Geographical Information System Based Landslide Probabilistic Model with trivariate approach-A case study in Sikkim Himalayas.

L.P. Sharma, Nilanchal Patel, M.K. Ghosh, P. Debnath

Presentation By
L.P. Sharma(lp.sharma@nic.in)
Scientist-D & Principal System Analyst
National Informatics Centre, India
Investigators:

**Shri L.P. Sharma**, B.Tech (ECE), M.C.Sc., Ph.D. (Ongoing)
Principal System Analyst & Scientist In-charge
Geo-Informatics Cell, National Informatics Centre, Sikkim

**Dr. Nilanchal Patel**, M.Tech. (Applied Geology), Ph.D
Remote Sensing
Professor, Department of Remote Sensing, Birla Institute of Technology, Mesra, Ranchi, India

**Dr. M.K. Ghose**, Senior Scientist/ISROW (Retd.)
Professor & HOD, Computer Science Department
Sikkim Manipal Institute of Technology, Mazitar, Sikkim, India

**Dr. P. Debnath**, Bsc. (Agri), Msc (Agri), Ph.D. (Soil Science)
Assistant Professor
College of Agriculture Engineering and Post Harvest Technology
Ranipool, Sikkim, India
Sikkim - Land of Eternal Beauty
Such Natural Beauties are often disturbed by the Terror of Landslides
Landslides

- Landslide has been a disaster of Big Concern.

- In 1968 the state lost 3300 lives and properties worth rupees million when a prolonged monsoon triggered landslides in many places.

- Since then the Landslide has been disturbing the civil lives, public properties and private properties in many ways.

- Some times the infrastructure projects are washed away while at completion phases.

- The local governments are finding it tough to make the development activities sustainable and ensure safety to public from landslide hazards.
Characteristics..

- Average Slope > 60%
- Soil Texture is Mostly Coarse Loamy
- Weak Rocks like Chlorite, Phyllite/Sericite Mostly Prevail
- Average Rainfall up to 3000 mm per Annum.
- Lies in the boarder of Indian and Eurosian Plate and has high Seismic Threat.
- Civil Construction and Urbanization is rapid to meet the demand of growing Population.
The Scope of this Study

- To explore the possibility of GIS based Landslide Vulnerability Study and to measure its accuracy.
- To delineate the highly Vulnerable Area within the Study Area for implementation of immediate precautionary measures.
- An attempt to demonstrate the technology driven Vulnerability Assessment as a replacement for Conventional Methods.
- An attempt to demonstrate the importance of spatial data.
# Data Used for Study

## Table 1. List of Data Used in the Study

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Name of Thematic Layers</th>
<th>Original Map Scale</th>
<th>Data Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Slope Map</td>
<td>1:50,000</td>
<td>DEM/50k Topographic Map</td>
</tr>
<tr>
<td>2</td>
<td>Land Use &amp; Forest Map</td>
<td>1:50,000</td>
<td>NIC-GIS Databank</td>
</tr>
<tr>
<td>3</td>
<td>Geological Map</td>
<td>1:50,000</td>
<td>Geological Survey of India.</td>
</tr>
<tr>
<td>4</td>
<td>Soil Map</td>
<td>1:250,000</td>
<td>NIC-GIS/NBSS&amp;LUP</td>
</tr>
<tr>
<td>5</td>
<td>Road Map</td>
<td>1:50,000</td>
<td>NIC-GIS Databank</td>
</tr>
<tr>
<td>6</td>
<td>Drainage Map</td>
<td>1:50,000</td>
<td>Digitized from Topographic Map</td>
</tr>
<tr>
<td>7</td>
<td>Topographic Map</td>
<td>1:250,000</td>
<td>Rural Management Dev. Department, Govt. of Sikkim.</td>
</tr>
<tr>
<td>8</td>
<td>Cartoset Pan Image</td>
<td>2.5 m Res.</td>
<td>NRSA</td>
</tr>
<tr>
<td>9</td>
<td>Quick Bird Image</td>
<td>0.6 m Res.</td>
<td>Wikimapia</td>
</tr>
<tr>
<td>10</td>
<td>Landslide Events Map</td>
<td>1:10,000</td>
<td>Digitized from cartoset/wikimapia verified with field survey.</td>
</tr>
</tbody>
</table>
The Landslide Information Value for the jth polygon was calculated as:

\[
LSIV_j = W_{1j} \sum_{i=1}^{p(1)} X_{ij}(W1) LD_{ij}(W1) + W_{2j} \sum_{i=1}^{p(2)} X_{ij}(W2) LD_{ij}(W2) + \ldots + W_{n_j} \sum_{i=1}^{p(n)} X_{ij}(Wn) LD_{ij}(Wn)
\]

Where  
- \( W_1, W_2, \ldots, W_n \) are the expert based weights of the Nth identified parameters.  
- \( X_{ij}(Wn) \) is the variable value of Ith variable of the Wn parameter for the Jth polygon.  
- \( LD_{ij}(Wn) \) is the Landslide Density due to Ith variable of Wn Parameter for the Jth polygon.
## Classification of Parcels

<table>
<thead>
<tr>
<th>LSIV</th>
<th>No. of Polygons</th>
<th>Area (Sq. Km)</th>
<th>No. of Landslides</th>
<th>Vulnerability Zones</th>
</tr>
</thead>
<tbody>
<tr>
<td>78-110</td>
<td>1309 (13%)</td>
<td>10.91 (30%)</td>
<td>3 (11%)</td>
<td>Least Vulnerable</td>
</tr>
<tr>
<td>111-144</td>
<td>3800 (39%)</td>
<td>14.7 (41%)</td>
<td>9 (32%)</td>
<td>Moderately Vulnerable</td>
</tr>
<tr>
<td>145-328</td>
<td>4651 (48%)</td>
<td>10.66 (29%)</td>
<td>16 (57%)</td>
<td>Most Vulnerable</td>
</tr>
<tr>
<td>1100</td>
<td>9760 (100%)</td>
<td>36.27 (100%)</td>
<td>28 (100%)</td>
<td></td>
</tr>
</tbody>
</table>
Production of Zonation Map

Study Area-Sang Revenue Circle Landslide Zonation Map

Legend
- Least Vulnerable Zone
- Moderately Vulnerable Zone
- Most Vulnerable Zone

1,600 750 0 1,600 Meters

Study Area-Sang Revenue Circle Landslide Inventory Map

Legend
- Rock Slide
- Creep
- Debris Fall
- Debris Flow
- Debris Flow & Slide
- Debris Slide
- Village boundary

1,600 750 0 1,600 Meters
Bar Chart with Statistics

Bar Chart Showing Area Falling in Different Vulnerability Zones

Area In Sq. Km.

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<thead>
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</tbody>
</table>

Bar Chart Showing No of Landslides in Different Vulnerability Zones

No of Landslides

<table>
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<td>57%</td>
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The Study Concludes

- Geographical Information System is very useful in assessing the vulnerability to landslide hazards.
- Using GIS accurate prediction of landslides is possible using highly accurate spatial data.
- The method of tri-variate approach is simple and gives around 70%-80% accuracy in assessing the landslide vulnerability.
- The application of GIS will go a long way in making our development activities sustainable.
Stakeholders of National GIS

- **SOI**
  - Base frame work data
  - Surveying

- **DOS**
  - Satellite Images
  - Wasteland Mapping

- **Others**
  - FSI - Forest Cover
  - SLUSI - Soil
  - CGWB - Ground Water

- **Non-Spatial Data**
  - RGI - Census 2001
  - Educational Survey
  - Health Survey

- **NIC**
  - Facilitator
  - Integrator
  - Standardization
  - Dissemination-Enterprise

- **National GIS**
Enterprise Framework Architecture
Spatial Data

Non-Spatial Data

Web Based GIS Application

Internet

Spatial Data

Web Services like WMS, WFS

Browse

LAN

Thick Client – GIS

Local Data

Thick Client - open Source/Proprietary

Data Sharing / Access Models

Local Data
Administrative Boundary Database

- Mapping of 6,38,387 Villages of India with other administrative units linked with Census 2001.
- Forms core data for e-governance applications.
- Socio-economic indicators and Demographic Studies.
- Verification, update, roll out plan in progress
National GIS - Web based Dissemination System with GIS functions like navigation, query, analysis, print.
Web GIS for Village Level Mapping of Demography and Amenities
Thematic Atlas for the entire Country

National GIS Project

INDIA

STATE ATLAS - ANDHRA PRADESH

DISTRICT ATLAS - KURUKULA

Number of Primary Schools

Source: 30Census 2011
Maps Composed by NIC

Number of Primary Schools

0-489
490-777
778-1468
1469-5657
5657-4446
Raster Data Services

- Countrywide mosaic of Topo-maps
- Countrywide mosaic of Satellite images of various resolution upto 5m.
- Quick Bird (60 Cm) images for district Head Quarters.
- Image Classification and Infrastructure Mapping
Visualization from maps/sat. images

PAN with Topo Maps

Quick Bird Image for Rupnagar, Punjab
Key GIS Implementations

- Dissemination using Enterprise GIS Architecture
- Planning of mobile services across the country.
- Emergency Planning and Response system
- Watershed Management System
- Value Added services for operational MIS services.
- GIS based Election Management
GIS BASED EMERGENCY PLANNING & RESPONSE SYSTEM
FOR MAJOR HAZARDOUS INDUSTRIES

- Offsite emergency planning tool developed using Map Objects.
- Chemicals modeling using ARCHIE/ALOHA integrated with MO. Over 2000 footprints generated.
- Implemented in 40 districts & hazardous Industries.
- Response Inf. data sheets for 463 chemicals.
Value Addition to MIS

Agricultural Marketing Network

- Mapping of around 7000 agricultural Markets.
- Daily Arrival of commodities.
- Price Index
- Market Profile
- Demand Supply Chain
Better civic services to citizens at large through computer assisted mapping of utilities

• Utility Mapping model implemented for Delhi.

• This model is further replicated in the six cities of Mumbai, Chennai, Kolkata, Bangalore, Hyderabad and Ahmedabad.
To summarize

✓ Integrated Services Delivery using GIS is a essential component to e-gov process.

✓ National GIS has triggered the process of integration of data from various sources.

✓ We continue to provide our support for evolving common standards and policies, human resources and knowledge sharing.

✓ Spatial Data Infrastructure accomplishes the delivery of effective and efficient implementation of e-governance programmes through GIS at grass root level.
Thank You