Image Processing and DEM of Spatial Information Technology in Landslide Vulnerable Mapping

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Abstract - The growth in geospatial technologies has enabled communities to make maps of their lands, relief phases and resource uses, and to bolster the legitimacy of their customary claims to measure and to resources. This research paper on which it is based emerged out of common and yet distinct concerns among the authors that spatial information technologies at least in certain contexts and at certain scales alter the complexion and distribution of power. In order to test and refine our ideas about the Image processing and Digital Elevation Model of Geographic Information Technology in the mapping of Landslide areas, we carried a research case study of part of Nilgiri Dist, T.N. The landslide activity is related to the following causative factors like slope, geology, land use and rainfall etc., Thematic maps were prepared for the factors land use, slope and soil, which were described and exchanged by using Extensible Markup Language (XML). The land use map was derived from the image processing technique called ‘supervised classification’ which is completely generated based on the spectral signature values of the satellite image; the slope map was derived from the digital elevation model (DEM) and the soil map was derived from the analysis of image interpretations elements. Vulnerable mapping was prepared by integrating the effect of various triggering factors. Digital image processing involves the manipulation and interpretation of digital images with the aid of computer. The digital image data became widely available for land remote sensing applications. The central idea behind digital image processing is quite simple. The image is fed into a computer one pixel at a time. The computer is programmed to insert these data into an equation, or series of equations, and then store the results of the computation for each pixel. These results from a new digital image that may be displayed or recorded in pictorial format or may itself be further manipulated by additional programs. The objective of image classification is to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This normally involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image. When these decision rules are based solely on the spectral radiances observed in the data, we refer to the classification process as spectral pattern recognition.

An attempt has been made to suggest suitable remedial measure for the highly vulnerable zones by generating the factors from the algorithms of image processing.

Keywords – Image processing, DEM, XML, Land Use, Slope, Soils, Landslides, Spatial Information Technology

I. INTRODUCTION

Landslides are frequent and annually recurring phenomenon in the Nilgiri district. Outward and downward movement of mass, consisting or rock and soils, due to natural or man-made causes is termed as landslide. High intensity rainfall triggered most of the landslides in the Nilgiri district. As long as landslides occur in remote, unpopulated regions, they are treated as just another denudation process sculpting the landscape, but when occur in populated regions, they become subjects of serious study. Most of the landslides occur due to exhaustive deforestation for the development of urbanization and plantation. In these areas rainwater directly penetrates into the soil and cause landslides.

A. Classification of Landslides

1. Slow Flowage: Rock Creep and Soil Creep
2. Rapid Flowage: Earth movements, Mudflows, Debris Avalanche
3. Sliding: Slumps, Rock Slides, Rock falls, and Landslips
4. Subsidence: Sinking of mass

B. Causes of Landslides

Internal factors: The steeping of the slope, water content of the stratum and mineralogical composition and structural features, which are tending to reduce the shearing strength of the rocks.

External factors: A slight vibration or jerk to the mass would greatly add up against the frictional resistance and the mass would become unstable. The heavy traffic on hill roads is of great contributing factors towards causing the imbalance of the masses.

II. OBJECTIVES

- To create spatial database in Geographic Information environment
- To demarcate landslide vulnerable mapping by image processing technique which is ‘supervised classification’
- To visualize landslide prone areas in 3D view for hill are planning
- To describe and exchange the data from thematic layers by using Extensible Markup Language (XML)
III. STUDY AREA

Study area is located in Nilgiri district, which is a mountainous terrain in the North West part of the TamilNadu, and the study area covers a part of the Kothagiri Taluk. It is geographically located between 76° 14’ 00” and 77° 02’ 00” E longitude and 11° 10’ 00” and 11° 42’ 00” N latitude. The study area falls under the Survey Of India toposheet No: 58A/15 on scale 1:50,000 scale.

IV. METHODOLOGY

A. Landslide Hazard Zonation Mapping

Landsat – 7 of satellite image was processed from the image processing techniques and then contour maps were generated from the SRTM data which is downloaded from the open web source. The SRTM data / contour maps are given as input into the GIS – 3D analyst. Here, the 3D visualization of the study area is created. Various thematic layers (slope, land use, soil) are digitally interpreted from the image processing. The delineated thematic layers were vectorized. The landslide model is created and the ranks and weights are assigned to each category. Based on themes and its impacts different zones were delineated.

B. Database Generation for Landslide Vulnerable Zonation Mapping

The landslide investigation and hazard zonation mapping study involves preparation of number of thematic databases such as slope, soil, rainfall, geomorphology, geology, and landuse of the area. As the main purpose of the study is to prepare landslide hazard zonation map and collection of these information being carried out for several decades through the traditional, conventional- ground based surveying and mapping methods, which had taken a lot of time, more man power and cost. But nowadays the emerging satellite based remote-sensing techniques has become more efficient tool for obtaining such information with less cost and time. In the present study, three thematic maps have been interpreted digitally by the image processing and by the Digital Elevation Model. The different thematic maps are slope map, soil map and landuse land cover map.

1) Slope Map: Slope map is very important factor for landslide analysis. If the slope is higher then there is a possibility of occurrence of landslide. Contour maps have been used for the preparation of slope map. Using the GIS – 3D analyst, the Elevation model for the study area is created from the derived contour map. From the elevation model, slope map was generated using “derive slope” command.

2) Soil Map: By interpreting the Landsat – 7 image with help of photo interpretation keys like tone, texture, associated feature and with help of agricultural engineering soil maps, soil types present in the study area have been delineated and mapped. Eight soil series are identified in the study area.

3) Land use Map: Landuse refers to "man's activities and various use which carried on land". Land cover refers to "natural vegetation, water bodies, rock, soil, artificial cover and other resulted due to land transformation". In the present study, landuse / landcover map has been prepared on 1:50,000 scale using Landsat – 7 by image processing.

C. Image Processing / Image classification

Digital image processing involves the manipulation and interpretation of digital images with the aid of computer. The digital image data became widely available for land remote sensing applications. The central idea behind digital image processing is quite simple. The image is fed into a computer one pixel at a time. The computer is programmed to insert these data into an equation, or series of equations, and then store the results of the computation for each pixel. These results from a new digital image that may be displayed or recorded in pictorial format or may itself be further manipulated by additional programs.

The objective of image classification is to replace visual analysis of the image data with quantitative techniques for automating the identification of features in a scene. This normally involves the analysis of multispectral image data and the application of statistically based decision rules for determining the land cover identity of each pixel in an image. When these decision rules are based solely on the spectral radiances observed in the data, we refer to the classification process as spectral pattern recognition.

In contrast, the decision rules may be based on the geometric shapes, sizes, and patterns present in the image data.

Figure 1 summarizes the three basic steps involved in a typical supervised classification procedure. In the training stage (1), the analyst identifies representative training areas and develops a numerical description of the spectral attributes of each land cover type of interest in the scene. Next, in the classification stage (2), each pixel in the image data set is categorized into the land cover class it most closely resembles. If the pixel is insufficiently similar to any training data set, it is usually labeled “unknown.” The category label assigned to each pixel in this process is then recorded in the corresponding cell of an interpreted data set (an “output image”). Thus, the multidimensional image matrix is used to develop a corresponding matrix of interpreted land cover category types. After the entire data set has been categorized, the
results are presented in the output stage (3). Being digital in character, the results may be used in a number of different ways that are amenable to inclusion in a spatial information technology.

Fig. 1. Basic steps in supervised classification.

V. GIS ANALYSIS

In order to generate the landslide prone areas map for Kothagiri area, a model has been developed in a GIS environment. Data in the form of thematic maps such as slope, soil and land use were input in to GIS. The detailed method of assigning weights has been discussed below. Finally the landslide vulnerable map has been prepared.

1) Slope: Slope is a very important parameter in any landslide hazard zonation mapping. In the study area slope varies from 0 to greater than 54 deg. The entire slope contour map was divided in to four categories as follows:

Table 2

<table>
<thead>
<tr>
<th>Slope</th>
<th>Slope Description</th>
<th>Category</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Very steep slope</td>
<td>&gt;54°</td>
</tr>
<tr>
<td>2</td>
<td>Steep slope</td>
<td>36° - 54°</td>
</tr>
<tr>
<td>3</td>
<td>Moderate slope</td>
<td>18° - 36°</td>
</tr>
<tr>
<td>4</td>
<td>Gentle slope</td>
<td>0° - 18°</td>
</tr>
</tbody>
</table>

Thus, the slope contour map has got four categories and suitable weights are assigned. The contour map (Figure 2) has been derived from the DEM data (Figure 3).

Fig. 2. Contour Map derived from DEM.

2) Soil: The occurrence of landslide is mainly due to the presence of huge thickness of loose soils when mixed with water, it triggers the landslide. In the study area, based on the soils erodable nature, it is divided in to four categories as follows:

- Very highly erodable
- Highly erodable
- Moderately erodable
- Poorly erodable.

Thus, the Soil map (Figure 5) has got four categories and suitable weights are assigned.

Fig. 5. Soil Map.

3) Land Use: Landuse / land cover map of an area under investigation has got direct or indirect influence in triggering the landslides. Different types of landuse /land cover features are identified in the study area are such as tea, tea+tree, agriculture, grassland, others, settlement and forest. Suitable weights are assigned. Figure 6 summarizes the input and output of the image scene.

Fig. 3. 3D View of the study Area with Image Scene.

Fig. 4. Slope Map derived from the Elevation Data.

Fig. 6. Summarizes the input and output of the image scene.
Fig.6. Input of the satellite image and Output of the image scene.

4) Criterion Table:

<table>
<thead>
<tr>
<th>Theme</th>
<th>Rank 1</th>
<th>Rank 2</th>
<th>Rank 3</th>
<th>Rank 4</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Weight-4</td>
<td>Weight-3</td>
<td>Weight-2</td>
<td>Weight-1</td>
</tr>
<tr>
<td>Land Use</td>
<td>Grass land, Agriculture</td>
<td>Tea, Tea+Silve roak</td>
<td>Forest</td>
<td>Settlement</td>
</tr>
<tr>
<td>Soil</td>
<td>NL1</td>
<td>NL3,NL2</td>
<td>NL2,NL4, NL5</td>
<td>NL1,NL6</td>
</tr>
<tr>
<td>Slope</td>
<td>36° - 54°</td>
<td>18° - 36°</td>
<td>&gt;54°</td>
<td>0° - 18°</td>
</tr>
</tbody>
</table>

5) Landslide Hazard Zonation Mapping:

Using union command, Landslide hazard zonation map was prepared by integrating the effect of various triggering factors. The zonation map divides the study area into four zones of landslide vulnerability viz., very high, high, moderate and poor. Thus, the landslide prone areas having four zones were obtained.

The Extensible Markup Language (XML) has been developed to compliment HTML, taking over from simply defining what data looks like to describe what is actual is. An XML element can declare its associated data to be an address, a point value with associated attribute data or any other desired data element.

VI. CONCLUSION

Geospatial technologies play a significant role in landslide zonation mapping. Landslide identification, which is a crucial parameter for any regional landslide hazard assessment, can be very well done particularly with image processing. Coupled with satellite image, Geographic Information Technology is an excellent tool to display the spatial distribution of landslides along with their attributes.

REFERENCES