5.1

IDENTIFICATION OF LANDSLIDE-PRONE AREAS USING REMOTE SENSING TECHNIQUES

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INTRODUCTION

The landslides are one of the most important types of natural hazards. Large landslides create loss of both human life and property. However, people living in the mountainous regions are accustomed to live with them. With the increased tourism over the past few decades, residential areas have spread over mountainous slopes, which naturally require new communication system. This tampers the natural slopes and environment of the mountainous regions, thereby increasing susceptibility to landslides occurrence.

A review of the historical events leads to the understanding of the processes involved and thereby suggests remedial/ mitigation strategies. Such studies ultimately result in the identification of high susceptible zones of occurrence by preparing landslide zonation maps for typical regions. Slope failure processes are the major causes of concern, especially in areas like Chamoli and Uttarkashi districts, since they not only retard the developmental activities, but also bring a change in the set-up of natural environment. It is, therefore, required that slopes vulnerable to failure may be identified in advance, so that proper measures may be taken up to check the failure processes.

OBJECTIVES

To understand the causative factors, processes and relationships of various geo-environmental factors which finally are used in the preparation of Landslide Hazard Zonation map, depicting areas of slope failures according to the degree of severity.

STUDY AREA

Chamoli and Uttarkashi districts in Garhwal Himalayas of North Western mountainous region of Uttarakhand. The study area extends 170 km from North to South and 25 km from East to West and is bounded by latitude 29° 55′ N to 32° 25′ North and longitude 77° 50′ to 80° 10′ East. The geographical area covered by Chamoli and Uttarkashi is 9,125 sq. km and 8,016 sq. km, respectively.

METHODOLOGY

The Landslide Hazard Zonation (LHZ) map divides the land surface into zones of varying degrees of stability, based on the estimated significance of causative factors in inducing instability. These LHZ maps were prepared based on the basic causative factors of slope instability. The numerical technique was applied for the present study, so that the Bureau of Indian Standard guidelines could be well taken.

Earlier, the work concerning the preparation of landslide hazard zonation was of conventional nature only and there is a lot of scope in the improvement of the methodology, particularly with the advent of remote sensing data, GIS techniques and fast computers. A proper combination of conventional methods with the latest spatial tools and techniques provided a better and faster methodology for the preparation a LHZ maps.

RESULTS/ OUTPUTS

After assessing the contribution of various causative factors and assigning the rating for the same, the stability of slopes was determined from the combined effect of these parameters by superimposing over each other and getting the Total Estimated Hazard (TEHD) value for individual points. These TEHD values indicate the net probability of occurrence of landslide at that particular point. The final results were presented in the form of maps, where TEHD equal to rating of geology + linear features + land-use/ land-cover + slope + aspect + relative relief + drainage. Accordingly, using the Bureau of Indian Standard rating scheme, the TEHD Maps for the study area, viz. Chamoli & Uttarkashi districts, were prepared.

The Integrated Land and Water Information System (ILWIS) developed by International Institute of Aerospace Survey and Earth Science (ITC), The Netherlands, was used to handle the large volume of data. After preparation of thematic maps of various triggering factors for the study area comprising Chamoli and Uttarkashi districts of Garhwal Himalayas in Uttarakhand, they were digitized and converted to raster format for further analysis. Subsequently, thematic maps were converted to score maps after assigning the score values to different subclasses of each thematic map. These maps were superimposed over each other to get their combined effect for Landslide Hazard Zonation. The LHZ map was, then categorized into five classes, viz. (1) Very Low Hazard Zone, (2) Low Hazard Zone, (3) Moderate Hazard Zone, (4) High Hazard Zone, and (5) Very High Hazard Zone. The map was presented after assigning suitable colours and symbols for each of the categories.

The Very Low Hazard and Low Hazard zones are generally safer for developmental schemes. The Medium Hazard zones may contain some local pockets of unstable slopes. Investigations are to be carried out to identify these pockets so as to adopt proper remedial measures. The High Hazard and Very High Hazard Zones are mostly consisted of unstable slopes, which may be active. Especially in the case of High Hazard zones, detailed investigations of unstable slopes should be carried out by mapping the slopes on 1:1000 to 1:2000 scales in order to evaluate the nature of instabilities.

5.2

ENVIRONMENTAL HAZARD ZONATION AND OPTIMAL RESOURCES USE IN THE ALAKNANDA VALLEY, GARHWAL HIMALAYAS USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM TECHNIQUES

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INTRODUCTION

The Alaknanda River originates from the base of Chowkhamba peak and joins the Bhagirathi at Deo Prayag to form the river Ganga. The main tributaries of the Alaknanda are: the Mandakini, the Pindar, the Nandakini, and the Dhauliganga. The valley attracts a large number of religious and other tourists because of the pilgrim centres like Badrinath, Kedarnath, Joshimath, Tungnath, Trijuginaryan, etc. and its scenic beauty exhibited by the Valley of Flowers and many other natural areas. However, due to deforestation, geological upheavals and anthropogenic activities such as road construction, the ecology of the valley has become very fragile and landslides have become a regular feature, especially during the monsoon season. The Alaknanda valley is a repository of rich biological diversity and possesses, within its precincts Nanda Devi Biosphere Reserve (NDBR) and Valley of Flowers, the International heritage sites. Due to several natural and anthropogenic phenomena/processes, the Alaknanda valley faces a number of environmental problems. Some of them have assumed critical dimensions in many parts. The present study was aimed at environmental hazard zonation and optimal resources use in the Alaknanda valley.

OBJECTIVES

- Identification of areas most vulnerable/susceptible to landslides and identification of critically degraded zones/watersheds,
- To find ecological health/status of biosphere reserves (NDBR, Valley of Flowers) in the Alaknanda valley, and
- To analyse and the resource-use pattern and development of management model for optimal resource use.

STUDY AREA

Alaknanda valley in the Garhwal Himalayas, which lies between 30° 0' to 31° 10' North latitudes and 78° 30' to 80° 10' East longitudes

METHODOLOGY

Environmental hazard maps were prepared by using thematic information on the existing/known landslides, forest/vegetation status, lithology, lineaments, drainage, slope and land forms generated using satellite data as well as other sources. Information on bio-resources, environmental hazards, derived using remotely sensed satellite data, ground truth data on related ecological aspects, ancillary data on environmental hazards and socio-cultural data were collated and integrated in GIS environment for the development of an optimal resource-use plan.

The satellite data of IRS LISS-III and PAN of 1999 for certain sites only were used along with LANDSAT-TM data of 1986 for the purpose of vegetation dynamics. Thematic maps were prepared to understand the ecological set-up such as geomorphology, land use, slope, soils, lithology, structural geology, drainage and road net-work. Archived satellite data was analyzed for understanding the dynamics of eco-system components such as forests, grasslands/meadows. Spatial and non-spatial databases were created. Areas affected from landslide hazards were identified and delimitation of hazard-prone areas was done using satellite data and Geographical Information System (GIS). Data on socio-economic and cultural aspects of the people and their resource demands were also collected from sources like census and field surveys. Assessment of bio-resources and environmental hazards in the NDBR and Valley of Flowers was done besides collation and integration of data in GIS environment to analyze resource-use pattern for suggesting suitable plan for optimal resource use.

RESULTS/OUTPUTS

It was found regarding landslide hazard zonation that occurrence of landslides was an indicator of the instability of slopes in various landscape units. The landslide location map was prepared and used in the further analysis of various thematic maps. Landslide Hazard Zone Map was prepared for the entire Alaknanda valley in GIS mode by integrating various thematic layers. In the Alaknanda valley, forests occupied 4,198.51 sq. km area (35.4%), snow 5,042.13 sq. km (42.5%), agriculture 1,017.32 sq. km (8.57%) and grasslands 661.72 sq. km (5.58%) area. Analysis of degraded zones and watersheds showed that 33,508 ha area was under degraded forests. Lower ranges were maximally degraded wherein Chir pine occupied 7,515 ha area under degraded forests while mixed degraded forests had 10,355 ha area. In the higher reaches, Juniper-degraded forests occupied 7,219 ha area.

As far as optimal resource-use was concerned, the Alaknanda valley occupied 11, 86,282 ha of area having 2,433 revenue villages. The results were presented with the description of land-cover/vegetation types, their area, resource availability and consumption. the fodder and fuel wood consumption in the Alaknanda valley was calculated as 8,46,765 tonnes/year and 4,56,411 tonnes/year, respectively. At optimal level of extraction, fodder was deficit (-12,602 tonnes /year), while fuel wood was surplus (+2, 14,599 tonnes /year) in the revenue villages. Considering revenue as well as non-revenue land together fodder was still deficit (-2, 73,562 tonnes/year) at optimal level of extraction, while fuel wood was surplus. Fodder and fuel wood consumption and availability have also been worked out sub-watershed-wise and village-wise.

5.3

LANDSLIDE RISK ASSESSMENT IN DARJEELING HIMALAYA USING REMOTE SENSING AND GEOGRAPHIC INFORMATION SYSTEM

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INTRODUCTION

The landslide hazards, in general, cannot be completely prevented; however, the intensity and severity of their impacts can be minimized if the problem is recognized before the development or deforestation begins. Determining the extent of landslide hazard requires identifying those areas of the landslide occurring with some time period. In general, specifying a time frame for the occurrence of a landslide is difficult to determine even under ideal conditions. As a result, landslide hazard is often represented by landslide susceptibility, also referred to as landslide hazard.

Through landslide susceptibility mapping, an area can be classified into different susceptibility classes according to the degree of actual or potential hazards from landslides. In other words, the landslide susceptibility map delineates the areas with varying potential for future landslide occurrences. Further, it is always necessary to estimate the consequences of the hazardous phenomena to assess the risk. This deals with the economic, societal and environmental elements at risk. A landslide risk map indicates different degrees of risks involved in different hazard-prone areas. This type of study can be accomplished more systematically and scientifically using remote sensing and Geographic Information System (GIS) techniques. An ideal GIS for landslide hazard donation combines conventional GIS procedures with image processing capabilities and a relational data base. Necessary GIS functions include map overlay, reclassification and a variety of other spatial functions incorporating logical, arithmetic, conditional and neighborhood operations. With this in view, the present study on landslide risk assessment was carried out in parts of Darjeeling Himalayas, which is known to be highly prone to landslide occurrence.

OBJECTIVES

- To delineate the zones of potential landslide hazards and assess the landslide risk in the Darjeeling Himalayas using the remote sensing data and its analysis in GIS environment
- To prepare various thematic maps from satellite images, topographic maps, field data, etc., and

- To do landslide susceptibility mapping for identifying critical zones of instability by analyzing the spatial data in GIS and assessment of risks in the hazard-prone areas.

STUDY AREA

Darjeeling hills, covering an area of about 254 km including localities of Darjeeling, Sonada and Sukhiapokhri

METHODOLOGY

Data of Survey of India (SOI) toposheets numbering 784/4.A/8,B/1 of 1:50,000 scale and 78A/8/2, A/8/6, B/5/1of 1:25,000 scale were used. Besides IRS-IC LISS III and IRS-ID PAN satellite data, information from published geology and soil maps were used for the preparation of base map. As landslides were the result of interaction of complex factors, the spatial prediction of landslide susceptibility was a difficult task.

The methodology involved selection of factors, generation of data layers in the GIS, numerical rating assignment to factors, data integration in GIS, computation of landslides potential index, suitable classification of landslide susceptibility and validation of resulting map. Attempts were also made to validate the map with existing landslides distribution and statistical significance test.

RESULTS/OUTPUTS

The landslide susceptibility map was prepared using remote sensing and GIS in the study depicting the existing and potential areas of landslide hazards. The merging of Indian Remote Sensing multi-spectral and panchromatic satellite data greatly improved the quality of terrain features in the image. The landslide susceptibility map of the area was prepared in GIS. The landslide susceptibility map divided the area into four classes of susceptibility, viz. high, moderate, low and very low. The map was checked in the field and it was observed that the areas of high susceptible zones showed significant indications of slope instability marked by landslides, erosion and subsidence. Determining landslide frequency of each susceptible class also validated the map. The statistically significant value of the chi-square test validated the susceptibility classes of the map. The landslide susceptibility map was then used to assess the landslide risk. For this, the risk elements considered were habitation, roads, tea plantation, agriculture and forest. The risk assessment for these risk elements was carried out which was based on the degree of susceptibility in the region. The risk maps prepared showed the degree of risk associated with the risk elements.

To be more specific about the future landslide occurrence in the region, more detailed investigations were required. Further, any change in the natural environment by human interference, may change the existing landslide susceptibility of the area. Hence, such maps need to be updated periodically. It was always better to avoid the highly susceptible zones, but if not possible, corrective measures need to be worked out. The risk maps prepared were of immense use for disaster management/planning.