GIS for Climate Vulnerability Assessment

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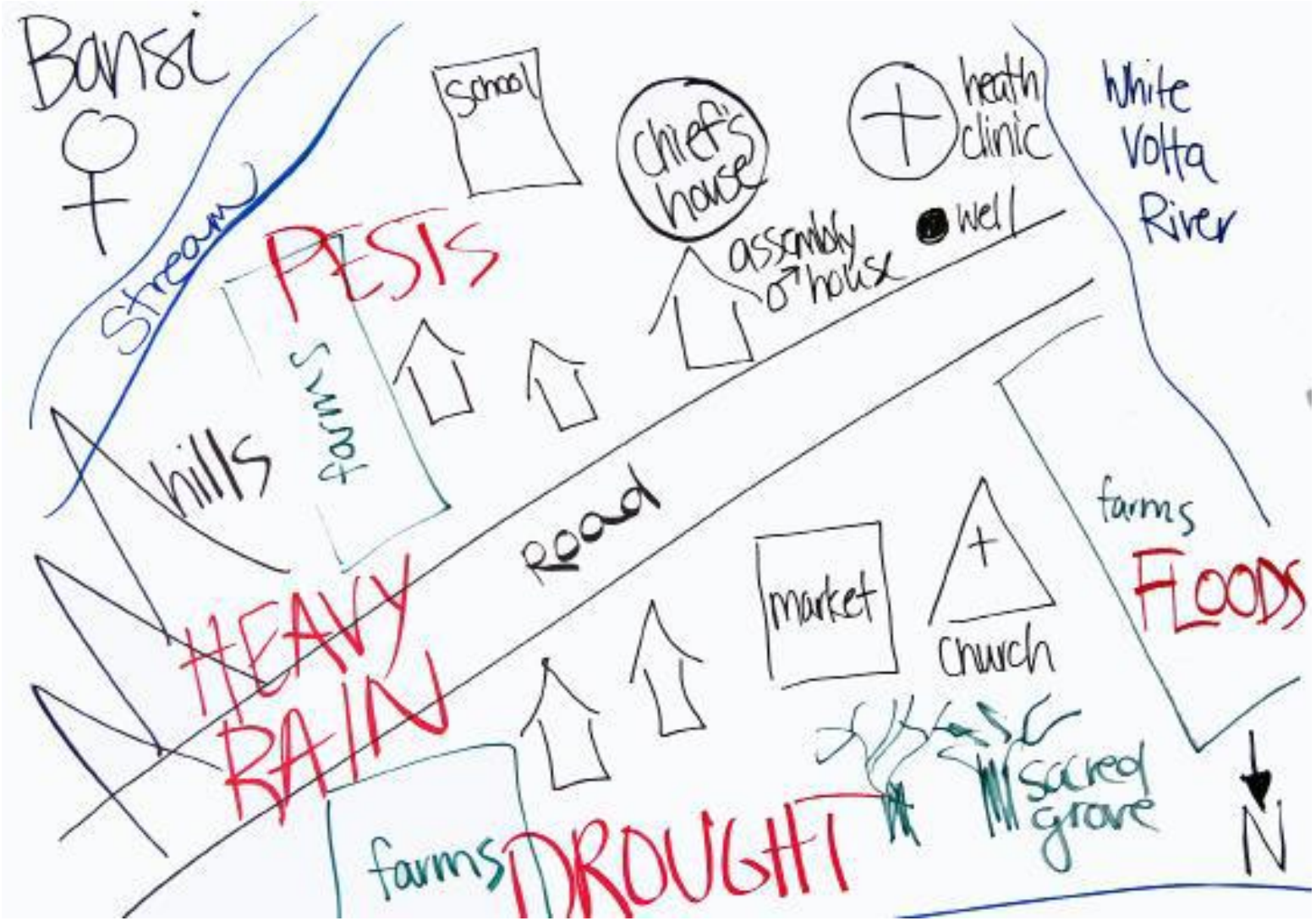
Presentation Outline

- Definition of Geographic Information Systems (GIS)
- Object Classification and Information extraction
- GIS Approach to Vulnerability Assessment
- Different types of data used for specific vulnerability assessments
- Role of GIS Applications in Disaster management
- GIS Applications for Stages in Disaster Management
- Experience during UN Disaster Charter
- GIS and its importance for vulnerability assessment
- Conclusion
- Class activity - Flood risk disaster mapping as a decision support system for vulnerability assessment

Story – How we analyze spatial events (hazards) before the use of GIS



Disadvantages

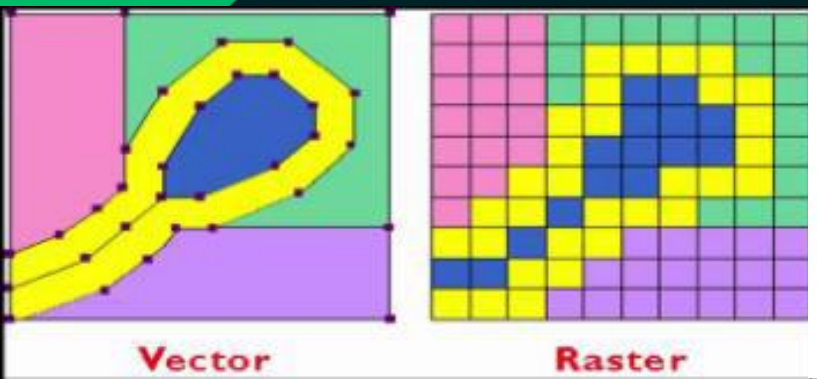
- No specific scale or extent of coverage
- No modeling scenarios for impact assessment
- No geo-coding and time series updates
- No database for attributes
- No rapid response analysis for vulnerability maps
- Data loss overtime due to analogue nature
- No synergy between organizations

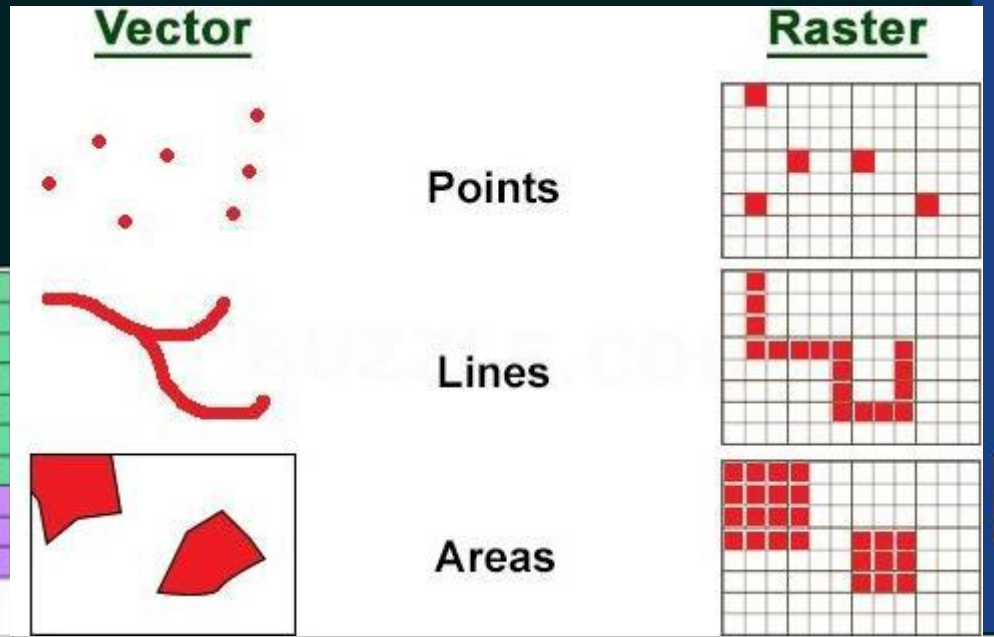
A Hazard Map showing the key resources and the hazards affecting them

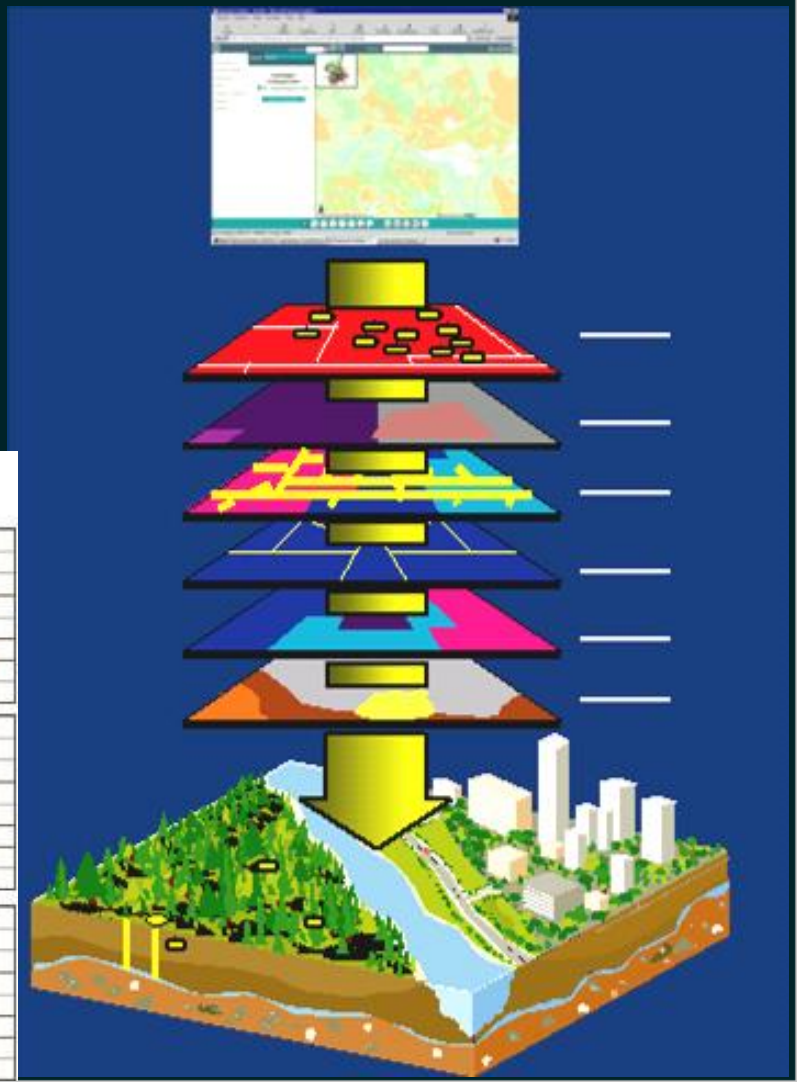
❖ A geographic information system (GIS) is a framework for gathering, managing, and analyzing data

❖It analyzes spatial location and organizes layers of information into visualizations using maps and 3D scenes

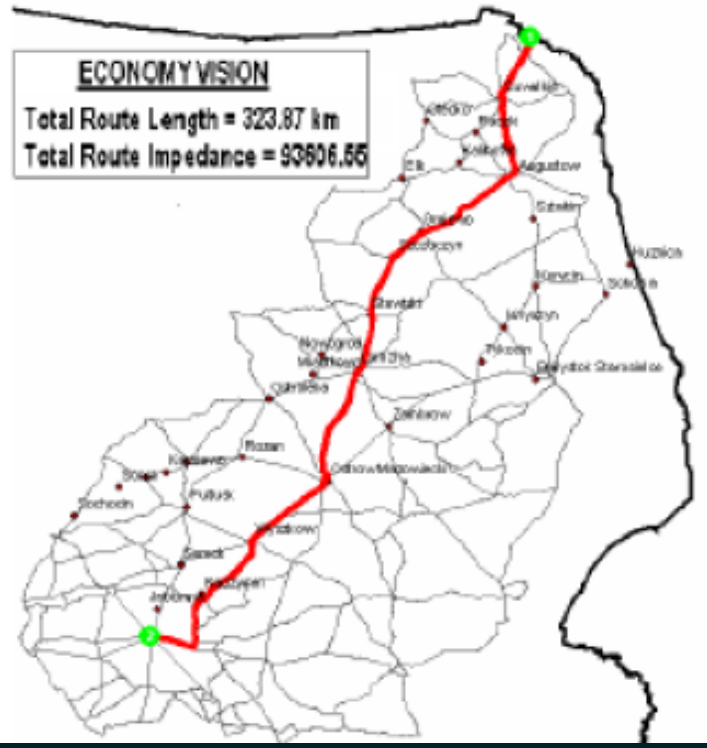
❖ GIS reveals deeper insights into data, such as patterns, relationships, and situations helping users make smarter decisions. Esri 2018.





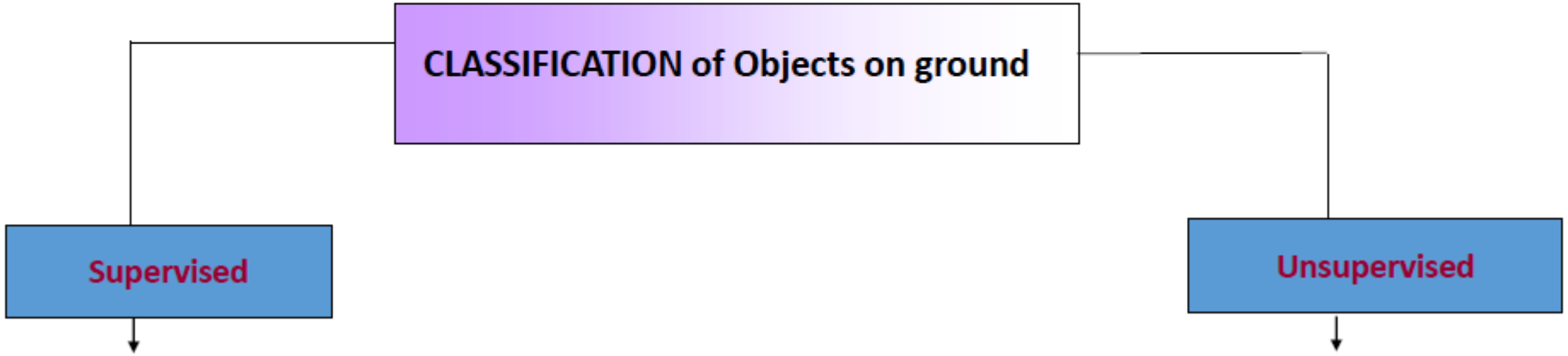


Another important advantage: the ease with which valuation criteria can be changed to visually illustrate the implications of spatial decisions.



Take a case of constructing a Dyke or Flood barriers within a city or country for **Ecology or Economic Vision**

GIS and Remote Sensing

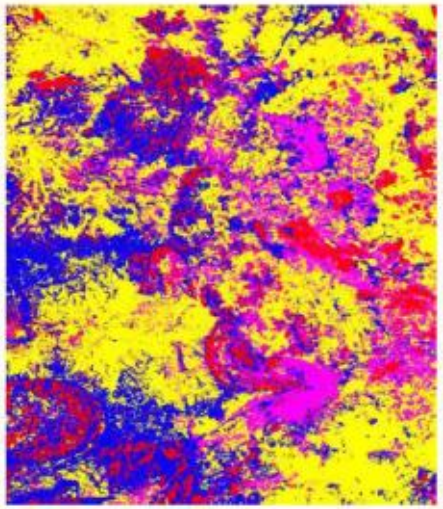


- Image analyst picks out areas of an image that he is familiar with (e.g. fields of corn; water) and letting the computer find other pixels in the image that share the same/similar channel value.
- Require a training site/sample sites
- Then the Computer will classify the image by comparing the Pixel values of the interpretation key to each pixel in the image.

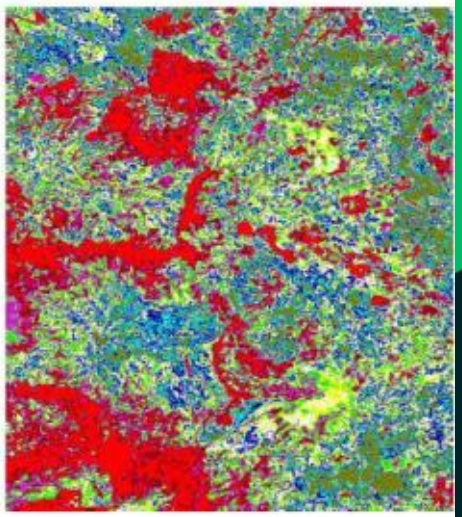
- Computer assign the image's pixel to a defined number of classes based on their value in different channels (i.e. no training areas used)
- Then Image analyst determines the land cover identity of the spectral groups by comparing the classified image data with ground reference data.

Examples of Classification

Original Image



Classification of the Image through Sample Sets.



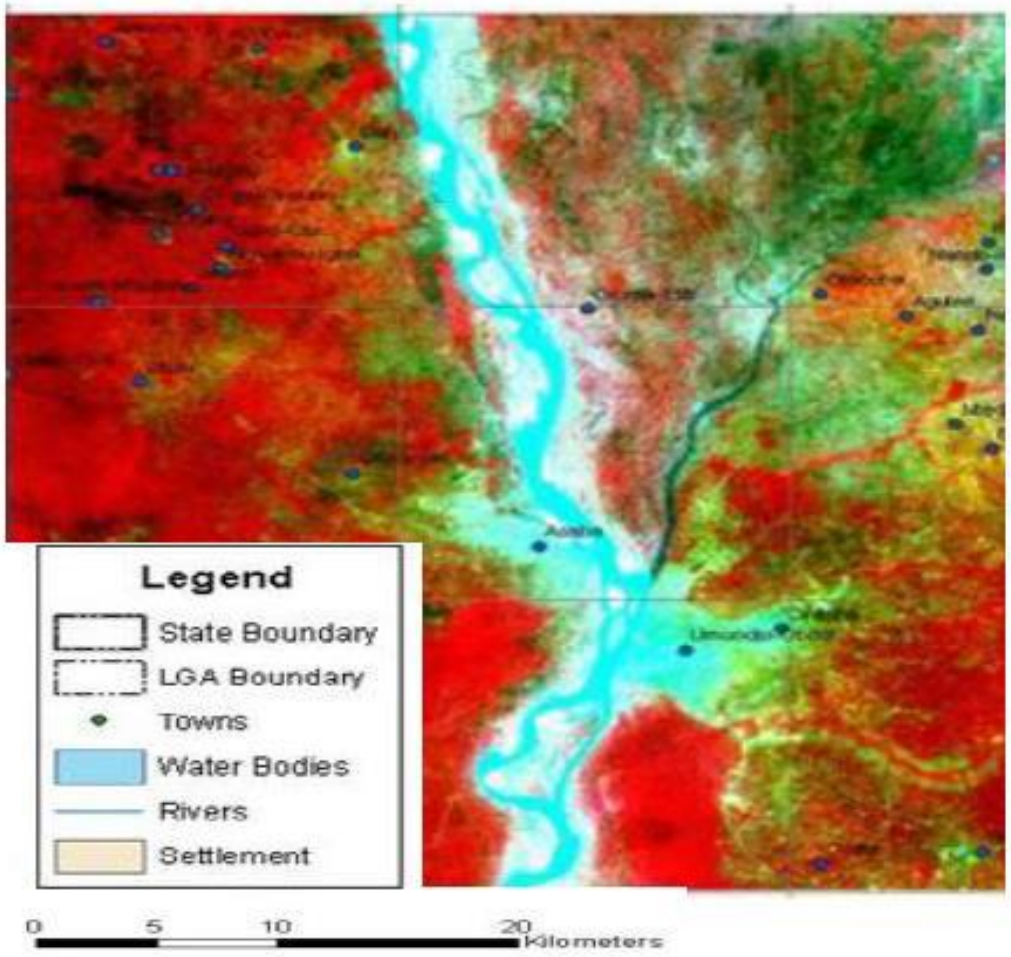
Classification from linear filter: Unsupervised

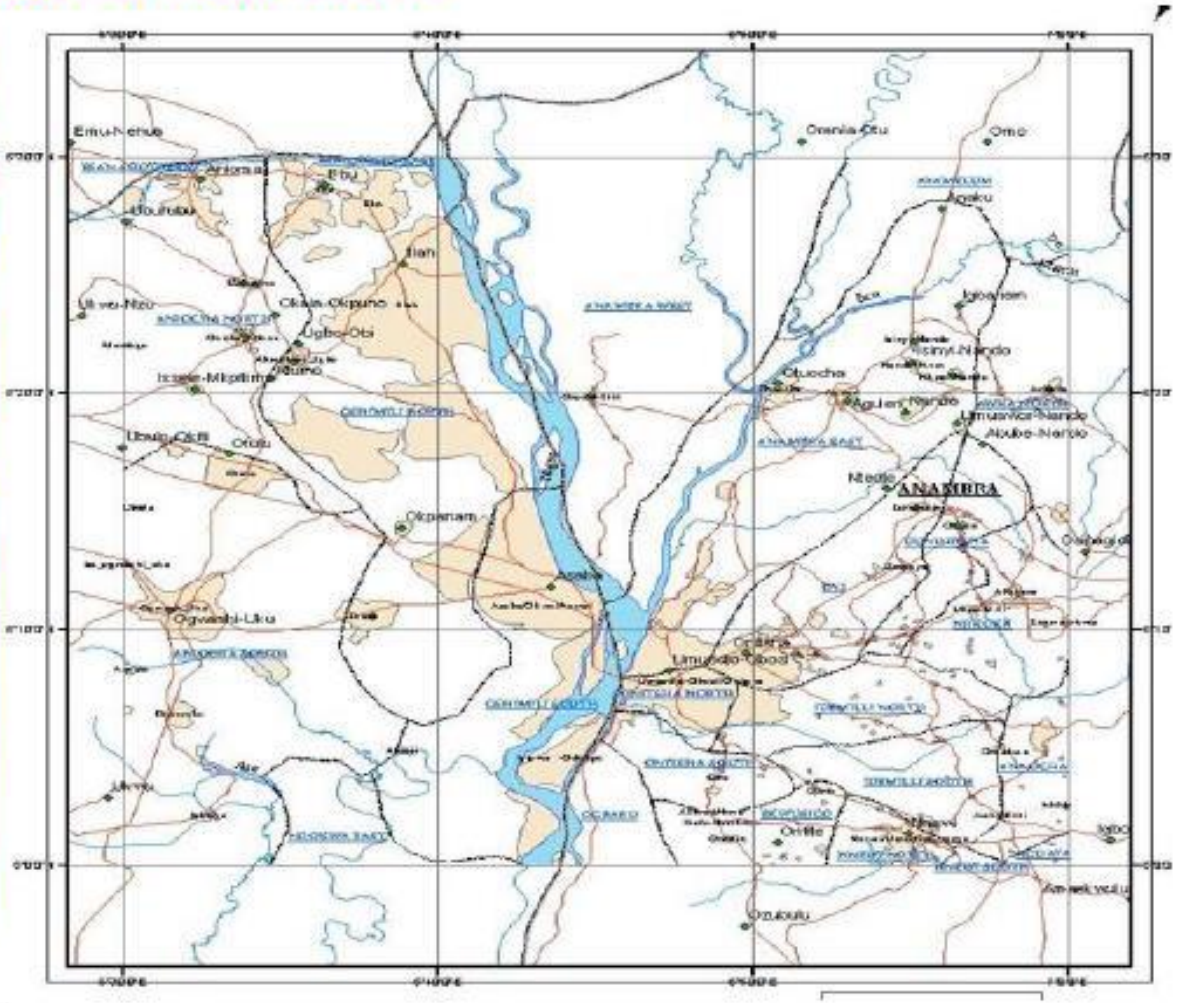
The appearance of different surface features for the different composite images is summarized

	True Color Red: Band 3 Green: Band 2 Blue: Band 1	False Color Red: Band 4 Green: Band 3 Blue: Band 2	SWIR (GeoCover) Red: Band 7 Green: Band 4 Blue: Band 2
Trees and bushes	Olive Green	Red	Shades of green
Crops	Medium to light green	Pink to red	Shades of green
Wetland Vegetation	Dark green to black	Dark red	Shades of green
Water	Shades of blue and green	Shades of blue	Black to dark blue
Urban areas	White to light blue	Blue to gray	Lavender
Bare soil	White to light gray	Blue to gray	Magenta, Lavender, or pale pink

Image extraction from satellite imagery using GIS

Identification & Mapping of Settlements, Major Roads & Water Bodies

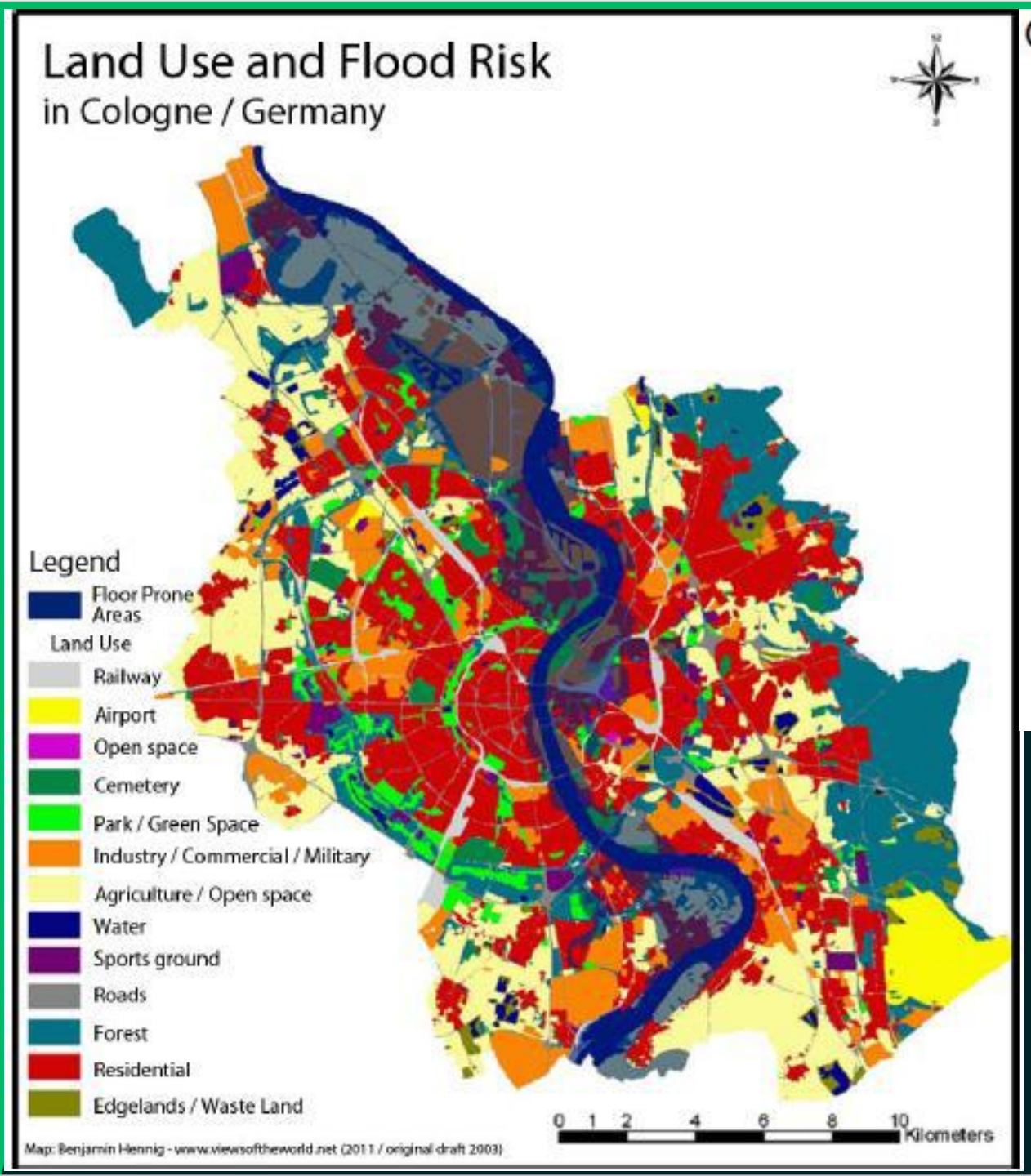




Final composite map of part of Anambra State, Nigeria showing the extracted features from the satellite images

Part of Anambra State

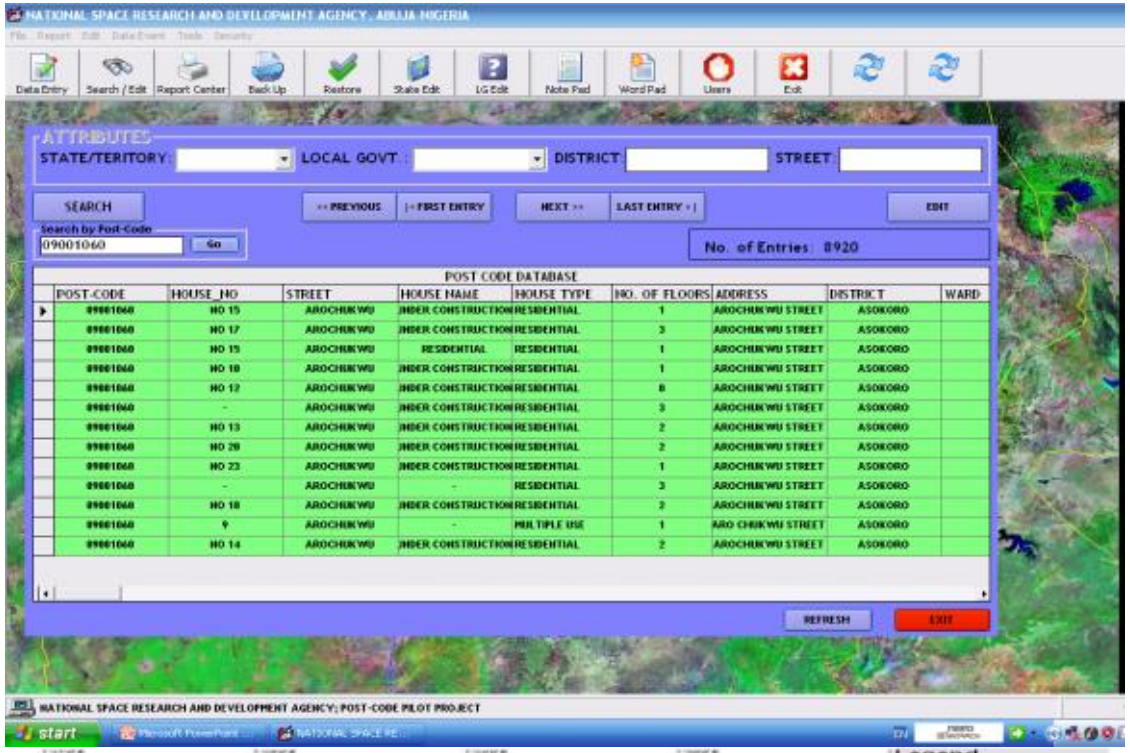
Source: NASRDA, 2010

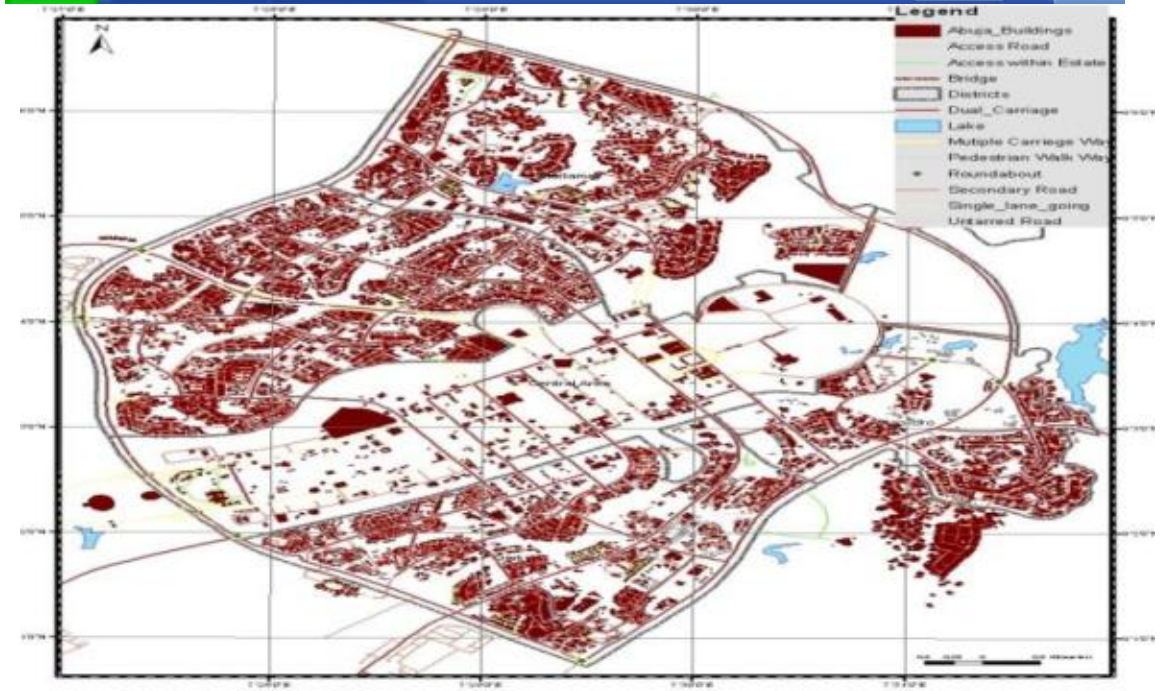


Objectives Used to Assess Plan

- Minimise risk to infrastructure
- Manage risk to agricultural land
- Minimise risk to human health and life
- Minimise risk to community
- Minimise risk to, or enhance, social amenity
- Support the achievement of good ecological status/potential under the EU Water Framework Directive
- Minimise risk to sites with pollution potential
- Avoid damage to, and where possible enhance, the flora and fauna of the catchment
- Avoid damage to, and where possible enhance, fisheries within the catchment
- Protect, and where possible enhance, landscape character and visual amenity within the catchment
- Avoid damage to or loss of features of cultural heritage importance, their setting and heritage value within the catchment

Map produced after information extraction from satellite imagery





Information extraction for Geo-data base

3 important criteria to evaluate data usefulness

1. Content; are the variables relevant/useful
2. Quality; are the data reliable, up-to-date
3. Size and Coverage

Map Source: Alade and Adepoju, 2010

BUILDING/STRUCTURES IDENTIFICATIONS FROM SATELLITE IMAGERY

NIPOST HQTRS
Garki Area 11
Post Code: FC 2 14BK

NDE Building Wuse Zone 2
Post Code: FC3 2AX

Vulnerability and related data sets

❖ Vulnerability to climate change is the degree to susceptibility and incapability of a system to confront adverse effects of climate change (IPCC 2001)

❖ Determined by two sets of factors IPCC (2003);

➢External factors consist of magnitude, and rate of climate change, and variation to which the system is exposed.

➢ Internal factors are the sensitivity and adaptive capacity of the system itself.

Component	Data Layer	Original data format
Exposure	Average annual precipitation Long-term trend in temperature Flood frequency	Raster (with point inputs)
Sensitivity	Household wealth or Poverty index Infant mortality rate soil quality	Point Polygon Raster (with point inputs)
Adaptive Capacity	Education level of mother Health infrastructure index Accessibility to basic infrastructure	Point Point Raster (with polyline inputs)

1. Highly Vulnerable

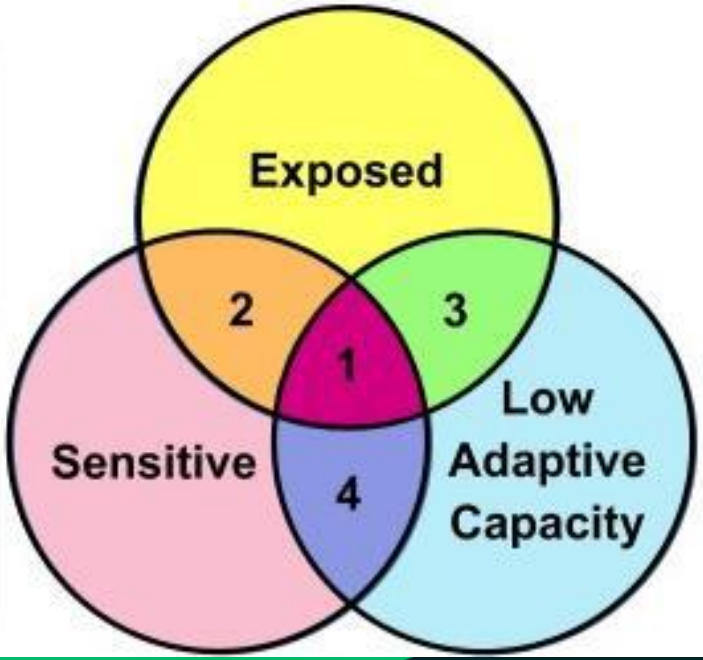
At greatest risk

- Specific research needed
- Interventions generally needed

2. Potential Adapters

May be at risk

- Monitor and support adaptive responses



3. Potential Persisters

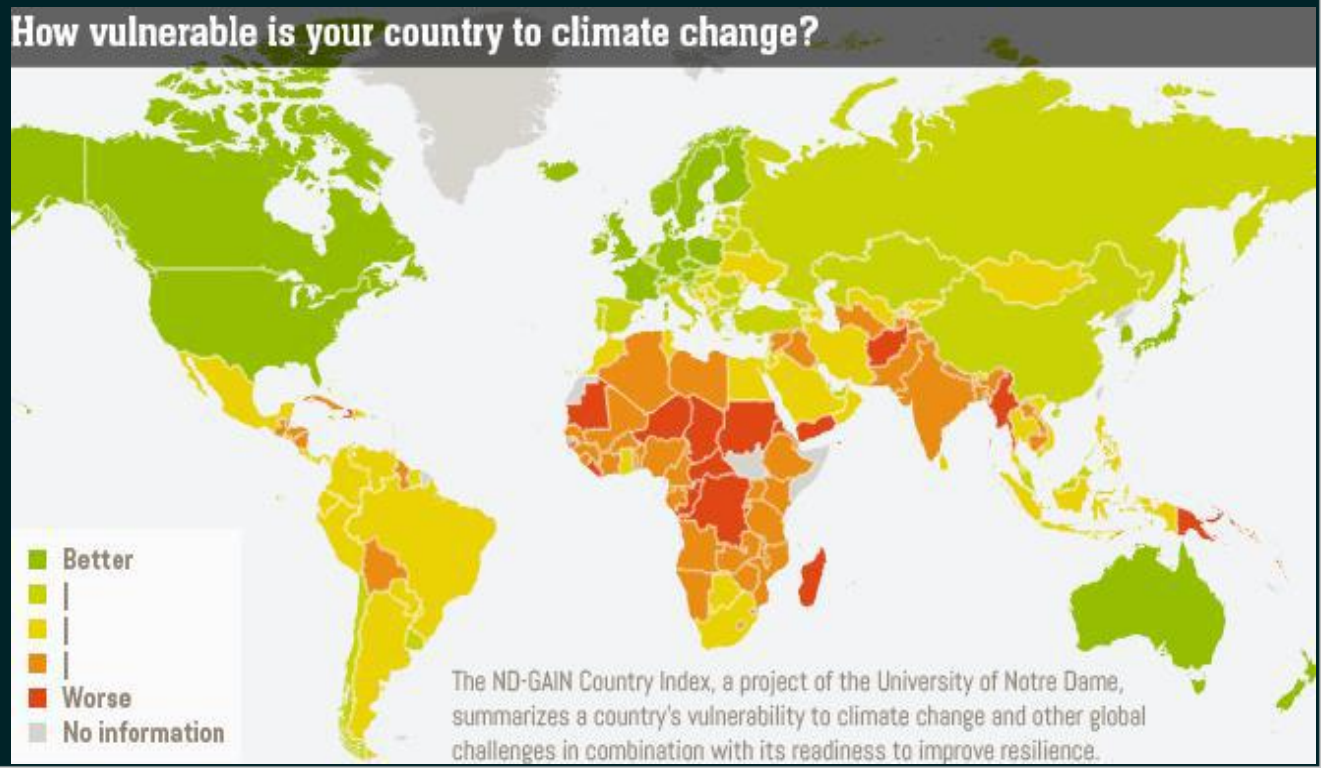
May not be at risk

- Monitor population trends

4. High Latent Risk

Not currently at risk

- Monitor environment



A RECORD OF TWO MAJOR EARTHQUAKES

Haiti

- 12 January 2010
- 7.0 -magnitude
- Death toll: 46,000 - 316,000
- Displaced: 895,000 - 1.5M

Chile

- 27 February 2010
- 8.8 - magnitude (500 times more energy releases)
- Death toll: 550

DIFFERENCES IN VULNERABILITY

- Location and timing of earthquake
  - *Chile: at 34 km depth, offshore*
  - *Haiti: at 13 km depth, on the edge of Port-au-Prince*
- Area affected
  - *Chile: 18 persons/km²*
  - *Haiti: 361.5 persons/km²*
- Socio-economic conditions
  - *Chile: GDP > USD 10,000 / capita*
  - *Haiti: GDP < USD 800 / capita*
- Level of preparation
  - *Chile: building codes, emergency response agencies, history of handling seismic catastrophes*
  - *Haiti: none*

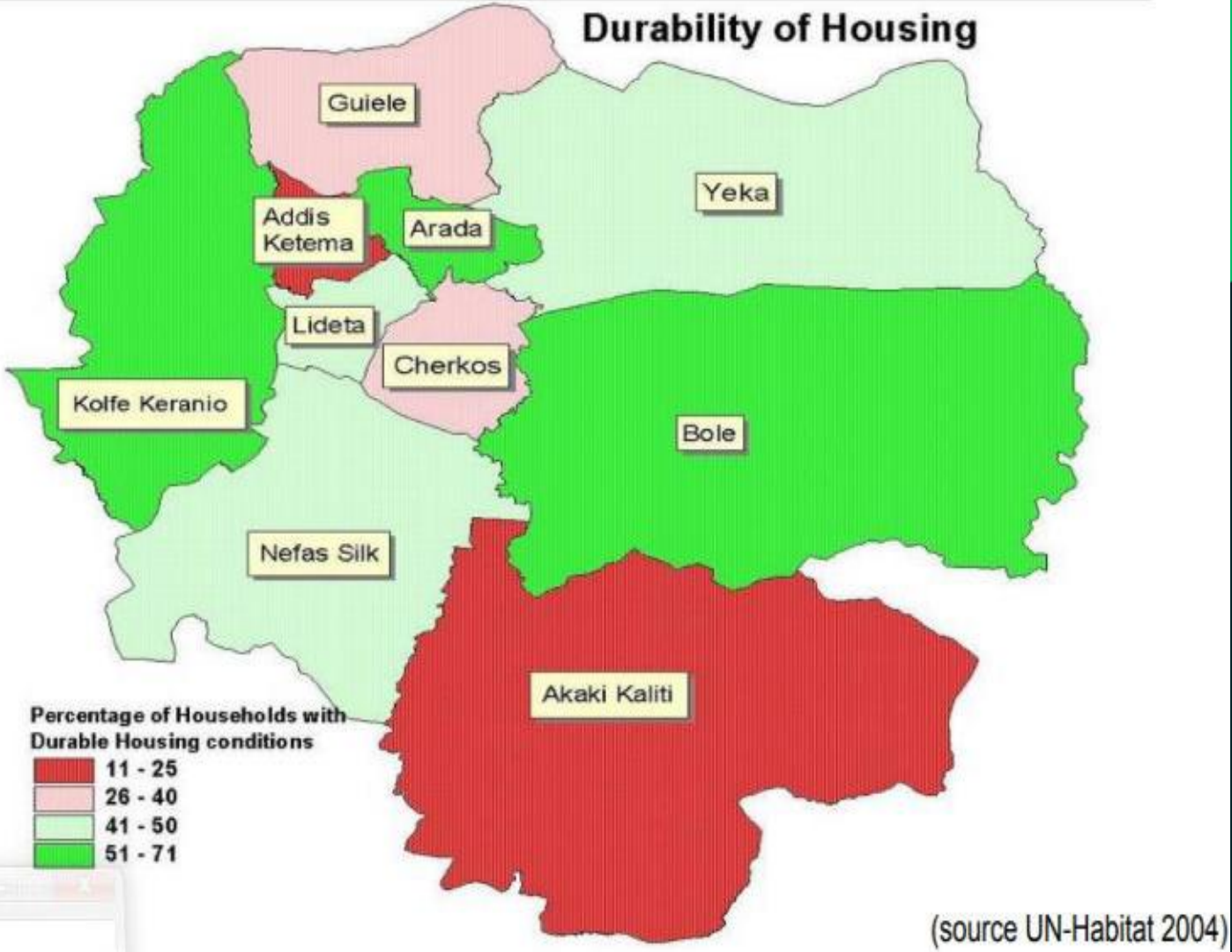
Earthquakes

Typhoon of same intensity

Japan

Philippines

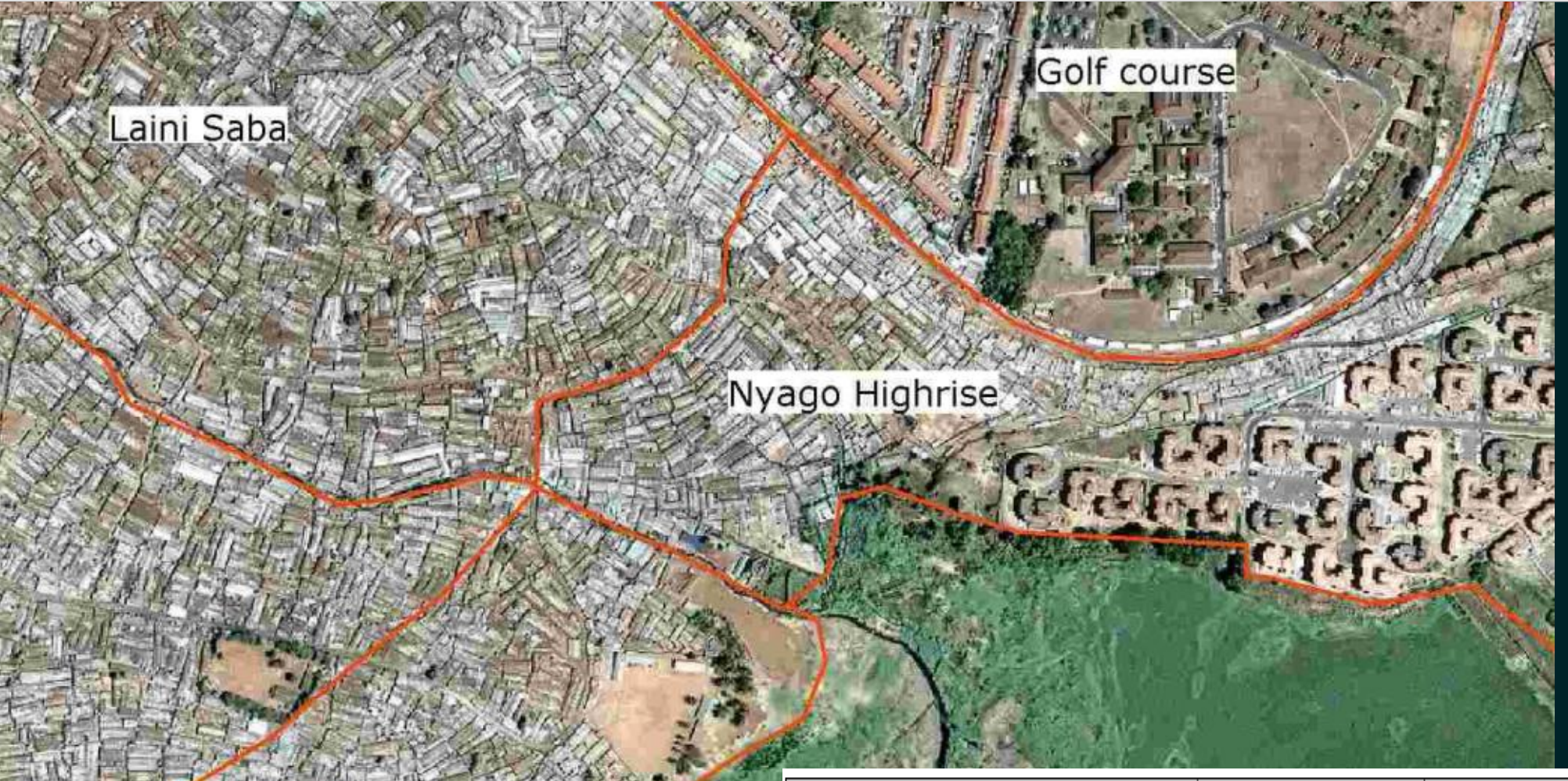
Durability of Housing, Addis Ababa, Sub-city Level



(source UN-Habitat 2004)

Ibadan

What are the attributes of a durable building???

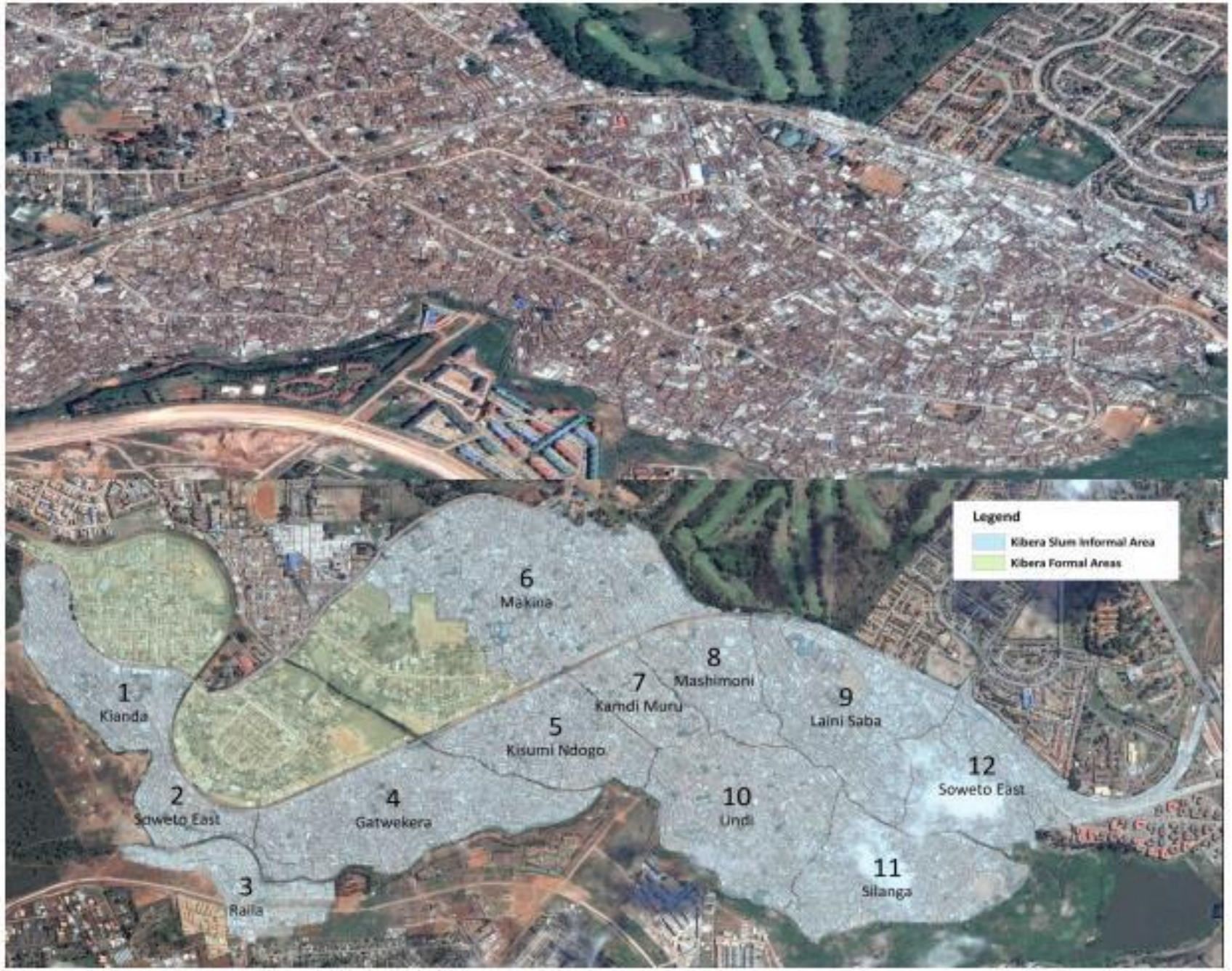


Satellite Image of a slum area in Nairobi and basic statistics of three neighborhoods (sub-locations)

What are the other visible information that can be acquired from the satellite imagery???

Sub-Location	Laini Saba	Golf Course	Nyayo Highrise
Population	26,800	10,260	25,440
Area	29 Ha	168 Ha	46 Ha
Population Density	924 P/Ha	61 P/Ha	553 P/Ha
Slum Households	99%	10%	70%
Connected to main sewer or septic tank	1%	88%	29%

Kibera formal/informal settlement – Different levels of drainage infrastructure and proneness to flood



Population, extent of damage and compensation amounts can be approximated using this imagery for GIS analysis

GIS Applications for Stages of Disaster Management

- Prevention (Mitigation): Actions taken in disaster-prone areas in order to limit the consequences of a possible shock

- Preparedness: Identifies human and material resources needed during a specific possible disaster.

- Response: Issues warnings and evacuations. Shelters are prepared, actions are taken, and the situation is assessed.

- Recovery: Focuses on cleanup and rebuilding, concentrating on the longer-term response to the disaster.

The Information and Data Required for Impact, Vulnerability and Adaptation Assessment and Planning

Policy relevant impact and vulnerability assessment and effective adaptation planning requires a large range of data and information such as: climatic data, including

- Systematic observations of temperature, precipitation, weather patterns and hazards;
- Non-climatic data, including environmental, socio-economic and technical information
- and historic, local and traditional knowledge.

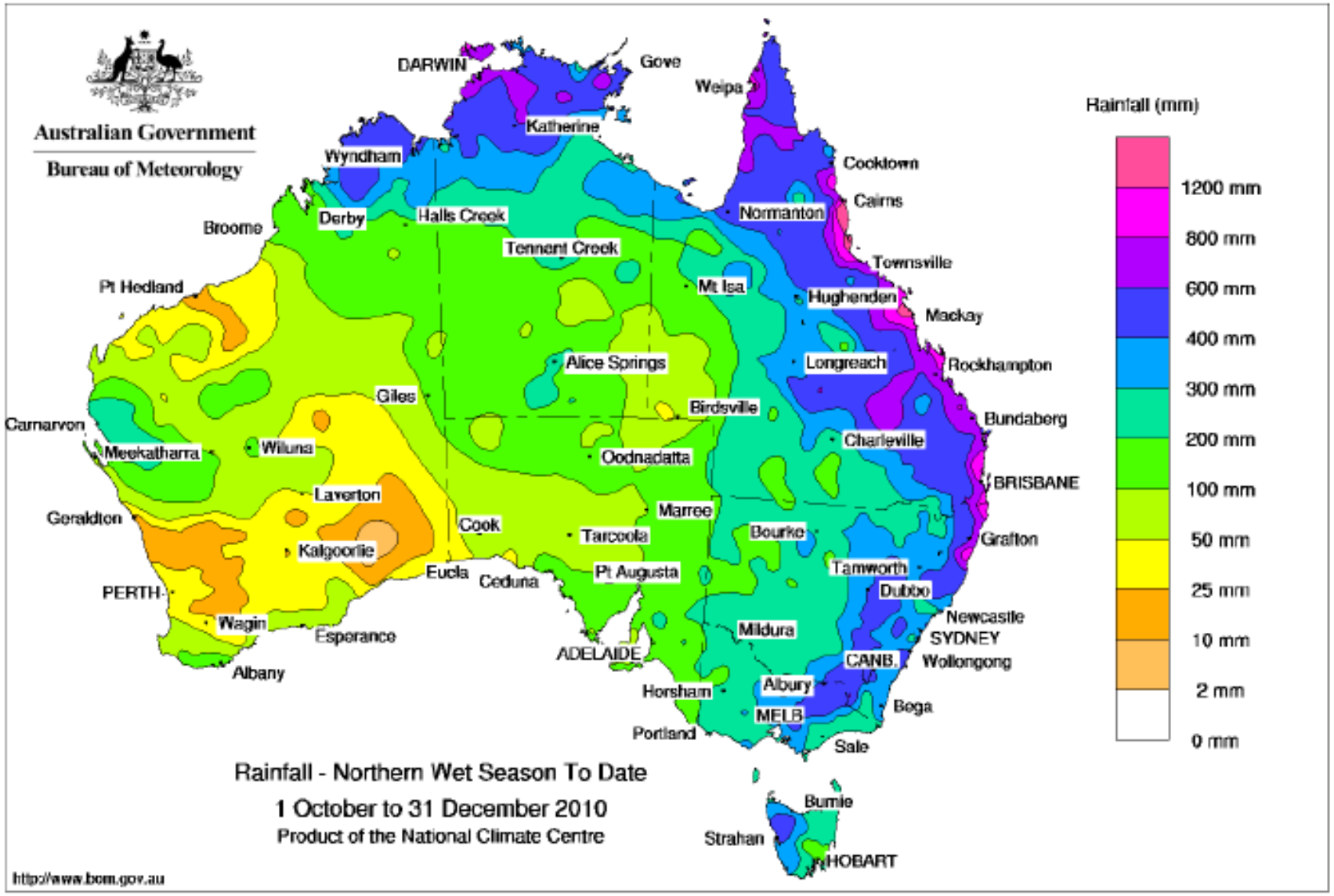
Role of GIS in Flood Disaster Management

Mitigation	Preparation	Response (Rescue)	Recovery
Mapping flood prone areas	Flood detection	Flood mapping	Damage Assessment
Delineating flood plains	Early warning system	Evacuation planning	Spatial planning
Land-use mapping	Rainfall mapping	Damage Assessment	
	Number of disasters in the past	Magnitude and location of the shock	
	Population at risk	Forecast of the shock evolution	
		Infrastructures of the impacted area	
		Population in need of assistance	
		Possible areas of intervention	

Mitigation Stage and GIS Data Use

Mitigation Measures	GIS Data
Mapping flood prone areas	Base maps and shape files for soil types, topographic maps, vegetation cover and land-use
Delineating flood plains	Flood prone maps and land-use maps
Land-use mapping	Land use types – Residential, open spaces, educational, government buildings, commercial, transport routes, important buildings

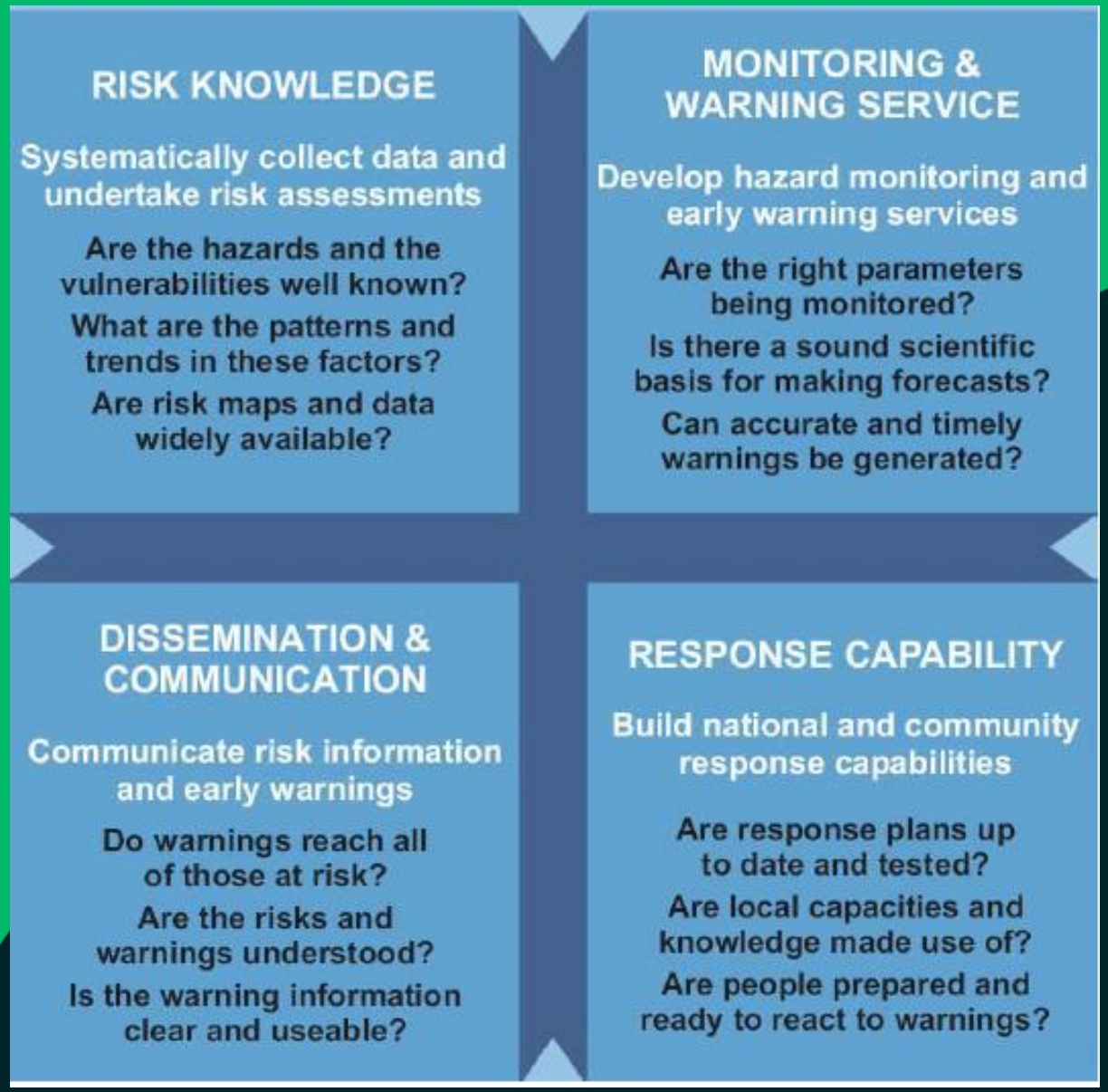
Climatic Data Used in GIS for Mitigation and Preparation for flood and drought



What is an example of a mitigation action in a deep yellow area ???

Preparation Stage against flood disaster and GIS Data Use

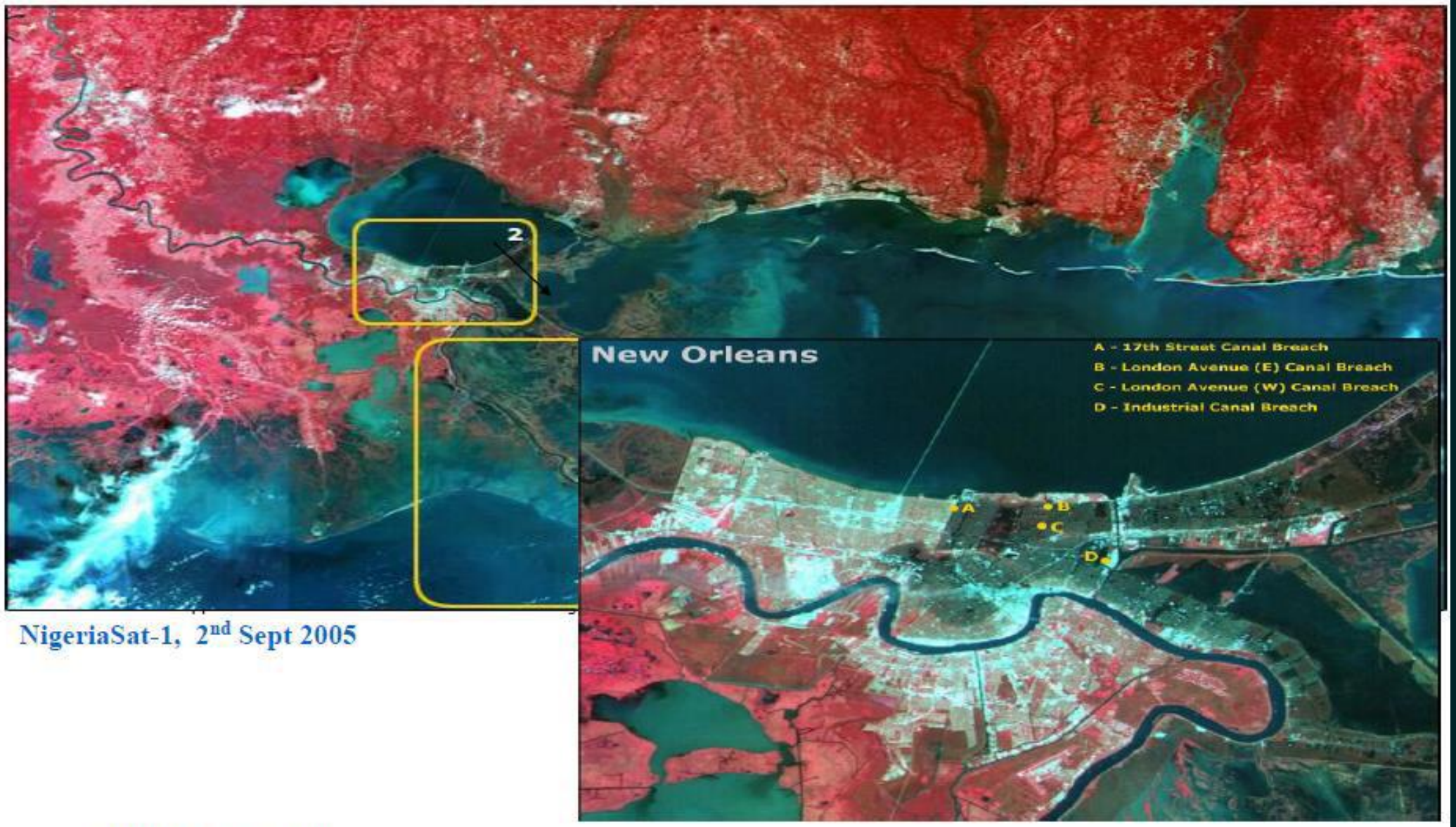
Preparation	GIS Data
Flood detection	Satellite imagery (for change and extent detection)
Early warning system	Risk Knowledge, Monitoring and Warning Service , Dissemination and Communication, Response Capability – GIS database established to store all disaster and natural hazard risk information for EWS's
Rainfall mapping	Climatic data for trends analysis
Number of disasters in the past	Flood disasters in the past spatially geo-coded to specific locations.
Population at risk	Formal or informal settlements, quality of building, infrastructures – rainwater pipes, close highland for evacuation, flood plains and overflow areas for rivers e.t.c



Early Warning System as a Preparation against flood disaster

Response Scenario using NigeriaSat-1

New Orleans from NigeriaSat-1 showing the effect of Hurricane Katrina



NigeriaSat-1, 2nd Sept 2005

Source: NASRDA, 2010

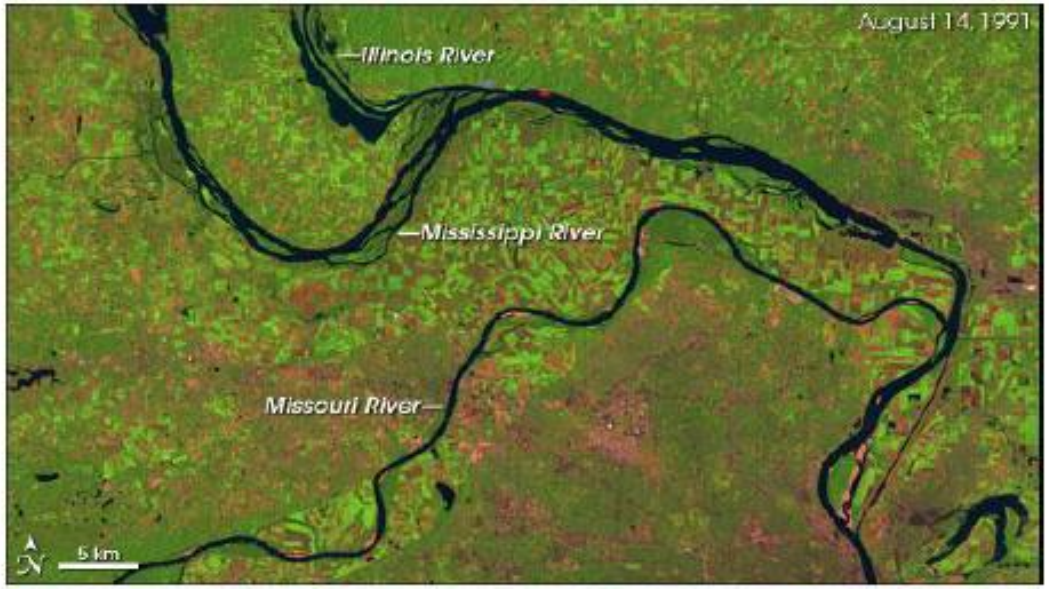
Calgary Pre-Flood/Post-Flood Comparison

Before flood: Google Earth Image
September 2008

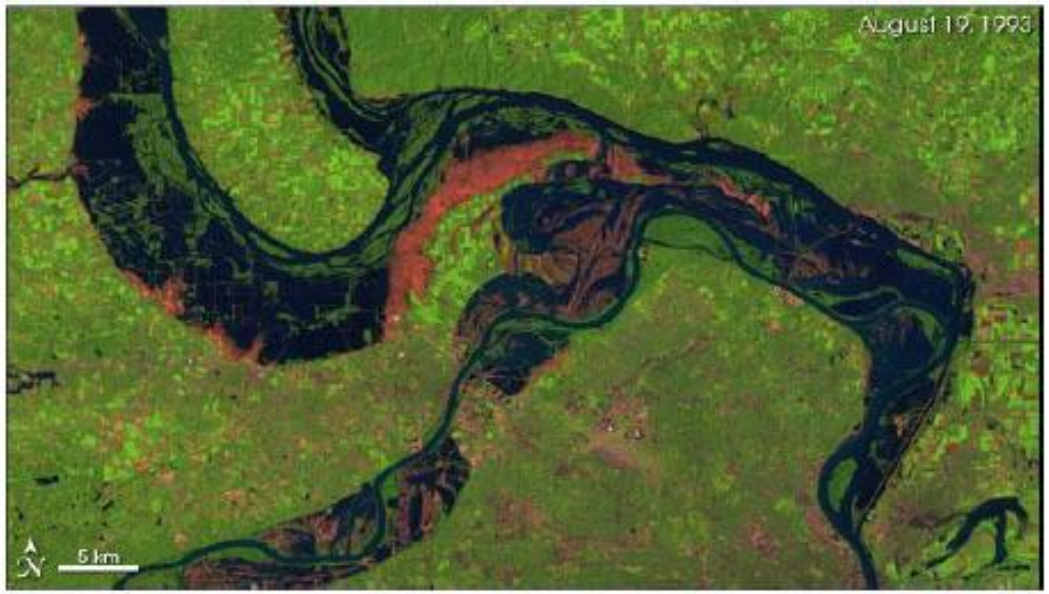
After flood: NASA/ISERV Image
June 22, 2013

Use of GIS and Remote Sensing in pre/post flood scenario (Disaster Response)

Response Stage to assess flood situation and GIS Data Use for Change Detection of the Great flood from Mississippi river



Before flood on August 14, 1991



Connected also to Illinois and Missouri river

After flood - August 19, 1993..

IDP SETTLEMENTS IN WAU SHILLUK, UPPER NILE STATE, SOUTH SUDAN

Analysis with WorldView 2 Data Acquired 17 February 2014 and 16 December 2013

GIS used in suitability analysis as a **response** for IDP settlements of flood victims

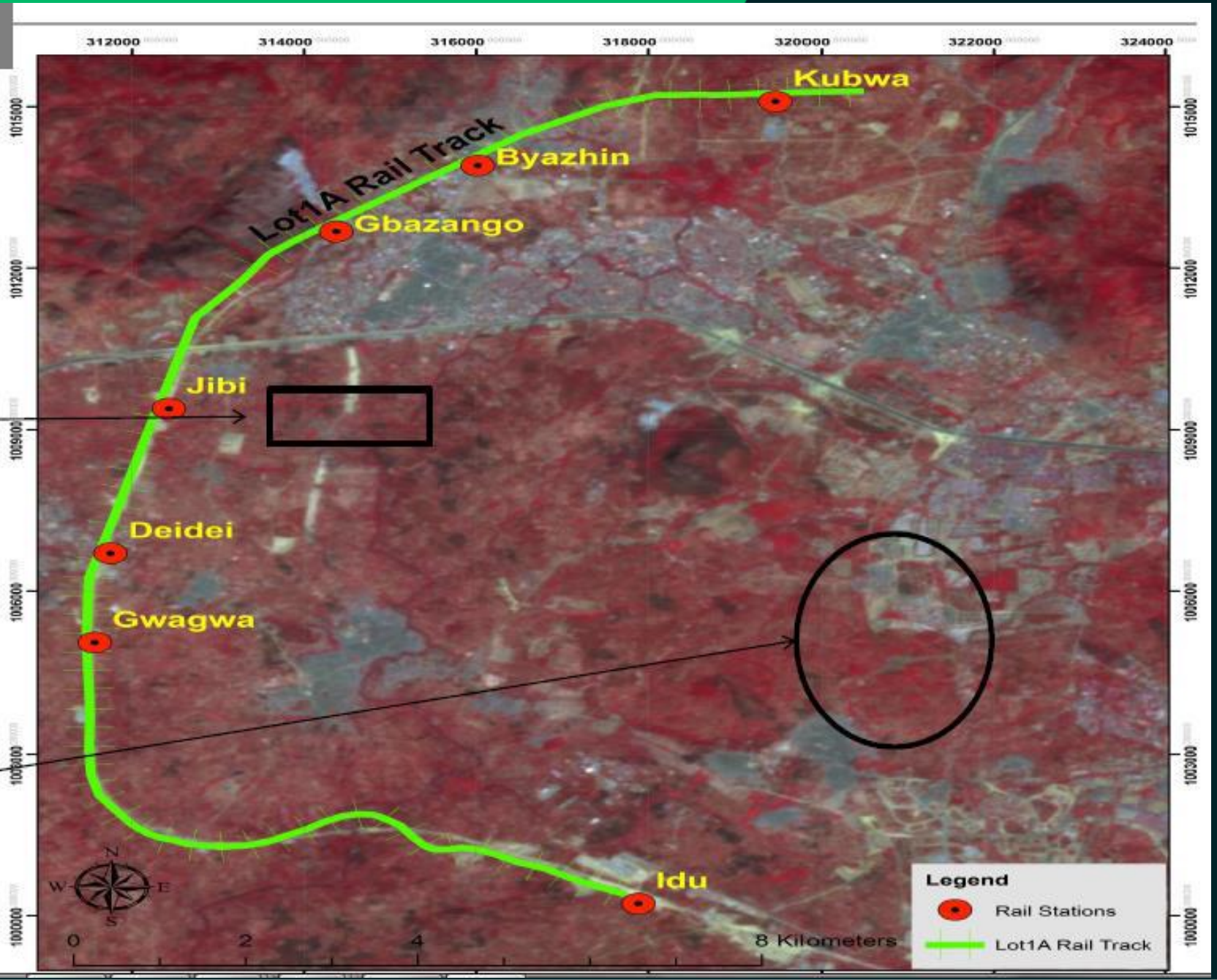
What kind of factors were considered during the suitability analysis???

Response Scenario using Nigeria-Sat X

Accessibility Scenario 1:

Better area of relocation (higher elevation, closer proximity to rail transport at Jibi stop with space and good proximity to facilities at Gbazango settlement)

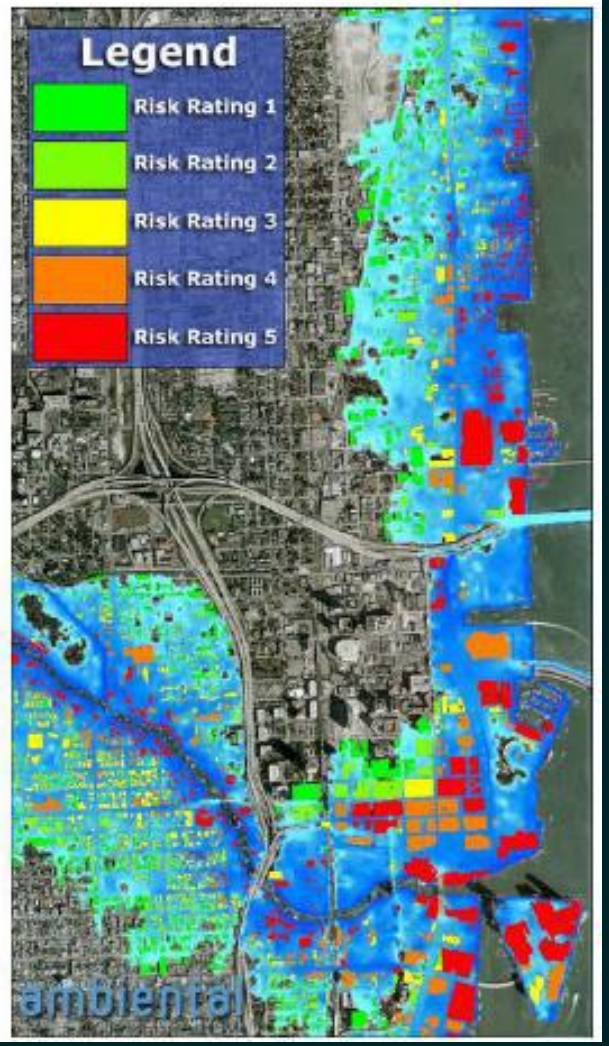
Assumed area of flood

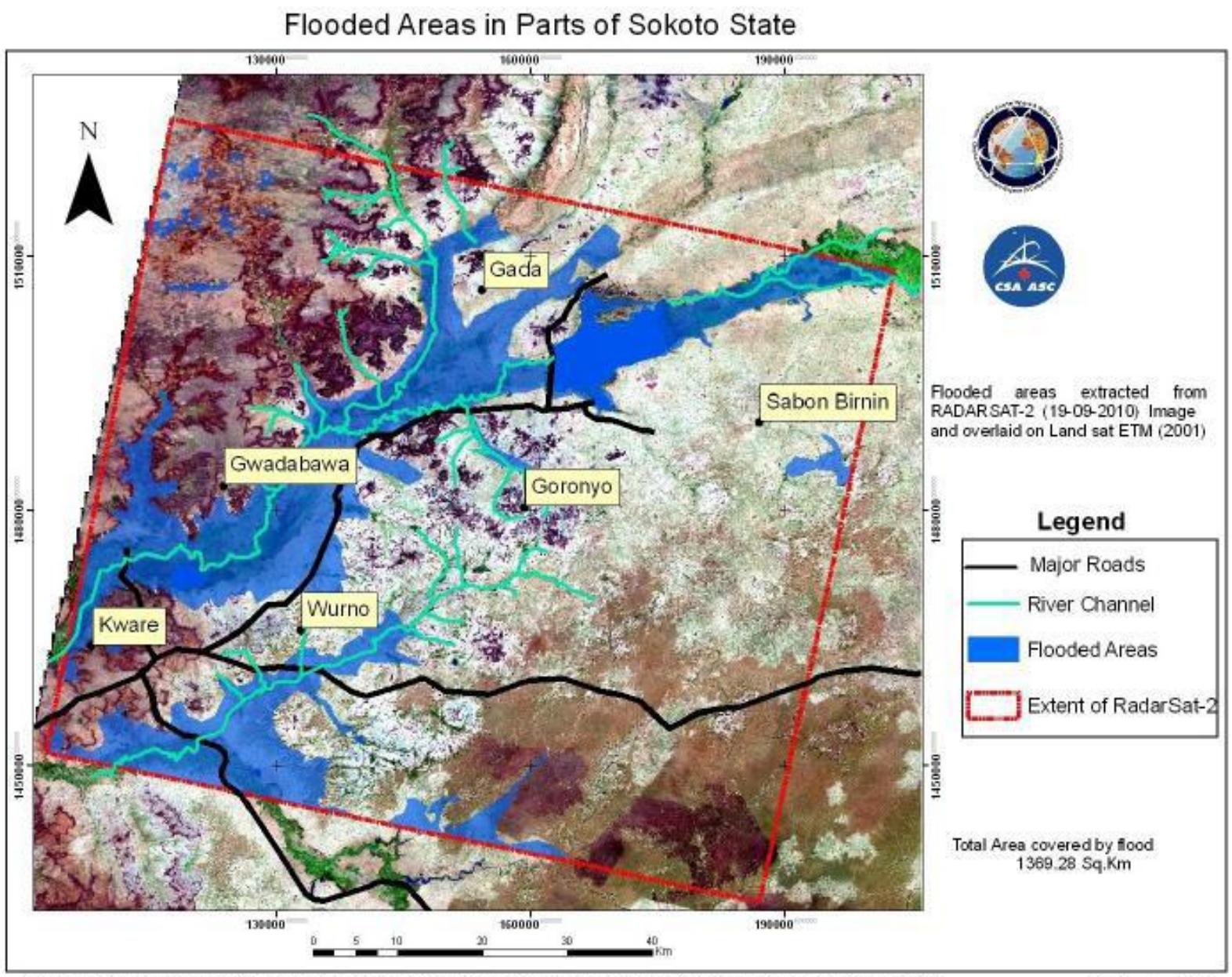


Source: Alade, 2013

Shared experiences from the United Nations Disaster Charter

Sharing my experience about the scientific procedure as one of the project managers for the charter – Talk session



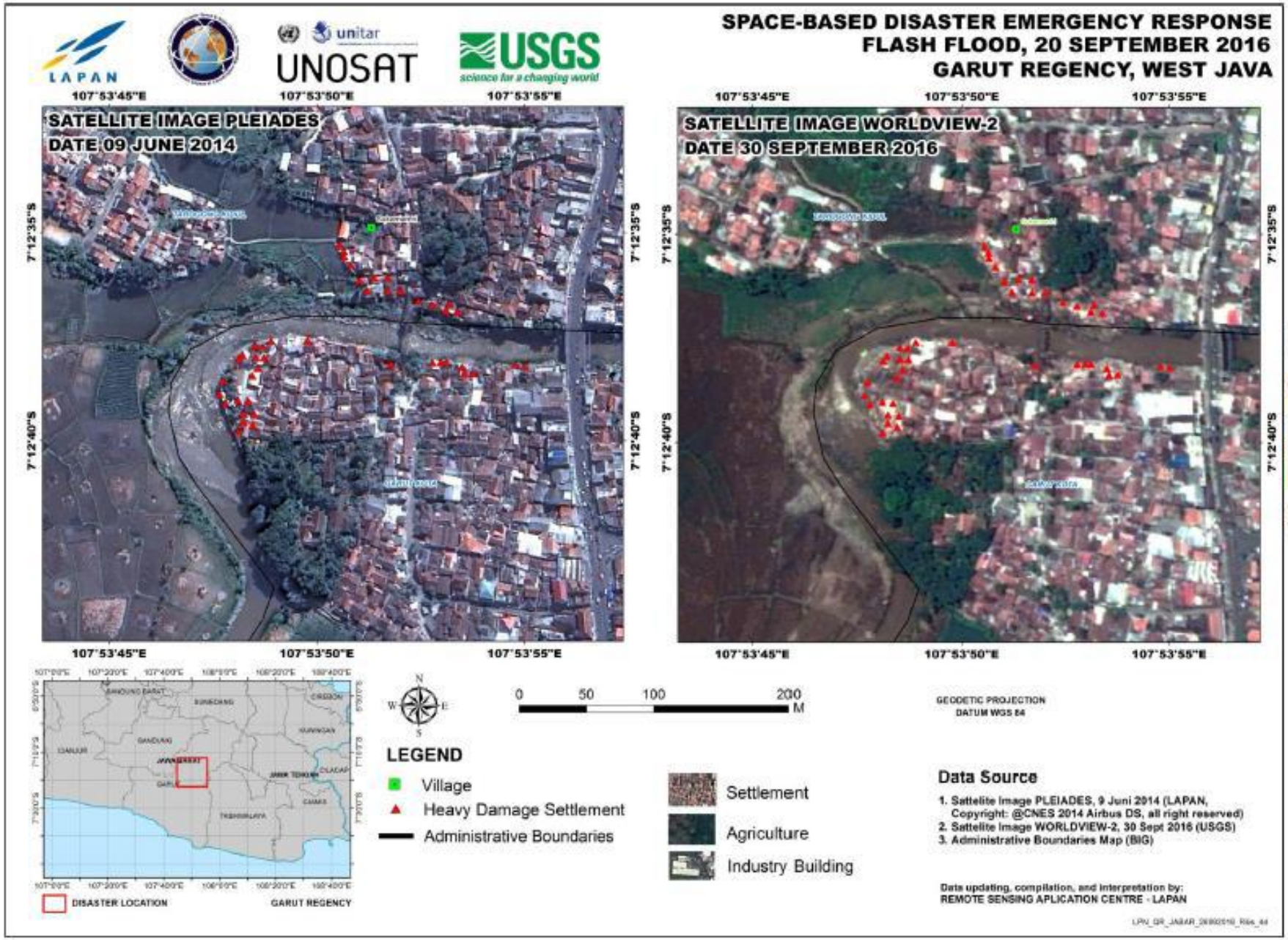


Vulnerability Assessment as a component of UN Disaster Charter activation

Acquired: Pre-disaster: 09/06/2014 - Post-disaster: 07/10/2016

UN Disaster Charter activation

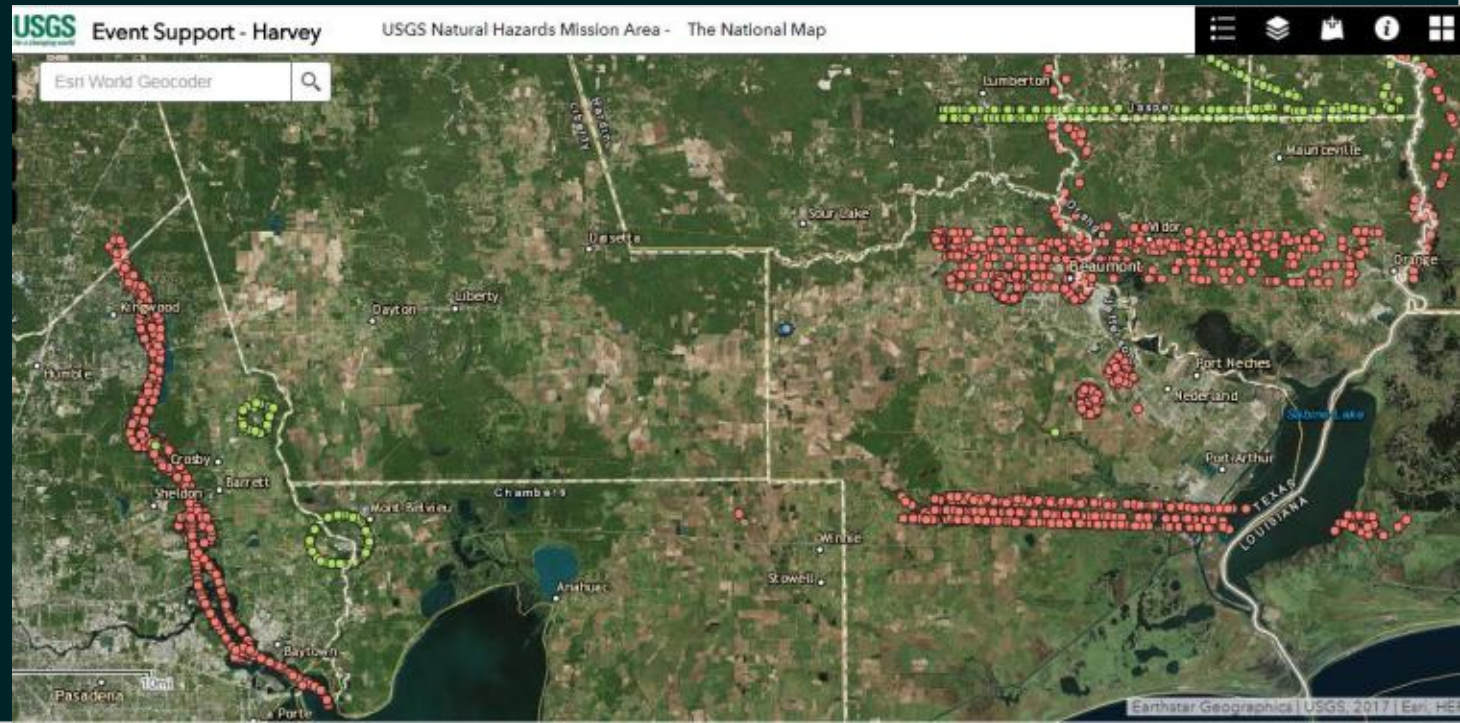
- Torrential rains triggered floods and landslides on **Indonesia's Java** Island
- Garut district - worst affected.
- 36 people killed
- 22 are missing
- over 6000 people left homeless.
- City's business district brought to a halt.
- Jakarta's police force with the government begun to evacuate affected communities and provide inflatable boats. **How many?**
- The president of Jakarta - **anti-flood projects** as the city is prone to intense flooding during **monsoon season.**



UN Disaster Charter activation, 2016 In west java, showing heavily damaged Settlements in red triangles

Benefits of Vulnerability Assessment

- Improved communication about risks and what is threatened
- Better visual presentations and understanding of the risks and vulnerabilities
- Allows for decision on mitigating measures
- Prevent or reduce loss of life, injury and environmental consequences before a disaster occurs
- Or determine where to respond first and best evacuation routes
- Used as overlay on flood inundation and slope stability zones with property maps to determine buildings at risk on water inundation or slope failure



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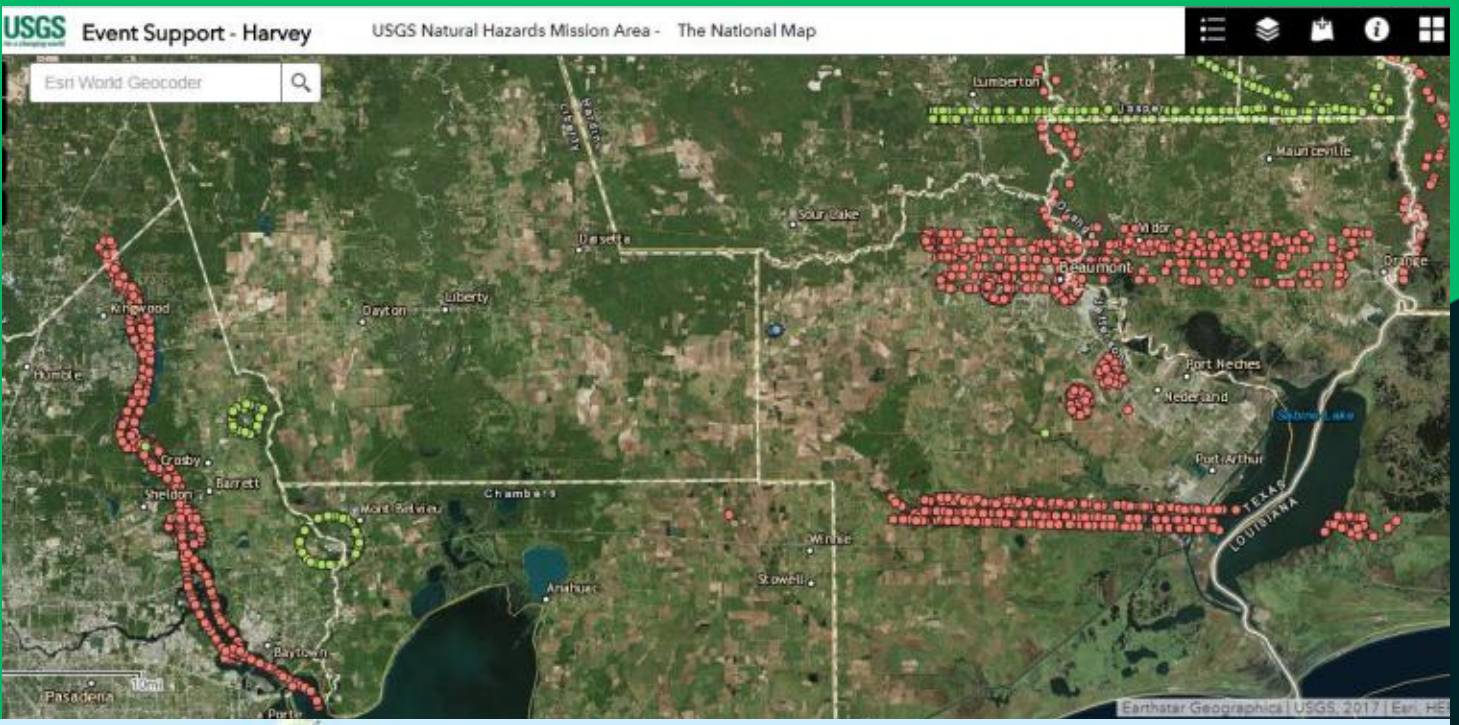
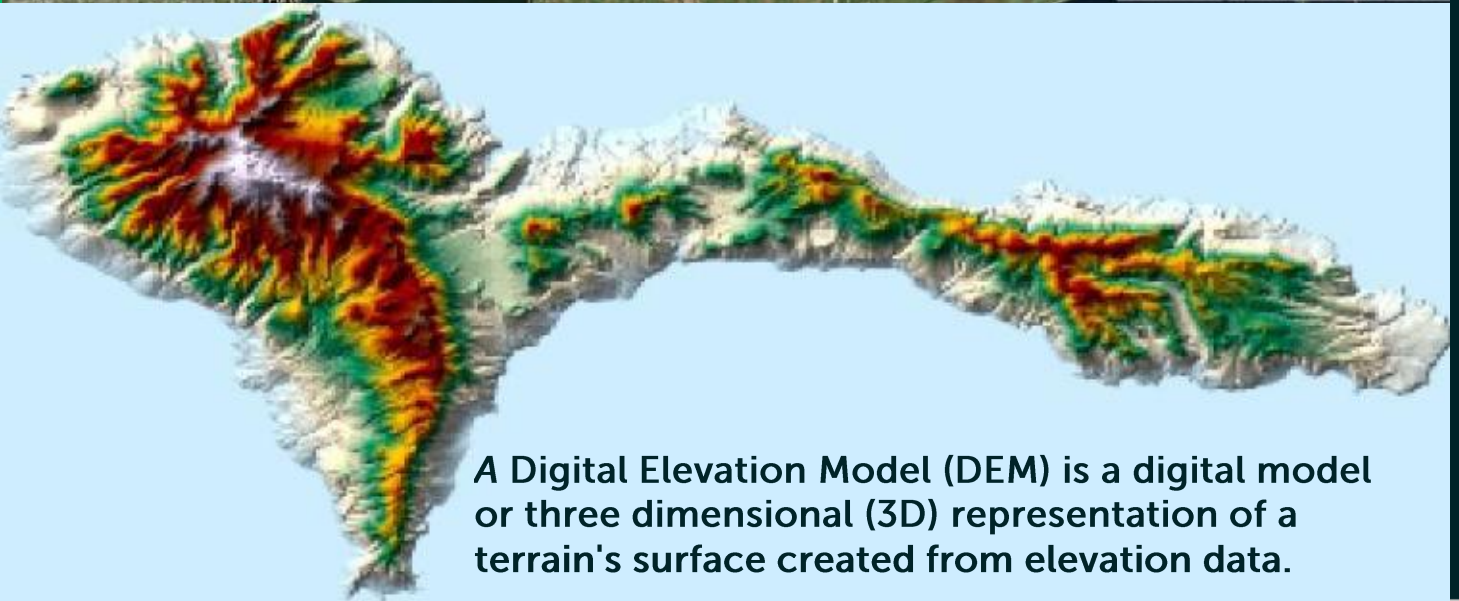
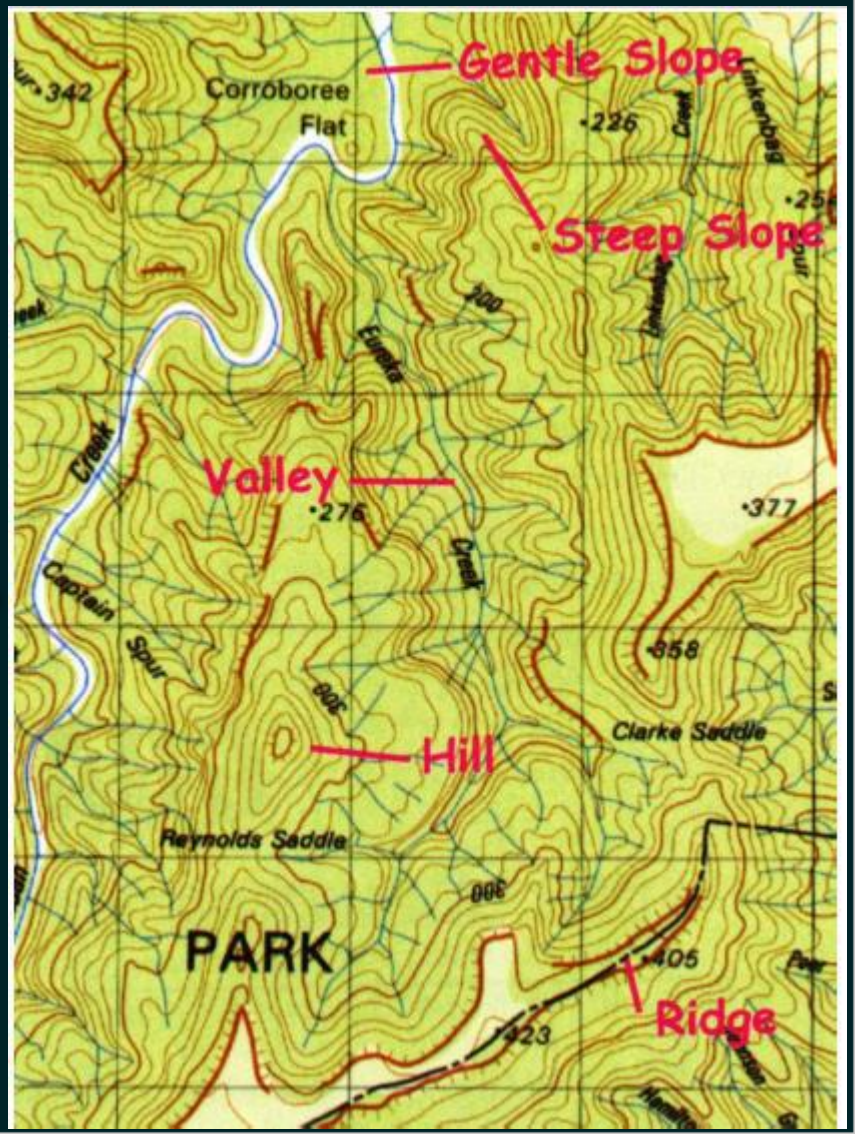




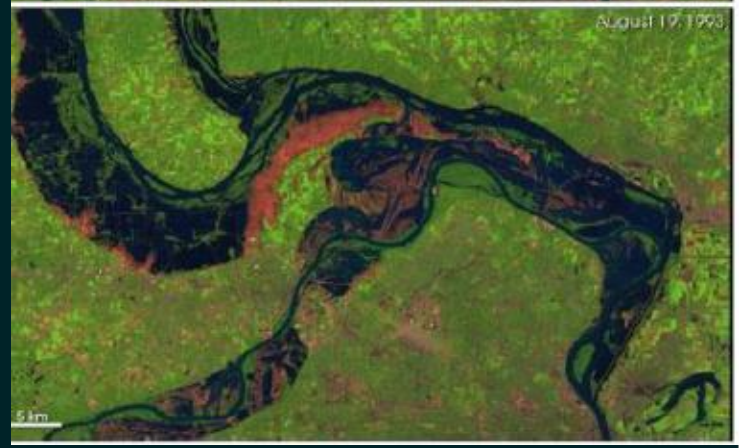
A Digital Elevation Model (DEM) is a digital model or three dimensional (3D) representation of a terrain's surface created from elevation data.

Different sources of elevation data

- Point elevation data
- Contour and stream-line data
- Space-borne and air-borne remotely sensed elevation data



Conclusion



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At greatest risk

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May be at risk

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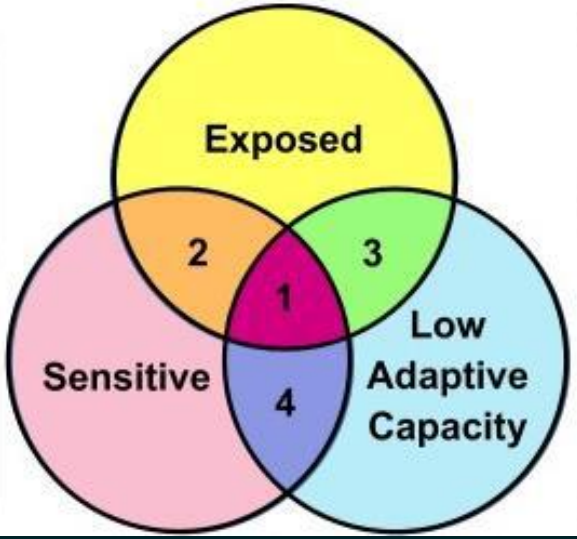

3. Potential Persisters

May not be at risk

- Monitor population trends

4. High Latent Risk

Not currently at risk

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Thank You