

# Application of Geo-spatial Technology in Landslide Hazard Vulnerability Study



L.P.Sharma, [lp.sharma@nic.in](mailto:lp.sharma@nic.in)  
National Informatics Centre  
Department of Information Technology  
Government of India

# RS& GIS in Landslide Management

- **Landslide is a serious problem for the hilly regions.**
- 
- **Landslide causes losses to lives properties and resources thereby disturbing natural lifestyles of the citizens.**

# RS& GIS in Landslide Management

- Landslide analysis is a complex analysis, involving multiple impact factors. Systematic approach may however lead to exact location of the landslide prone areas.
- The development of computational technology in terms of speed and capacity has empowered geospatial technology for efficient analytical modeling of geo-data for probabilistic study, zoning and forecasting of landslide hazards.
- Spatial Decision Support System for landslide hazard forecasting and management have become a possibility.

# Landslide Study & Management

## ● Input Data Requirement

- Geological Map
- Structural Map
- Geomorphologic Map
- Pedological Map
- Petrology or Lithology Map
- Topographic Map
- Administrative Boundary Map
- Transportation Network Map
- Drainage and Water bodies Map
- Land Use/Land Cover Maps
- Contour Maps
- Major Thrust Area Map
- Slope Angle Map
- Aspect map

## ● Satellite Imagery

IRS-IC Multi-spectral LISS –III/IV or Quickbird/Worldview image of few years taken during end-monsoon seasons.

- IRS-ID Panchromatic Image
- Arial Photos

## ● Statistical DATA

- Annual Precipitation data of the study area
- Demographic Data
- Seismological Data

# Factors Causing Landslide

- Controlling/Conditioning factors
  - Rock types----Petrology Map
  - Rock Structure----Geological Map/ Structural Map
  - Slope Angle----- Slope Map/DEM
  - Soil Type---- Soil Map from Soil Survey Near By Thrust Area---Satellite Image/Ariel Picture
  - Surface Tectonism-----Seismic Ranking



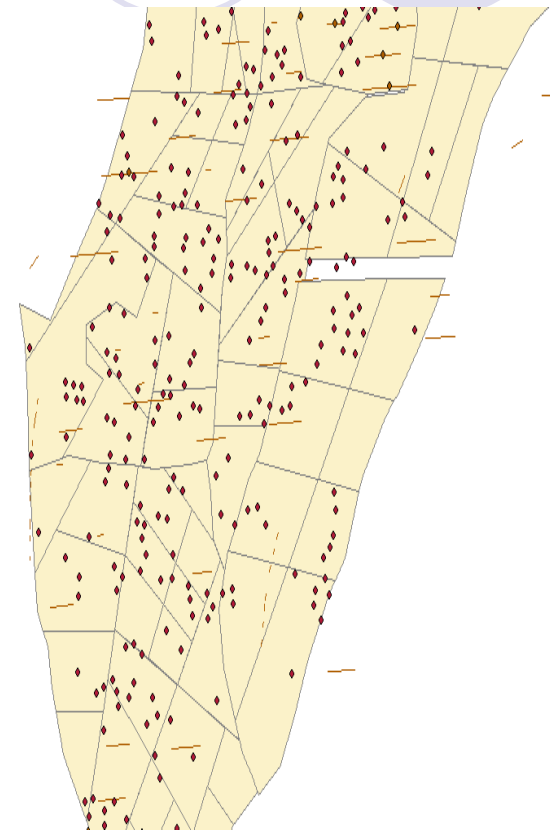
Expected Factors Causing Landslides

## ● Triggering Factors

- Rainfall-----Weather Bureau/Rain Gauge
- Seismic Occurrence---Earth Quake History
- Anthropogenic Interference
  - Road Construction----Survey Work/Activity Map
  - Rail Link Construction—Survey Work/Activity Map
  - Deforestation----Survey work/Activity Map.

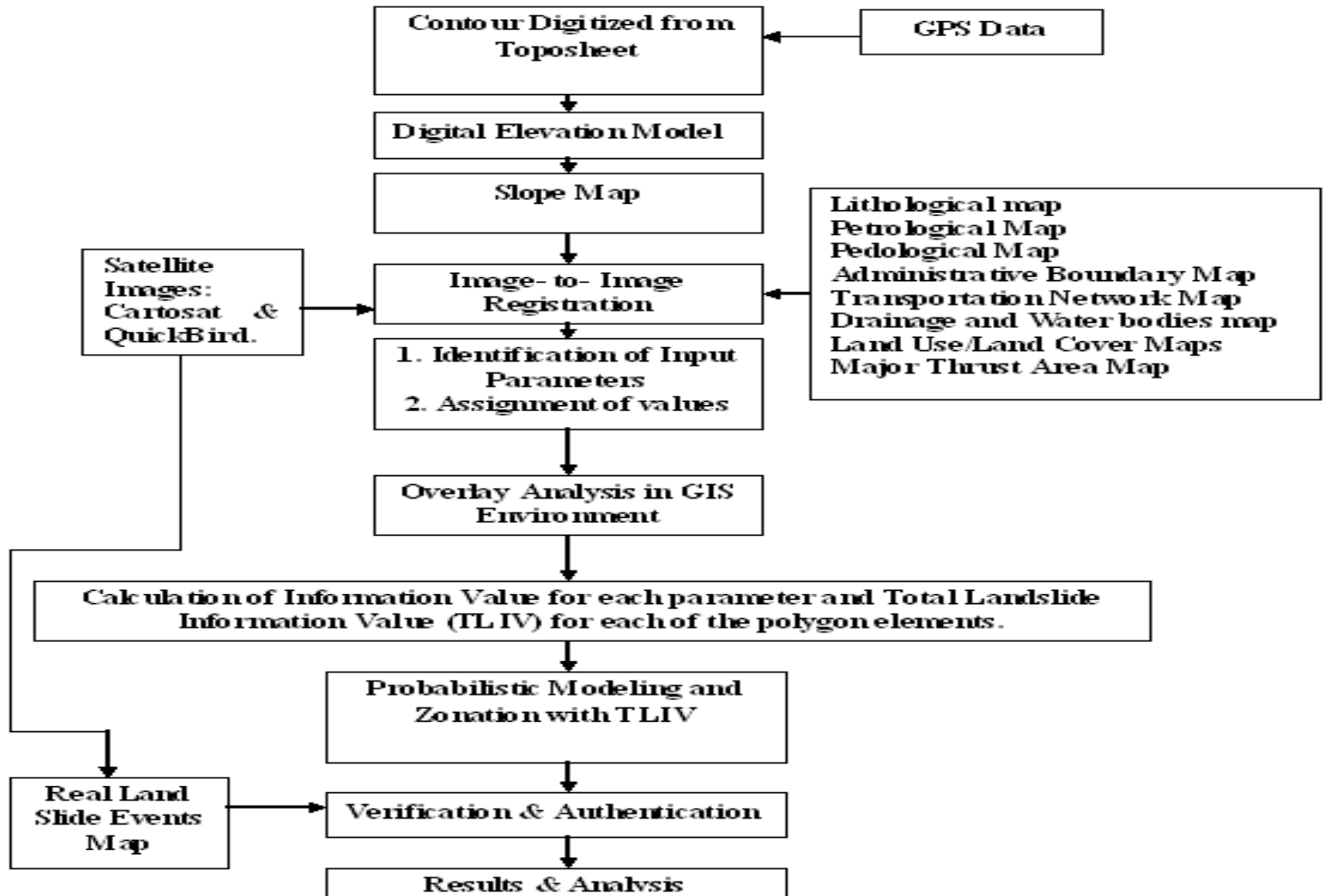
## Major Steps for Landslide Vulnerability Study with Geo-Data

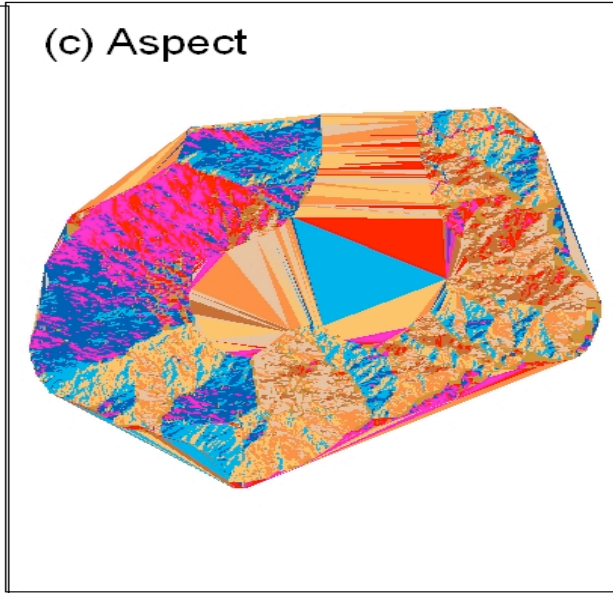
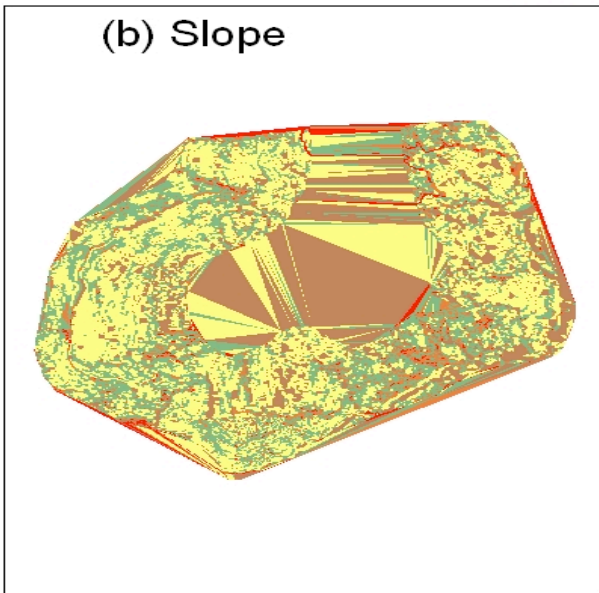
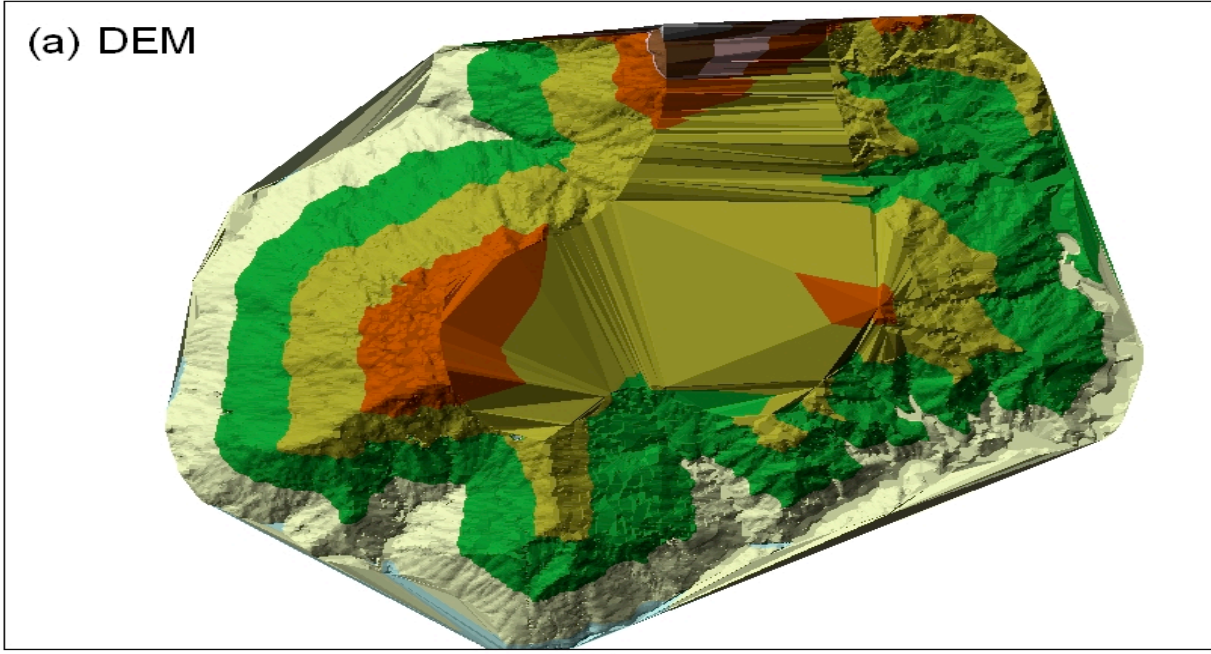
- GPS Survey of the Study Area/Digitization of Contour Maps from Topographic map
- Generation of DEM out of the GPS Data/Contours
- Identification of triggering factors (variables)
- Dividing the study area based on ward/village boundaries or control points and geological coherence into many divisions
- Categorization of variables and constants for every small portion of the study area.
- Identification of variable values for each such portion of the study area



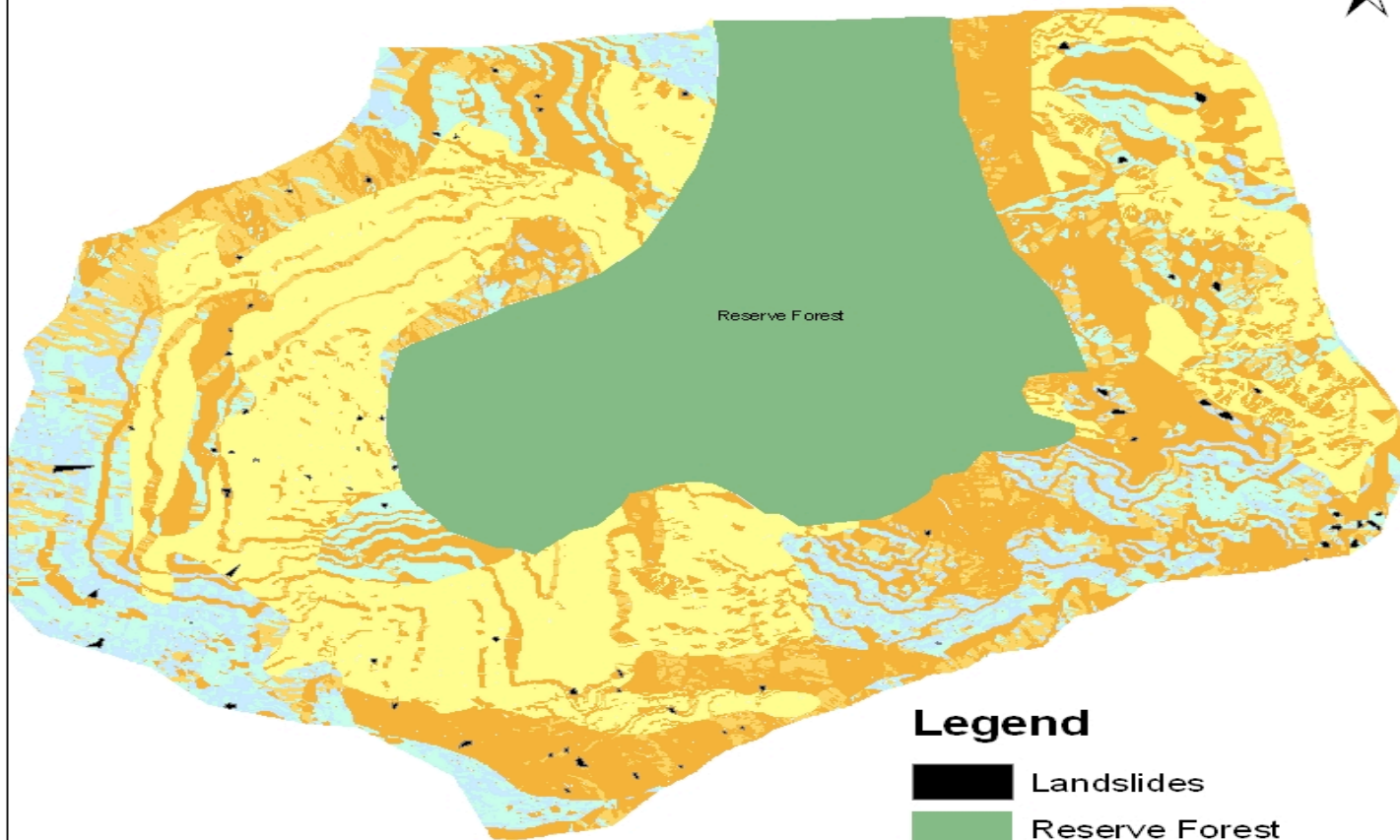
- Proposing a formula for landslide probability based on the various triggering factors.
- Calculation of landslide Information Value for elements in the area using various methods like statistical, deterministic, Fuzzy Logic, Information Value Model, Logistic Regression, Bayesian Network or Artificial Neural Network (ANN).
- Checking it with the real landslide history of the past.
- Repeating the process unless the calculation matches with the landside history data.
- Publishing a table of identified locations that are prone for landslide within a range of precipitation.

# Methodology Flowchart





# Rumtek Samdong Area-Landslide Vulnerability Zonation with Fuzzy Average(AR) combination



## Legend

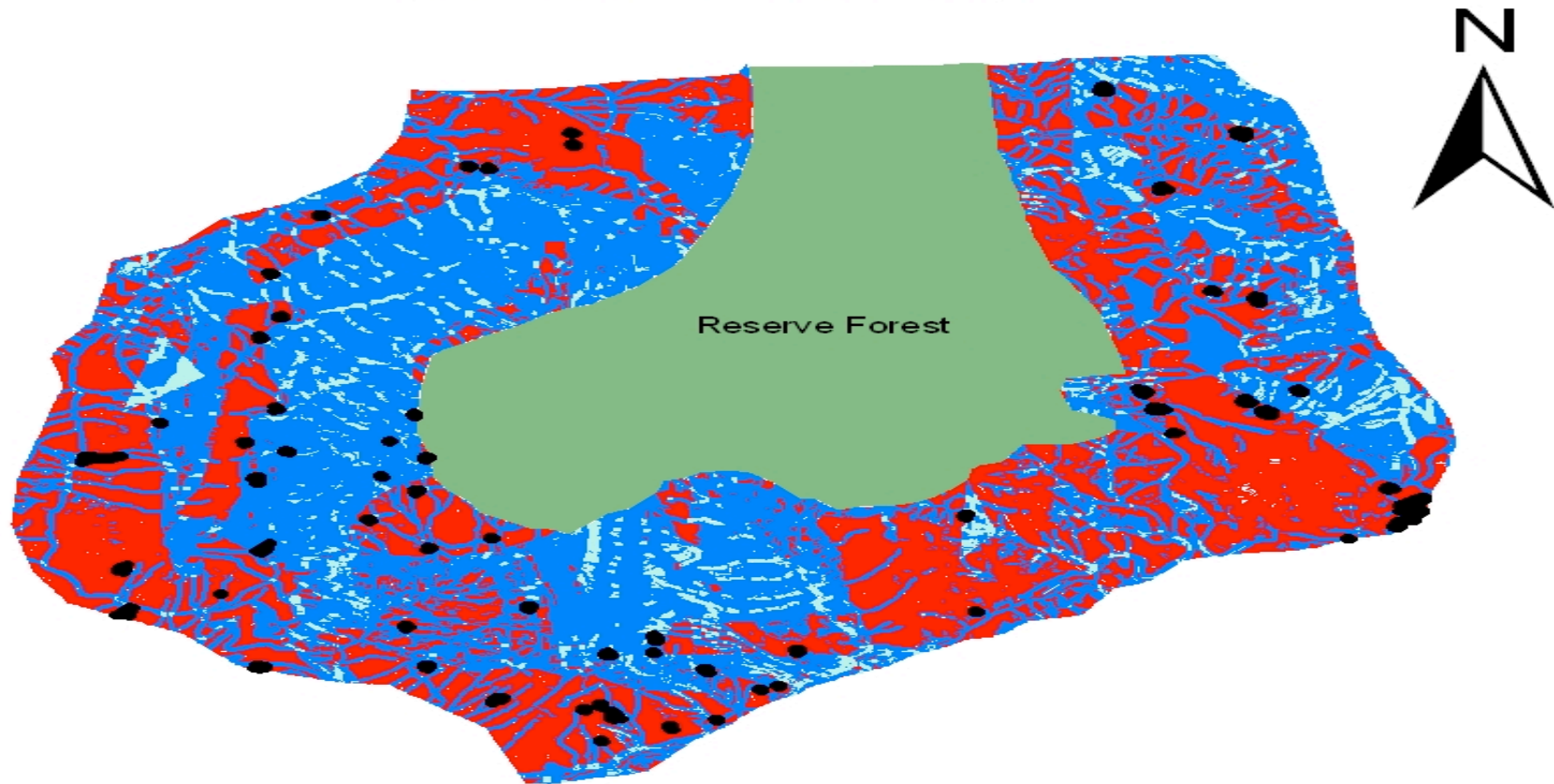
- Landslides
- Reserve Forest
- LSI Fuzzy Average(AR)
  - 0.485000 - 0.495000
  - 0.495001 - 0.545000
  - 0.545001 - 0.550000
  - 0.550001 - 0.700000
  - 0.700001 - 0.850000

1,800 900 0 1,800 Meters






# Prediction Verification

	Prediction Accuracy
<b>Fuzzy Operators</b>	
Fuzzy Algebraic Sum	96.25%
Fuzzy Algebraic Product	30.26%
Fuzzy And	45.26%
Fuzzy OR	85.68%
Fuzzy Average(SP)	70.36%
Fuzzy Average(AR)	77.04%
Fuzzy	
Gama(Gama=.025)	70.52%
Fuzzy Gama(Gama=.05)	70.52%
Fuzzy Gama(Gama=.1)	70.36%
Fuzzy Gama(Gama=.2)	70.36%
Fuzzy Gama(Gama=.3)	70.52%
Fuzzy Gama(Gama=.4)	70.52%
Fuzzy Gama(Gama=.5)	70.85%
Fuzzy Gama(Gama=.6)	70.52%
Fuzzy Gama(Gama=.7)	70.52%
Fuzzy Gama(Gama=.8)	70.52%
Fuzzy Gama(Gama=.9)	70.52%
Fuzzy Gama(Gama=.95)	70.36%

# Rumtek Samdung Area: Landslide Vulnerability Zonation Map (Information Value Model)



## Legend

-  Landslide Spots
-  Reserve Forest
-  Least Vulnerable Zone
-  Moderately Vulnerable Zone
-  Most Vulnerable Zone

4 Kilometers

# Prediction Verifications-Information Value Model

<b>Type of Zones</b>	<b>No of Polygons</b>	<b>No of Polygons with Landslides</b>
Least Vulnerable	8792 (11.33%)	44 (7.17%)
Moderately Vulnerable	43782 (55.95%)	260 (42.35%)
Most Vulnerable	25682 (32.82%)	310 (50.49%)



# Conclusion

- Geospatial Technologies are Indispensable tools for disaster studies.
- Accurate prediction of Landslide Hazards is possible with spatial analysis and modeling of high scale geo-data



Thank You  
**Thank You**