percentage |
|---|---|---|---|---|
| I | <3.5 | Very low hazard zone | 0.00 | 0.00% |
| II | 3.5–5.0 | Low hazard zone | 115.02 | 17.68% |
| III | 5.0–60 | Moderate hazard zone | 152.27 | 23.40% |
| IV | 6.0–7.5 | High hazard zone | 380.43 | 58.46% |
| V | >7.5 | Very high hazard zone | 3.00 | 0.46% |

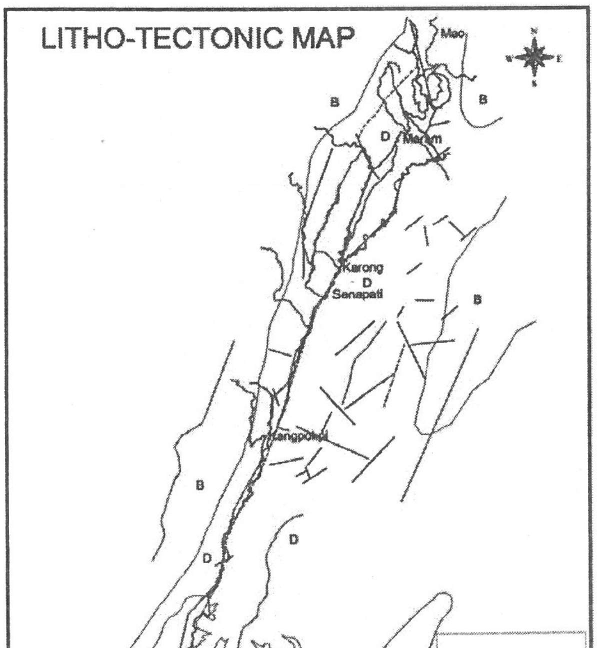


Fig 3. Litho-tectonic map.

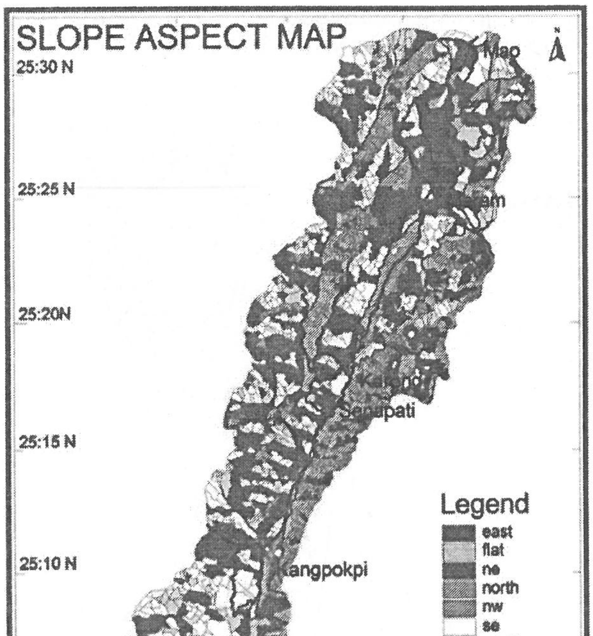


Fig 4. Facet with slope direction map.

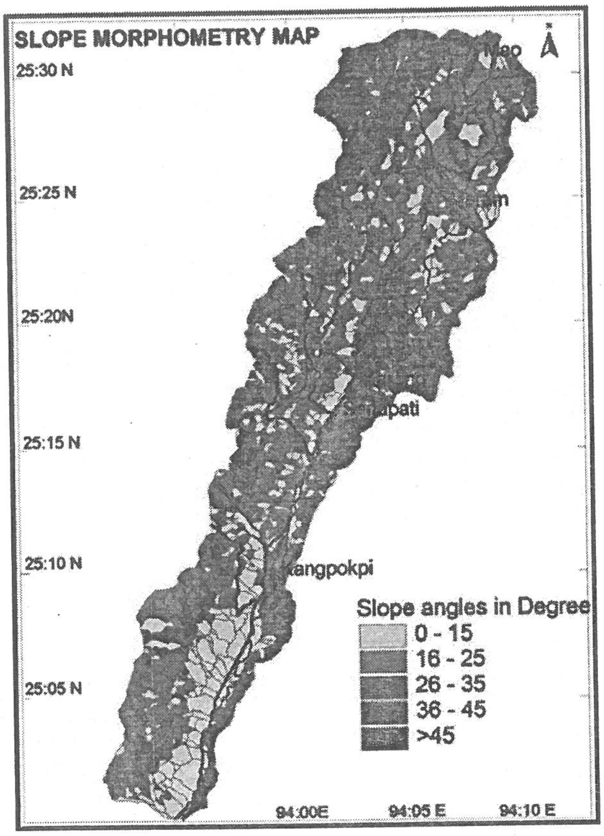


Fig 5. Slope morphometry map of study area.

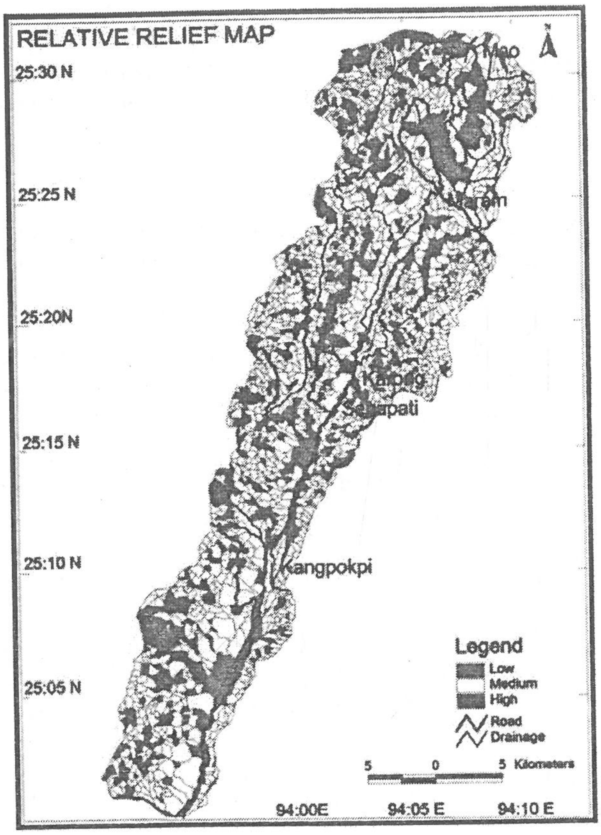


Fig 6. Relative relief map of study area.

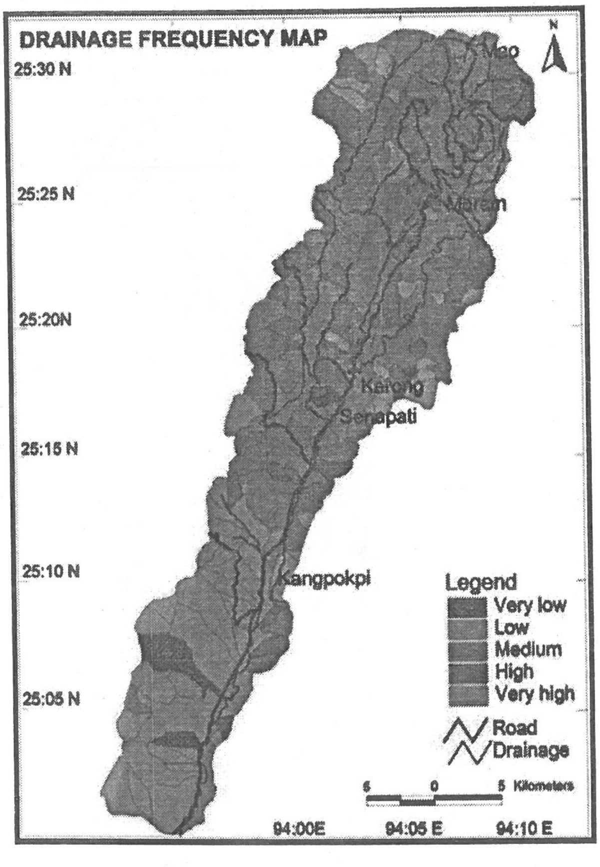


Fig 7. Drainage frequency map of study area.

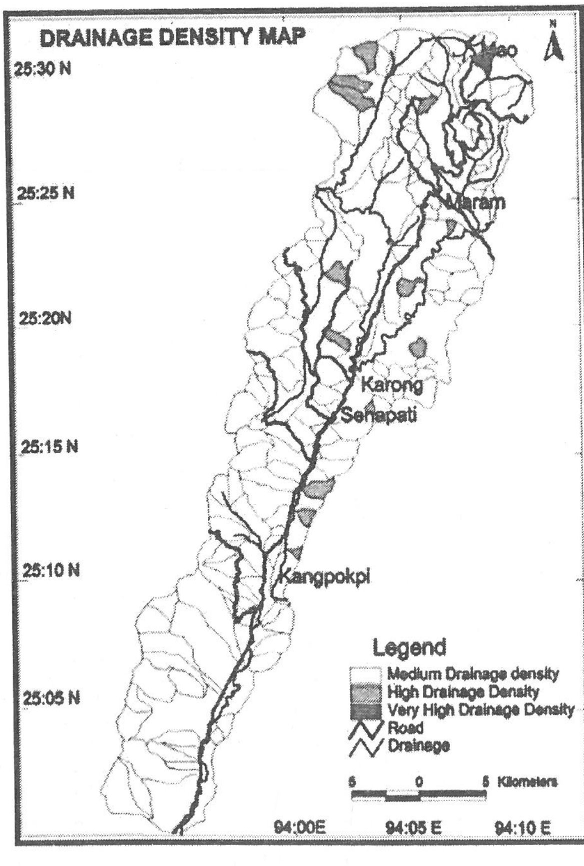


Fig 8. Drainage density map of study area.

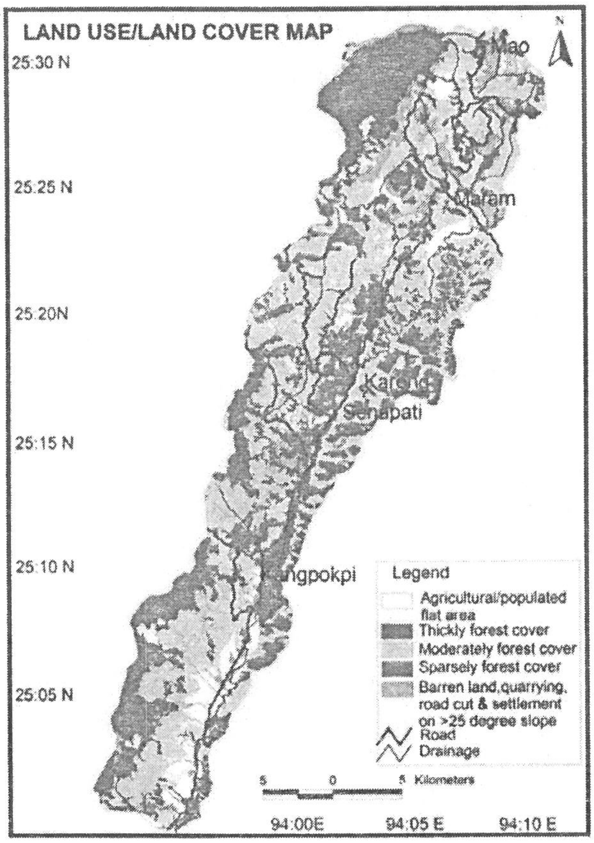


Fig 9. Land use and land cover map of study area.

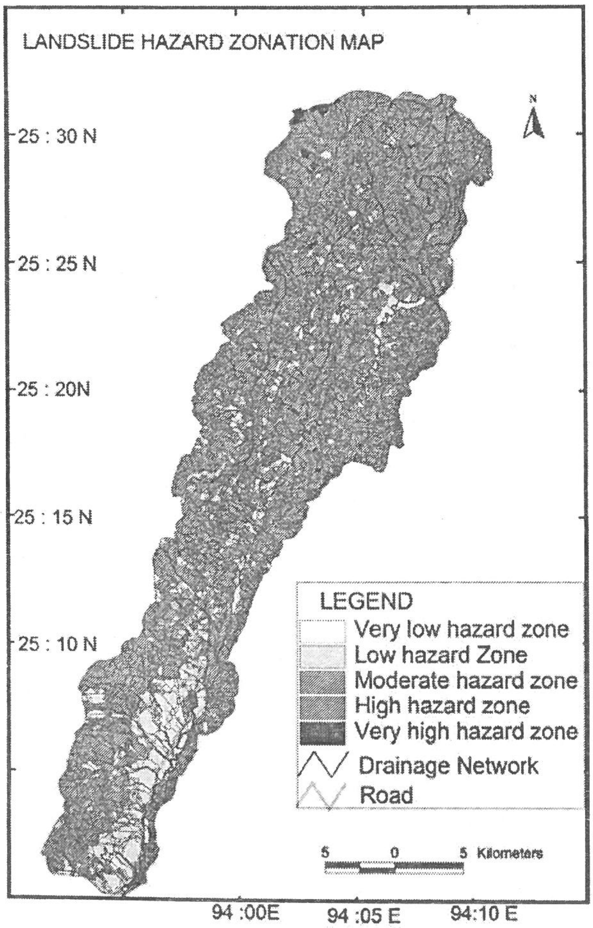


Fig 10. Landslide Hazard Zonation map of study area.

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