Remote Sensing & GIS Applications in Landslide Management: Focus North East India

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Landslide

- Movement of a mass or rock, debris, or earth (soil) down a slope
- although large catastrophic events are rare
- small movements are very frequent &
- produce long term large amount of economic losses

Global Scenario

- 3rd ranked in terms of number of deaths among the top ten natural disasters (UN/INSDR, and CRED 2006)
- Approximately 4 million people were affected by landslide in 2006 (CRED, 2006)

- Regions with highest landslide risk are found in Colombia, Tajikistan, India and Nepal where the estimated number of people killed per year per hundred Sq. Km was found to be greater than 1 (Nadim et al., 2006)

National Scenario

- Approximately 0.49 million sq. km area of the country is vulnerable to landslide hazard (GSI, 2006)

- 0.098 million sq. km are located in North Eastern Region and rest is spread over Himalayas, Nilgiris, Ranchi Plateau, Eastern & Western Ghats.

- more than 50% of the national highway located in this region is affected by frequent landslide especially during monsoon season.

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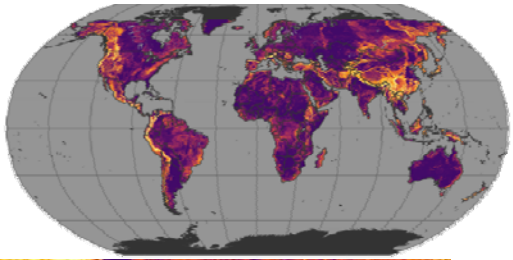
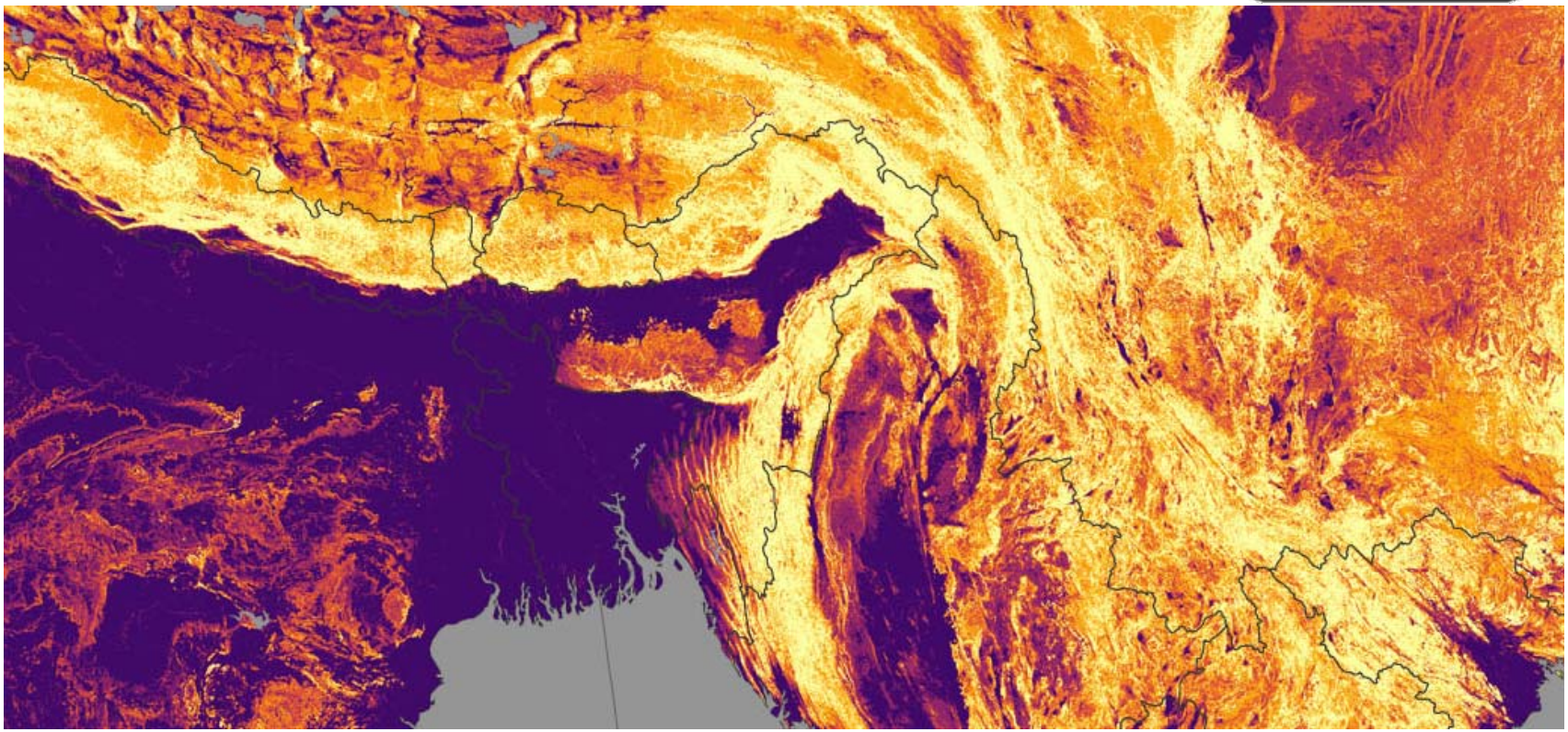
Global View of Landslide Susceptibility



After Dalia Kirchbaum & Thomas Stanley For Hazard Monitoring System
30TH March, 2017



Part of NE & Adjoining areas

Landslide Mitigation

Form by three elements:

- HAZARD ASSESSMENT
- VULNERABILITY ASSESSMENT
- RISK ASSESSMENT

- HAZARD ASSESSMENT:
  - Identifying the areas that are likely to be affected by landslide
  - Frequency and Magnitude
  - Representing them on the map which areas are likely to be affected.

- VULNERABILITY ASSESSMENT
  - Assessing the degree of lost that these events/landslides will cause to
    - Population
    - Buildings
    - Infrastructure
    - Economic activities etc.
- RISK ASSESSMENT
  - Quantifying the numbers of
    - Lives likely to be lost
    - Persons injured
    - Cost of damage to property & disruption of economic activities
    - Preparation of maps indicating the risk areas

Landslide mitigation can be successful only after having detail knowledge in terms of

- expected frequency, character & magnitude of the events in an area

Hazard Zonation is the basis for mitigation with adequate and understandable information for planners & decision makers

- hazards are commonly shown on maps as areas or zones
- display the spatial distribution of hazard classes

Zonation refers to "the division of land in homogenous areas or domains and ranking according to degrees of actual/ potential hazards" (Varnes, 1984)

LHZ is defined as the "mapping of areas with equal probability of occurrences of landslides of a given type & magnitude within a specified period of time (Guzetti et.al 1999, Varns, 1984)

- Hazard zonation requires
  - a detail knowledge of the geodynamical processes that are or have been active in the area
  - on the factors leading to the occurrences of landslide
  - considered the task of geologist, geophysicist, geomorphologist etc.

- Vulnerability analysis & the determination of elements at risk requires
  - a detail knowledge of the population density
  - engineering characteristics of the infrastructure
  - value of economic activities
  - specialist from other discipline e.g. urban planning & management, civil engineers, social geography, economist

Role of Remote Sensing & GIS

Remote Sensing data derived from satellites are

- an integrated, well developed &
- excellent tools in the mapping of spatial distribution of landslides within a relatively short period of time.

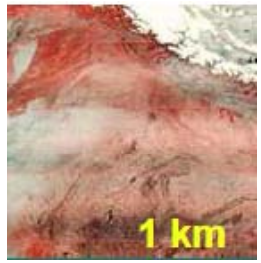
Plays a significant role in

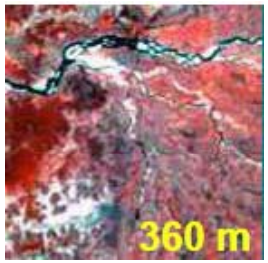
- evaluation of landslide susceptibility
- analysis of specific landslide events
- analysis of individual landslide events if coverage taken both prior to & after the events for legal proceedings and /or insurance consideration
- Temporal/multi-seasonal imagery – facilitate the recognition of certain important features & landforms that may be indicative of potential hazards/landslide.

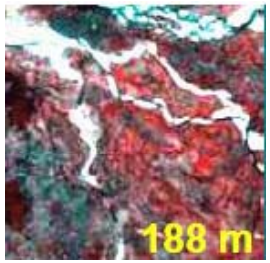
Role of GIS (Geographic Information System)

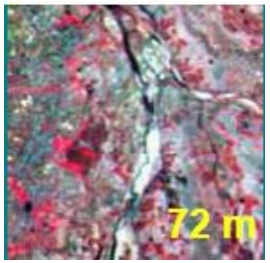
- **Computer aided system for managing the spatial data.**
  - **Geographic**- data items are known or can be calculated in terms of geographic coordinates (X, Y, Z).
  - Information - data in GIS are organized to yield useful knowledge, often as coloured maps and images, but also as statistical graphics, tables and various on – screen responses for interactive queries.
  - System - a GIS is made up from various interrelated and linked components with different functions.

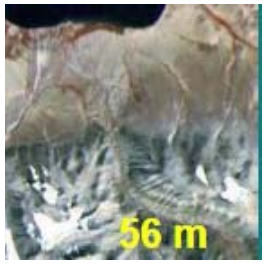
- Thus, GIS have the functional capabilities for data
  - capture, input, manipulation, transformation, visualization, combination, query, analysis, modelling and output.
  - capable of handling large number of data for analysis

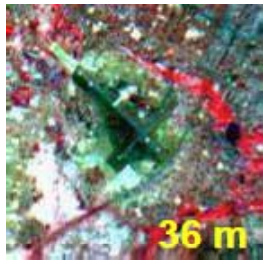


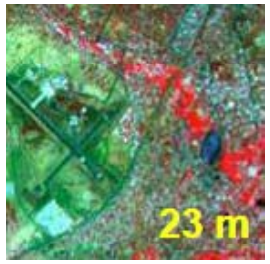


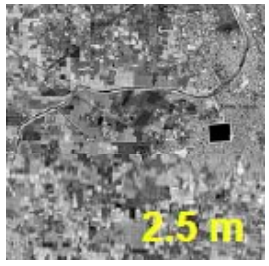












Experimental
Bhaskara 1/2

IRS 1A/1B
Operational-1G
LISS-1&2: 72/36 m

IRS P2
Research
LISS-II

IRS 1C/1D
Operational-2G
LISS-III: 23/70 m
PAN: 5.8m, WiFS:188m

IRS P3
WiFS, MOS,
X-Ray

IRS P4
Oceansat-1
OCM, MSMR

INSAT 2E
Operational Met
CCD: 1Km res,,
every 30 min

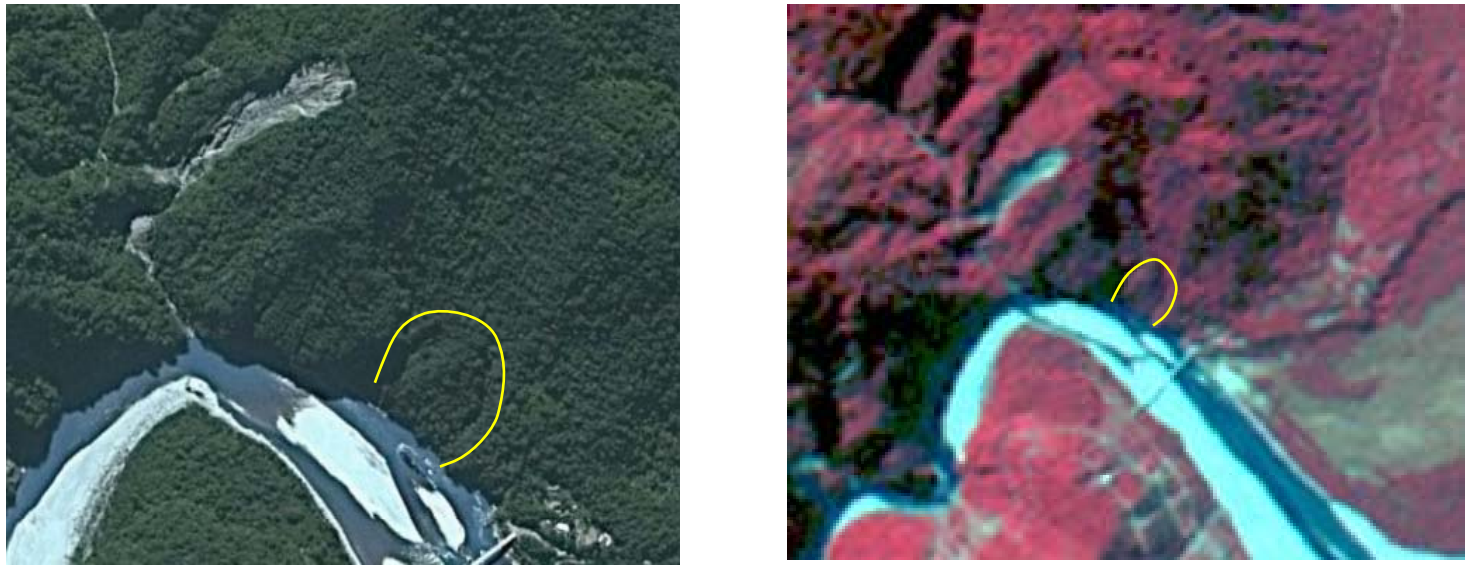
IRS P6
Resourcesat-1
LISS-3: 23m, 4-XS
LISS-4: 5.8m, 3-XS
AWiFS: 56m, 4-XS

IRS P5
CARTOSAT-1
PAN : 2.5m res

Use of remote sensing data in landslide study depends upon their characteristics such as:

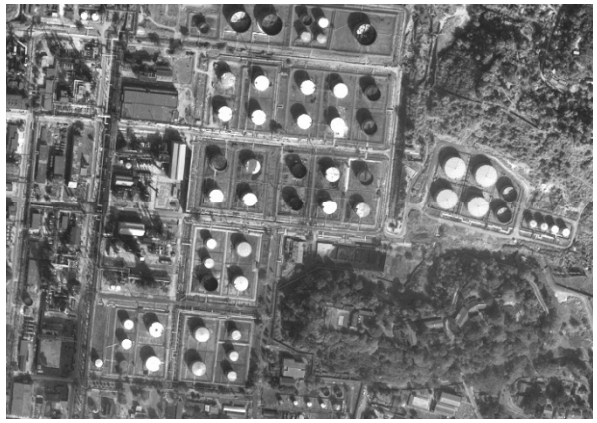
Spatial , temporal & Spectral Resolution

Spatial resolution plays important role in landslide mapping, identification of vulnerable location, landforms susceptible to landslide etc.

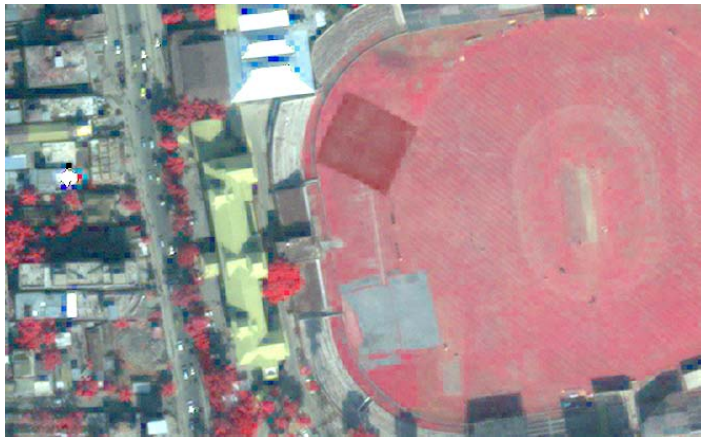


Identification of vulnerable location

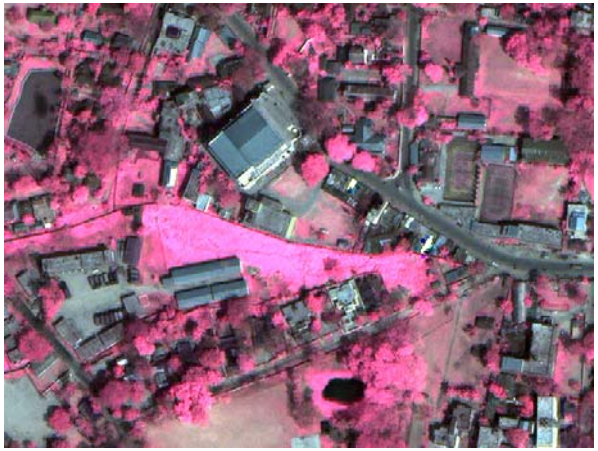
Very high resolution imagery has become the best option for landslide mapping



World View- 1 Panchromatic
0.46m resolution



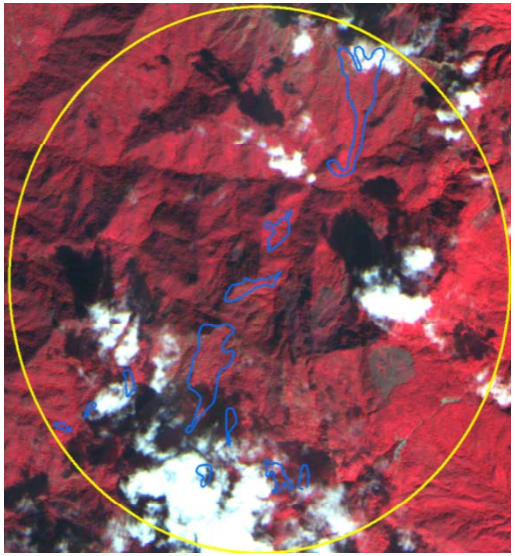
World View- 2 Multispectral
2.08m resolution



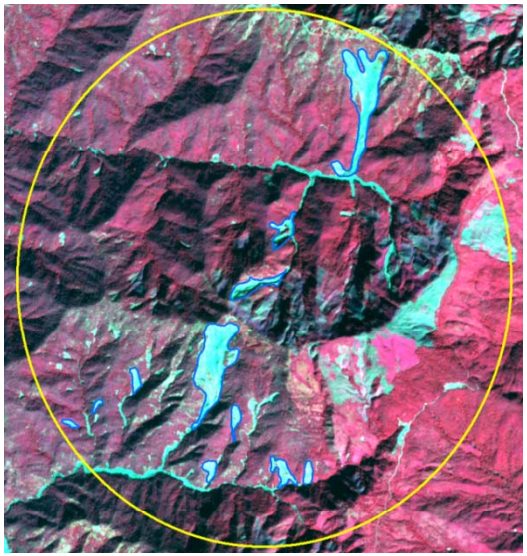
QuickBird1 Multispectral
2.4m resolution

Cartosat1 Panchromatic
2.5m resolution

Pre & Post landslide Satellite data of Joumol Village, Chandel District, Manipur that kills 20 villagers and swept away 12 houses. (1st August, 2015)



Pre landslide Image



Post landslide Image

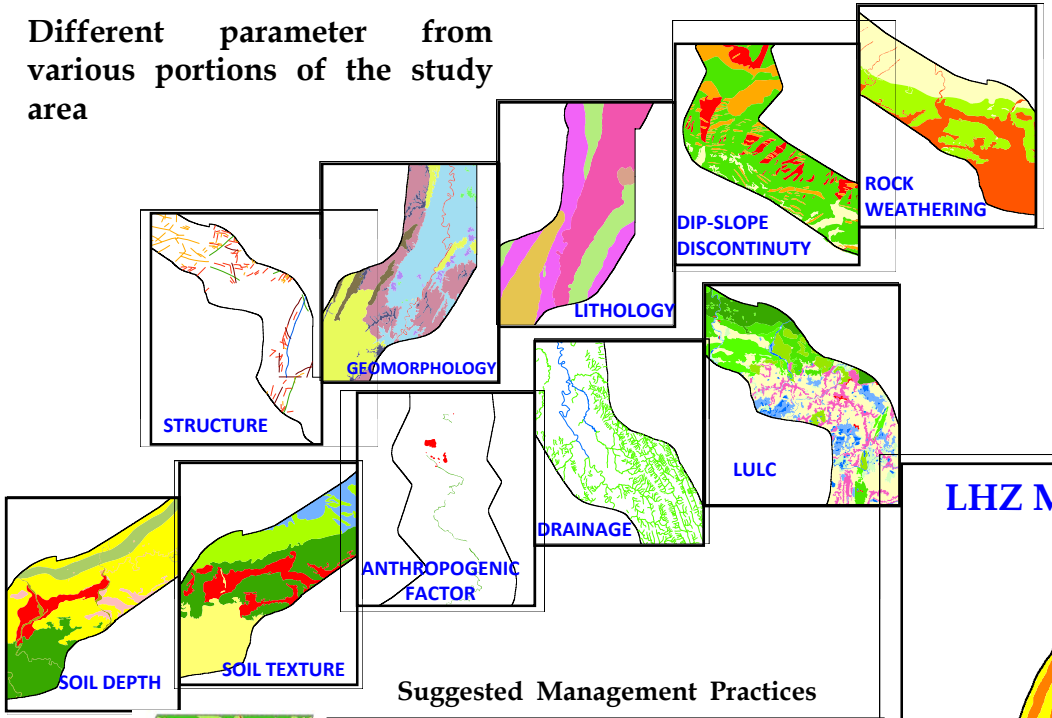
Joumol Landslide, Chandel, Manipur

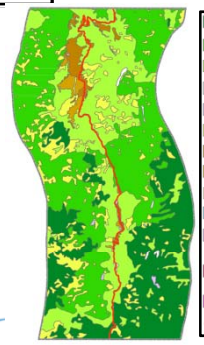
Rescue Operation

Case Studies

LANDSLIDE HAZARD ZONATION MAPPING ALONG SHILLONG – SILCHAR – AIZAWL HIGHWAY (NH-44) CORRIDOR IN NORTHEASTERN REGION (305 Km)

Different parameter from various portions of the study area

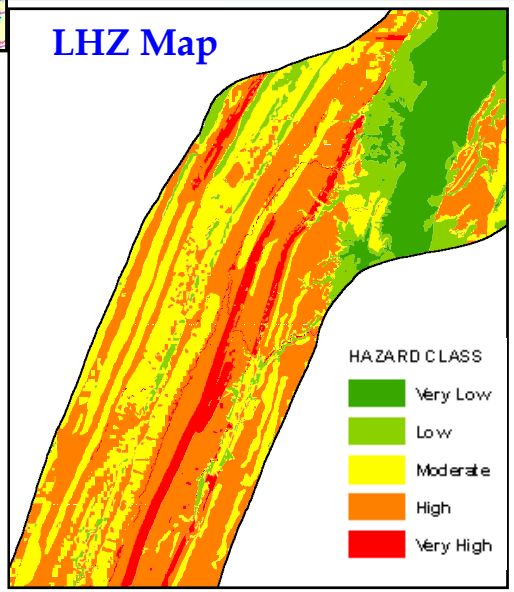




LANDSLIDE HAZARD MANAGEMENT MAP

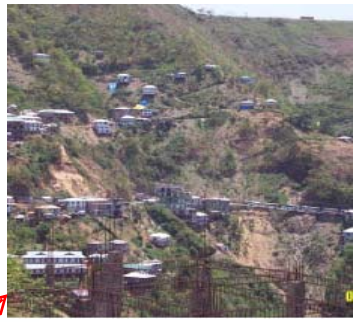
Suggested Management Practices

- Forest conservation and channelisation
- Afforestation and forest conservation
- Biotechnical measures and afforestation
- Channelisation and geotechnical measures
- Terrace cultivation, biotechnical measures, afforestation and grass land development
- Terrace cultivation and soil conservation measures, lining of irrigation/ natural channels
- Geotechnical measures, channelisation and avoid further construction activity
- Controlled construction activity with geotechnical measures and channelisation
- Channelisation and planned development
- Very low hazard perceived, at places bank erosion is to be prevented
- Site specific geotechnical measures, retention wall, breast wall, trench drain and slope modification
- Site specific remedial measures such as gabion wall, retention wall, breast wall, trench drain, terracing and lining of natural water course
- Geotechnical measures, afforestation and further no modification of slopes
- Main Route



Massive landslide in Sonapur, Meghalaya

Massive landslide near Kolasib town, Mizoram



Old slide area near Aizawl town

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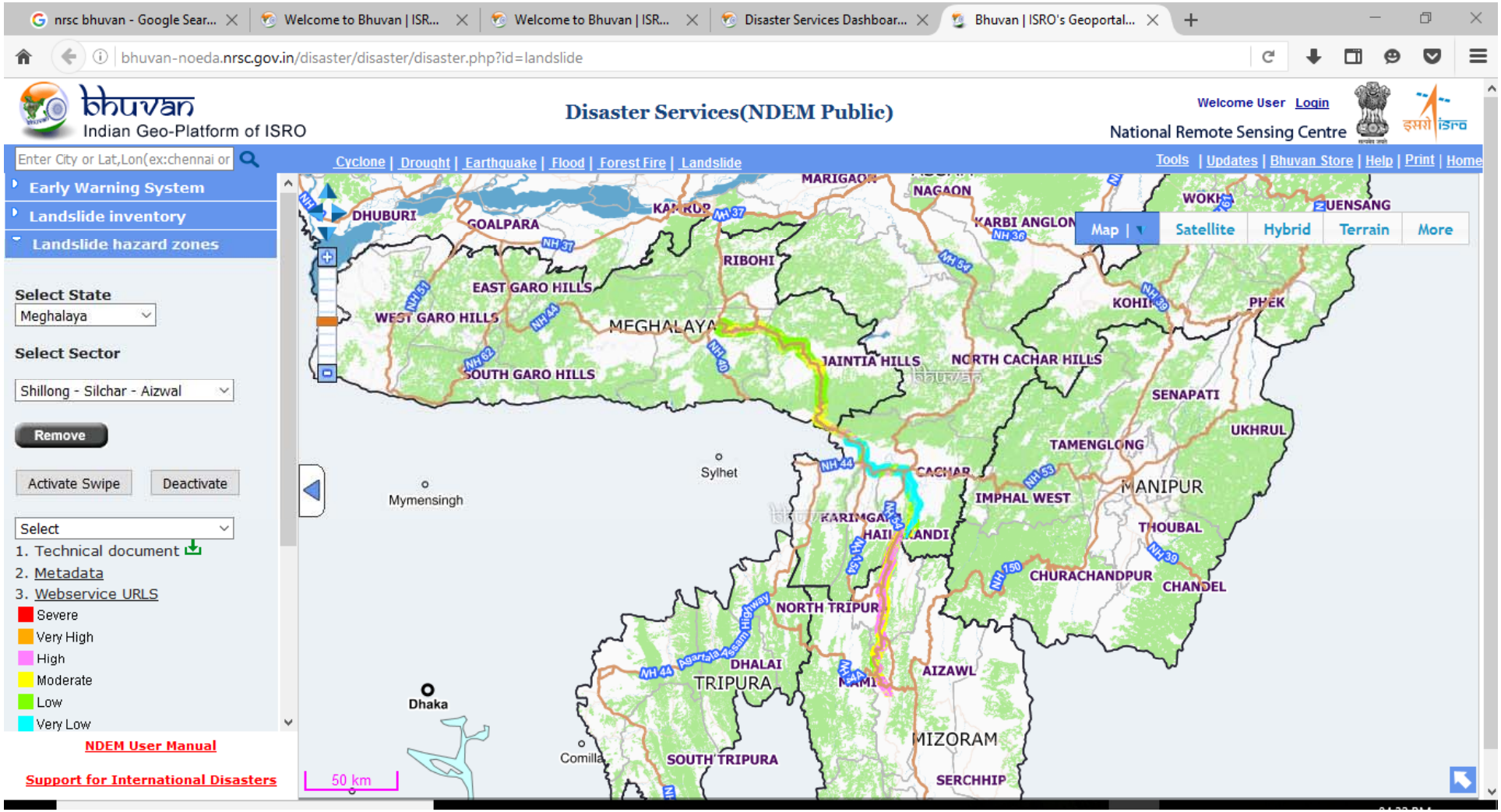

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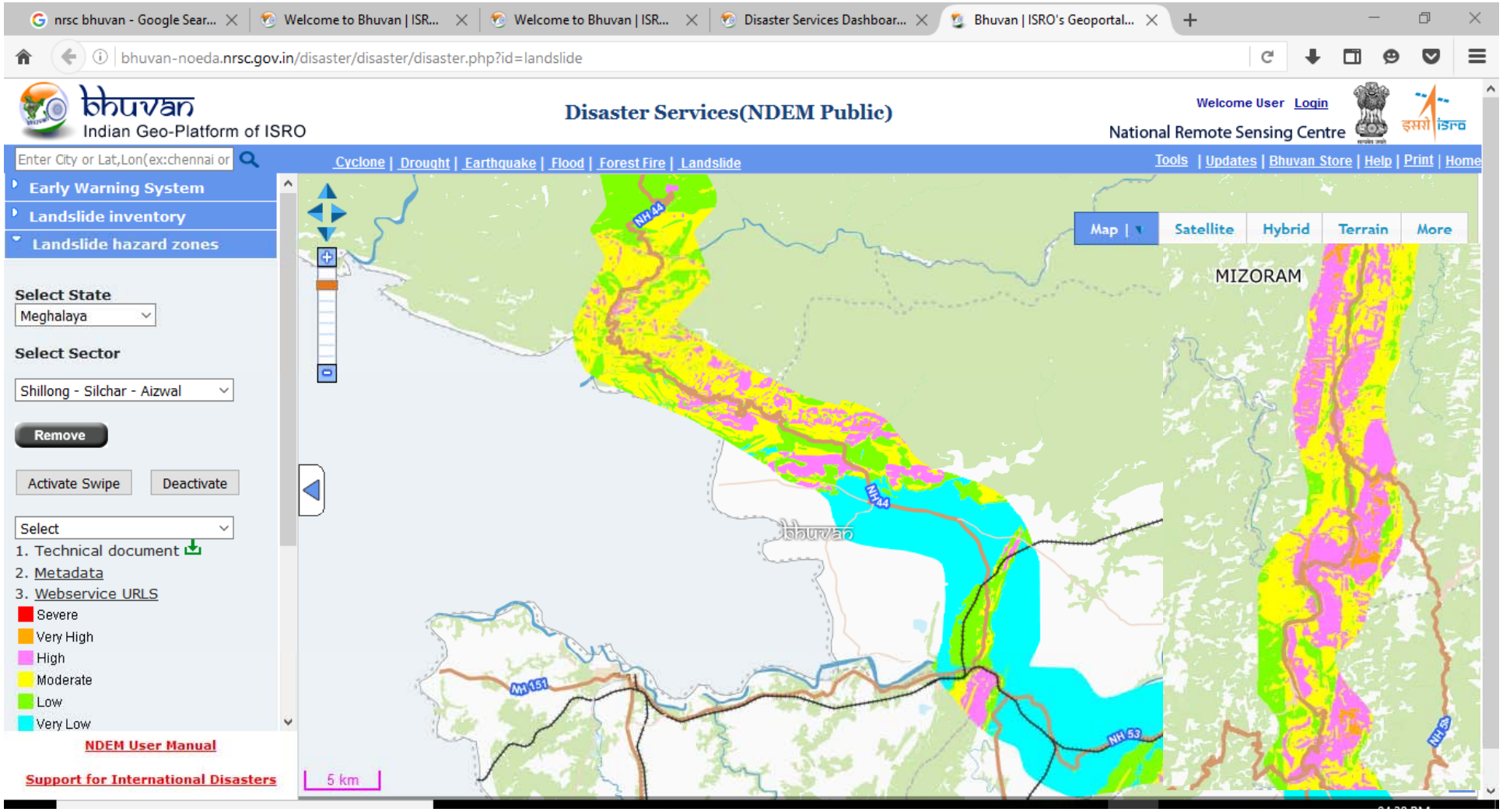
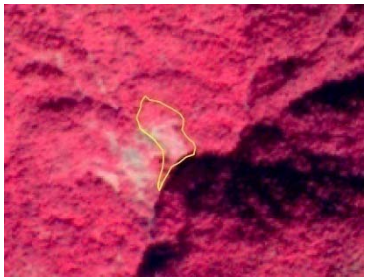


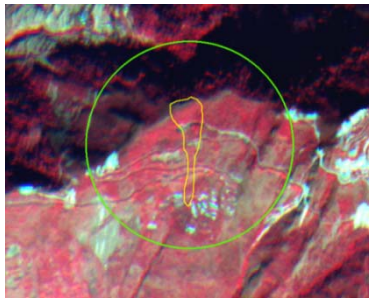
Seasonal Landslide Inventory Mapping (SLIM) NER

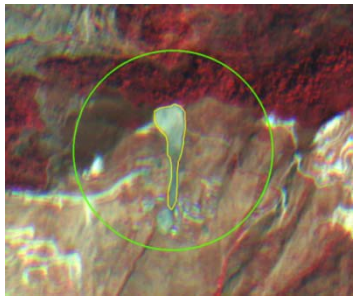
Objective:

- To Prepare Seasonal Landslide Inventory Map using Pre & Post Monsoon Satellite Data

Arunachal Pradesh







Pre - Monsoon Image

Post - Monsoon Image

Manipur

Pre - Monsoon Image

Post - Monsoon Image

Detection of Landslide & Identification of Affected Area is a Key Requirement for

- Planning Post - disaster Rescue & Relief Operations
- Landslide Susceptibility & Hazard Assessment.
- Total Area of Mapping, Aruanchal Pradesh) = 83,743 Sq. Km
- Plain Area = 6 Toposheet (Approx.)
- Total Area Of Mapping, Manipur = 22, 327 Sq. Km
- Plain Area = 2 Toposheet (Approx.)

Data used: LISS IV MX data of pre - and post-monsoon

ACHIEVEMENT: INVENTORY MAP IS ACCESSIBLE THROUGH NRSC BHUVAN PORTAL

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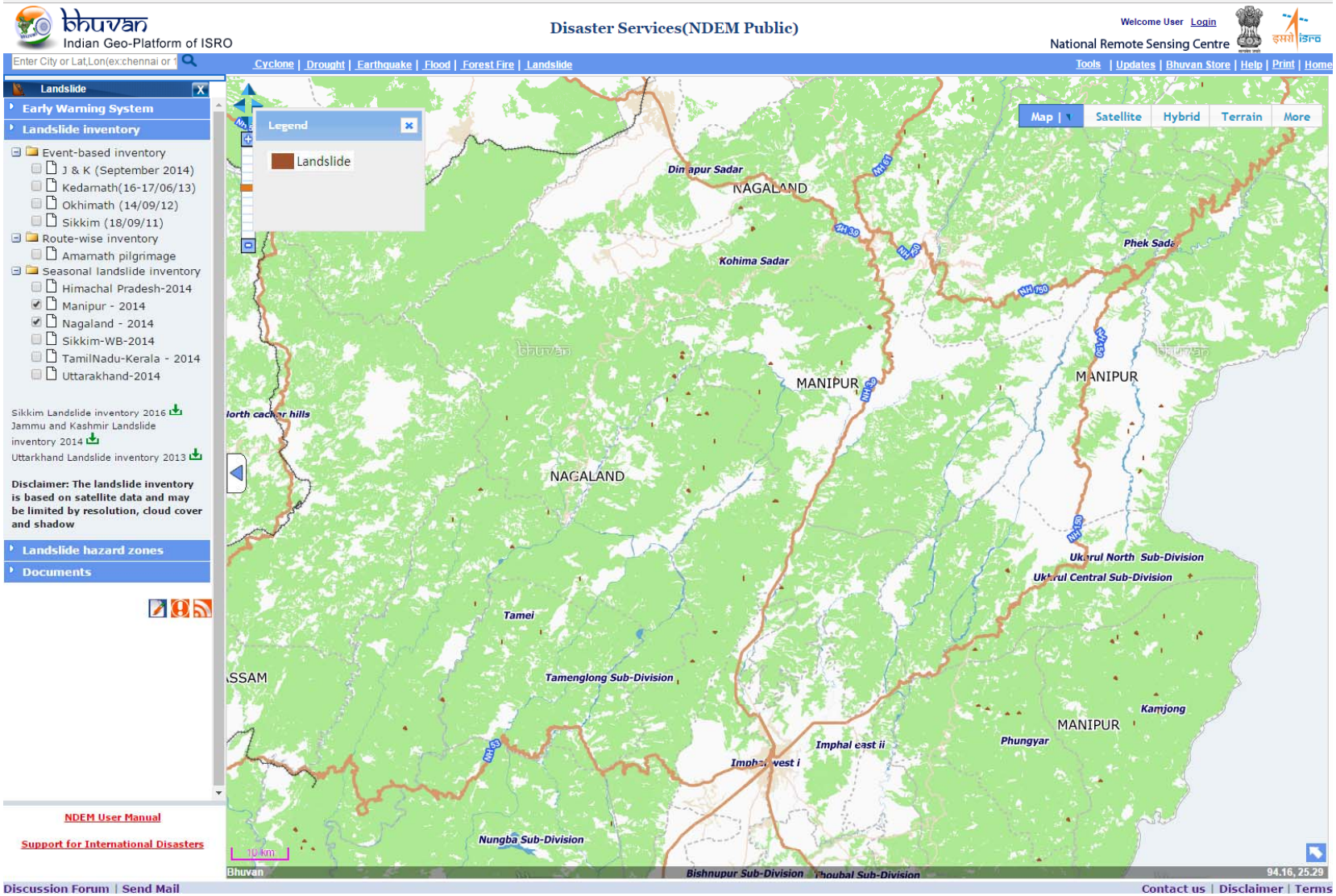
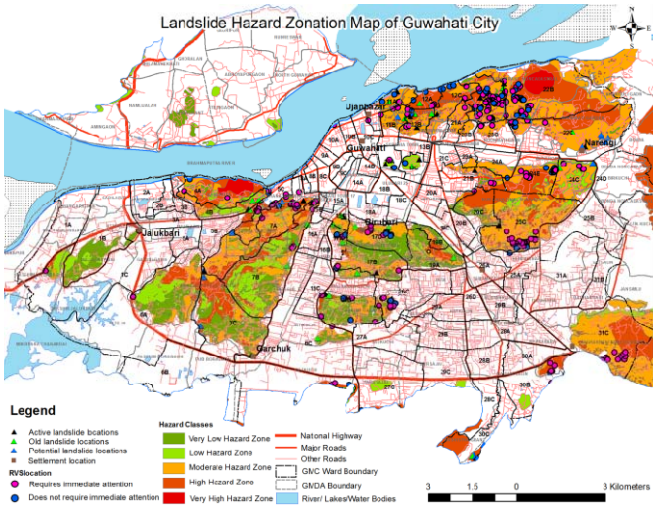
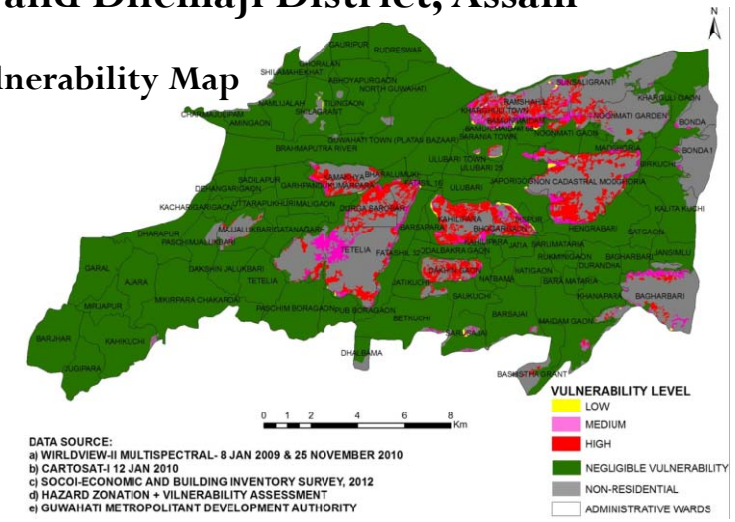


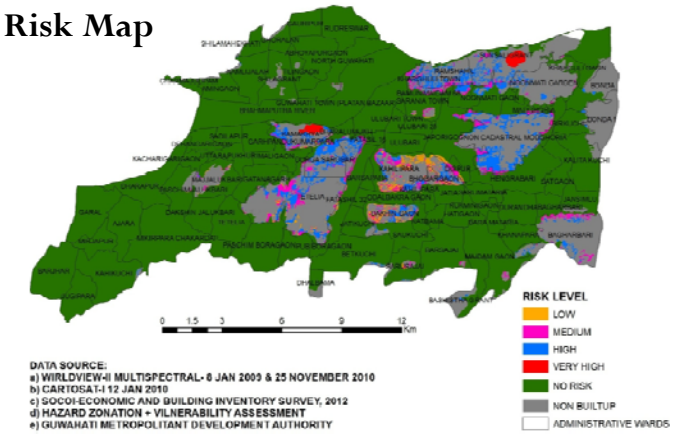
Remote Sensing and GIS Based Inputs for Hazard Vulnerability Risk Assessment (HVRA) Guwahati City, Silchar, Dibrugarh Towns and Dhemaji District, Assam



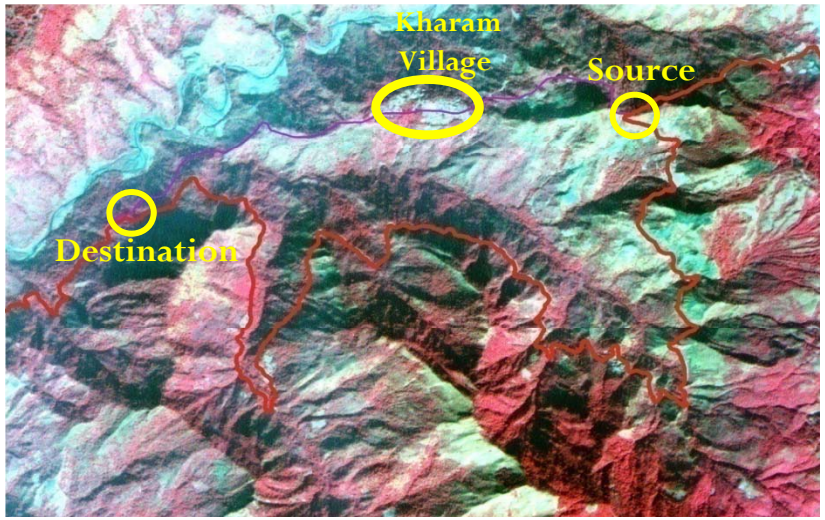
Vulnerability Map



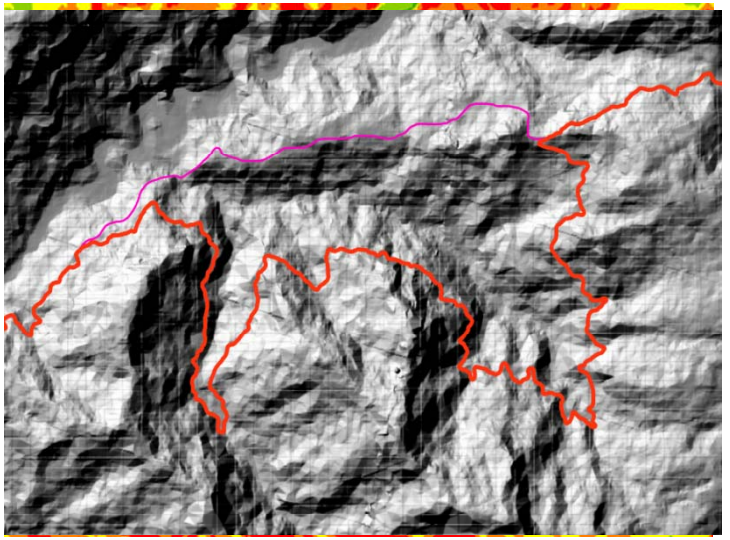
Risk Map



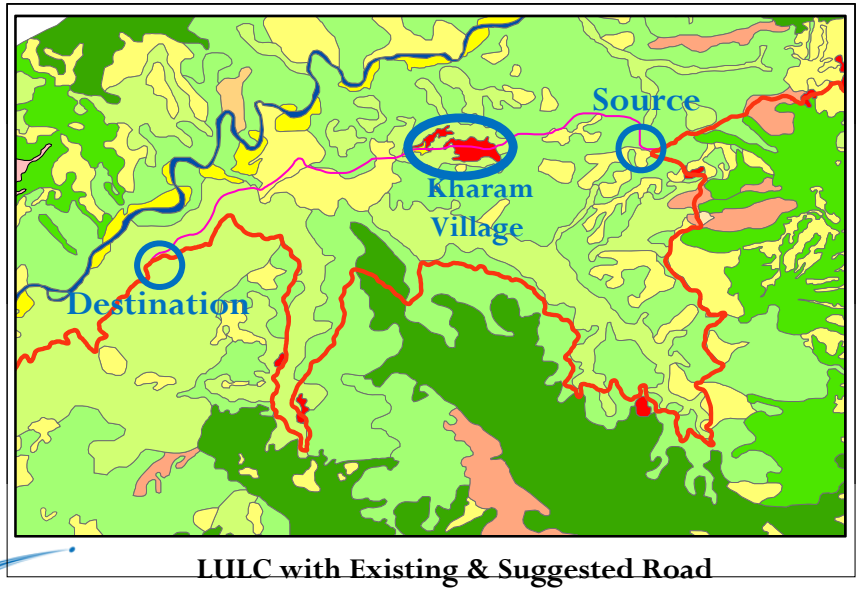
Field Photo



Imagery with Existing & Suggested Road



DEM/L Susceptibility with Existing & Suggested Road



LULC with Existing & Suggested Road

Class	
	Existing Road (NH-53)
	Suggested Road (new align)

Existing Road Segment-NH-53

- distance(Source to Destination) – 16.98 Km

Suggested Road (Source to Destination) – 5.85 Km

- shortened – 11.13 Km
- cross one stream (Kharam Lok)

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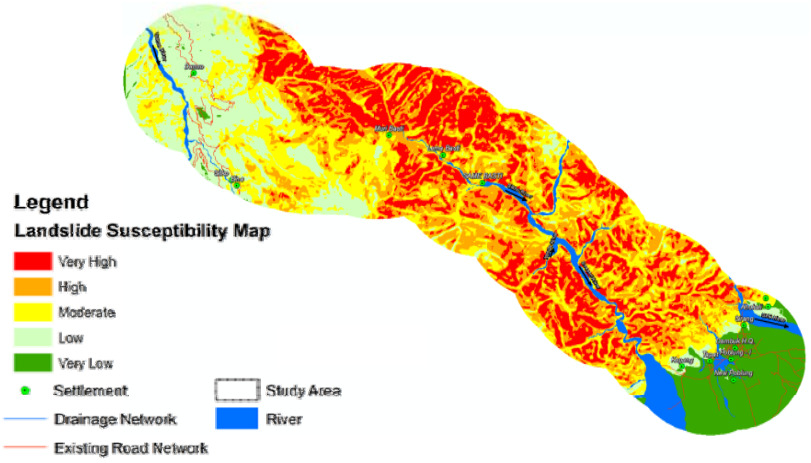
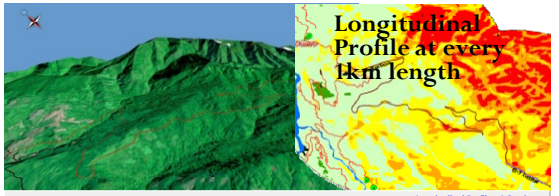
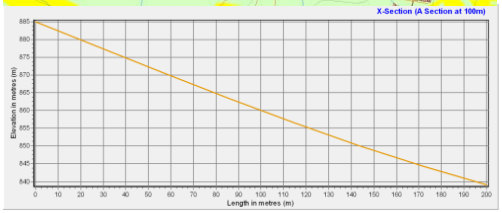
Remote Sensing And GIS Based Inputs And Analysis For Suitable Road Alignment Planning From Dumro To Same Basti, Upper Siang And Lower Dibang Valley Districts Arunachal Pradesh

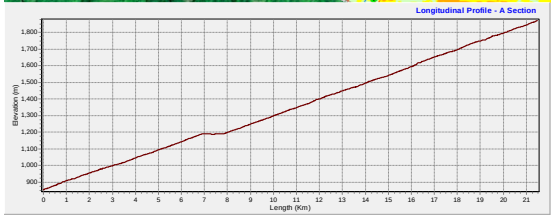


Objectives:

- Generation of landslides susceptibility map on 1:50000 scale
- suggestion of a new road alignment using landslide susceptibility map and DEM with predefined criteria 20:1.

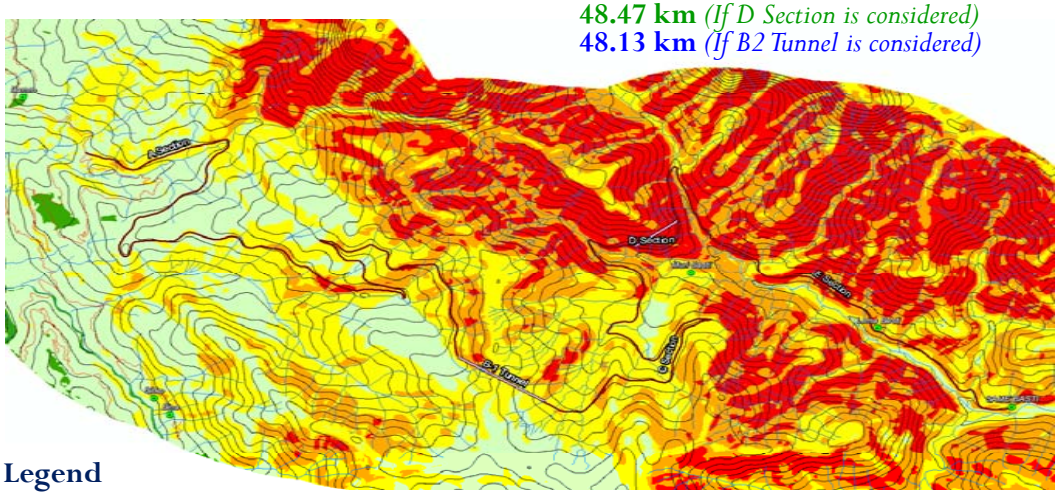






Total Road Length:

48.47 km *(If D Section is considered)*
48.13 km *(If B2 Tunnel is considered)*



Legend

Aligned Road - ———

Border Roads Organization (BRO), 761 BRTF (GREF), Project Brahmank, Arunachal Pradesh

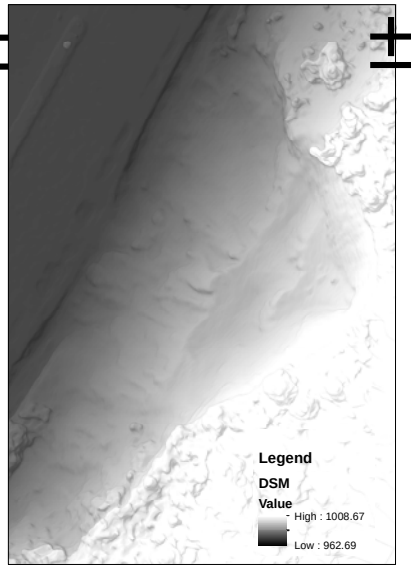
UAV Remote Sensing

Detail study of individual landslide investigation initiated on experimental basis

- Demarcation of scarp area
- Volume estimation
- Damage assessment
- Possibilities of reactivation
- Monitoring

Shangbangla, GS Road

Umling, GS Road



Opposite to NEPA entrance

19th Miles, GS Road

Conclusion

- Hazard, vulnerability & risk assessment of landslide is very important & necessary today due to its strong influence on the process of mitigation & management
- Remote sensing is an excellent tool in the mapping of spatial distribution of landslides within a relatively short period of time
  - landslide susceptibility/hazard mapping
  - specific landslide events
  - damage assessment for legal proceeding /insurance /compensation
- RS helps in understanding the terrain factors such as slope, lithology, geological structures, landuse, geomorphology, anthropogenic activities etc., which are important for a landslide to occur in an area.

- GIS has a great advantage in landslide studies for its capability of collecting, storing, retrieving, transforming, displaying & combination of a large number of spatial data of real world using models

Recommendation

- Users of hazard assessment/zonation maps are mostly institutions in the public or semi- public sector which are involved in
  - planning of future landuse
  - urban & lifeline infrastructure
  - development of renewable & non-renewable natural resources
  - environmental monitoring & management
  - disaster management input/support

- However, there is still a gap in the communication between the decision makers in such institutions & earth scientist involve in the task of hazard assessment.

- It is utmost importance between the earth scientist & planners to determine a term of reference of the mapping activities for details such as level of information, map scale, area specific/administrative unit, legends etc.

THANK YOU