

Application of Geographic Information Systems (GIS) To Climate Vulnerability Assessment

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Presentation Outline

- GIS and its importance for vulnerability assessment
- Vulnerability assessment
- Benefits of vulnerability mapping
- GIS and Remote sensing for vulnerability assessment
- Different types of data used for specific vulnerability assessments
- GIS Applications for Stages of Disaster Management
- Determination of the greatest risks zones and their potential consequences
- United Nations International Charter and Major Disasters to provide vulnerability assessments

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

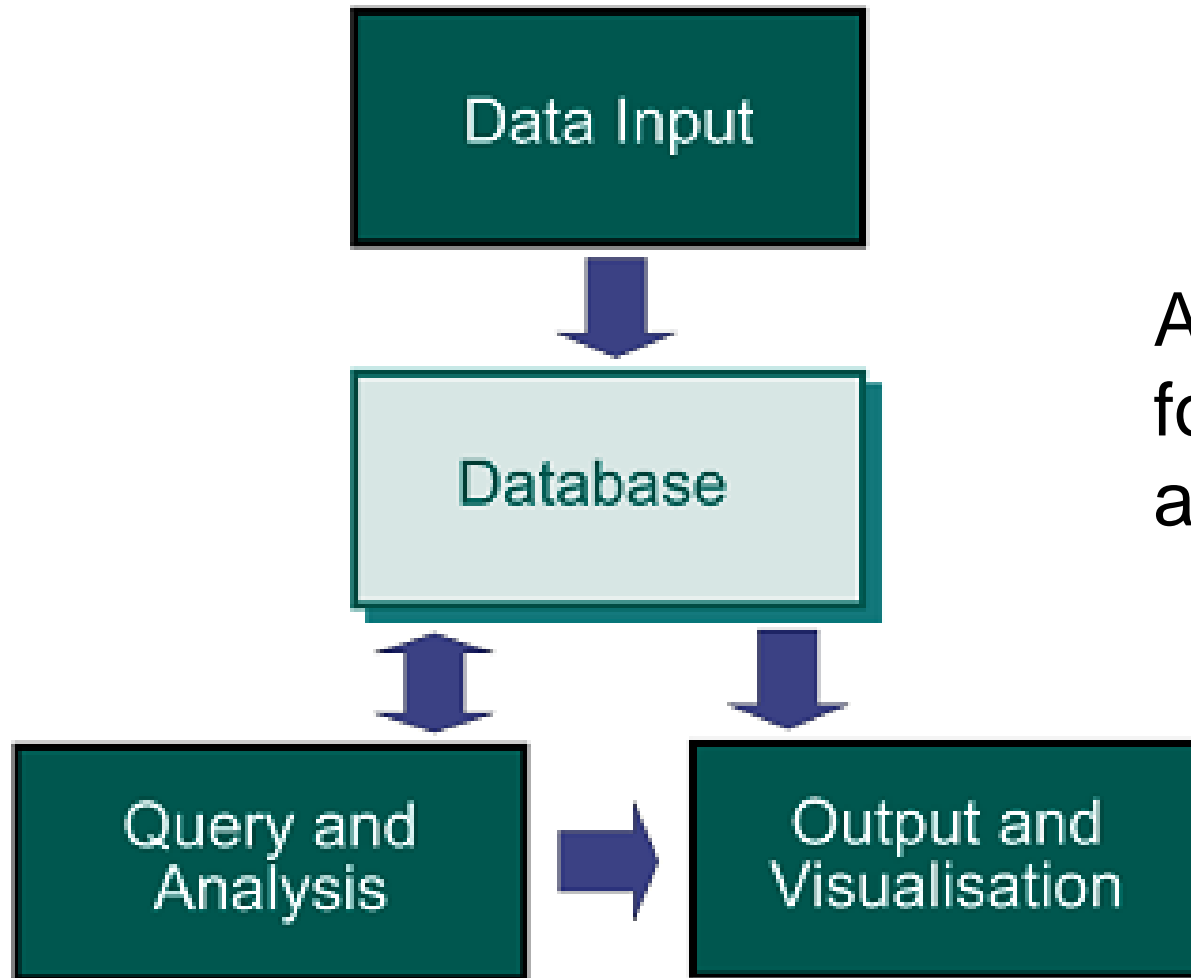


Disadvantages

- 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 for synchronized GIS system or NGDI.

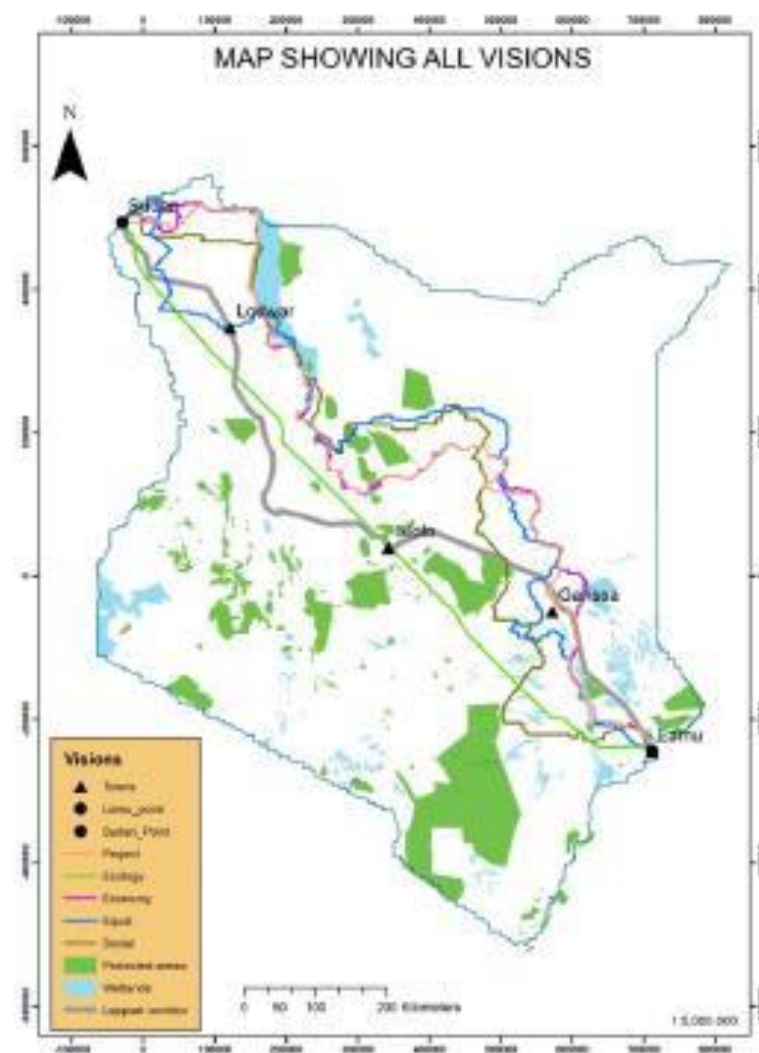
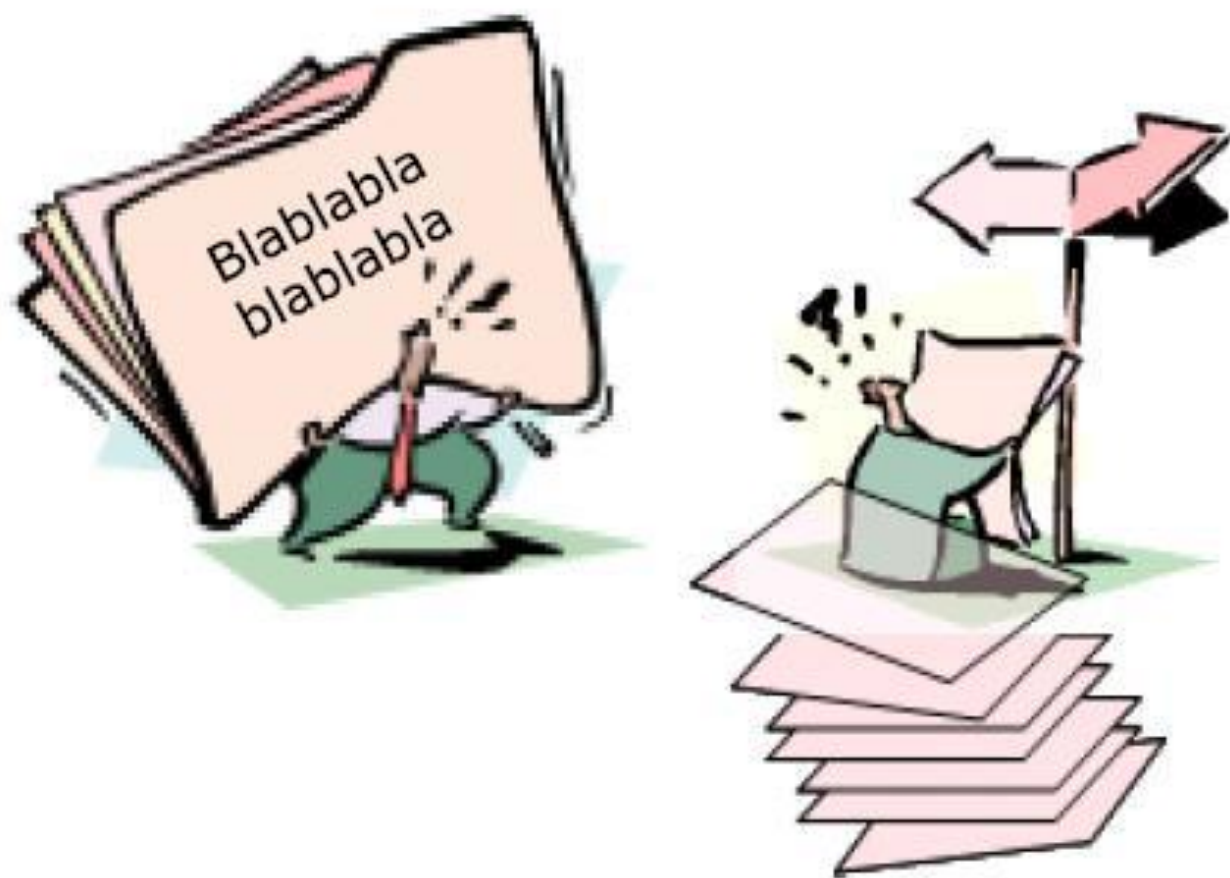
A Hazard Map showing the key resources and the hazards affecting them

What is GIS?



A GIS is a computer–assisted system for the **acquisition, storage, analysis** and **display** of geographic data.

A map says more than a thousand words!



Urban GIS layers



Planning map layers

Building layer, Land use layers

Network and admin. boundaries layers

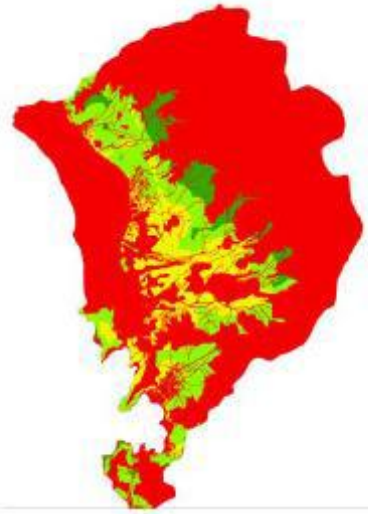
Natural resource layers

Satellite image, Ortho-rectified

Topographical base maps

A geographic information system (GIS) lets us visualize, question, analyze, and interpret data to understand relationships, patterns, and trends (Esri, 2016).

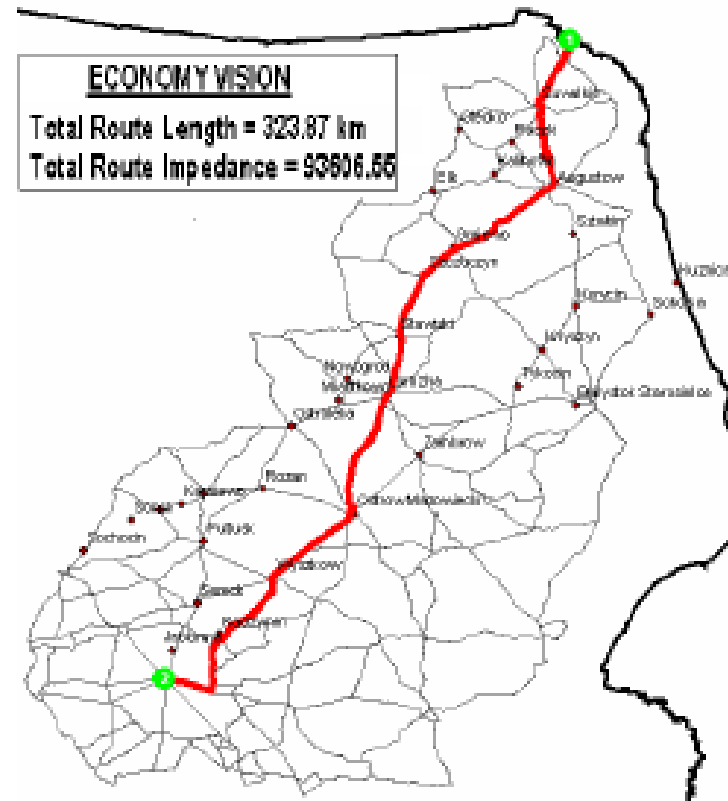
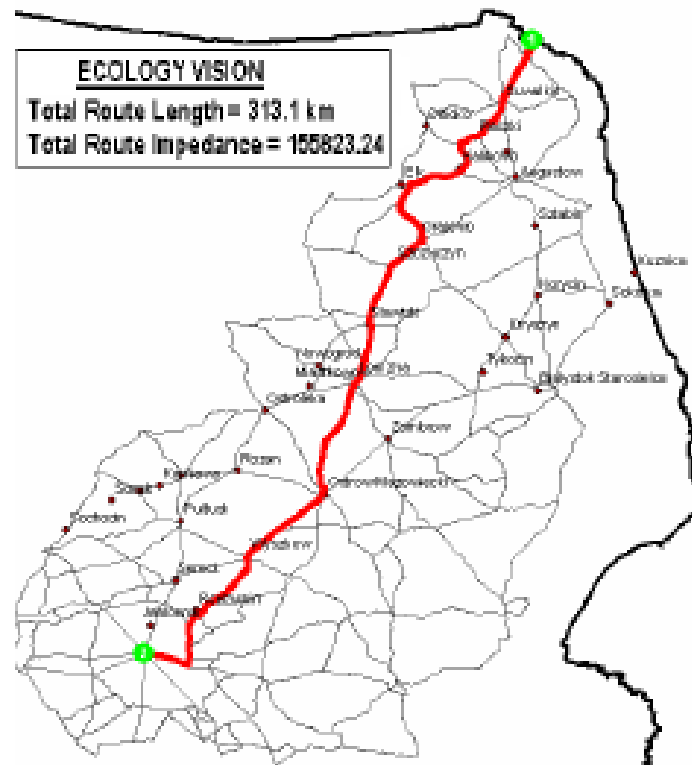
GIS as an Inclusive Decision Support Systems for Vulnerability Assessment



Stakeholders participation and provision of spatial and non spatial data for real-time and trend scenarios

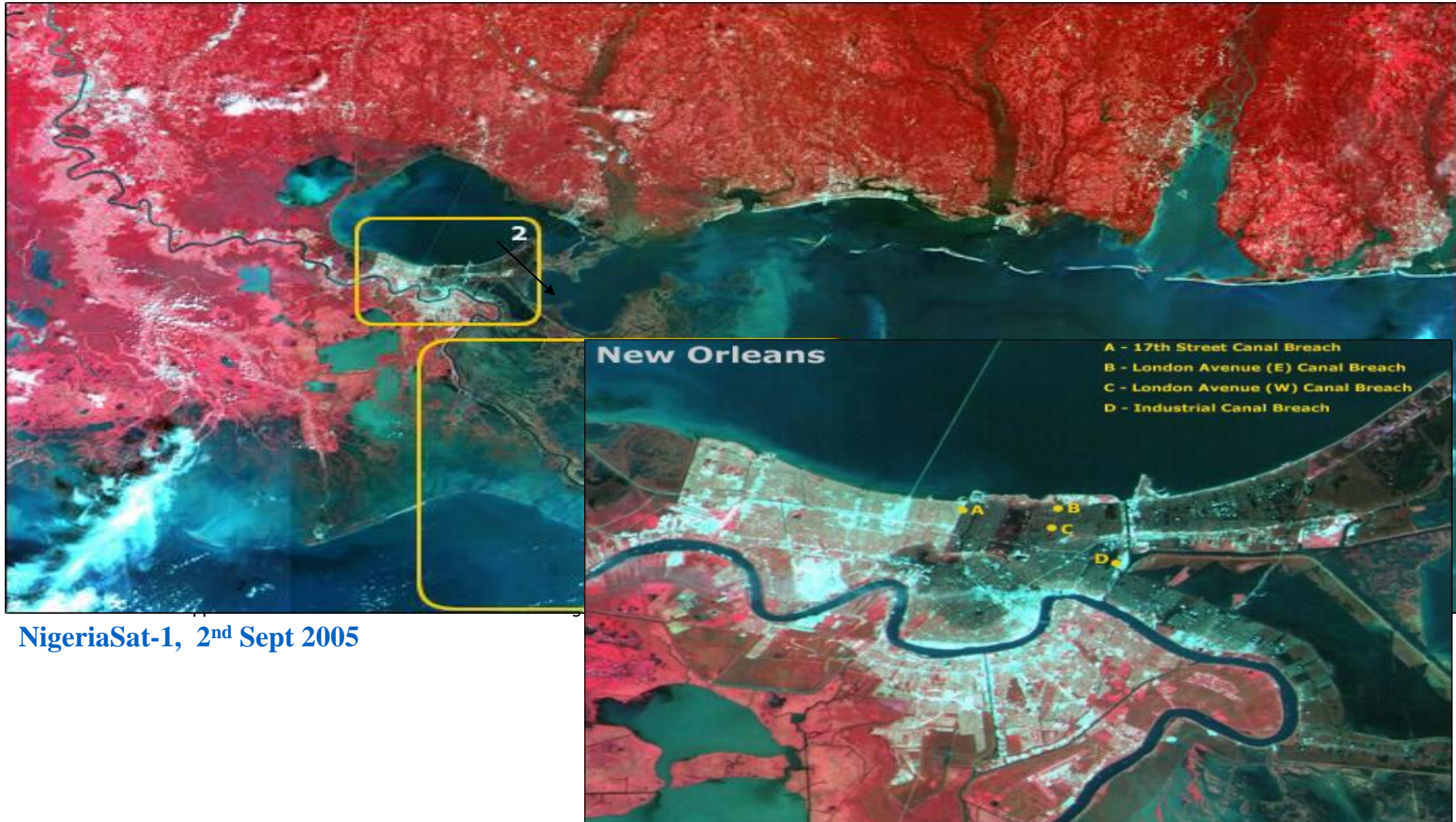
- Most EA's involve several alternative options and numerous stakeholders with different views and perceptions.
- In many EA's an extensive and often qualitative assessment of alternative options and possible variants is carried out.
- The aim is to justify the choice of one or only a few 'preferred' alternatives and then carry out the EA on those selected.

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**

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



NigeriaSat-1, 2nd Sept 2005

Vulnerability

- ...“Vulnerability is the real driver for disaster risk, and hazard is merely the trigger” [David Alexander (2013), after Kenneth Hewitt (1983)]

Dimensions of vulnerability

- Physical
- Economic
- Social
- Ecological
- Cultural
- Institutional

Key (Causal) Factors For Vulnerability

- 1 Exposure
2. Susceptibility (fragility)
3. Lack of resilience or societal response capacity
4. Hazard

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

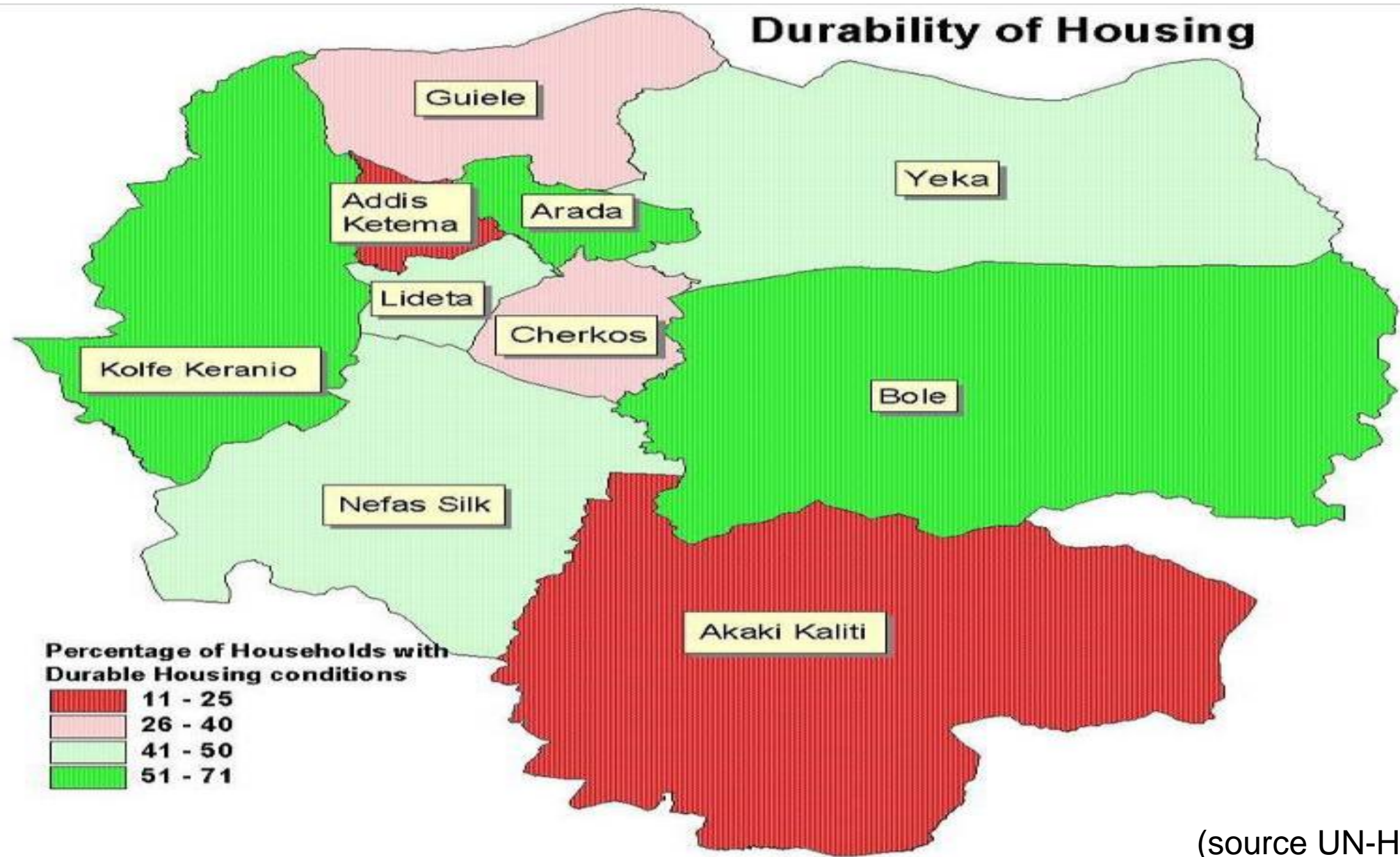
- 27 February 2010
- 8.8 - magnitude
(500 times more energy releases)
- Death toll: 550



DIFFERENCES IN VULNERABILITY

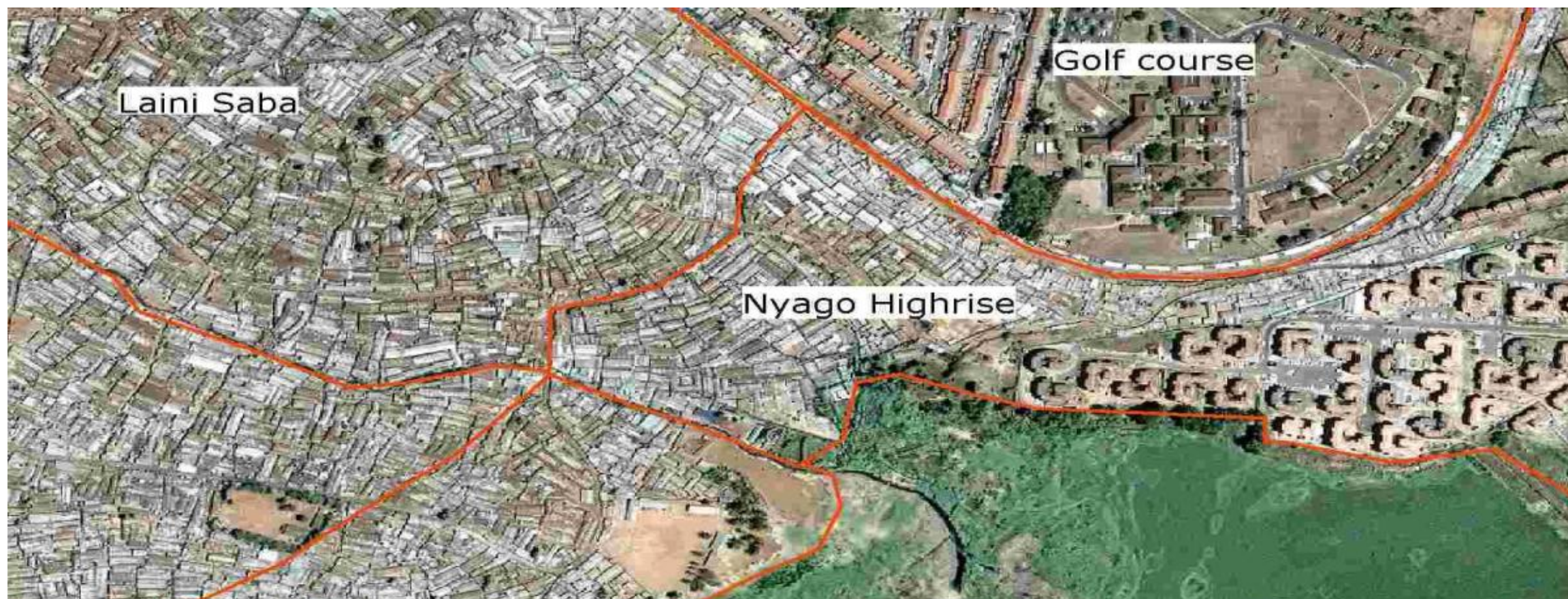
- **Location and timing of earthquake**
 - Chile: at 34 km depth, offshore
 - Haiti: at 13 km depth, on the edge of Port-au-Prince
- **Area affected**
 - Chile: 18 persons / km²
 - Haiti: 361.5 persons / km²
- **Socio-economic conditions**
 - Chile: GDP > USD 10,000 / capita
 - Haiti: GDP < USD 800 /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

Durability of Housing, Addis Ababa, Sub-city Level



(source UN-Habitat 2004)

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



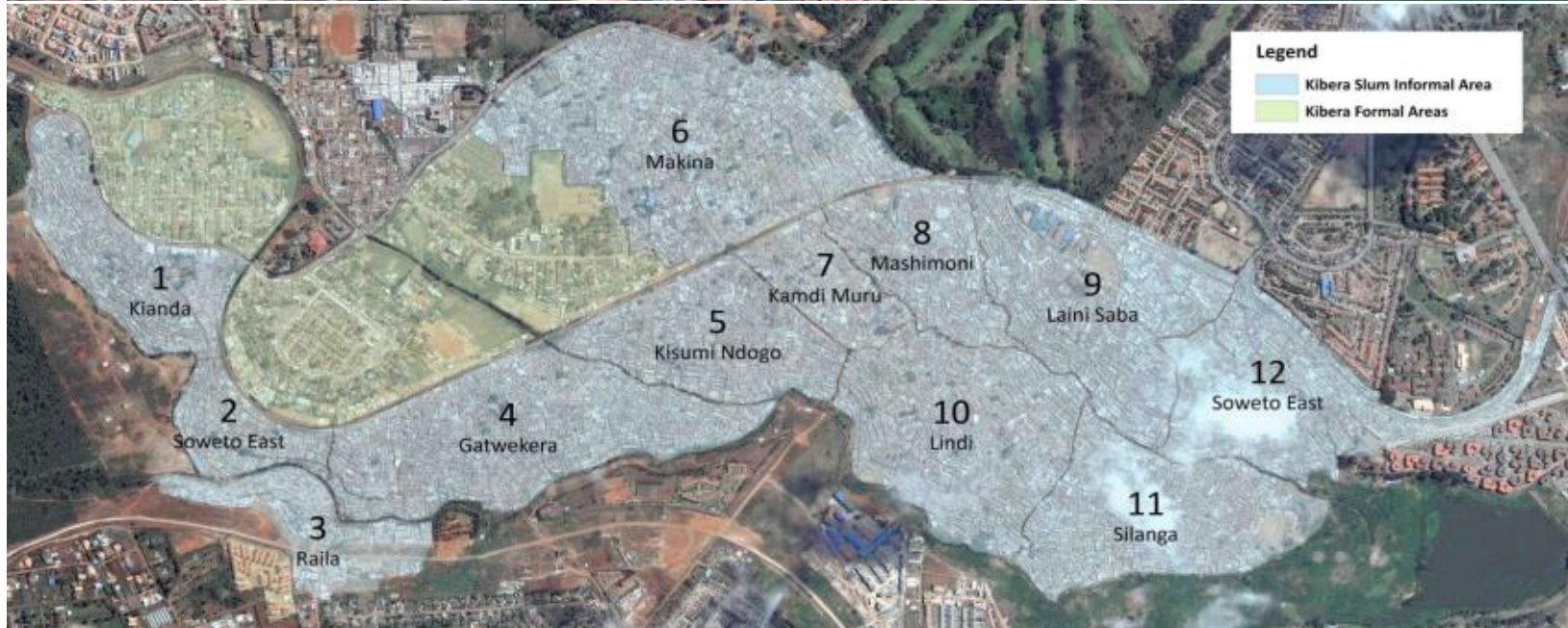
| Sub-Location | <u>Laini Saba</u> | <u>Golf Course</u> | <u>Nyayo Highrise</u> |
|--|--------------------------|---------------------------|------------------------------|
| Population | 26,800 | 10,260 | 25,440 |
| Area | 29 Ha | 168 Ha | 46 Ha |
| Population Density | 924 P/Ha | 61 P/Ha | 553 P/Ha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



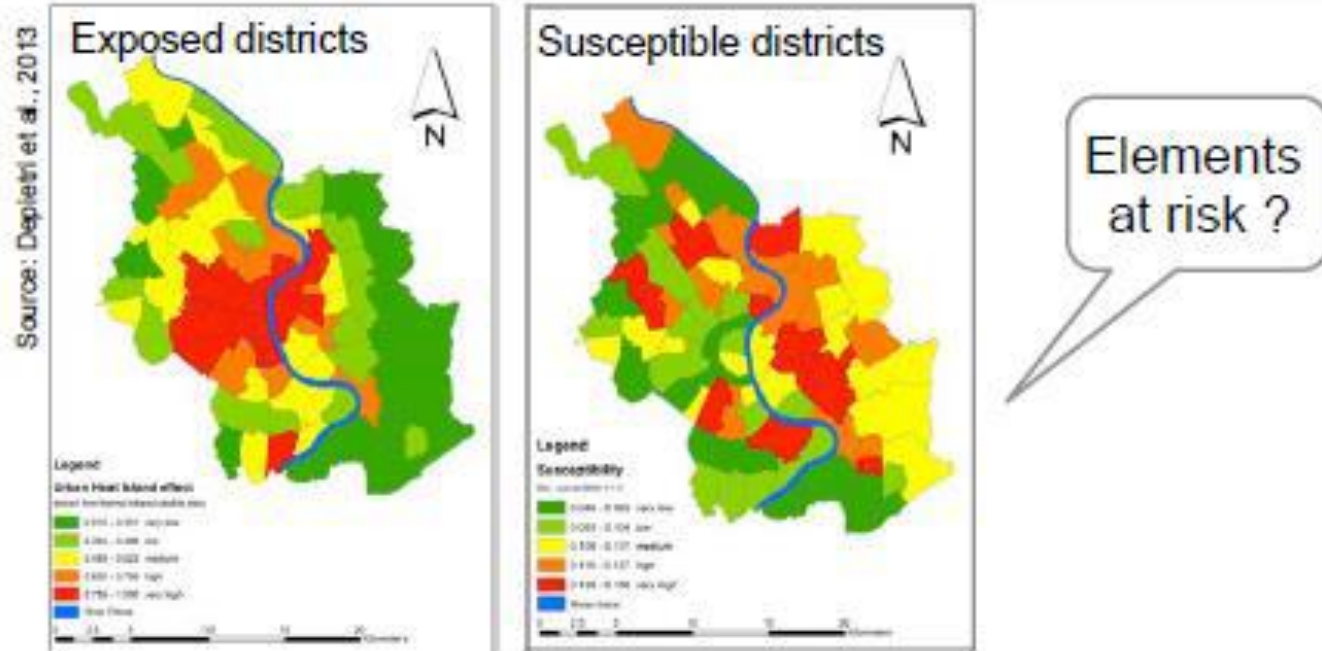
Kibera formal/informal settlement – Different levels of drainage infrastructure and proneness to flood



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



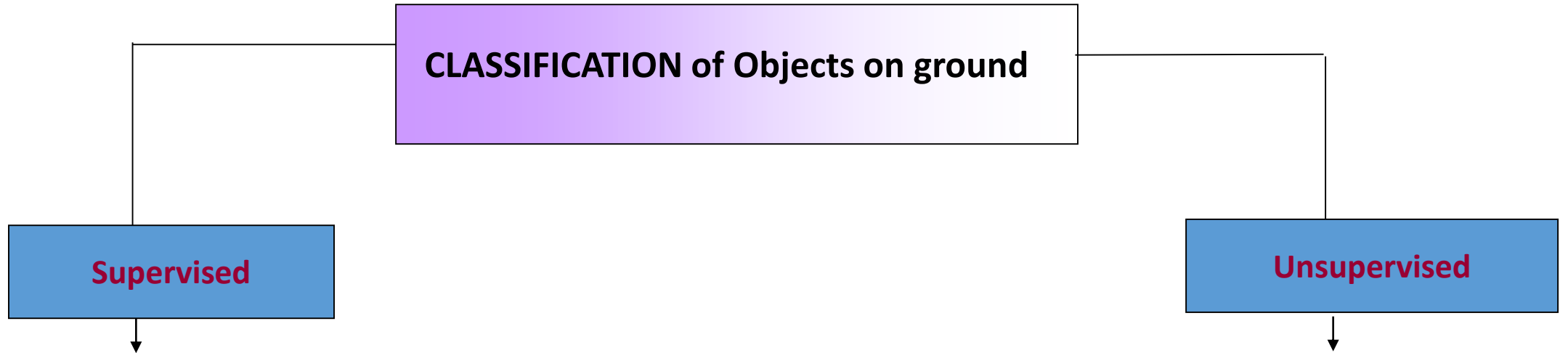
EXPOSURE VERSUS SUSCEPTIBILITY



Exposure: Extent to which a unit of assessment falls within the range of the hazard

Susceptibility: The predisposition of elements at risk to suffer harm from the hazard

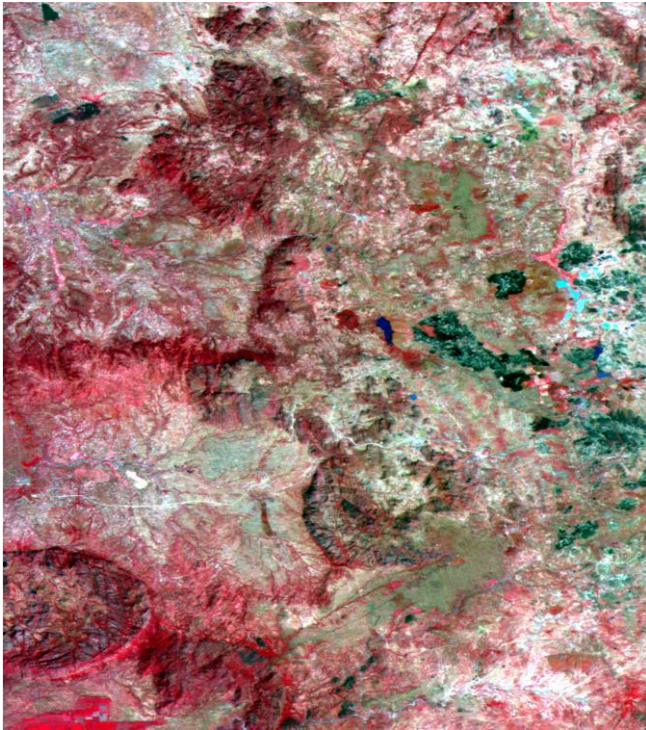
GIS and Remote Sensing



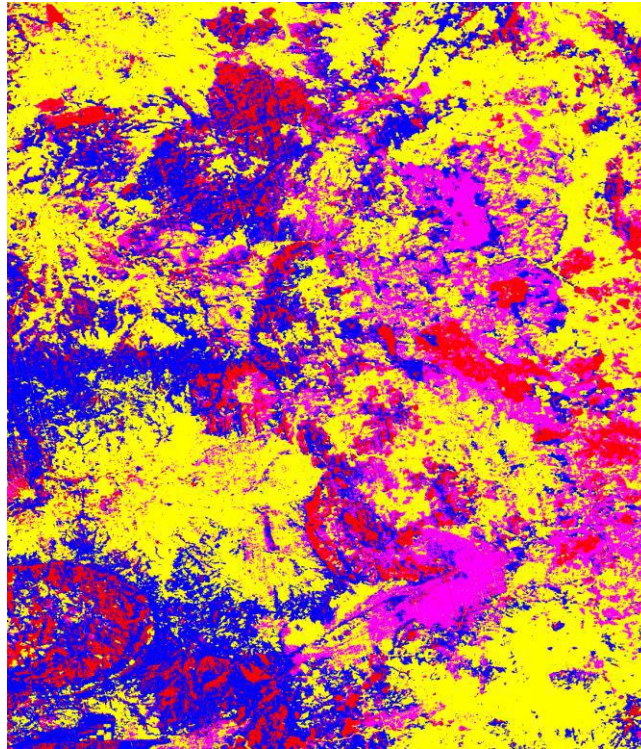
- Image analyst picks out areas of an image that he is familiar with (e.g. fields of corn; water) and letting the computer find other pixels in the image that share the same/similar channel value.
- Require a training site/sample sites
- Then the Computer will classify the image by comparing the Pixel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

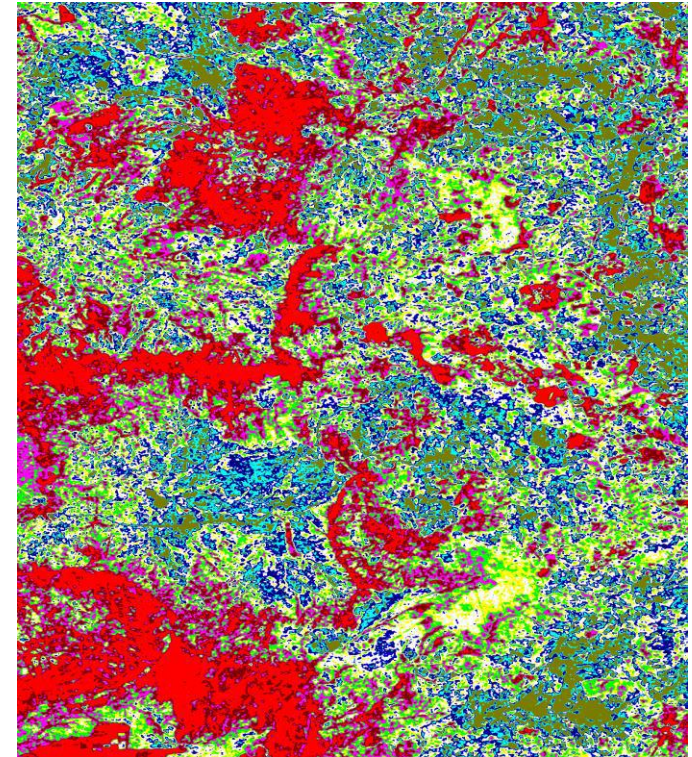
Examples of Classification



Original Image



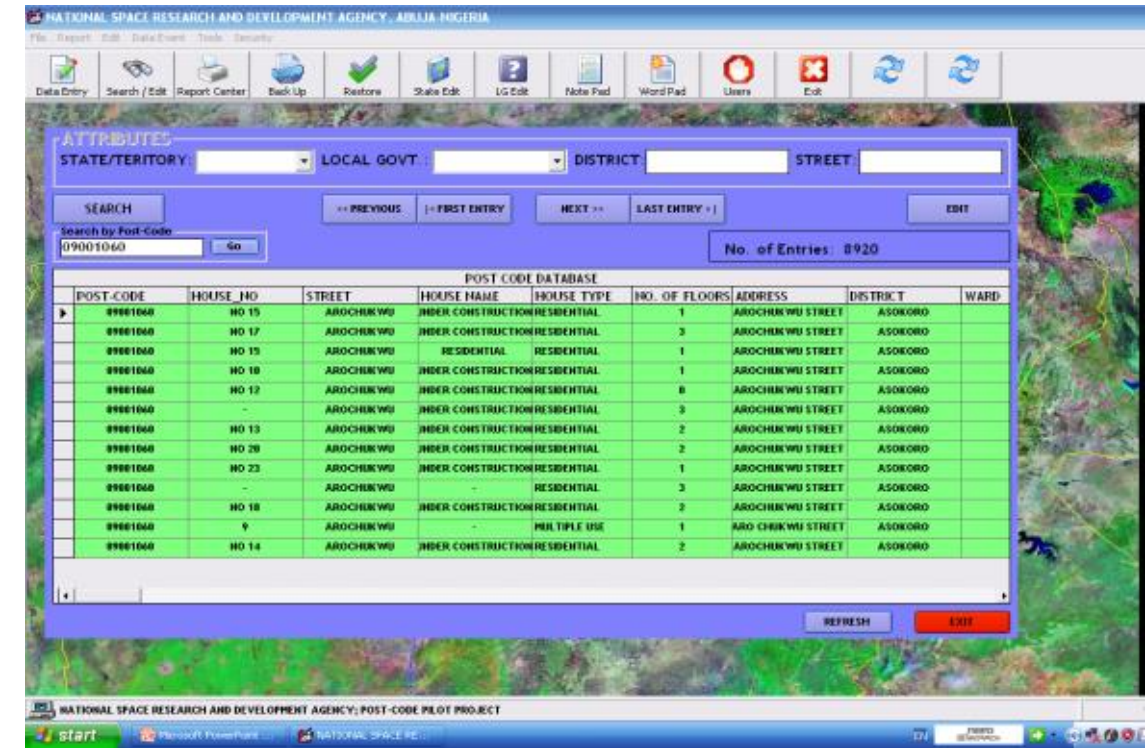
Classification of the Image through Sample Sets.



Classification from linear filter: Unsupervised

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

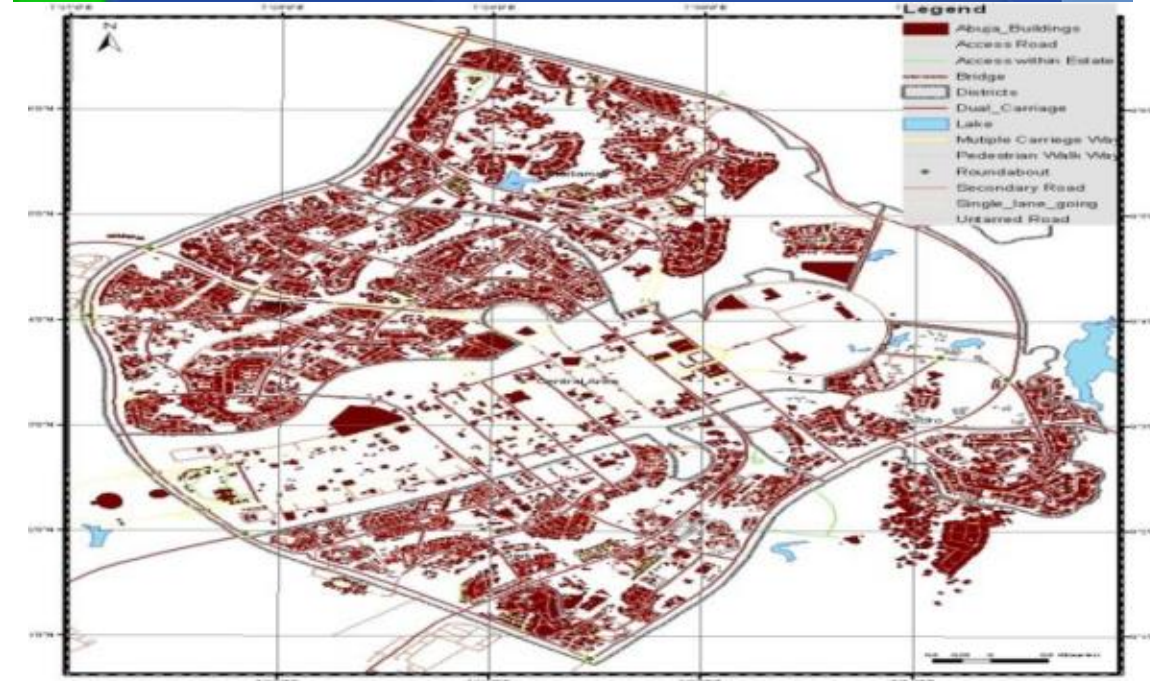
| | True Color Red: Band 3 Green: Band 2 Blue: Band 1 | False Color Red: Band 4 Green: Band 3 Blue: Band 2 | SWIR (GeoCover) Red: Band 7 Green: Band 4 Blue: Band 2 |
|---------------------------|---|--|--|
| Trees and bushes | Olive Green | Red | Shades of green |
| Crops | Medium to light green | Pink 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 |



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



BUILDING/STRUCTURES IDENTIFICATIONS FROM SATELLITE IMAGERY

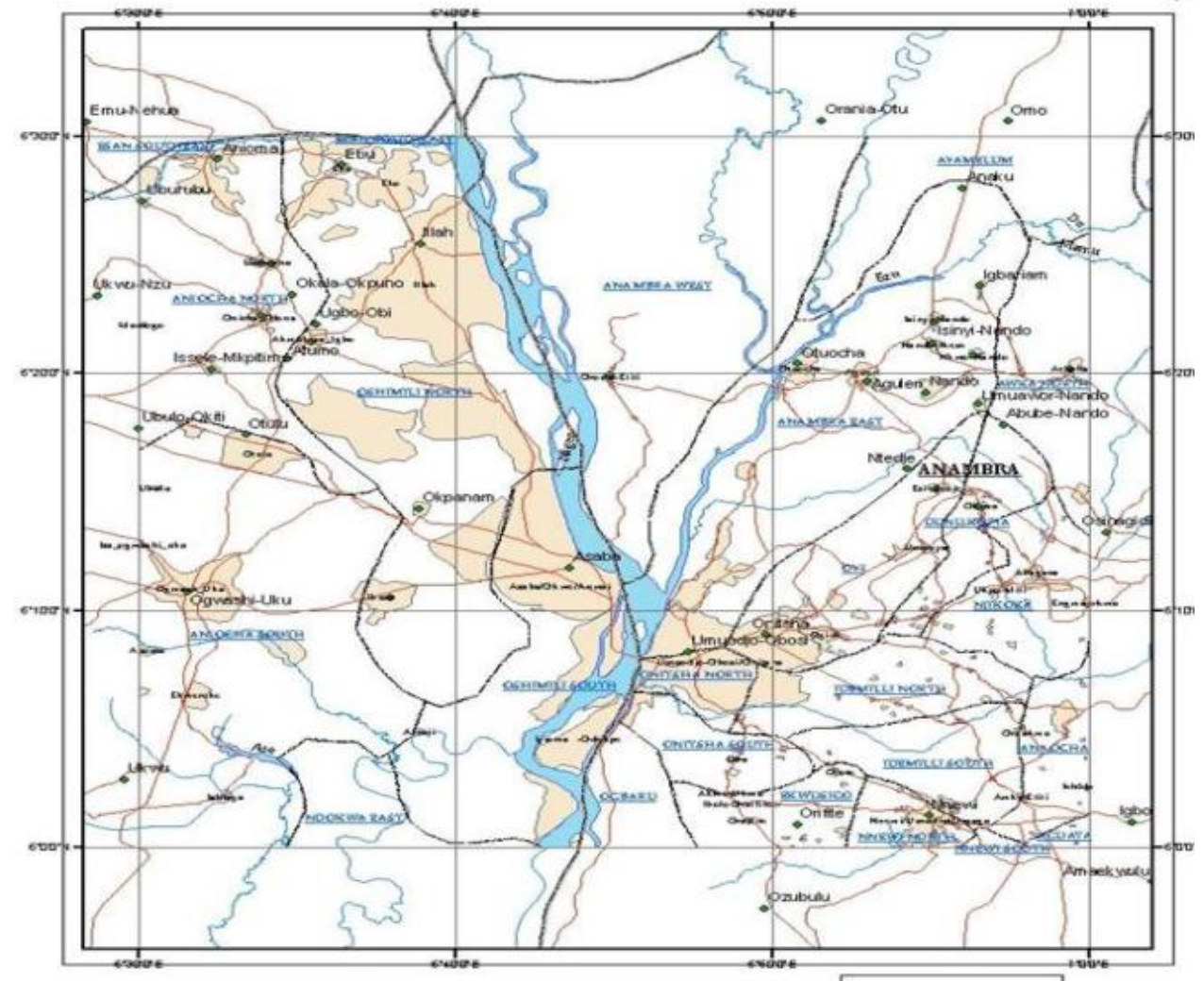
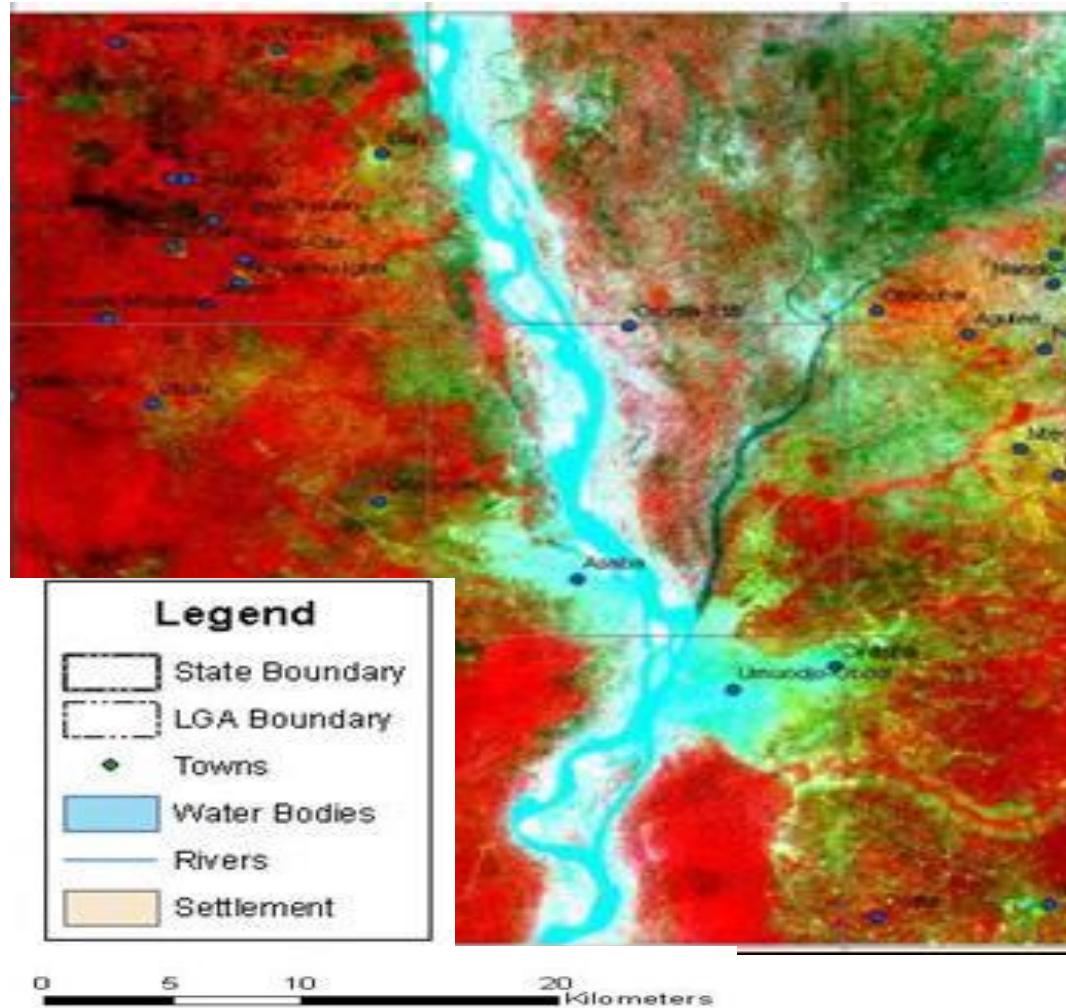


NIPOST HQTRS
Garki Area 11
Post Code: FC 2 14BK



NDE Building Wuse Zone 2
Post Code: FC3 2AX

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

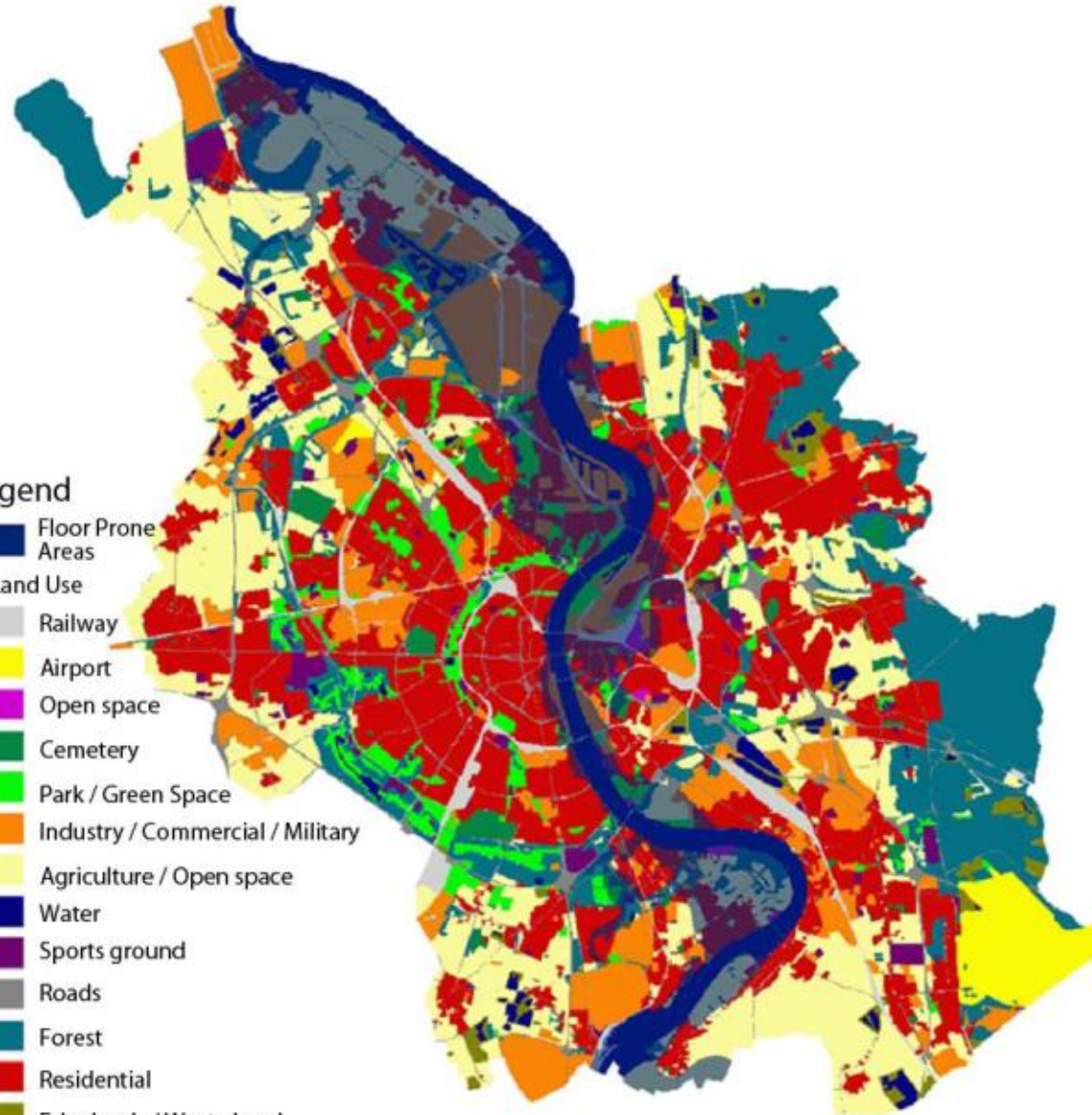
Source: NASRDA, 2010

Land Use and Flood Risk in Cologne / Germany



Legend

- Flood Prone Areas
- Land Use
 - Railway
 - Airport
 - Open space
 - Cemetery
 - Park / Green Space
 - Industry / Commercial / Military
 - Agriculture / Open space
 - Water
 - Sports ground
 - Roads
 - Forest
 - Residential
 - Edgelands / Waste Land



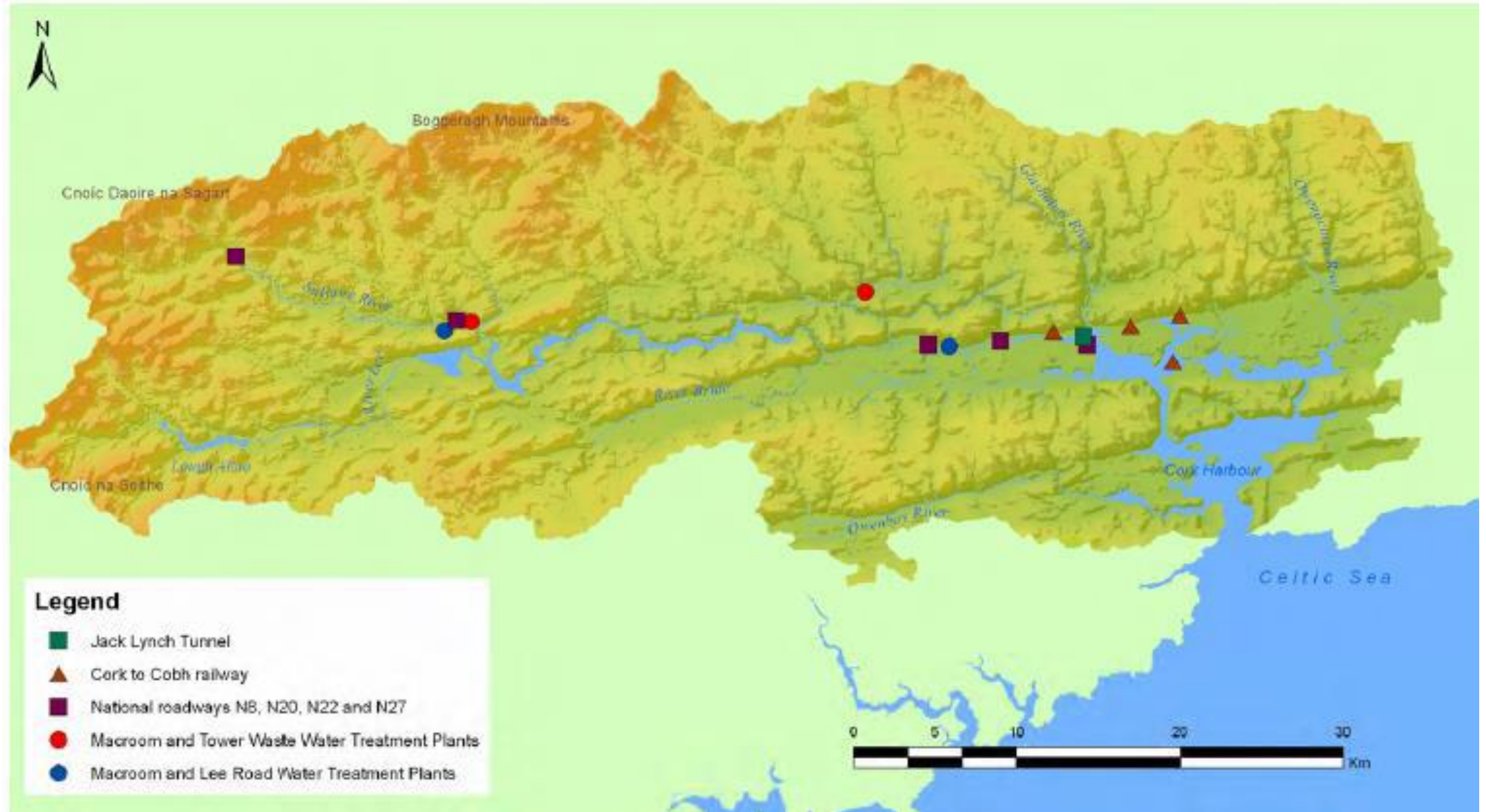
Map: Benjamin Hennig - www.viewsoftheworld.net (2011 / original draft 2003)

Map produced after
information extraction from
satellite imagery

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

Individual Risk Receptors



GIS Applications for Stages of Disaster Management



- **Prevention:** 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

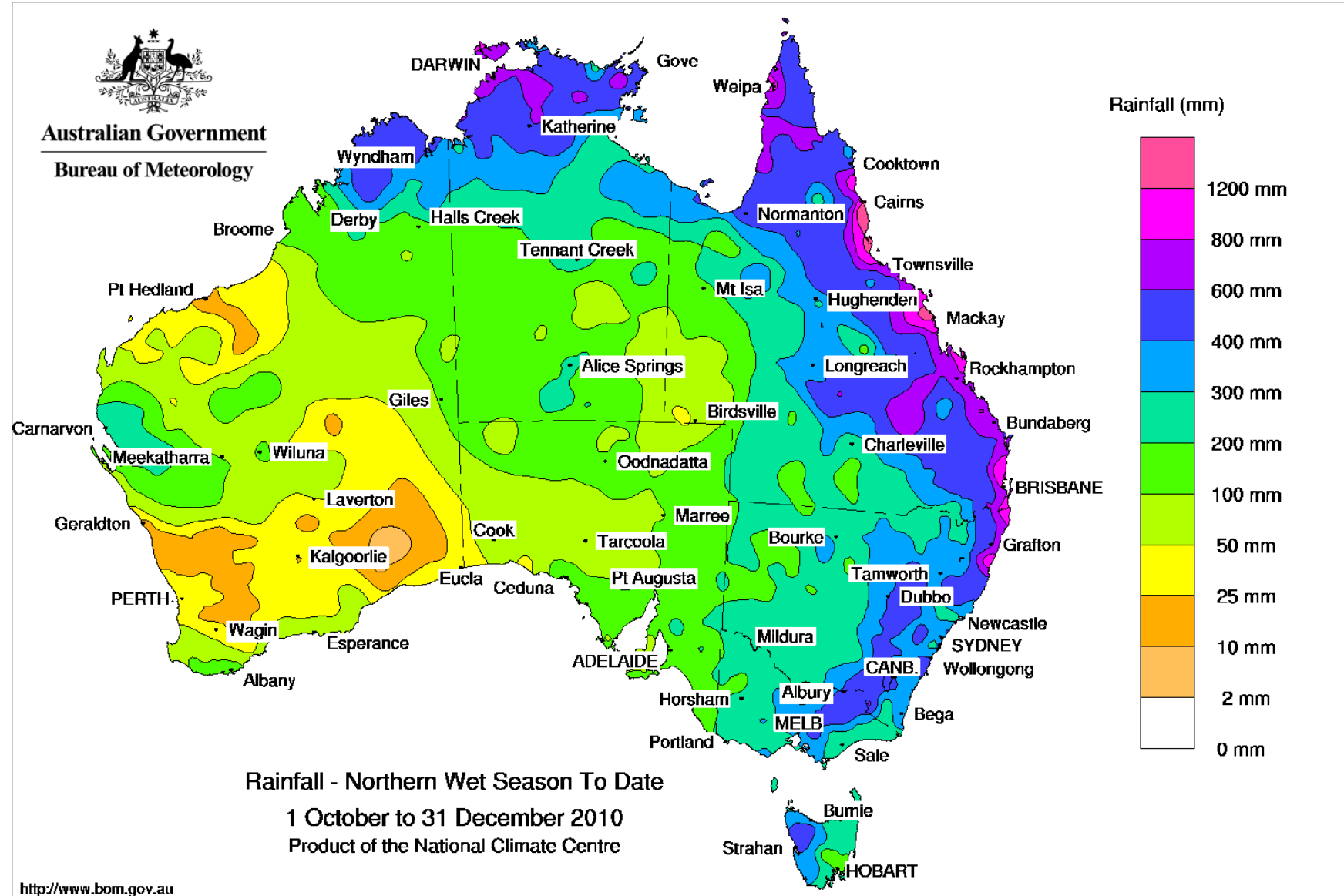
Policy relevant impact and vulnerability assessment and effective adaptation planning requires a large range of data and information such as: climatic data, including

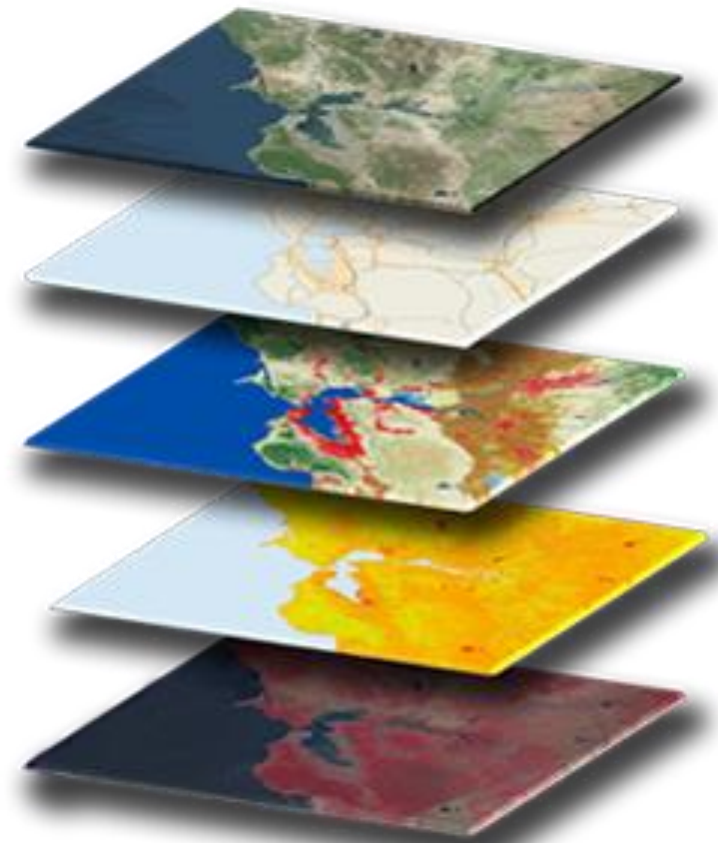
- Systematic observations of temperature, precipitation, weather patterns and hazards;
- Non-climatic data, including environmental, socio-economic and technical information
- and historic, local and traditional knowledge.

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 | |

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

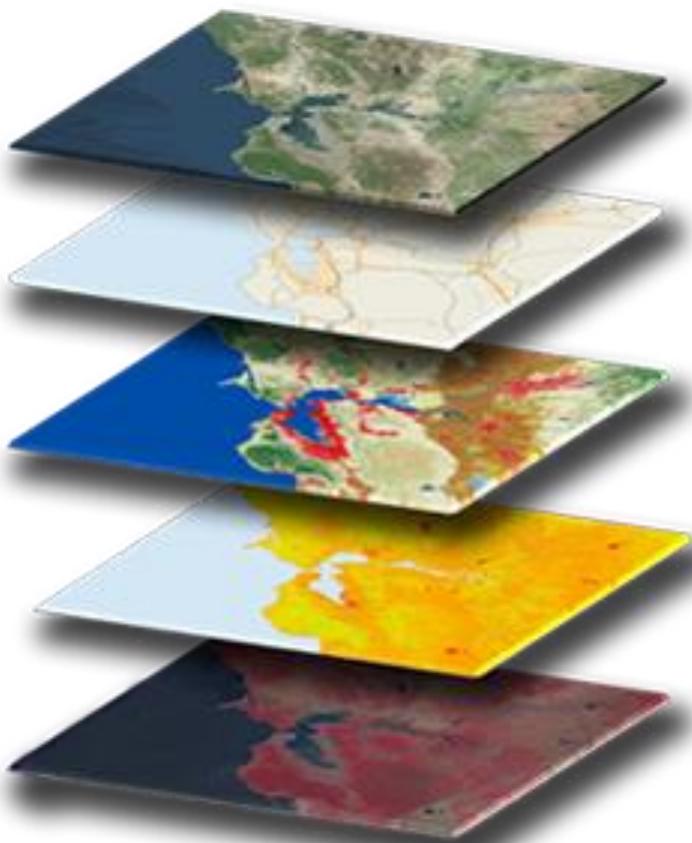




Use of topographic map as a dataset for GIS analysis in Vulnerability assessment

Mitigation Stage and GIS Data Use

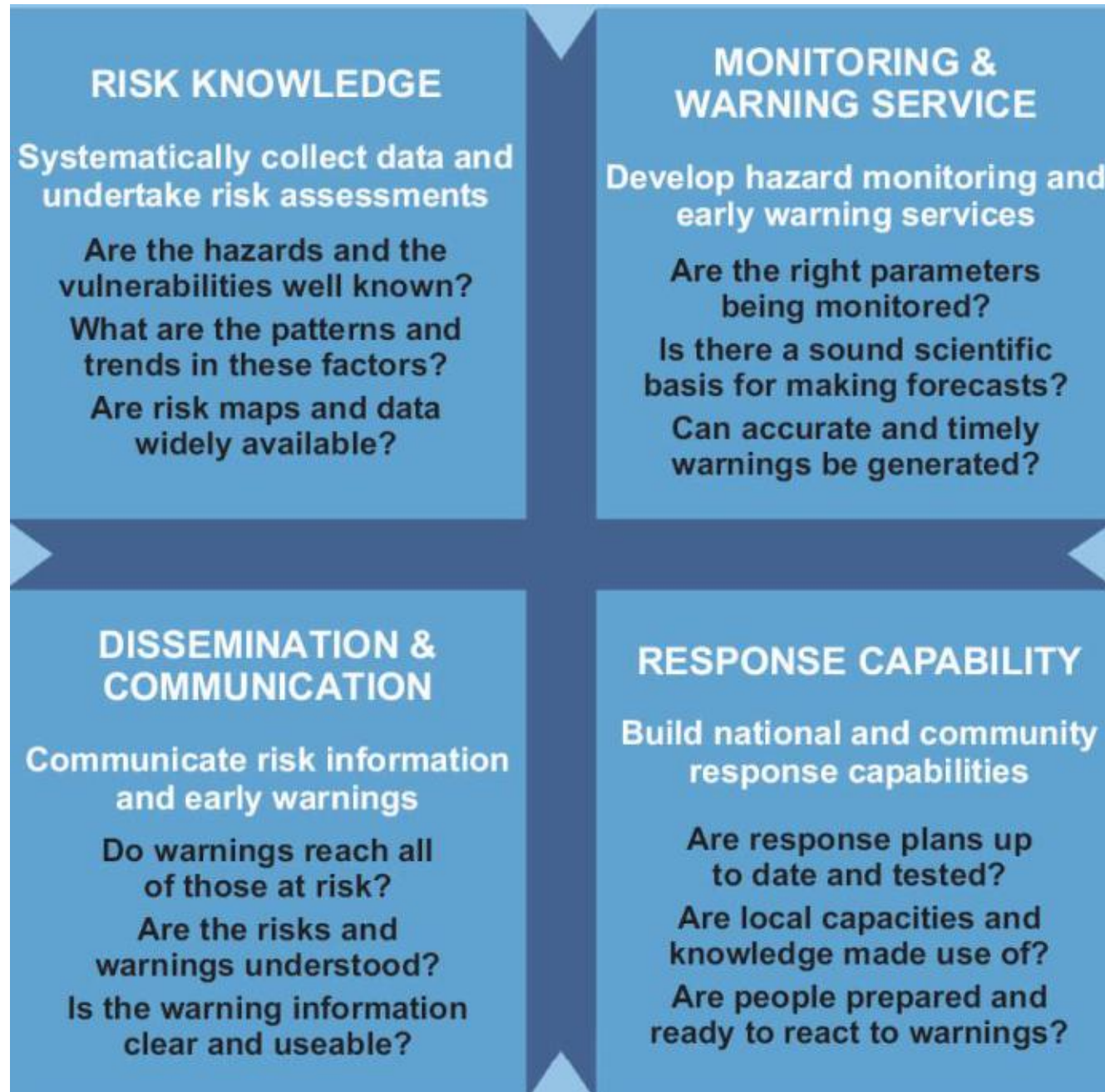
| Mitigation Measures | GIS Data |
|---------------------------|---|
| Mapping flood prone areas | Base maps and shape files for soil types, topographic maps, vegetation cover and land-use |
| Delineating flood plains | Flood prone maps and land-use maps |
| Land-use mapping | Land use types – Residential,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



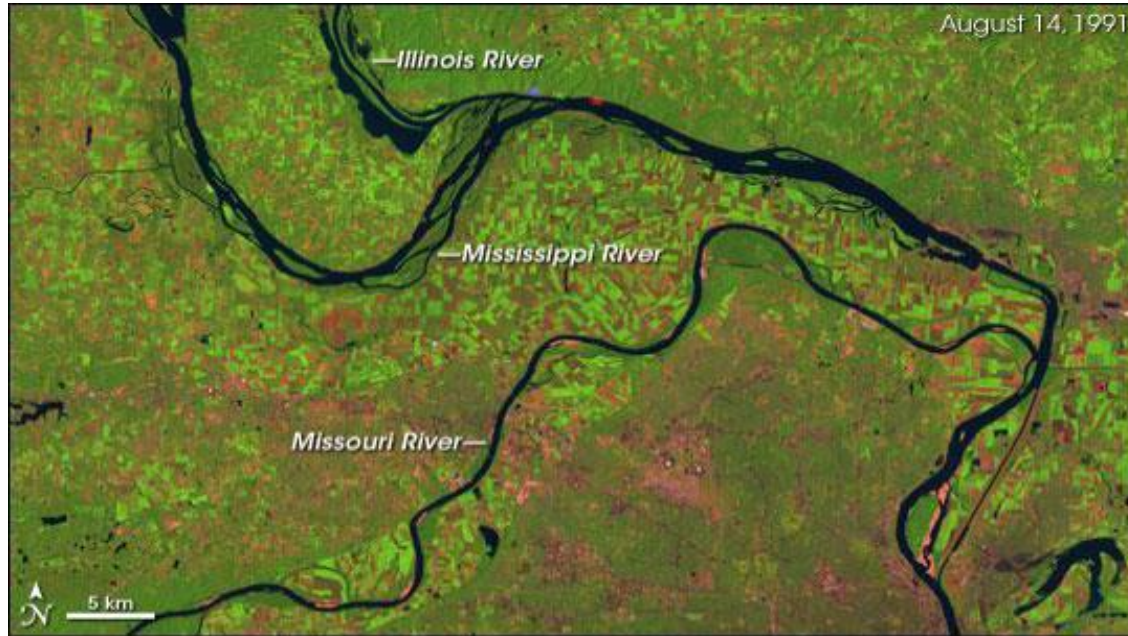
Preparation Stage against flood disaster and GIS Data Use

| 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

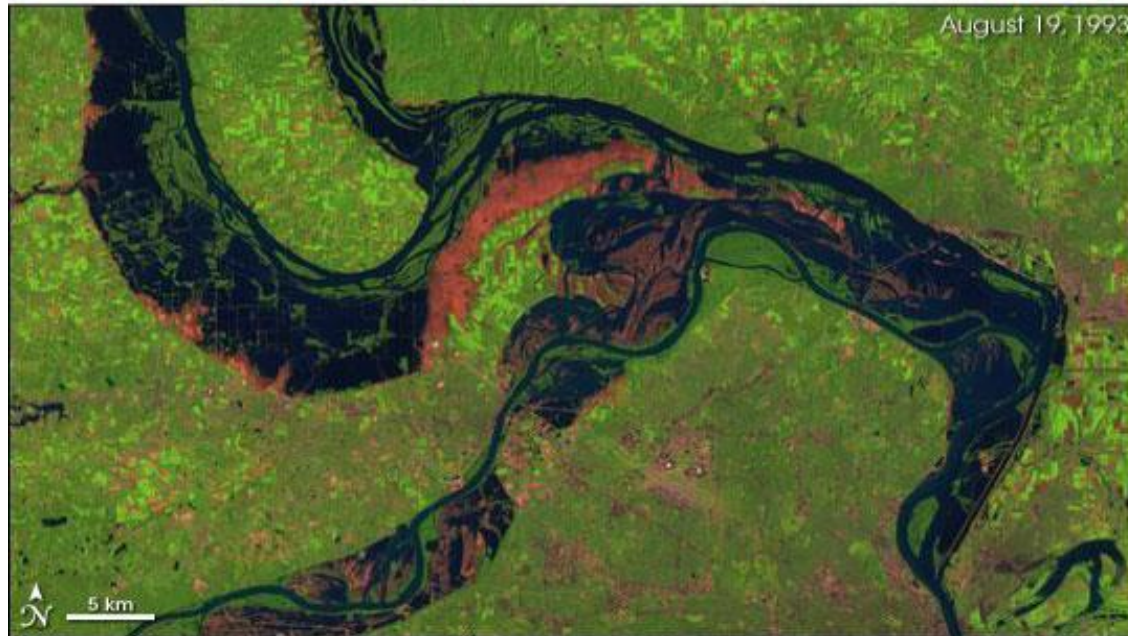


Response Stage to assess flood situation and GIS Data Use for Change Detection of the Great flood from Mississippi river



Before flood on August 14, 1991

Connected also to Illinois and Missouri river



After flood - August 19, 1993..

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)

This image was taken by ISERV-- a new NASA-developed testbed camera onboard the International Space Station.



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

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

This map illustrates satellite-detected areas of IDP structures and structures in Wau Shilluk, Upper Nile State, South Sudan using WorldView-2 data recorded 17 February 2014 and 06 December 2013. An estimated 1,157 new structures have been detected between 06 December 2013 and 17 February 2014 along the White Nile River. This is a preliminary analysis & has not yet been validated in the field. Please send ground feedback to UNITAR / UNOSAT.



IDP Camps

Production Date: 24/02/2014
Version 1.0
Activation Number: CE20131218SSD

SUDAN
SOUTH SUDAN
ETHIOPIA
Addis Ababa

LEGEND

- Roads
- IDP Settlement Extent

Map Scale for A3: 1:26,000

Satellite Data (1): WorldView-2
Imagery Dates: 17 February 2014
Resolution: 50cm
Copyright: DigitalGlobe Inc.
Source: US Department of State, Humanitarian Information Unit, NextView License
Satellite Data (2): WorldView-2
Imagery Date: 06 December 2013
Resolution: 50cm
Copyright: DigitalGlobe Inc.
Source: US Department of State, Humanitarian Information Unit, NextView License
Road Data: UNOSAT
Other Data: USGS, UNCS, NASA, NOAA
Analysis: UNITAR / UNOSAT
Production: UNITAR / UNOSAT
Analysis conducted with ArcGIS v10.1

Coordinate System: WGS 1984 UTM Zone 38N
Projection: Transverse Mercator
Datum: WGS 1984
Units: Meter

The depiction and use of boundaries, geographic names and related data shown here are not warranted to be error-free nor do they imply official endorsement or acceptance by the United Nations. UNOSAT is a program of the United Nations Institute for Training and Research (UNITAR), providing satellite imagery and related geographic information, research and analysis to UN humanitarian and development agencies and their implementing partners.

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unitar
United Nations Institute for Training and Research

UNOSAT

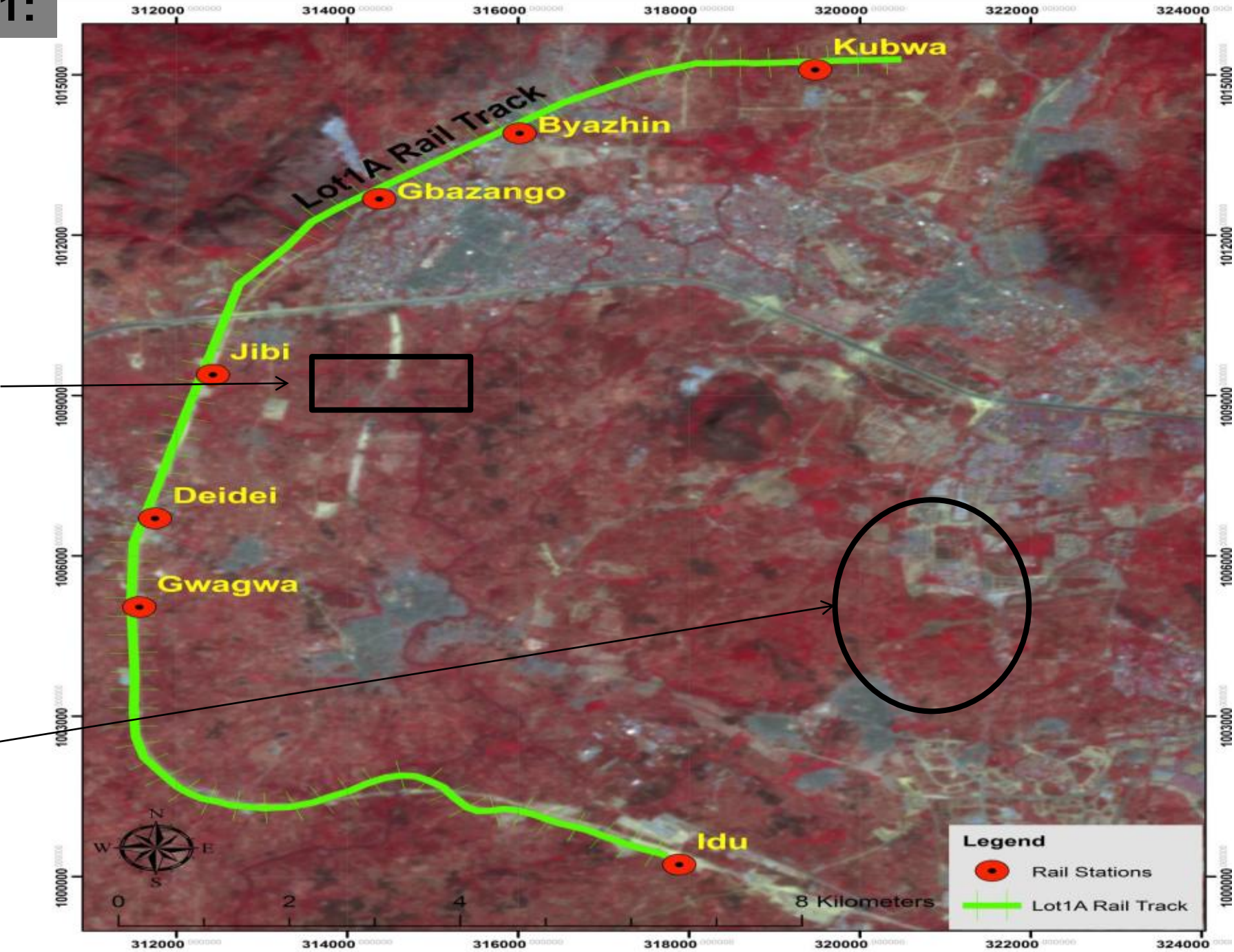
Contact Information: unosat@unitar.org
24/7 Hotline: +41 76 487 4993
www.unitar.org/unosat

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

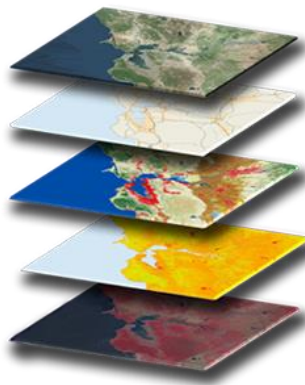
Accessibility Scenario 1:

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



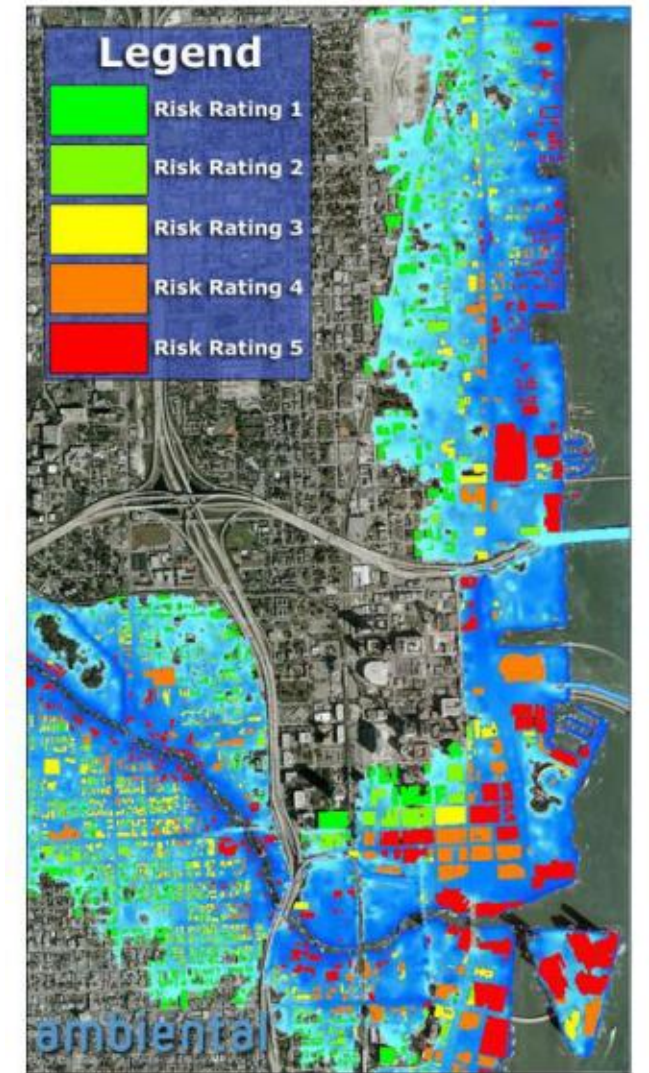
Benefits of Vulnerability Mapping



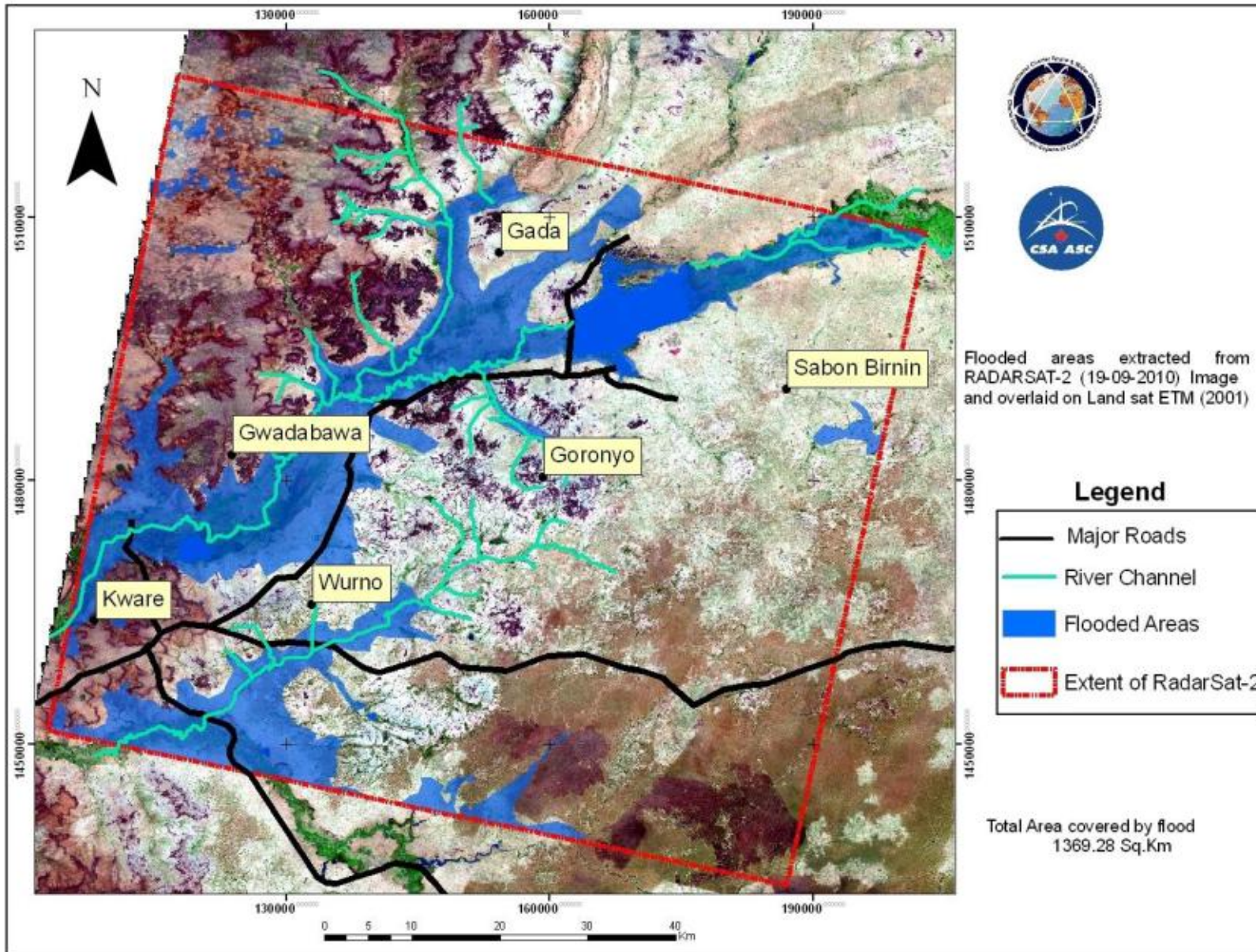
- Improved communication about risks and what is threatened
- Better visual presentations and understanding of the risks and vulnerabilities
- Allows for decision on mitigating measures
- Prevent or reduce loss of life, injury and environmental consequences before a disaster occurs or determine where 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

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



Flooded Areas in Parts of Sokoto State



Vulnerability Assessment
as a component of UN
Disaster Charter activation

ANALISIS DAMPAK BANJIR BANDANG DI KABUPATEN GARUT TANGGAL 20 SEPTEMBER 2016 BERBASIS DATA SATELIT PENGINDERAAN JAUH



Gambar - 1



Gambar - 2



- 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**.

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

UN Disaster Charter activation

SPACE-BASED DISASTER EMERGENCY RESPONSE FLASH FLOOD, 20 SEPTEMBER 2016 GARUT REGENCY, WEST JAVA

SATELLITE IMAGE PLEIADES
DATE 09 JUNE 2014



SATELLITE IMAGE WORLDVIEW-2
DATE 30 SEPTEMBER 2016



LEGEND

- Village
- ▲ Heavy Damage Settlement
- Administrative Boundaries

- Settlement
- Agriculture
- Industry Building

Data Source

1. Satellite Image PLEIADES, 9 Juni 2014 (LAPAN, Copyright: @CNES 2014 Airbus DS, all right reserved)
2. Satellite Image WORLDVIEW-2, 30 Sept 2016 (USGS)
3. Administrative Boundaries Map (BIG)

Data updating, compilation, and interpretation by:
REMOTE SENSING APPLICATION CENTRE - LAPAN

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



Thank You