Multi-temporal image derived Ratio Vegetation Index and NDVI in a landslide prone region

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Abstract: Landuse maps are prepared from satellite imagery and field observations were conducted at various locations in the study area. Compared to the field data and NDVI and RVI thematic maps, NDVI is better than RVI, because it compensates for changing illumination conditions, surface slope, aspect and other factors. Clouds, water and snow have negative values for RVI and NDVI. Rock and bare soils have similar reflectance in both NIR and visible band, so RVI and NDVI are near zero. In forest areas with good vegetation cover, NDVI is high and landslide occurrence is less. But if annual and biennial vegetations are present and if cultivation practices are changed frequently, NDVI is medium and landslide occurrence is moderate. In areas where deforestation and settlement is in progress, NDVI is less and landslide occurrence is more. The NDVI FCC thematic map may be used as an important layer in GIS application for landslide studies. Analyzing other layers such as slope, rainfall, soil, geology, drainage, lineament, etc with NDVI FCC layer will give a better idea about the identity of landslide prone areas.

1. Introduction

Landslide is a natural phenomenon that occurs mostly in hilly regions and affects many lives, property, communication and road network. It is the movement of a mass of land along a slope which can be as small as 5°. Main causes of landslides include slope instability, intensive rainfall and snow, deforestation, increased urbanization and development, earthquakes, rise in pore water pressure, intensive agricultural activity in the soil and slopes with frequent changes in landuse etc.

Landslides occur frequently in different parts of Nilgiri district. Their occurrence has been found to be more severe since the last twenty-five years inflicting loss of lives, damage to road networks, railways and other infrastructures.

Remote sensing techniques are well suited to slope instability and landslide studies. Mapping using remote sensing technique is more effective, as remote sensing gives information about large areas with less time and effort when compared to ground survey.

The spectral composition of the radiant flux emanating from the earth's surface provides information about the biological, chemical and physical properties of soil, water and vegetation features in terrestrial ecosystem. Healthy green vegetation generally reflects 40% to 50% of the incident near infra-red energy and absorbs approximately 80% to 90% of the incident energy in the visible part of the spectrum [1]. Remote sensing techniques, models and indices are designed to convert the spectral information into a form that is readily interpretable The most popular method of using remotely sensed spectral reflectance data is by calculating the spectral indices [2].

RVI (Ratio Vegetation Index) and NDVI (Normalized Difference Vegetation Index) are the most common of the ratio transformations used as vegetation measures. They are obtained by ratioing a linear combination of the NIR and red bands by another linear set of the same bands.

$$NDVI = (NIR - RED) / (NIR + RED)$$

$$RVI = NIR / RED$$

These indices have been found effective in normalizing soil-background spectral variation

Conventional methods have been adopted for identifying landslide prone areas in the same location . They have given more importance for soil, rainfall, and elevation etc, and less importance for landuse practices [3]. In this study changing landuse pattern and vegetation are given more importance and are taken into consideration for landslide prone area identification.

By using digital image processing techniques and data from three seasonal images, NDVI maps are prepared and the areas were demarcated into separate zones based on the NDVI categories

2. Study Area and Image Data

The study area is in Nilgiris district and covers a mountainous region in the northwestern part of Tamil Nadu, South India. It is geographically located between 11°22' 30" and 11°30' 00" N latitude and 76°37' 30" and 76°45' 00"E longitude. The study area falls under the Survey Of India topographical sheet No:58A/11on 1:50,000 scale. In this study, Indian Remote Sensing satellites (IRS 1C / 1D) high-resolution data are used.

Table 1. List of IRS Satellite data products used

Sensor	Date of Pass	Resolution (m)
LISS III	22-jan-1999	23.5
LISS III	13-mar-2001	23.5
LISS III	12-jan-2002	23.5

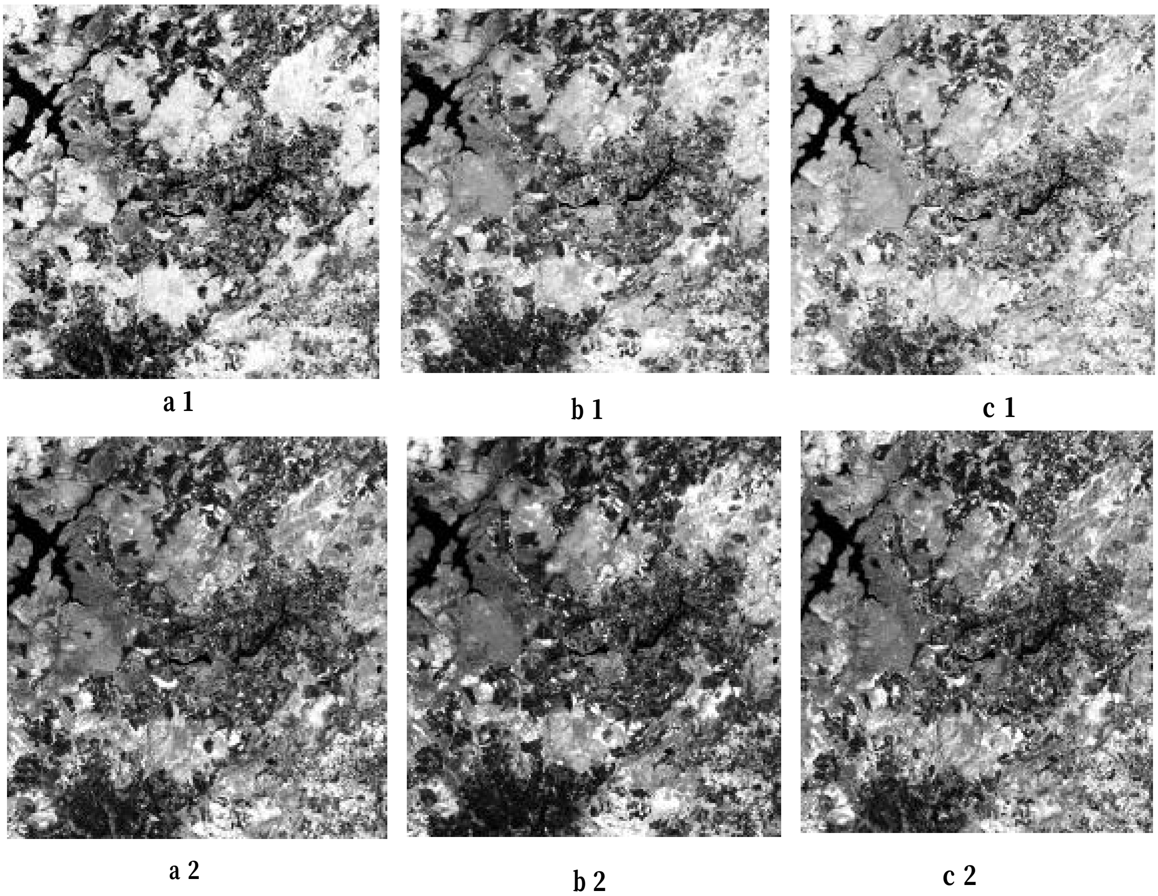

Fig. 1. NDVI images of 1999 (a1), 2001 (b1) and 2002 (c1) and RVI images of 1999 (a2), 2001 (b2) and 2002 (c2).

3. Methodology

RVI and NDVI maps (fig. 1) are prepared for three seasons from IRS 1C and 1D satellite data (tables 1 and 2). Comparative studies are made by using RVI and NDVI maps for identifying the vegetative cover in the study area. Density slicing was attempted on the NDVI images and various vegetation density classes are demarcated. This was compared with the landuse map and details from topographic map of the study area ,to demarcate the landslide prone areas.

Table. 2 LISS III Spectral Bands

Band	Wavelength (mm)	Nominal Spectral Location
I	0.52 - 0.59	Green
II	0.62 – 0.68	Red
III	0.77 – 0.86	NIR
IV	1.55 – 1.75	NIR

Table 3. NDVI values of three seasonal data

NDVI	January1999	March2001	April2002
Minimum	-1.00	-0.294118	-0.4231
Maximum	1.00	+0.6496	+0.7413

4. Results and discussion

It is known that the percentage of vegetative cover and soil background influence the NDVI values [4]. From the three NDVI maps and Table 3, it is seen that the values are between –1.00 and +1.00. High NDVI values and hence bright pixels in the image indicate the presence of more vegetation. Forests are found to have higher NDVI (>0.5) in the study area. These occur in and all the three NDVI images. If the area has more undisturbed vegetative cover, penetration of the extensive root system into the soil forms a barrier to control soil movement, making the area least prone to landslides.

In water bodies, bare soil and in certain deforested areas, the NDVI values are negative and are seen as dark pixels. This is because dead vegetation, soil and water bodies reflect less energy in the NIR region and more energy in the visible region [5]. Apart from water bodies wherever NDVI value is less than zero, there is more probability of landslides. Hence, any further developmental activities are to be avoided here.

Regions showing NDVI values between zero and 0.5 in the three maps may be less prone to for landslides. Slopes with tea and coffee plantations show lower NDVI than forest areas. Areas appearing as dull white pixels and regions showing more NDVI in one season and less NDVI in another season are moderately prone to landslides because of frequently changing cultivation practices.

5. Conclusion

Remote sensing and Digital Image Processing techniques are efficient tools for landslide identification. They provide information about extensive areas in a short time period. Comparing the NDVI and RVI thematic maps, NDVI depicts a feature on the target based on its spectral characteristics more accurately than RVI because, it compensates for changing illumination conditions, surface slope, aspect and other extraneous factors. In forests with healthy vegetation NDVI is high and landslide occurrence is less. But in slopes with intensive agricultural activity and frequently changing agricultural practices, NDVI is medium and landslide occurrence is moderate. In areas where deforestation and settlement is in progress, NDVI is less and landslide occurrence is more. So, it become evident that indiscriminate deforestation, intensive agriculture activity, slope cutting for building construction also contribute to slope instability resulting in landslides.

References

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