GEOSPATIAL TECHNOLOGY IN LANDSLIDE MITIGATION – A CASE STUDY IN NILGIRIS DISTRICT

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1.1 INTRODUCTION:

Landslides constitute one of the major natural catastrophes, which account for considerable loss of life and damage to communication routes, human settlements, agricultural and forestland. Most of the terrain in mountainous areas have been subjected to slope failures under the influence of variety of terrain factors and figured by events such as extreme rainfall or earthquake.

In India, landslides are occurring frequently in Himalayan region in North and Western Ghats in South. Advancement in remote sensing technology will enable us to identify the finer features on the terrain and to create high resolution Digital Elevation Model (DEM). Most of the landslide modeling using GIS involves contour interval of 20 metres or 10 metres and thematic maps generated from remote sensing data of resolution 30 and 5.8 metres. This paper evaluates the landslide hazard zonation using different kinds of spatial data (aerial photographs, satellite imagery) and also discusses the technological improvements in remote sensing sensors which greatly influence the accuracy of Landslide Hazard Zonation (LHZ) mapping

Remote sensing and GIS plays a very important role in preparation of LHZ. Many thematic maps such as geology, geological structures, landforms, landuse/landcover, slope, drainage, and aspect are needed for this purpose.

1.2 NEED FOR STUDY:

The best source of spatial data is aerial photographs, but it is an expensive technology, restricted for common availability. The alternative source is satellite imagery, but it does not give better resolution and hence accuracy for thematic map preparation is low when compared to conventional photogrammetric technique.

In the present day, remote sensing technology is highly improved with better resolution thereby it is possible to prepare thematic maps with finer details. In this paper, the conventional methods of photogrammetry and the modern techniques of remote sensing are compared for LHZ mapping.

1.3 OBJECTIVE:

The paper has the following objectives:

1. To prepare the LHZ mapping using aerial photogrammetry.
2. To prepare the LHZ mapping using satellite based remote sensing data
3. To identify the limitations of satellite based remote sensing when compared to photogrammetric techniques.
4. Assessing future trends in remote sensing and its implication on Landslide Hazard Zonation (LHZ) mapping.

1.4 LITERATURE REVIEW:

Landslide is the downward movement of a part of a slope, debris or soil, along a sliding surface where shear failure occurs. Landslides and mass movements are phenomena that occur in the process of geomorphologic transformation. The main types of landslides are Falling, Subsiding, Sliding and Flowing

Although by definition the term landslide is used only for mass movements occurring along a well-defined sliding surface, it has been used as the most general term for all mass movements, including those that involve little or no sliding. In this study, the term mass movements; landslides; slope movements and slope failures are used synonymously. Landslide hazard mitigation of an area requires prediction of the time and place of the threatening hazard. The prediction of landslide is still in its infancy even in developed countries.

Van westen et al (2003) have analyzed the evolution of the Tessina landslide using sequential aerial photographs and direct field mapping. The interpretations were converted into large-scale multi-temporal topographical maps resulting in detailed geomorphologic maps of the Tessina landslide for different periods. Further he emphasized the need of series of digital elevation models for different time steps to calculate the total volume of material removed and accumulated for the entire Tessina landslide quantitative volumetric analysis.

Landslide Hazard mapping in Austria studied by **Bernhard Klingseisen and Philip Leopold** of Austrian Research Centres. The factors or evidence themes determining the possible occurrence of landslides include geology, land use, slope, aspect and terrain roughness expressed as Surface to Area Ratio. In Arc-SDM each of the five factors enumerated above was duly given a weight and the probability of the occurrence of landslides over the whole area then computed for each raster cell on a scale of 0 to 1. To enhance the results for presentation to decision-makers, these values were transformed into three classes: Not endangered, Landslides possible and Endangered.

S.S.Ramakrishnan, et al has carried out extensive work on landslide analysis using aerial photographs. They used orthophotos for the preparation of thematic maps using aerial photograph of scale 1:6000. They generated contour map of 2 m, using which accurate prediction of risky area is possible.

1.5 METHODOLOGY:

There have been numerous studies conducted on landslide mitigation, which is one of the life threatening problems in developing nations like India where the population explosion requires more judicious practices for landslide management. This study has been focused on analyzing the aerial photography and satellite images with GIS, which is useful for identifying the landslide hazard zones on large scale. We hereby compare the results of these two studies. We also analyze the future trend where modern technologies are expected to offer better quality spatial data.

1.5.1 Study area:

The study area involves the district of Nilgiris in the area of Kothagiri, the extent of this study area lies between 11˚14´56" to 11˚30´07"N Latitude and 76˚ 29´ 56" to 77˚ 00´ 47" E Longitude. The study area falls under the Survey Of India toposheets No: 58 A/15. The main types of landslides occurring in the study area are: Falling, Subsiding, Sliding, and Flowing. In the study area, it has been observed that natural slopes are disturbed due to cutting of roads for construction purposes, prevention of natural drainage and the changing land use pattern are the factors contributing to landslides and landslips. Most of the times it is triggered by high intense down pour.

1.5.2 Data product:

The data used for this study involves the following:

- IRS-P6 LISS III
- IRS ID PAN

} SPATIAL RESOLUTION 5.8(merged)

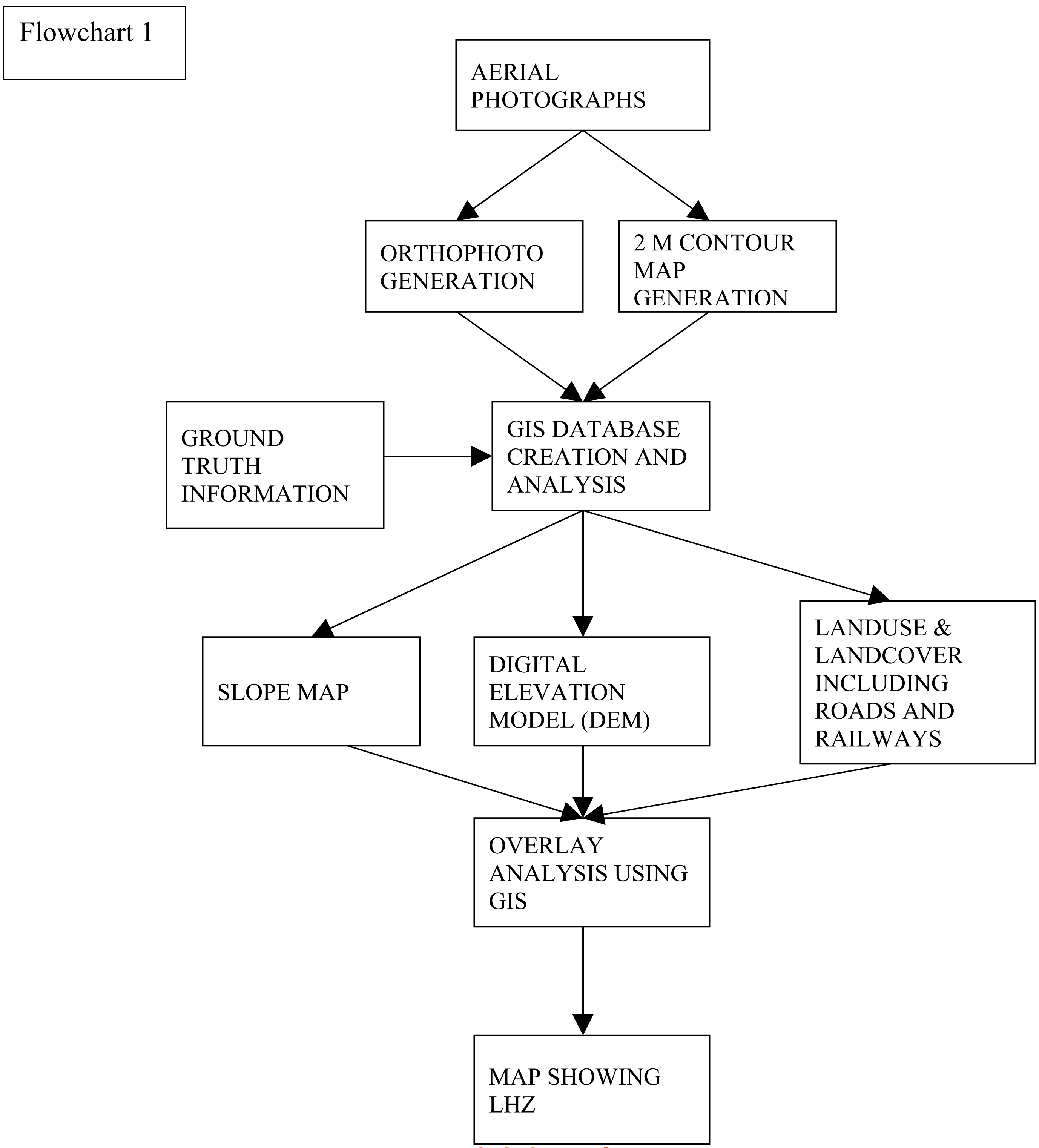
- Toposheets-Survey of India No: 58 A/15
- Aerial photographs

1.5.3 flow charts:

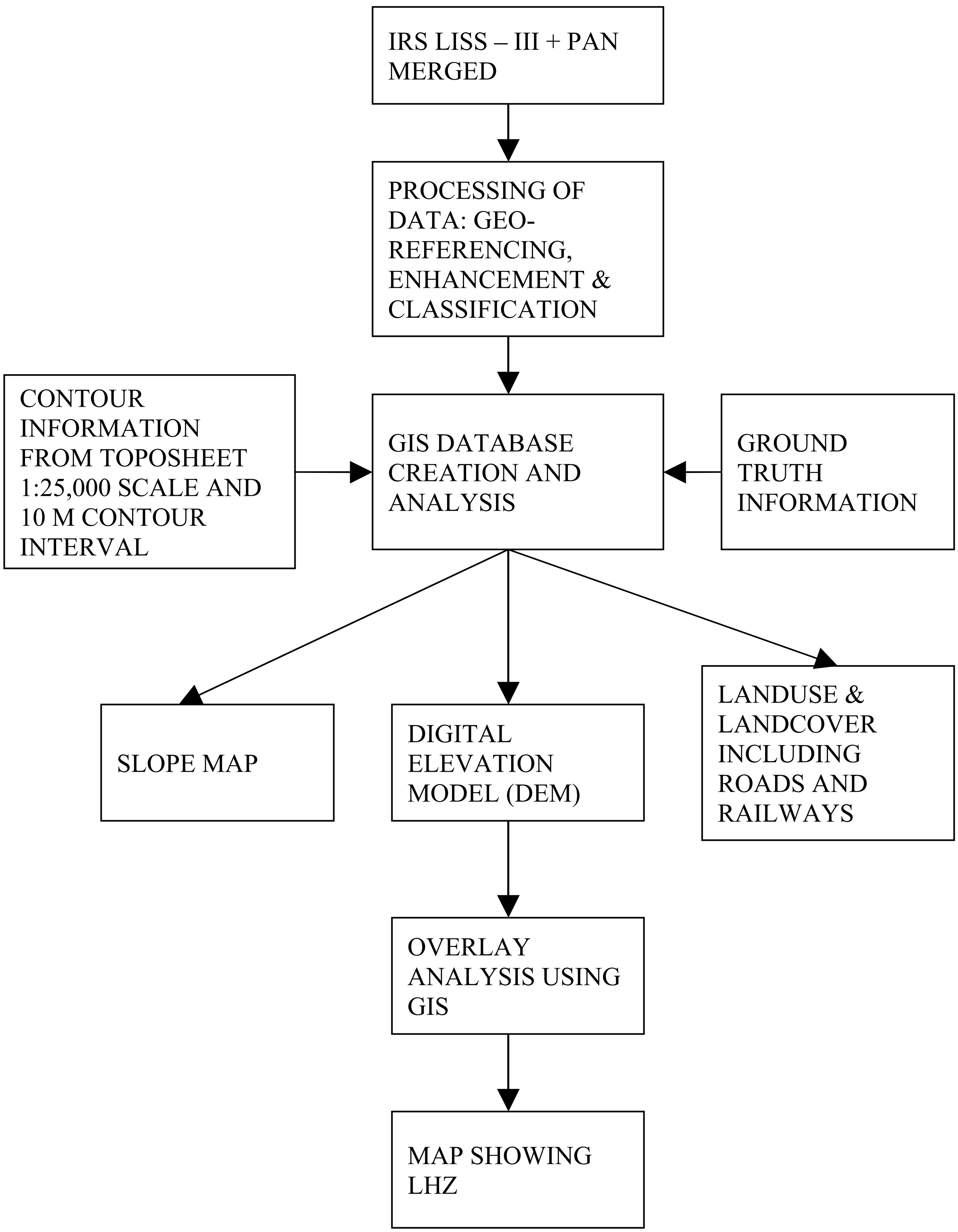
The flowchart is created for:

1. Flowchart for photogrammetric technique

2. Flowchart for remote sensing technique

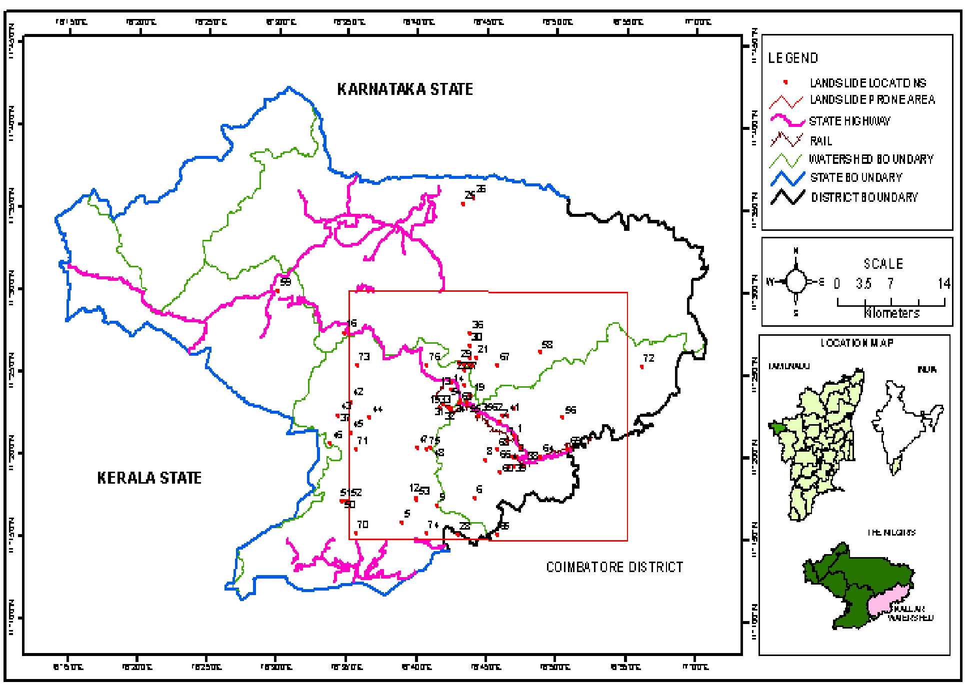


Flowchart 2


IRS LISS – III + PAN MERGED
PROCESSING OF DATA: GEO-REFERENCING, ENHANCEMENT & CLASSIFICATION
CONTOUR INFORMATION FROM TOPOSHEET 1:25,000 SCALE AND 10 M CONTOUR INTERVAL
GIS DATABASE CREATION AND ANALYSIS
GROUND TRUTH INFORMATION
SLOPE MAP
DIGITAL ELEVATION MODEL (DEM)
LANDUSE & LANDCOVER INCLUDING ROADS AND RAILWAYS
OVERLAY ANALYSIS USING GIS
MAP SHOWING LHZ

1.6 VALIDATION OF THE RESULTS:

The results obtained from remote sensing data are validated with field verification and historical details available. The most of the landslides/landslips have occurred in the location of prediction and the details were presented.



1.7 RESULTS AND DISSCUSSION:

Aerial photography of 1:8000 scales, which were taken during the year 1986, was taken for processing. A small part of the Kothagiri district was taken for contour and orthomap preparation Fig 1. Using Arc GIS 9.1 software, layers of spatial data like orthomap, contour, landuse & land cover map, road network were stored and retrieved for analysis.

Weightages were assigned to each theme ie, landuse, soil and slope. Based on weightages assigned, the entire study area is divided into 4 classes [Very High, High, Moderate and Low]. The Landslide Hazard Zonation (LHZ) is shown in Fig 2. The road network map is overlaid with slope and landuse map to identify sites, where mitigation works to be taken on priority basis.

As the photogrammetric technique for LHZ is very expensive, an attempt is made in this paper using satellite remote sensing. The satellite-based remote sensing data has unique advantages of economy and multitemporal nature. IRS-1C data of LISS-III + PAN merged was used for preparing landuse map and 10 m contour interval was derived from Survey Of India (SOI) toposheets. DEM was generated using above two sets of data. The road map is overlaid over the DEM and potential zones of landslide risk is marked by keeping in mind that wherever road crosses slope of more than 21 to 47% is riskier spots of landslide/landslip Fig 3.

Based on the above simpler approach, the following experience were gained:

1. Remote sensing data is economic, covering large area of interest.
2. Processing is much simpler and hence landuse/landcover and landslide map can be created easily and it can be updated also.
3. The available Survey Of India (SOI) toposheets is very economical for DEM generation, but 10 m contour interval is not sufficient for LHZ prediction.

The ideal scale and contour interval for LHZ are 1:5000 and 2 m respectively. Hence, it can be concluded that photogrammetric techniques are ideal for LHZ mapping as well as providing operational planning for mitigation measures.

Regional scale studies can be better done using satellite data and SOI maps. The present technology of satellite based remote sensing can be used for qualitative prediction of landslide. Because of upcoming high-resolution sensors, a better quality LHZ can be prepared.

Some of the mitigation measures are provision of proper drainage, slope stability technique and biological methods, which are explained in fig 4.

TABLE 1: CRITERION TABLE FOR LHZ

Theme	Weight (4)	Weight (3)	Weight (2)	Weight (1)
Landuse	Grassland, agriculture	Tea, tea +trees	Forest	Settlement
Soil	KG4, KG5	KG3, KG6	KG2, KG7, KG8	KG1, KG9
Slope	36-54 deg	18-36 deg	>54 deg	0-18 deg

1.8 FUTURE TRENDS IN REMOTE SENSING AND ITS IMPLICATION FOR LHZ:

The planned mission like Cartosat-2 by Government of India is very promising as it is capable to produce high-resolution images.

Quickbird-2 satellite with 0.61 m resolution in PAN mode can be effectively employed for landslide application.

Terra SAR-X, which will ultimately replace the need for aerial photography, as it can give 2 m contour interval and 1 m planimetric spatial data. More research has to be undertaken in use of SAR in landslide application and the Integrated study involving SAR Polarimetry, SAR Interferometry and optical data can be much more meaningful in zoning and monitoring landslides.

1.9 CONCLUSION:

The study has demonstrated the application of various remote sensing techniques in order to obtain the model for the effective mitigation. We can classify the hazard zones into very low, low, moderate, high and very high. This highly depends on the slope of the place. In this paper, we have analyzed the usage of the conventional methods such as photogrammetry along with the modern techniques of remote sensing using satellite images. We also discussed the use of advanced technology, which has been planned to be used in the future such as spaceborne SAR and high-resolution optical data.

REFERENCE:

1. Bernard Klingseisen and Philip Leopold, Austrian Research Centres, Austria “Landslide Hazard Mapping in Austria” published in GIM International, December 2006, Volume 20, Issue.
2. Ramakrishnan.S.S, Sanjeevi Kumar.V, Zaffar sadiq M.G.S.M, Venugopal.K & Arul raj.M. “LANDSLIDE DISASTER MANAGEMENT AND PLANNING-A GIS BASED APPROACH”, Indian Cartographer vol 2.

3. Ramakrishnan.S.S, Sanjeevi Kumar.V., Zaffar sadiq M.G.S.M, Venugopal.K & Arul raj.M. "AN INTEGRATED APPROACH FOR LANDSLIDE DISASTER MANAGEMENT PLANNING USING PHOTOGRAMMETRY AND 3D-GIS TECHNIQUES", The International archives of the photogrammetry, Remote sensing and spatial information services Vol 32(7)
4. Ramakrishnan.S.S, Sanjeevi Kumar.V., Venugopal.K (2004) "WEB BASED GIS FOR LANDSLIDE INVENTORY A CASE STUDY OF THE NILGIRIS DISTRICT", National seminar on GIS development march 2004.

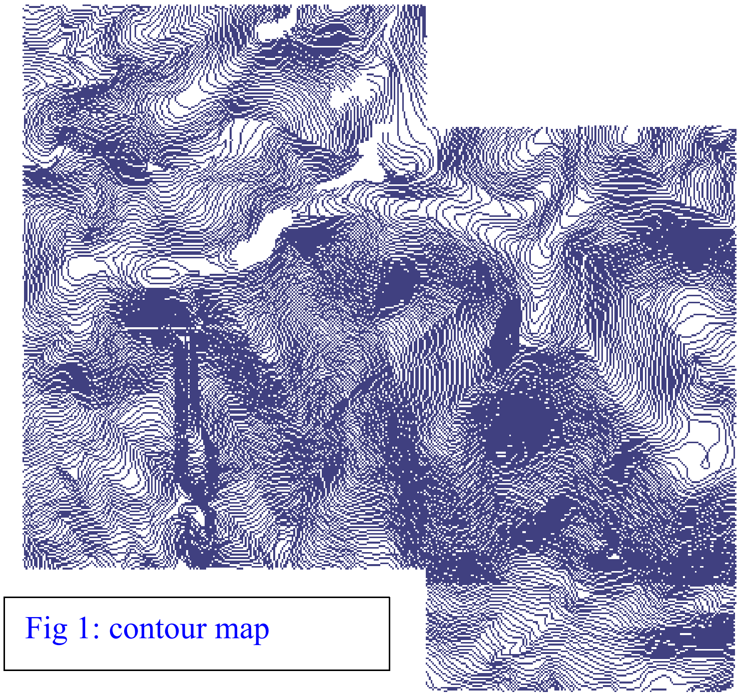
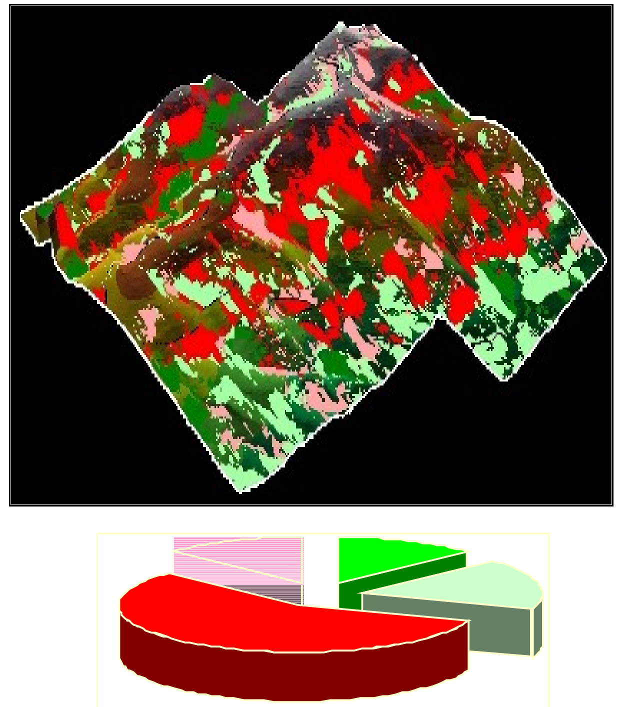
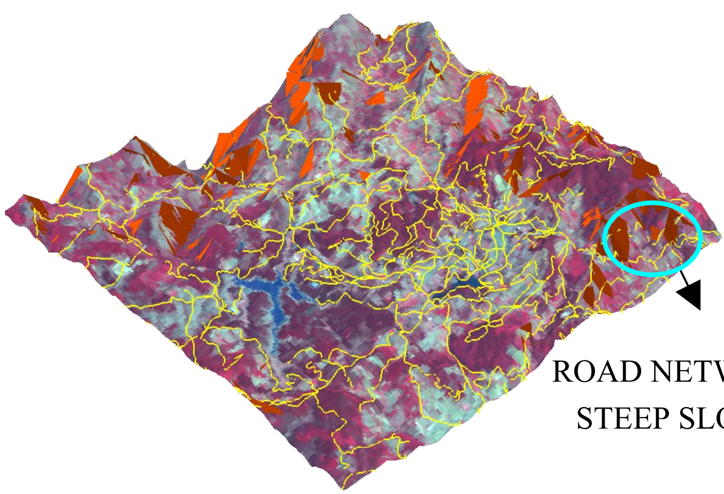


Fig 1: contour map



- Very high - 17%
- High - 34%
- Moderate - 28%
- LOW - 21%

Fig 2: 3D view of landslide zonation



ROAD NETWORK ON STEEP SLOPES

Fig 3: STEEP SLOPES and ROAD NETWORK on DEM

Fig 4: Nature's concept of soil reinforcement