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LANDSLIDE HAZARD ZONATION & VULNERABILITY ASSESSMENT USING REMOTE SENCING & GIS TECHNOLOGY

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ABSTRACT

The landslides are one such type of hazards usually triggered by the neo-tectonic movements, earthquakes, heavy precipitation and those induced due to land-use changes such as felling of trees, agriculture, mining and road cutting in hilly terrain. Slopes are one the most common landforms, and though most slopes appear stable and static; they are actually dynamic evolving systems. Material on most of the slopes is constantly moving down at rates that vary with imperceptible creep of soil and rock to thundering avalanches and rock-falls moving at tremendous speeds. Vulnerability to landslides can be evaluated only if we know the exposure to landslide hazard and our preparedness to face that hazard. Vulnerability will be close to nil in the case of well managed and protected slopes. It will be the maximum for unprepared populations living on slopes with a proven history of landslides.

I. INTRODUCTION

Natural earth processes contribute significantly in shaping the landscape of earth, and some of them are hazardous to people. These natural hazards must be recognized and must be avoided wherever possible, and their threat to human life and property must be minimized. Landslides are caused in hilly terrains due to factors like gravity, weathering, deforestation, earthquake, heavy precipitation etc, and result in loss to property and life. Landslide is a general term used to describe the down-slope of soil, rock and organic material under the influence of gravity. This phenomena cause property damage, injury, death and adversely affect a variety of resources in the disaster areas.

To monitor the landslide phenomena, it is imposed to represent the area under investigation by a number of points that are monument durably. Some stations are used to define a stable reference frame and the remaining stations are the monitoring points situated in the deformation area. In this way, the determination of the movement of the control stations is done relatively to the reference ones. Among the natural hazards, slope failure processes are the major cause of concern in mountainous terrain, since they not only retard the developmental activities in hilly areas, but also destroy lives and property and cause heavy environmental damages. The landslides are the cause of some of the worst human suffering in the past. Landslide, erosion and other slope failure processes are the most frequent natural calamity occurring under varied natural conditions. It is therefore, imperative that slopes vulnerable to failure should be identified in advance, so that proper measures may be taken up to check the failure processes. Alternatively, developmental activities may be planned in accordance with the slope stability conditions of a hilly region. However, this requires a thorough understanding of causative processes and their relationship with various geo-environmental factors. This can be achieved by preparing landslide hazard zonation map depicting areas of slope failure accordance to their degree of severity.

II. LITERATURE SURVEY

● Landslide Susceptible Zone Mapping In Uttara Kannada, Central Western Ghats

(sahyadri conservation series 7 envis technical report: 28 february 2012)

Large scale landslides involving human casualties and notable losses to property were practically unknown in Uttara Kannada district situated towards the central Western Ghat-west coast region of Indian peninsula. A rethinking has set in, however, following a major disaster in early October, 2009, when following rainfalls of unprecedented intensity for the period, over 20 landslides happened during a single day in Karwartaluk, in which 19 people were buried alive in a single locality itself, and in other places the residents had providential escape due to marginal shifts in the actual locations of slope failures from human habitations. That the threat for future is at large can be deduced from the recurrence of a rockslide hitting a running train during the rains of 2010, killing one person and injuring others.

●Landslide Hazard Zonation Of Aizawl District, Mizoram, India Using Remote Sensing And Gis Techniques

(R.K.Lallianthanga and F. Lalbiakmawia, Mizoram Remote Sensing Application Centre, Science & Technology, Planning Department, Aizawl Mizoram)

Landslide is the most frequently occurring natural hazard in the tectonically active region of the Himalaya. The immature geology with high degree of slope coupled with high rainfall are the natural causes of landslide in this region. In addition, the unplanned human activities also cause landslides. The present study was taken up to investigate the Landslide Hazard Zonation (LHZ) of Aizawl district, Mizoram that consists of four urban settlements and ninety seven rural villages. Using Remote Sensing and Geographic Information System (GIS) techniques, thematic layers like slope morphometry, geological structures like faults and lineaments, lithology, relative relief and land use / land cover were generated.

●Use Of Remote Sensing Data And Gis Technology For Assessment Of Landslide Hazards In Susa Valley, Italy

(Nora Tassetti, AnnamariaBernardini and Eva SavinaMalinverniDARDUS- UniversitàPolitecnicadelle Marche, Ancona, Italy)

The aim of the research was to monitor and assess landslide hazards by remote sensing data processing and GIS spatial analysis. The automatic classification of remote sensing images pro-vides many useful land use information to combine in a GIS environment with other spatial factors influencing the occurrence of landslide. The upper part of Susa Valley, in the Italian Western Alps, was chosen as test area because of a large variety of remote sensing data available by ISPRSWG VIII/2 with the aim to exchange infor-mation and experience in the field of geomatic techniques.

III. OBJECTIVES

The aim of the study is to find an efficient methodology to delineate the Landslide hazard areas. Also the another aim is to identify the locations of landslide factors controlling the landslides or slope stability in various high relief areas and to suggest Civil Engineering Measures to reduce the short term and long term damages caused by landslides based on the vulnerability assessment.

- Study the Geo- informatics approach towards Landslide Hazard and Vulnerability.
- Study the Spectral signature or reflectance characteristics of land with respect to slope instability.
- Study in detail the geomorphology, slope, lineaments, relative relief, Land-use, NDVI and drainage aspects of the Landslide area.
- Study the image interpretation keys or photo reorganization elements to identify Pre-occurred events and vulnerable sites.
- Develop a spatial database for landslide analysis
- Prepare the landslide susceptibility or Hazard Zonation Map after the analysis of generated RS and GIS layer combinations.
- Study geo -environmental and socio parameters related to the landslide vulnerability.
- Delineate the Vulnerable areas.
- Prepare Landslide Vulnerability Assessment with respect to Construction Management activities.
- Provide a decision support tool for hazard managers and planners

IV. PROPOSED WORK

• Geo-Informatics:

Geo-Informatics is the science and technology of gathering, analysing, interpreting, distributing and using geographic information. Geo-Informatics encompasses a broad range of disciplines including surveying and mapping, Remote Sensing (RS), Geographic Information Systems (GIS), and the Global Positioning System (GPS).

• Concept of Geo-Informatics:

Geo-Informatics is the synergy of multiple disciplines, namely, GIS, Remote Sensing, photogrammetric, cartography, GPS and geodesy. It is fundamental to all the disciplines which use data identified by their locations. Geo-Informatics deals with spatial and non-spatial data, their methods of acquisition, management, analysis, display, and dissemination. Applications of Geo-Informatics are mainly oriented to real world management problems pertaining to natural and man-made environments.

Geo-informatics Application:

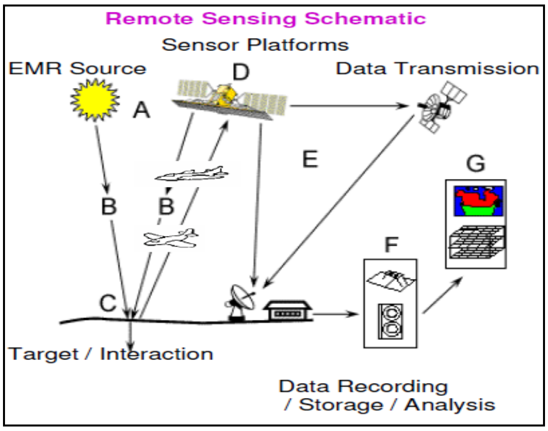
The approach takes into consideration various elements of natural resources, viz., all base layers, existing land use / land cover, soil map, hydro geomorphology, terrain slope, drainage, watershed maps and local peoples' aspirations with respect of socio economic considerations to suggest a suitable action plan for sustainable development of land and water after scientific analysis of the spatial and non-spatial data.

- **Remote Sensing:**

"Remote sensing is the science (and to some extent, art) of acquiring informationabout the Earth's surface without actually being in contact with it. This is done by sensing and recording reflected or emitted energy and processing, analysing, and applying that information". Remote Sensing is defined asthe measurement oracquisition of information of some property of an object or phenomenon, by arecording device that is not in physical or intimate contact with the object orphenomenon under study; e.g., the utilization at a distance (as from aircraft,spacecraft, or ship) of any device and its attendant display for gatheringinformation pertinent to the environment, such as measurements of force fields,electromagnetic radiation, or acoustic energy. The technique employs suchdevices as the camera, lasers, and radio frequency receivers, radar systems, sonar, seismographs, gravimeters, magnetometers, and scintillation counters.

- **Remote Sensing Process**

The process of remote sensing involves the detection and measurement of radiation of differentwavelengths reflected or emitted from distant objects or materials, by which they may beidentified and categorized by class/type, substance, and spatial distribution. The backgroundrequired for use of remote sensing tools may seem overwhelming at first. The decisive factor inthe successful application of remote sensing data, however, need not be the technicalsophistication of the user, but rather the suitability and precise use of the tool to obtain accurateand relevant data. A general grasp of the technical process that transforms electromagnetic energyinto useful information can improve and expand the appropriate use of these tools. Nevertheless,depending on the application, social scientists wishing to work with remote sensing imagerywould do well to partner with physical scientists with a deeper understanding of how the imageryrepresents physical processes on the ground.



Principle of Remote Sensing:

- Different objects return (reflects or emits) different amount & kind of energy in different bands of electromagnetic spectrum incident upon it.
- This unique property depends on the structural, chemical, physical properties of material & also surface roughness, angle of incidence, intensity & wavelength of radiant energy.
- RS is multidisciplinary science which includes optic, spectroscopic, photography, computer science, electronics & telecommunication, satellite tech. etc.
- All these technologies are integrated to act as remote sensing.

Gps- Global Positioning System

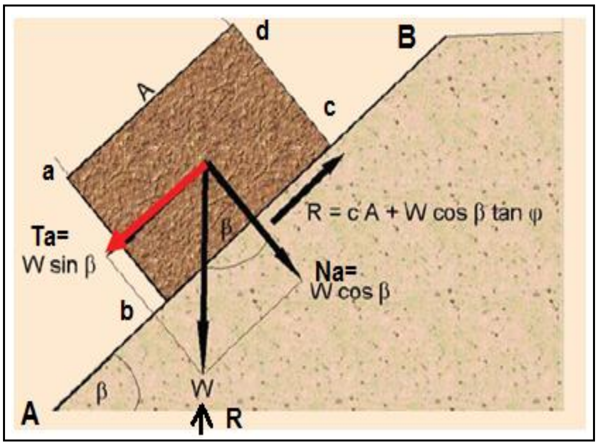
The Global Positioning System (GPS) is a burgeoning technology, which provides unequalled accuracy and flexibility of positioning for navigation, surveying and GIS data capture. The GPS provide continuous three-dimensional positioning 24 hrs a day throughout the world. The technology seems to be beneficiary to the GPS user community in terms of obtaining accurate data up to about 100 meters for navigation, meter-level for mapping, and down to millimeter level for geodetic positioning. The GPS technology has tremendous amount of application in GIS data collection, surveying, and mapping.

Functions Of Gps (Global Positioning System):

The Global Positioning System consists of constellation of 24 earth-orbiting satellites so that there are atleast 4 guaranteed satellites above the horizon for any point on earth at any time. In general there are normally 8 or so satellites "visible" to a GPS receiver at any given moment. Each satellite contains an atomic clock. The satellites send radio signals to GPS receivers so that the receivers can find out how far away each satellite is sometimes with millimeters precision at a given time. Because the satellites are orbiting at a distance of 11,000 miles overhead, the signals are fairly weak by the time they reach a GPS receiver. That means we have to be outside in a fairly open area for the GPS receiver to work. The GPS has become a very versatile input source for latitude, and longitude information in the recent past.

Mechanisum Of Landslides:

The occurrence of slope movements is the consequence of a complex field of forces (stress is a force per unit area) which is active on a mass of rock or soil on the slope. The consequence of these forces in conjunction to the slope morphology and the geotechnical parameters of the material define together the specific type of landslide which might occur. Movement occurs when the shear stress exceeds the shear strength of the material.



Let us consider a slope element, ‘abcd’, having unit length perpendicular to the section shown in the figure. The forces, ‘F’ that acts on the faces ‘ab’ and ‘cd’ are equal and opposite and may be ignored.

The weight of soil element (W) = Volume of soil element X Unit weight of Soil.

$$W = \gamma \times L \times H$$

The weight is resolved in two components as:-

1] Force perpendicular to plane AB = Na = W X Cosβ

$$Na = \gamma \times L \times H \times \cos\beta$$

2] Force parallel to plane AB = Ta = W X Sinβ

$$Ta = \gamma X L X H X Sin\beta$$

This is the force that tends to cause the slip along the plane at the base of slope element.

∴ Normal stress = σ = Na / Area of base

$$\sigma = W X Cos\beta / A$$

∴ Shear stress = τ = Na / Area of base

$$\tau = W X Sin\beta / A$$

The reaction to the weight (W) is equal and opposite to the force (R).

Therefore W = R

The normal component = Nr = R Cosβ ………with respect to plane 'AB'.

$$Nr = W X Cos\beta$$

The tangential component = Tr = R Sinβ ………with respect to plane 'AB'.

$$Tr = W X Sin\beta$$

The resistive Shear Strength at the base of element is,

$$\tau_d = c + \sigma \tan\phi$$

$$\tau_d = c + Na / A X \tan\phi$$

$$W X Sin\beta / A = c + W X Cos\beta / A X \tan\phi$$

$$R = cA + W X Cos\beta X \tan\varphi$$

$$\boxed{R = cA + W . Cos\beta . \tan\varphi}$$

This study uses remote sensing and GIS tools to extract detailed geomorphic, structural, land-use, slope and drainage information in hilly area and suggests an appropriate model for landslide hazard zonation and mitigation studies.

- **Causes Of Landslides Are Divided In Following Groups-**

1] Geological causes

2] Morphological causes

3] Physical causes

4] Human causes

5] Natural causes

- **Landslide Hazard Zonation:**

Most popularly, "Natural hazard" is defined as the probability of occurrence of potentially damaging phenomena within a given area and in a given period of time.

It incorporates three components: magnitude, geographical location and time.

Landslide hazard zonation (LHZ) refers to "the division of the land surface into homogenous areas or domains and their ranking according to degrees of actual/potential hazard caused by mass movement".

Landslide hazard is typically depicted on maps which show spatial distribution of hazard classes, or "landslide hazard zonations."

Demarcation or mapping of these zones requires knowledge of the processes active in the area and factors (geologic and triggering) causing landslides.

- **Scales Of Analysis**

1 National scale

2 Regional scale

3 Medium scale

4 Large scale

5 Site investigation scale

Factors Associated With Landslide Activity:

The distribution of past landslides within the area, type of bedrock, and slope steepness represent, respectively, geomorphic, geologic, and topographic factors. Each of these factors is described in more detail below to give the planner a better understanding of their contribution to landsliding.

A.Past Landslides and Their Distribution

B. Bedrock

C. Slope Steepness or Inclination

D. Hydrologic Factor

E. Human-Initiated Effects

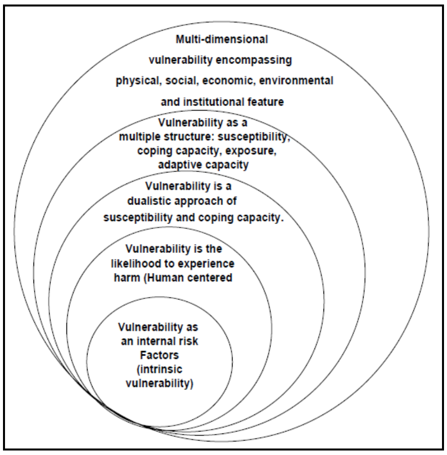
- **Vulnerability**

Vulnerability is defined as on the basis of exposure to risk and an inability to avoid or absorb potential harm. Vulnerability is defined as physical vulnerability as the vulnerability of the physical environment; social vulnerability as experienced by people and their social, economic, and political systems; and human vulnerability as the combination of physical and social vulnerability.

Vulnerability is defined in terms of susceptibility, exposure and copping capacity which can be expressed mathematically as below,

$$\text{Vulnerability} = \frac{\text{Susceptibility} \times \text{Exposure}}{\text{Coping } \textit{capacity}}$$

The concept of vulnerability is also expressed in terms of different levels of vulnerability sphere, starting from ‘vulnerability as an internal risk factor’ to multidimensional vulnerability incorporating physical, economic, social, economic, environmental and institutional features.



Conceptual spheres of vulnerability

V. CONCLUSION

The results obtained from the spatial analysis of thematic layers in the GIS environment in the form of Landslide Hazard Zonation, Landslide Susceptibility Mapping and Vulnerability Zonation has been discussed in short. Then the results obtained from the vulnerability assessment have been also included in this chapter

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[3] USE OF REMOTE SENSING DATA AND GIS TECHNOLOGY FOR ASSESSMENT OF LANDSLIDE HAZARDS IN SUSA VALLEY, ITALY (Nora Tassetti, Annamariabernardini And Eva Savinamalinvernidardus- Universitàpolitecnicadelle Marche, Ancona, Italy)