Applications of Geospatial Technologies and Data in support of Disaster Risk Management

Worshop1: Policy Issues Towards Effective Applications of Geospatial Technologies and Data in DRM

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Presented by Dr.Jacob Opadeyi,
Disaster Risk Management Consultant

UNITED NATIONS

ECLAC

CCRIF SPC

The Caribbean Catastrophe Risk Insurance Facility

Objective

Increase participants awareness on how geospatial technology and data is applied in disaster risk management.

Outline

- The Business Case for GST/D importance in DRM
- GST-based Applications in Use Today
- GST in Risk Assessment and Identification
- GST in Risk Reduction
- GST in Disaster Preparedness

The Business Case for GST/D

Building an information base

Providing Decision Support

Saving time

Increasing efficiency

Emergency Inventory Management

Components of Geospatial *Technologies*

- Global Positioning Systems (GPS)
  - a system of earth-orbiting satellites which can provide precise (100 meter to sub-cm.) location on the earth's surface (in lat/long coordinates or equiv.)
- Remote Sensing (RS)
  - use of satellites (and aircraft) to capture information about the earth's surface
- Geographic Information Systems (GIS)
  - at a minimum, comprises a capability for input, storage, manipulation and output of geographic information

GPS and RS are sources of input data for a GIS.
A GIS provides for storing and manipulating GPS and RS data.

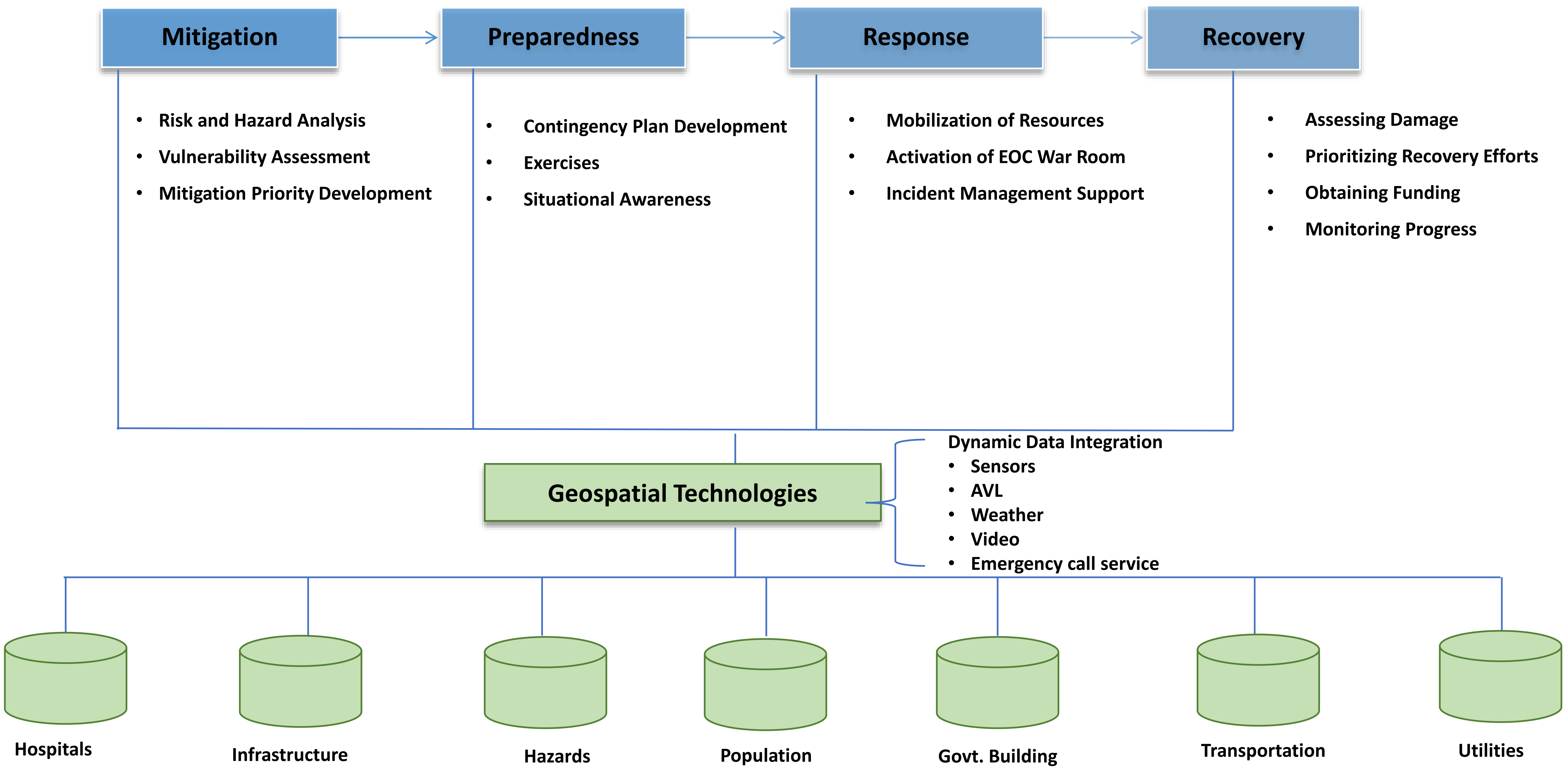


Figure GIS Support for Emergency Management Workflow

Role of Disaster information system in various phases of Disaster Management

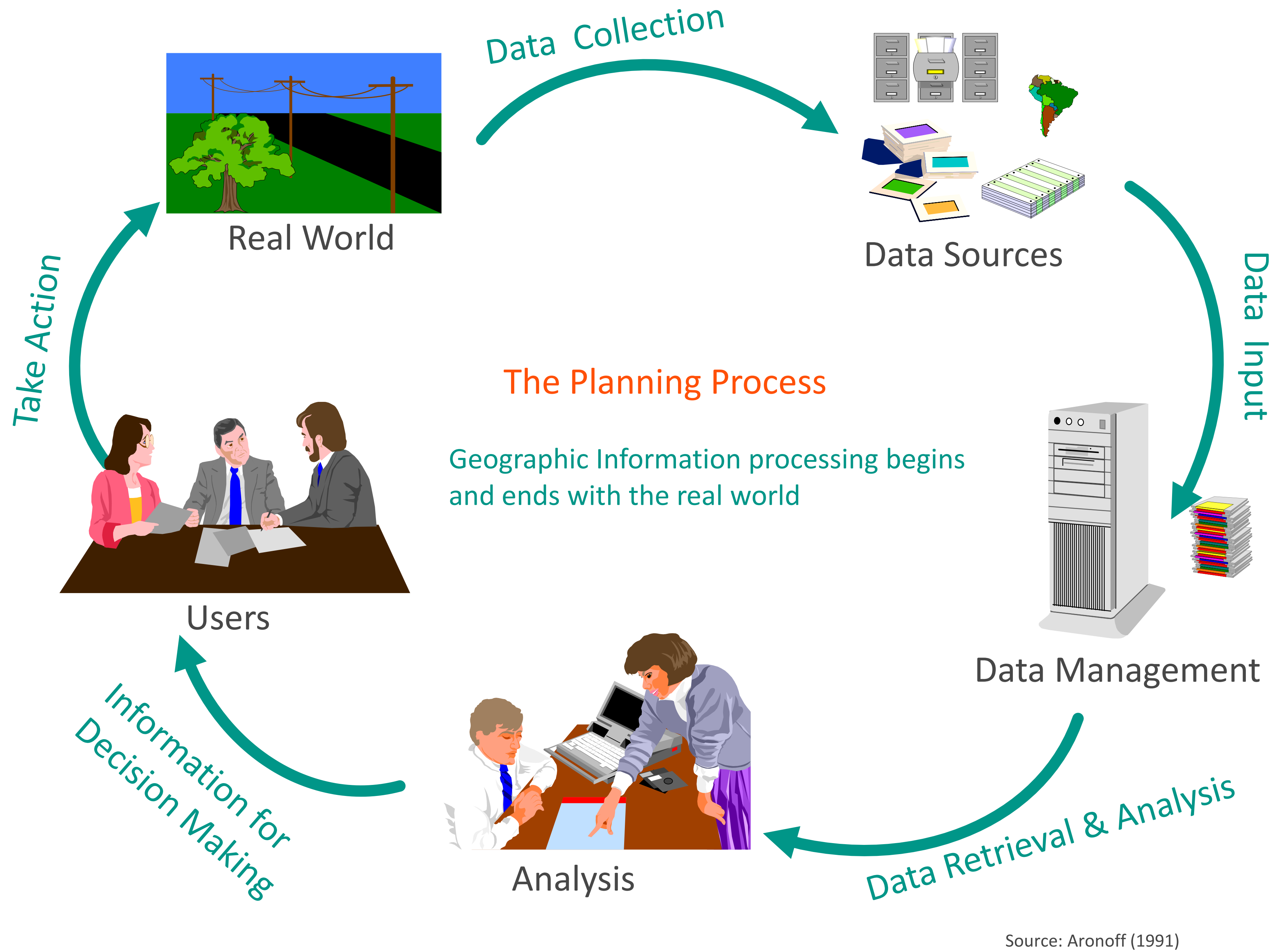
- **Risk & vulnerability identification**
  - A database of past disasters effects to determine the risks in particular geographic location.
  - Zoning of hazards using GIS.
  - Validating the disaster history database with hazard maps and other external data for accuracy in risk assessment.

- **Mitigation strategies and policies**
  - Mitigation strategies, policies and legislation based on statistical facts & figures from various databases.
  - Development of a virtual knowledge net for creation of a network of institutions, developmental organizations and Government dept. for information sharing and preserving the research efforts.

- **Preparedness for response & recovery**
  - Database of existing skilled human & material resources for emergency response.
  - Database on human resources trained on various aspects of disaster management.
  - Develop preparedness plans based on risk, available skill & resources.
  - Converting Disaster Management plans into electronic documents for easy accessibility and easy updating.

Technological resources required to build the prototype GIS-based flood EWS.

System Elements	Equipment Required
Flood hazard monitoring	Rain gauges
	Stream gauges
	River stages
	Data loggers
Flood hazard modelling software	Rainfall-run-off models
	WMS
	HEC-RAS
	FLO-2D
	MIKE II
Satellite Remotes Sensing Data	High resolution multispectral imageries
	Low resolution multispectral imageries (e.g. MODIS)
	Medium resolution radar imageries (e.g RADARSAT)
	Aerial photographs
Risk Assessment Applications	HAZUS or Vulnerability Assessment Tool (VAT)
GIS databases	Bio-physical databases
	Anthropogenic databases
	Critical facility databases
	Transportation databases
	Demographic databases
	Climate and weather databases
	Multi-hazard incidence databases
Data transmission and communication	Telemetric systems
	ALERT
Information technology	Personal computer



Data Collection
Real World
Data Sources
Data Input
The Planning Process
Geographic Information processing begins and ends with the real world
Take Action
Users
Data Management
Information for Decision Making
Analysis
Data Retrieval & Analysis
Source: Aronoff (1991)

A General Definition for GIS

*A system of integrated computer-based **tools** for end-to-end **processing** (capture, storage, retrieval, analysis, display) of data using **location on the earth's surface** for interrelation in support of **operations management, decision making, and science.***

- set of integrated tools for spatial analysis
- encompasses end-to-end processing of data
    - capture, storage, retrieval, analysis/modification, display
- uses explicit location on earth's surface to relate data
- aimed at decision support, as well as on-going operations and scientific inquiry

The main functions are

1. To capture

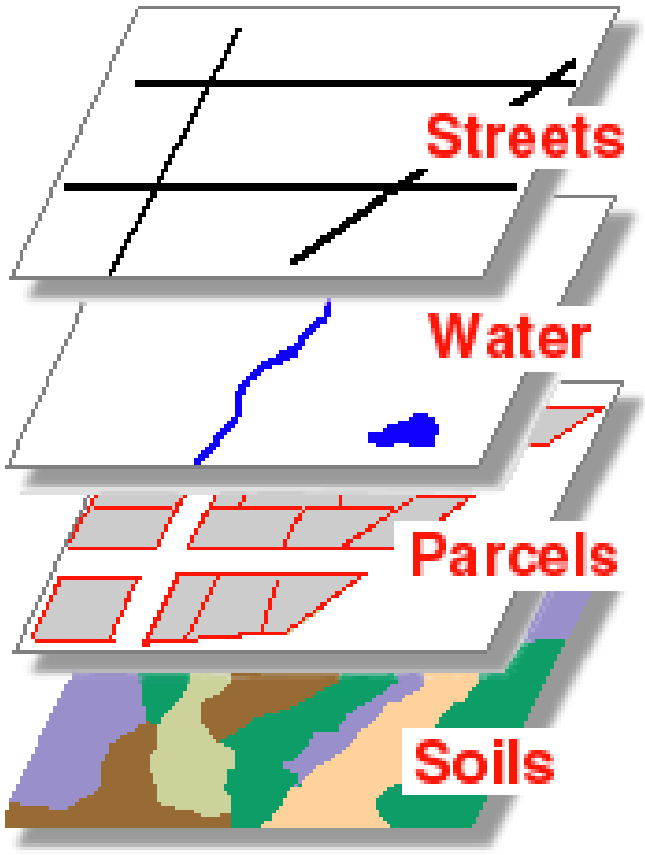
2. To store

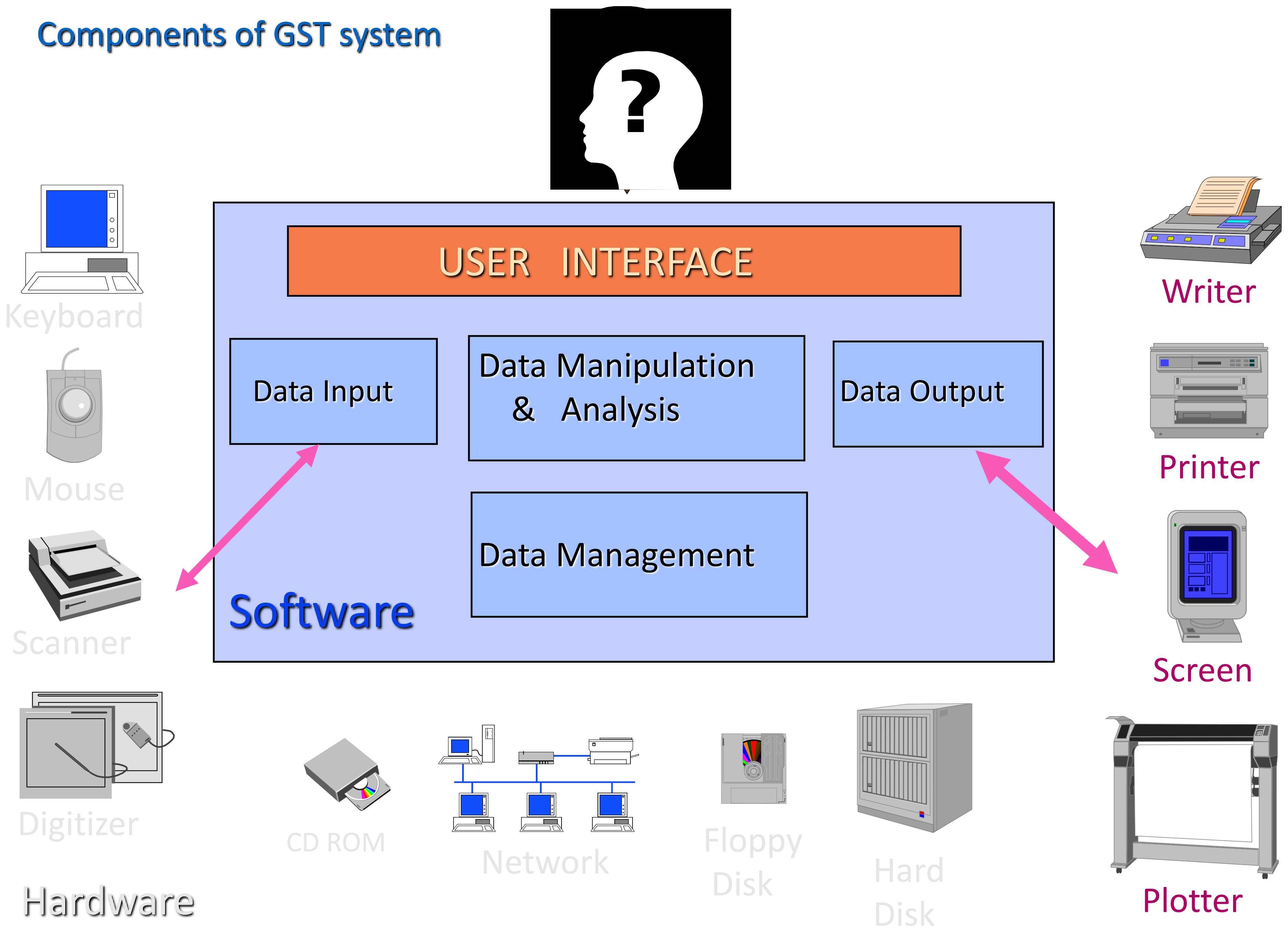
3. To organize

4. To analyze and query

5. To display

spatial data

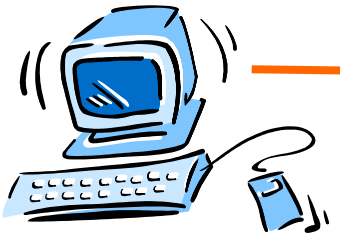




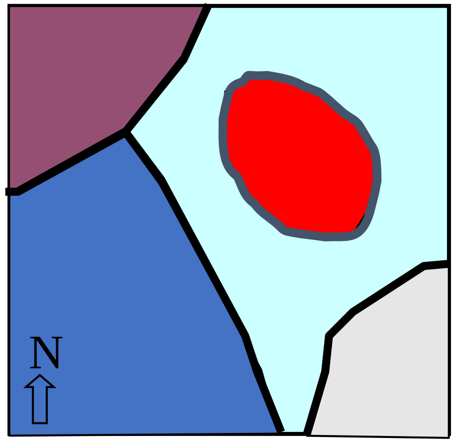
Components of GST system
USER INTERFACE
Data Input
Data Manipulation & Analysis
Data Output
Data Management
Software
Keyboard
Mouse
Scanner
Digitizer
Hardware
CD ROM
Network
Floppy Disk
Hard Disk
Writer
Printer
Screen
Plotter

What is GIS

GIS software links the location (map) data and the attribute data

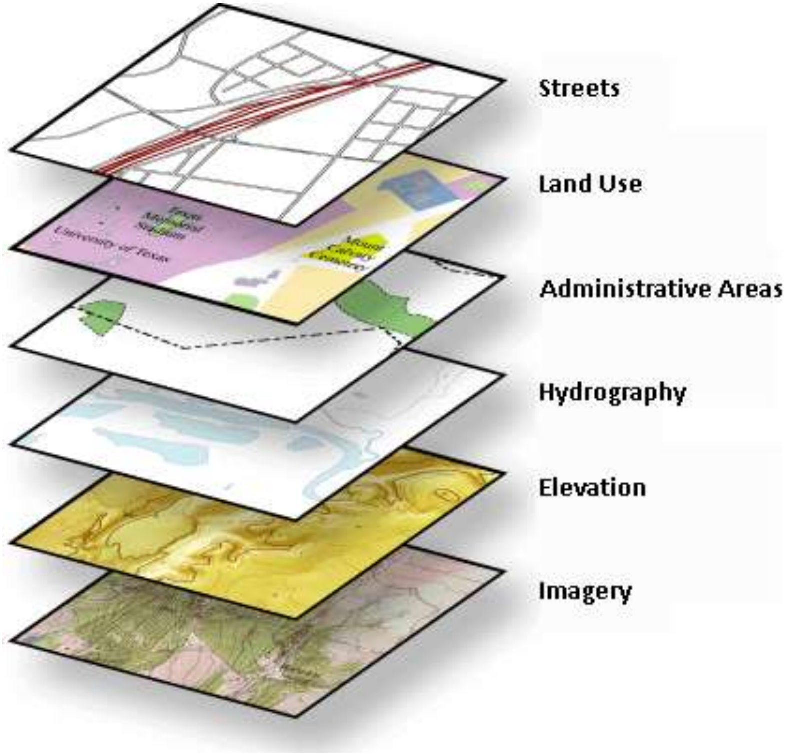


Map - features



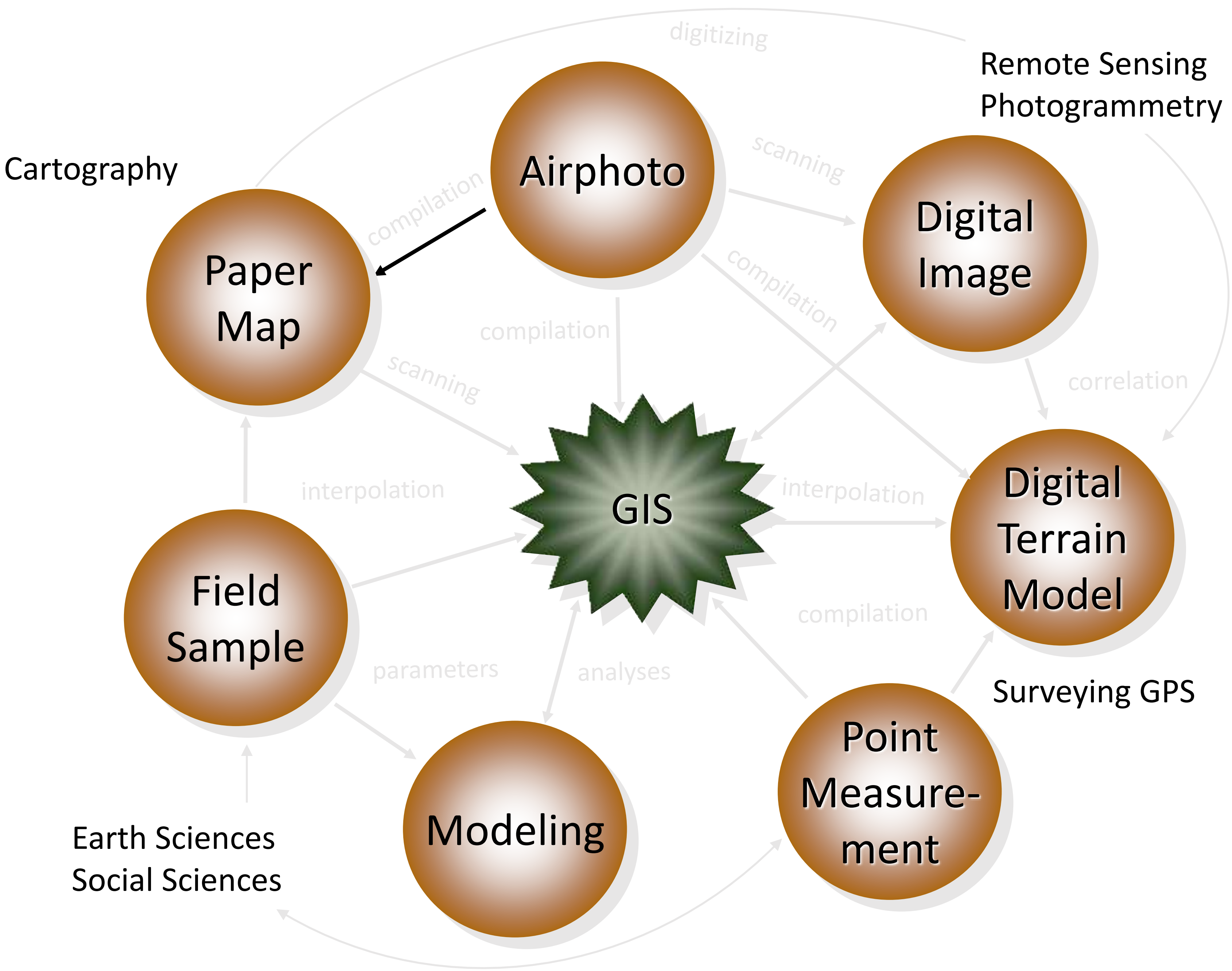
Polygon	Class	Rock Type	Age
1	9	Sandstone	Cambrian
2	6	Rhyodacite	E. Triassic
3	7	Granite	E. Triassic
4	4	Leucogranite	L. Triassic

Table - attributes

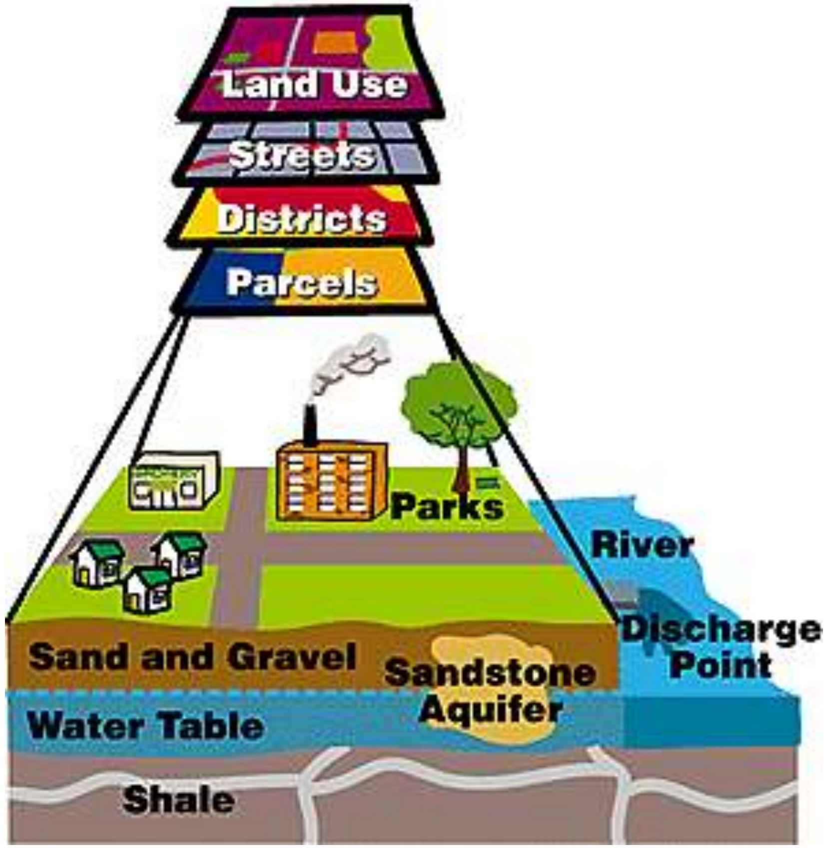


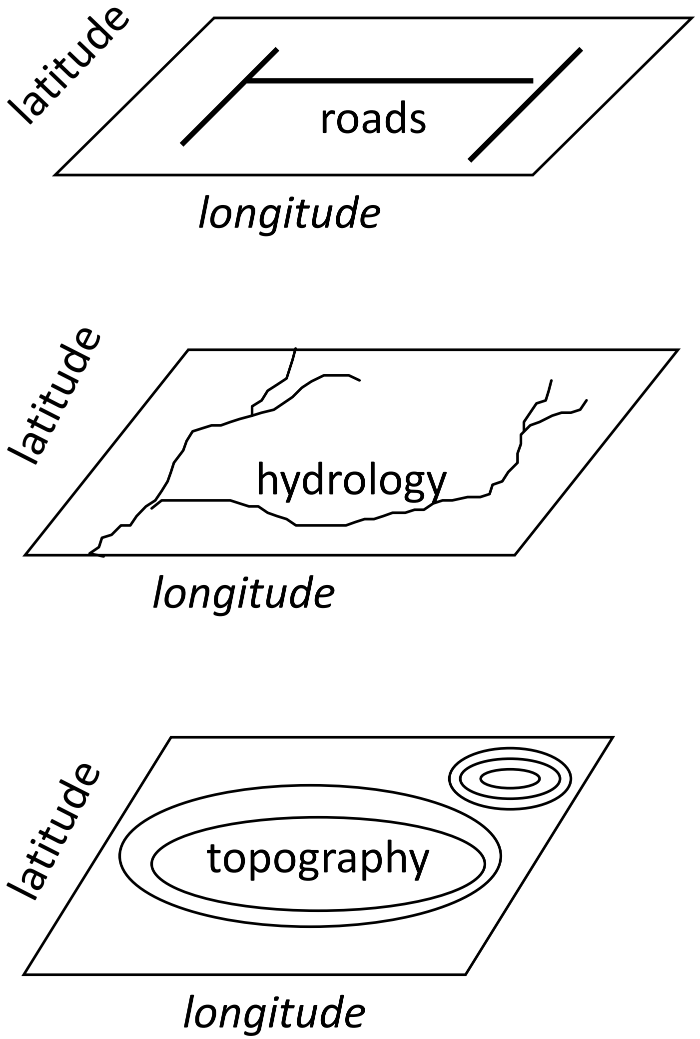
- GIS combines different levels of information about a particular geographic space
- Allows for easier understanding of that space
- Different information may be viewed together in an overlay

Geoinformation Data Types



- allows the **geographic features** in **real world locations** to be digitally represented and stored in a database so that they can be abstractly presented in **map** (analog) form, and can also be worked with and **manipulated** to address some **problem**





Here we have three <u>layers</u> or themes:
--roads,
--hydrology (water),
--topography (land elevation)
They can be related because precise geographic coordinates are recorded for each theme.

Layers are comprised of two data types

- *Spatial data* which describes location (where)
- *Attribute data* specifying what, how much, when

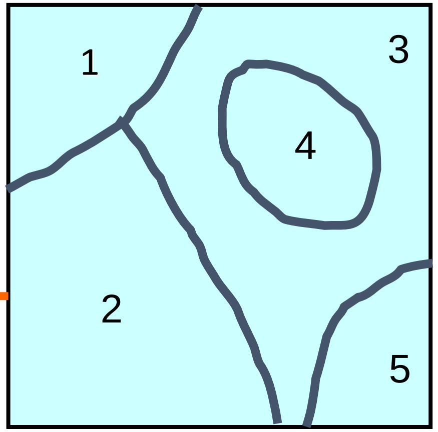
Layers may be represented in two ways:
•in *vector* format as points and lines
•in *raster(image)* format as pixels

All geographic data has 4 properties:
projection, scale, accuracy and resolution

Spatial Data Model

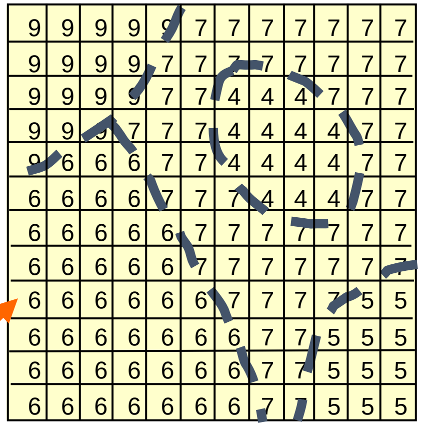
Vector

polygon attribute table



Raster

Raster (value) attribute table

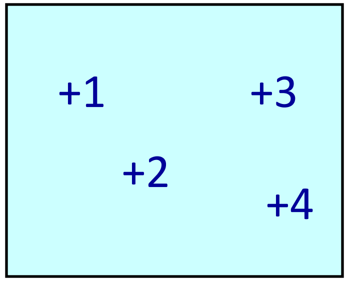


Non-spatial attributes

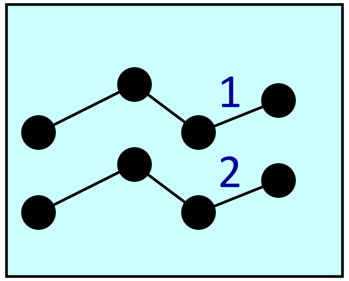
Polygon	Class	Rock Type	Age
1	9	Sandstone	Cambrian
2	6	Rhyodacite	E. Triassic
3	7	Granite	E. Triassic
4	4	Leucogranite	L. Triassic

Vector Data Models

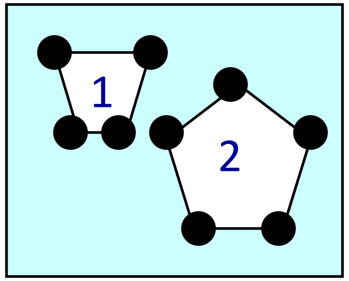
Features are assigned a sequence number or identifier. Coordinates can then be recorded for each feature by keeping a sequence number with the list of coordinates for each feature:



Point Number	x,y coordinates
1	2,4
2	3,2
3	5,3
4	6,2



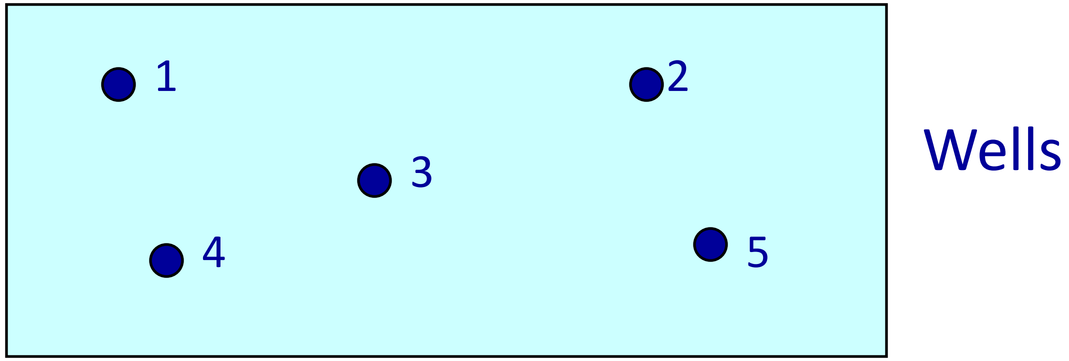
Line Number	x,y coordinates
1	1,5 3,6 6,5 7,6
2	1,1 3,3 6,2 7,3



Polygon Number	x,y coordinates
1	2,4 2,7 4,7 3,4 2,4
2	6,2 5,4 7,6 9,4 8,2 6,2

Representing Attribute Data in the Computer

Points



ID	Northing	Easting	Depth (m)	Salinity (ppm)	Date Drilled	Owner
1	4673000	252500	175	156	5-1-35	Dickinson
2	4674000	254000	250	228	8-5-35	Murray
3	4671000	253500	225	123	6-7-57	Smith
4	4667000	253000	150	457	4-4-46	McBran
5	4668000	254000	105	666	5-28-68	Harris

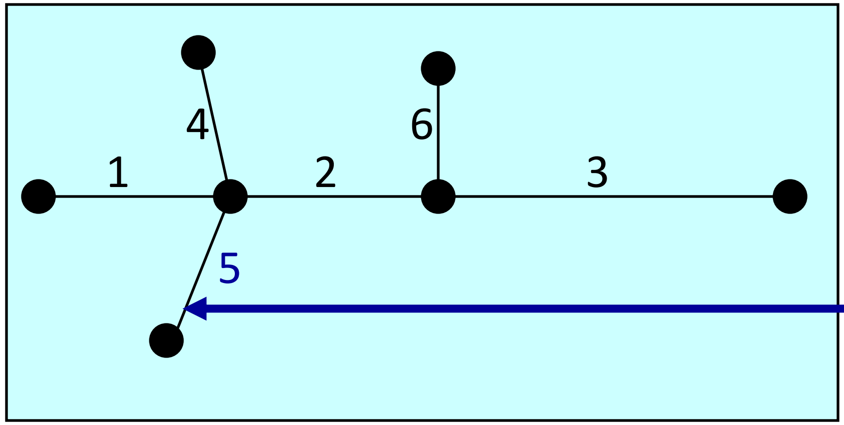
Record →

↑ Item

Point Data Attribute Table

Representing Attribute Data in the Computer

ARCS



Feature Coordinates

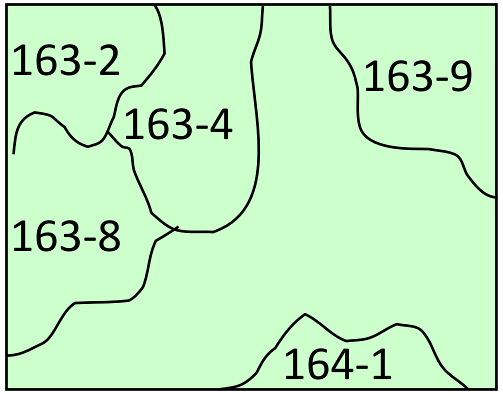
Feature_no	x,y Pairs
1	3,5 5,5
2	5,5 8,5
3	8,5 11,5
4	6,9 5,8 5,7 5,6 5,5
5	5,5 4,4 4,1
6	8,5 8,7

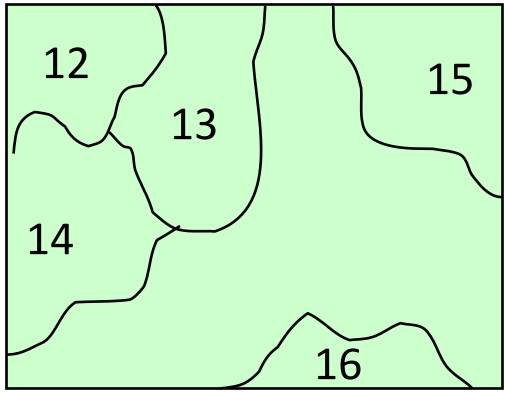
Feature_no	Road_type	Surface	Width	Lanes	Name
1	2	Asphalt	48	4	N MAIN ST
2	2	Asphalt	48	4	N MAIN ST
3	2	Asphalt	48	4	N MAIN ST
4	1	Concrete	60	4	Highway 42
5	1	Concrete	60	4	Highway 42
6	4	Asphalt	32	2	Elm ST

Representing Attribute Data in the Computer

Polygons

Forest stands have characteristics such as area, type, average height and harvest date





Descriptive Information (Tabular Data)

Stand_no	Type	Ave_height	Hrvst_date
163-2	WP	50	1993
163-4	DF	30	1995
163-8	WP	80	1989
163-9	WP	65	1991
164-1	MX	35	1996

Graphic Data / Tabular Data Integration

Linking Attribute Data Using Common Items

Relate

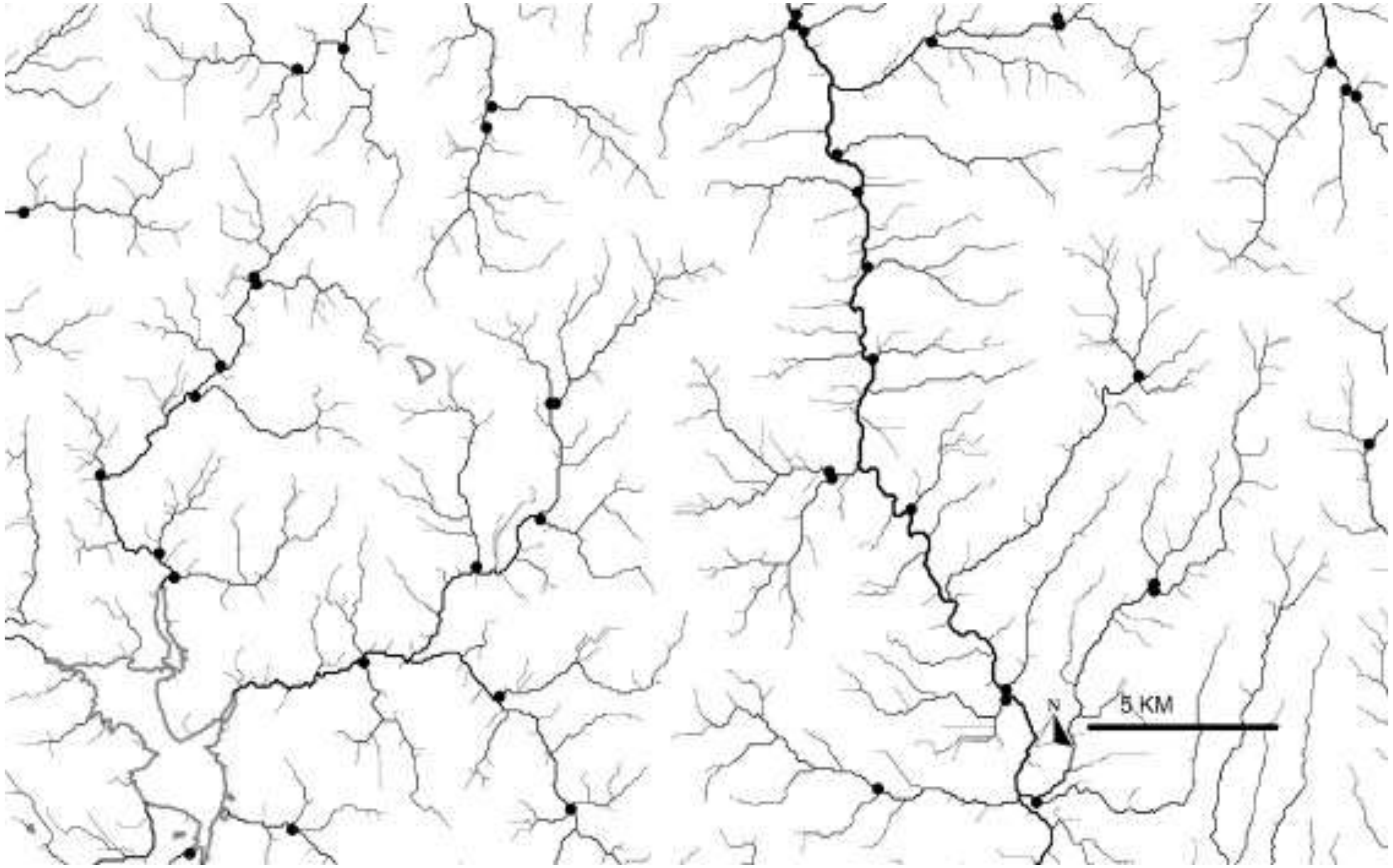
Join

Area	Peri	Stand	Stand_id	Stand_no
205	1331	2	12	163-2
355	2022	3	13	163-4
320	1931	4	14	163-8
240	1402	5	15	163-9
220	1600	6	16	164-1

Stand_no	Type	Ave_height	Hrvst_date
163-2	Pine	50	1993
163-4	Fir	30	1995
163-8	Pine	80	1989
163-9	Pine	65	1991
164-1	Mixed	35	1996

Points are zero dimensional objects which have locations and attribute information but are too small to be represented as areas.

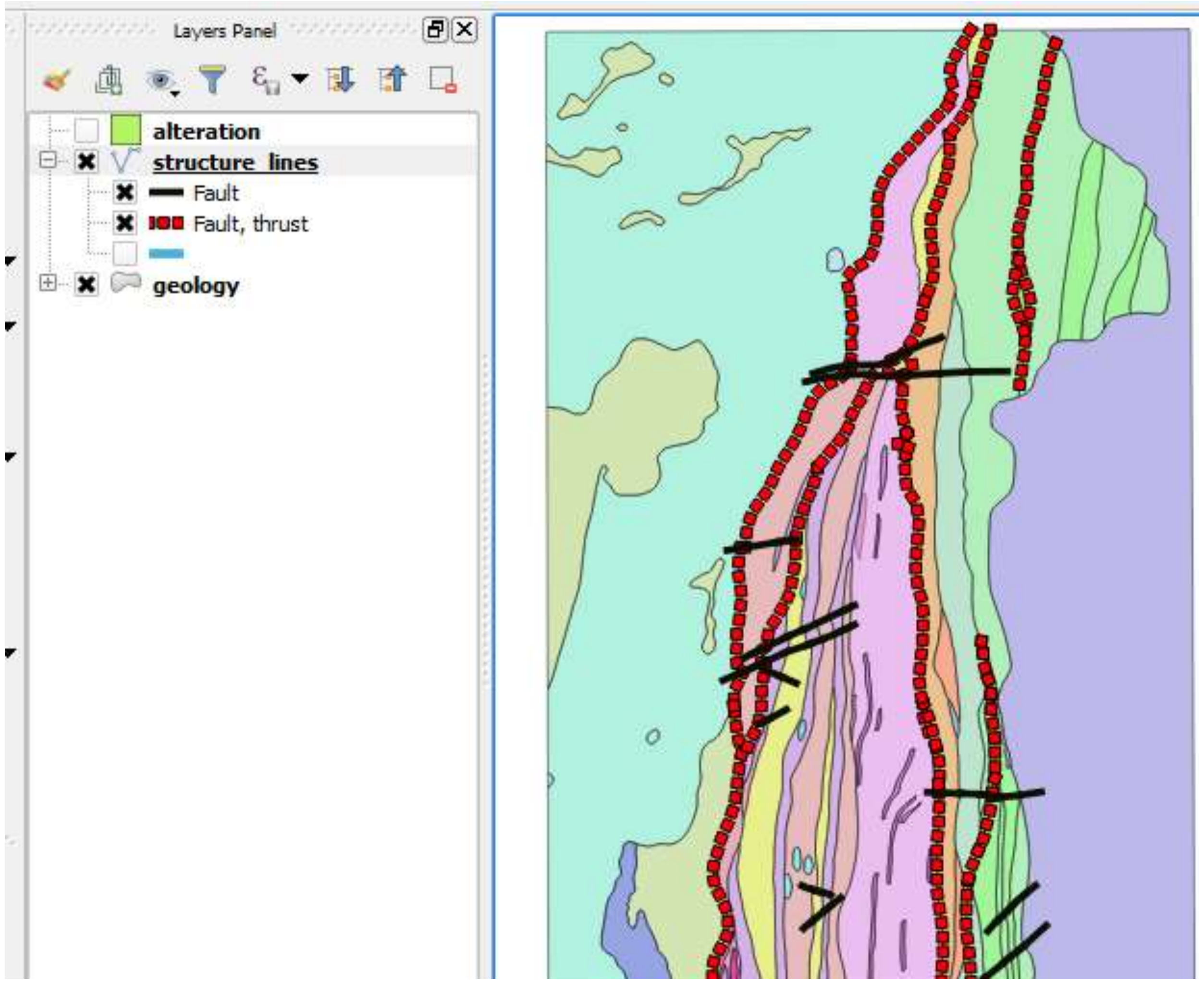
- Soil Samples
  - Type
  - pH
  - Contaminants
- Utility Poles
  - Owner
  - Height
  - Attachments
- Spill Locations
  - Accident Number
  - Type of Spill
  - Extent
- Parcel Centroid
  - Section/Block/Lot No.
  - Address
  - Owner
  - Assessment Data

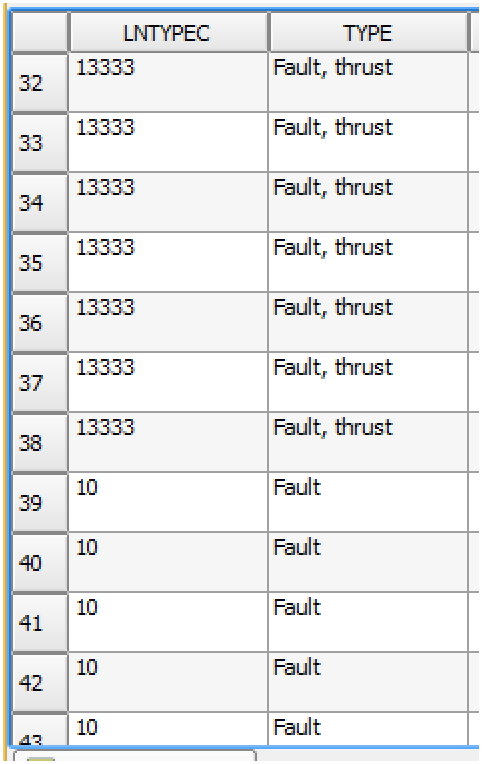

N
5 KM

Lines are one dimensional objects which have length but no area. Each line must begin and end at a node.

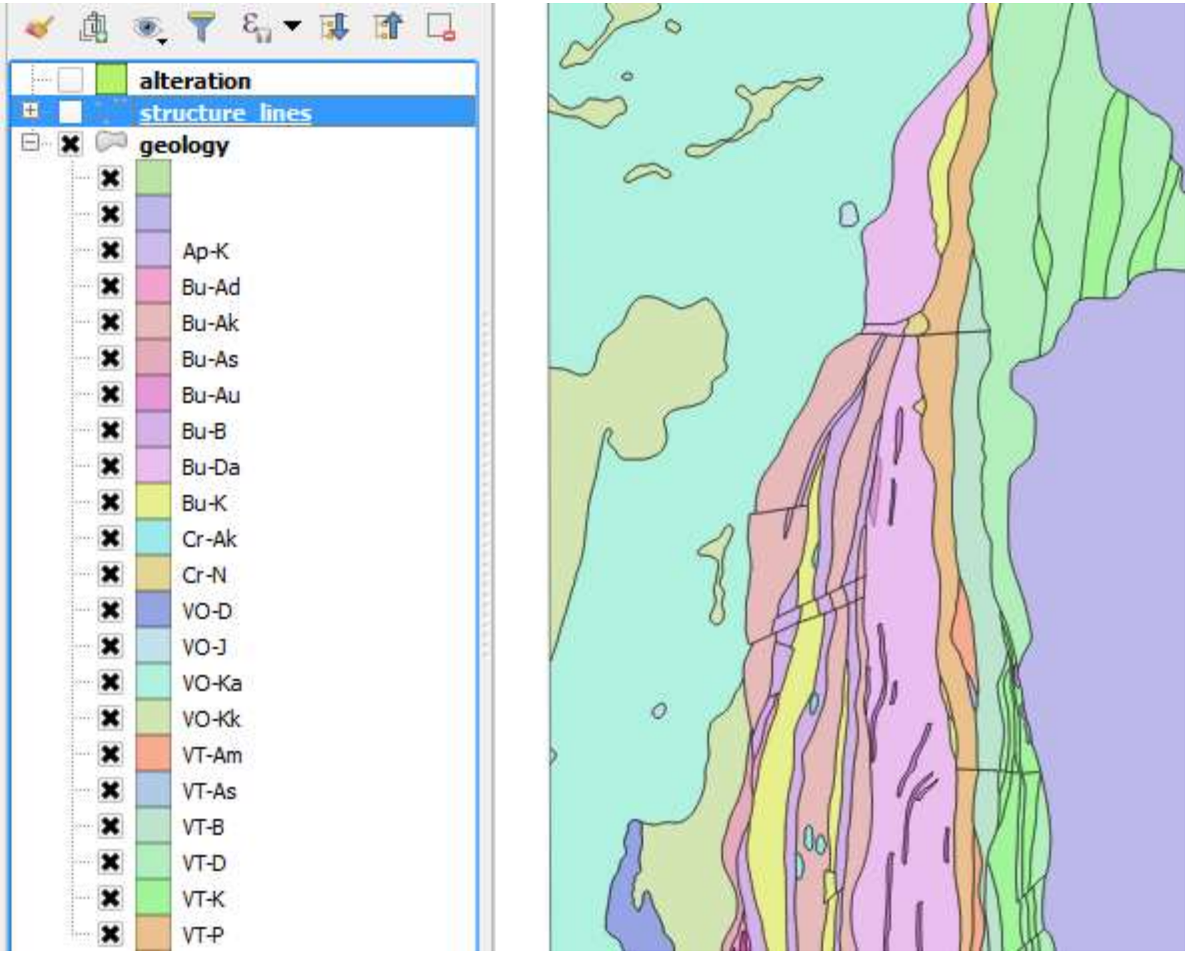
- Geologic structure
  - Fault
  - Lineament
  - Contact
- Stream
  - Depth
  - Quality
  - Flow Rate
- Street Centerline
  - Street Name
  - Address Ranges
- Water Main
  - Pipe size
  - Pipe Material
  - Date Installed

Geological structures





	LNTYPEC	TYPE
32	13333	Fault, thrust
33	13333	Fault, thrust
34	13333	Fault, thrust
35	13333	Fault, thrust
36	13333	Fault, thrust
37	13333	Fault, thrust
38	13333	Fault, thrust
39	10	Fault
40	10	Fault
41	10	Fault
42	10	Fault
43	10	Fault


alteration
structure_lines
geology
Ap-K
Bu-Ad
Bu-Ak
Bu-As
Bu-Au
Bu-B
Bu-Da
Bu-K
Cr-Ak
Cr-N
VO-D
VO-J
VO-Ka
VO-Kk
VT-Am
VT-As
VT-B
VT-D
VT-K
VT-P

Data Entry

- Digitizing hard copy maps
- Keyboard entry of coordinate data
- Scanning a map manuscript
- Importing existing data
- Live electronic data (GPS, Magnetometer, Web … etc.).

- Spatial data *(where)*
  - specifies location
  - stored in a *shape file* for example in Arc*GIS*
- Attribute (descriptive) data *(what, how much, when)*
  - specifies characteristics at that location, natural or human-created
  - stored in a database *table*
- GIS systems traditionally maintain spatial and attribute data separately, then “join” them for display or analysis


SXblue
SXPro GNSS
Collecteur de données /
Système de positionnement
Data Collector/Positioning System
Cartographie
Mapping
Carottage
Core Drilling
Placette-échantillon
Sampling Plot
Arpentage
Surveying
Campagne de terrain
Field Operations
Demandez une démo !
Ask for a Demo!


Map
Options
Layers
Trimble


archer


Performance
POWER
Accuracy
Champion


eBee
senseFly
eBee
The professional mapping drone


Collector is Part of ArcGIS Online
Collector is an OOTB App for iOS and Android
Consumes WebMaps Published in ArcGIS Online ***or Portal for ArcGIS
Licensed via your ArcGIS Online Organizational Account
In Summary – Let's Start with ArcGIS Online
App Store
Google play


Survey123
for ArcGIS (Beta)
Smarter Forms, Smarter Field Work
Go To My Surveys
Trial requires an ArcGIS Online account
Get a 60-day free trial
Asset Inspection


Freeance Mobile
A Breakthrough in GIS and Location
Live data to and from the field keeps you connected
One app for all smartphones
Easy to use and implement

Projection, Scale, Accuracy and Resolution: *the key properties of spatial data*

- **Projection:** the method by which the curved 3-D surface of the earth is represented by X,Y coordinates on a 2-D flat map/screen
  - distortion is inevitable
- **Scale:** the ratio of distance on a map to the equivalent distance on the ground
  - in theory GIS is scale independent but in practice there is an implicit range of scales for data output in any project
- **Accuracy:** how well does the database info match the real world
  - *Positional*: how close are features to their real world location?
  - *Consistency*: do feature characteristics in database match those in real world
    - is a road in the database a road in the real world?
  - *Completeness*: are all real world instances of features present in the database?
    - Are all roads included.
- **Resolution:** the size of the smallest feature able to be recognized
  - for raster data, it is the *pixel* size

The tighter the specification, the higher the cost.

Importance of GIS

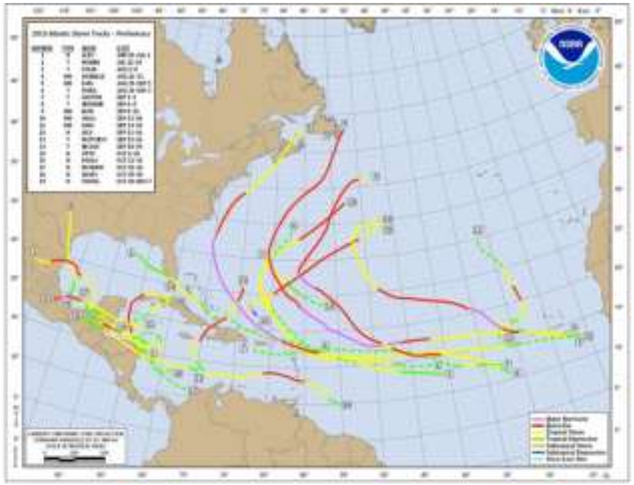
- The information relationships would become more integrated, resulting in less work overall.
- GIS data integration capabilities can help you leverage existing systems by enabling access to all your data from one place. You will also gain important visualization capabilities that give you a common operational picture of all your facilities and greater power to effectively control your operations.
- Products, such as maps, database queries, charts and tables can be easily created out of the GIS, integrating all the information into one or two presentation mediums.

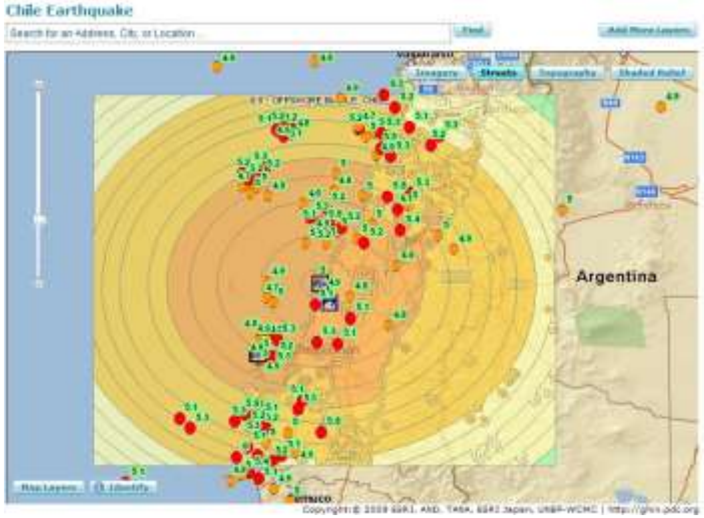
Examples of GST/D Applications in DRM

- Emergency response
- Site Selection
- Traffic Impact Analysis
- Epidemiology
- Vulnerability Assessment
- Weather Forecasts
- Predictive modeling
- Monitoring environmental risk
- Modeling stormwater runoff
- Management of watersheds, floodplains, wetlands, forests, aquifers
- Environmental Impact Analysis
- Groundwater modeling and contamination tracking

GST in Risk Assessment and Identification

- One principle of risk assessment is that risk due to natural catastrophes is location dependent which can be assessed within an acceptable range of uncertainty if reliable historical and location specific data is available
- In addition to assessing vulnerable zones, GIS can analyse risk graphically, allowing planners to model disaster scenarios and the potential damages
- Results can be used to plan mitigation strategies

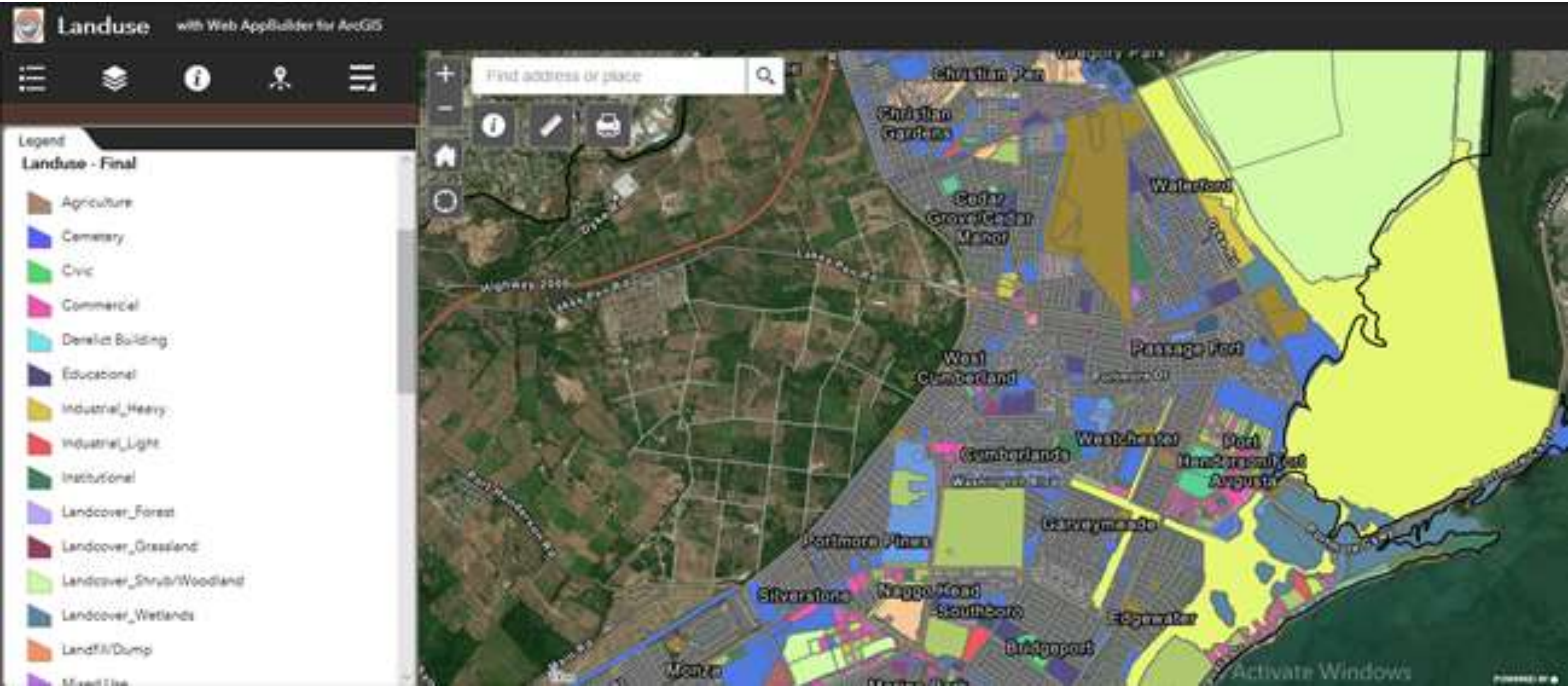




Monitoring Susceptible and High-Risk Areas

GST in Risk Reduction

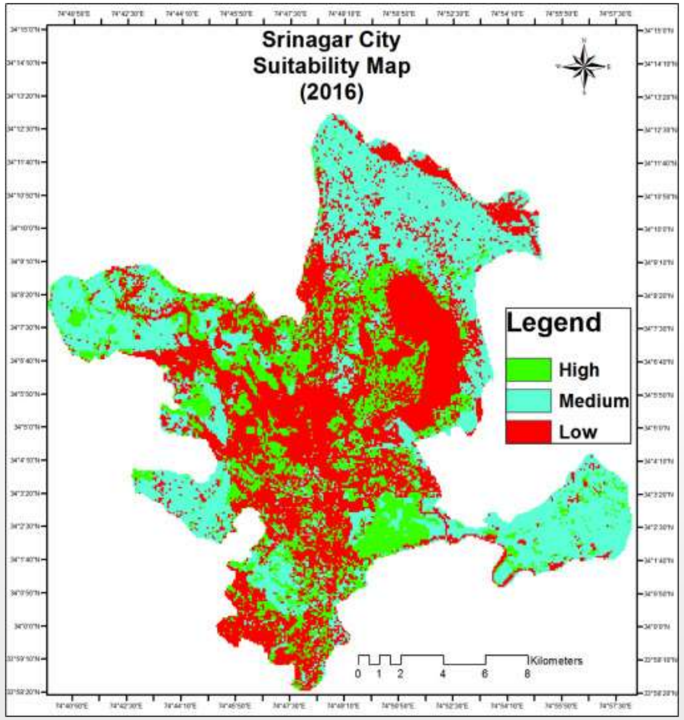
- GST facilitates risk-informed decision-making
- Actions are taken to avoid or reduce the likelihood of a disaster using data to create management plans in vulnerable areas, such as building restrictions in areas prone to floods.
- Susceptible areas may require more comprehensive plans to avoid detrimental effects from unavoidable events

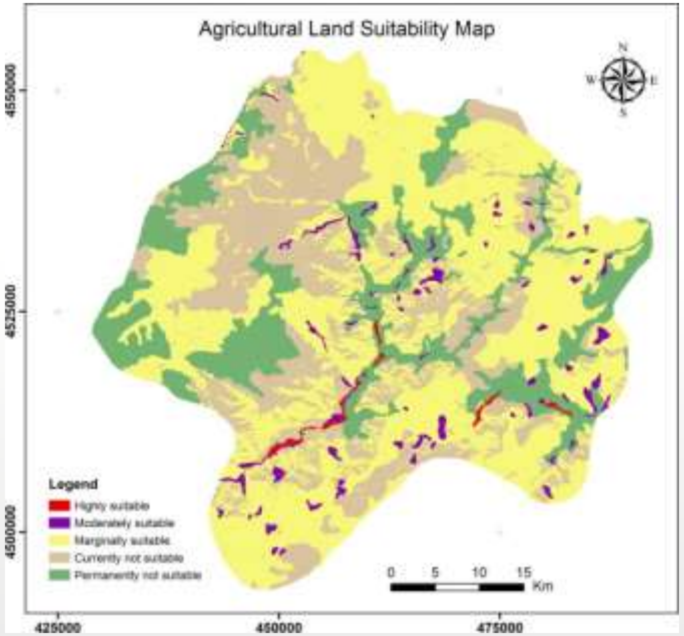


Landuse
with Web AppBuilder for ArcGIS
Find address or place
Legend
Landuse - Final
Agriculture
Cemetery
Civic
Commercial
Derelict Building
Educational
Industrial_Heavy
Industrial_Light
Institutional
Landcover_Forest
Landcover_Grassland
Landcover_Shrub/Woodland
Landcover_Wetlands
Landfill/Dump
Christian Pen
Christian Gardens
Cedar Grove/Cedar Manor
Waterford
Passage Fort
West Cumberland
Westchester
Cumberlands
Garveymeade
Portmore Pines
Silverstone
Naggo Head
Southboro
Bridgeport
Edgewater
Activate Windows

Portmore Vulnerability Web App
with Web AppBuilder for ArcGIS
Find address or place
Legend
Portmore_Vulnerability_Map2 - Boundary_Proj
Portmore_Vulnerability_Map2 - Total Vulnerability - Floods
Very low Vulnerability to Flood
Low Vulnerability to Flood
Medium Vulnerability to Flood
High Vulnerability to Flood
Very High Vulnerability to Flood
Portmore_Vulnerability_Map2 - Physical Vulnerability - Hurricane Winds
Very Low Physical Vulnerability - Hurricane Winds
Low Physical Vulnerability - Hurricane Winds
Medium Physical Vulnerability - Hurricane Winds
High Physical Vulnerability - Hurricane Winds
Very High Physical Vulnerability - Hurricane Winds
Central Village
Spanish Town
Christian Gardens
Cedar Grove/Cedar Manor
Lakes Pen
Corletts Pen/March Pen
Hill Run
Passage Forts
Westchester
Portmore Pines
Monza
Marine Park
Portmore
Belmont
Chedwin

Portmore FloodRisk
with Web AppBuilder for ArcGIS
Legend
Gregory Park
Christian Pen
Christian Gardens
Meadowvale
Waterford
Cedar Grove/Cedar Manor
Independence
Portmore_Flood_Risk_Map - TotalRisk_100yr_HurricaneFlood_proj
Very Low Total Risk
Low Total Risk
Medium Total Risk
High Total Risk
Very High Total Risk
Portmore_Flood_Risk_Map - TotalRisk_100yr_RainstormFlood_proj
Very Low Total Risk
Low Total Risk
Medium Total Risk
High Total Risk
Very High Total Risk
Portmore_Flood_Risk_Map - TotalRisk_10yr_RainstormFlood_proj
Very Low Total Risk-10yr Rainstorm Flood

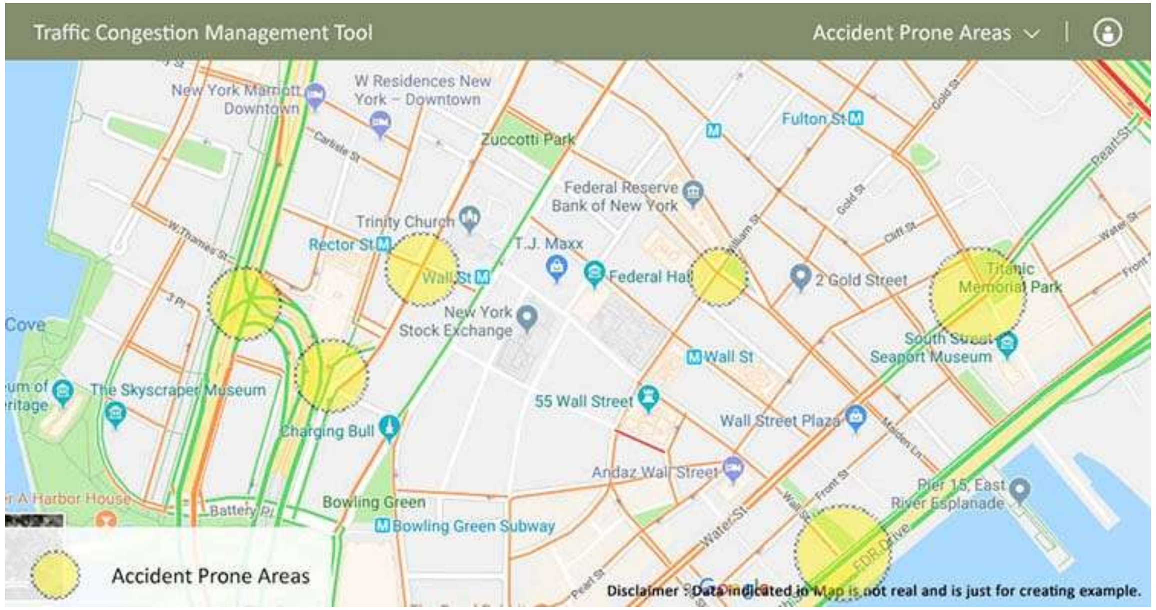

Srinagar City
Suitability Map
(2016)
Legend
High
Medium
Low
Kilometers
0 1 2 4 6 8

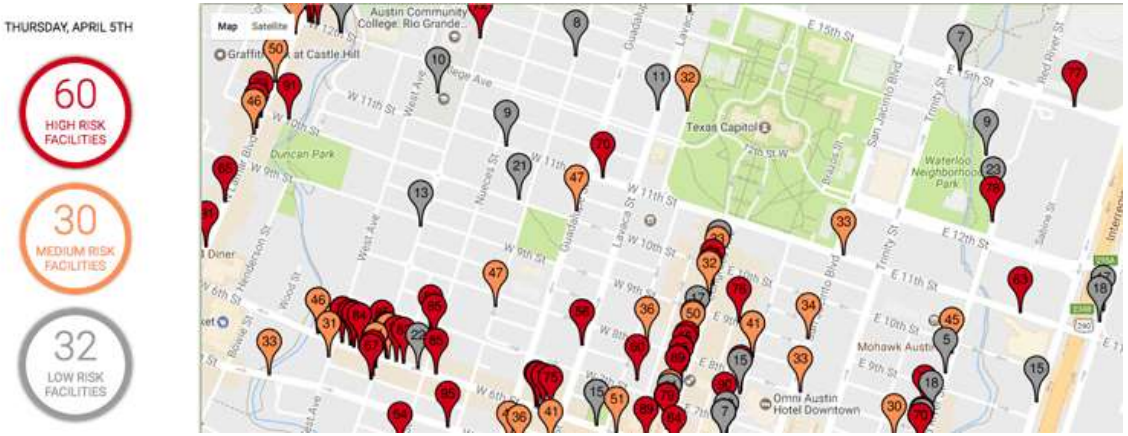

Agricultural Land Suitability Map
Legend
Highly suitable
Moderately suitable
Marginally suitable
Currently not suitable
Permanently not suitable
0 5 10 15
Km
4550000
4525000
4500000
425000
450000
475000

GST in Disaster Preparedness

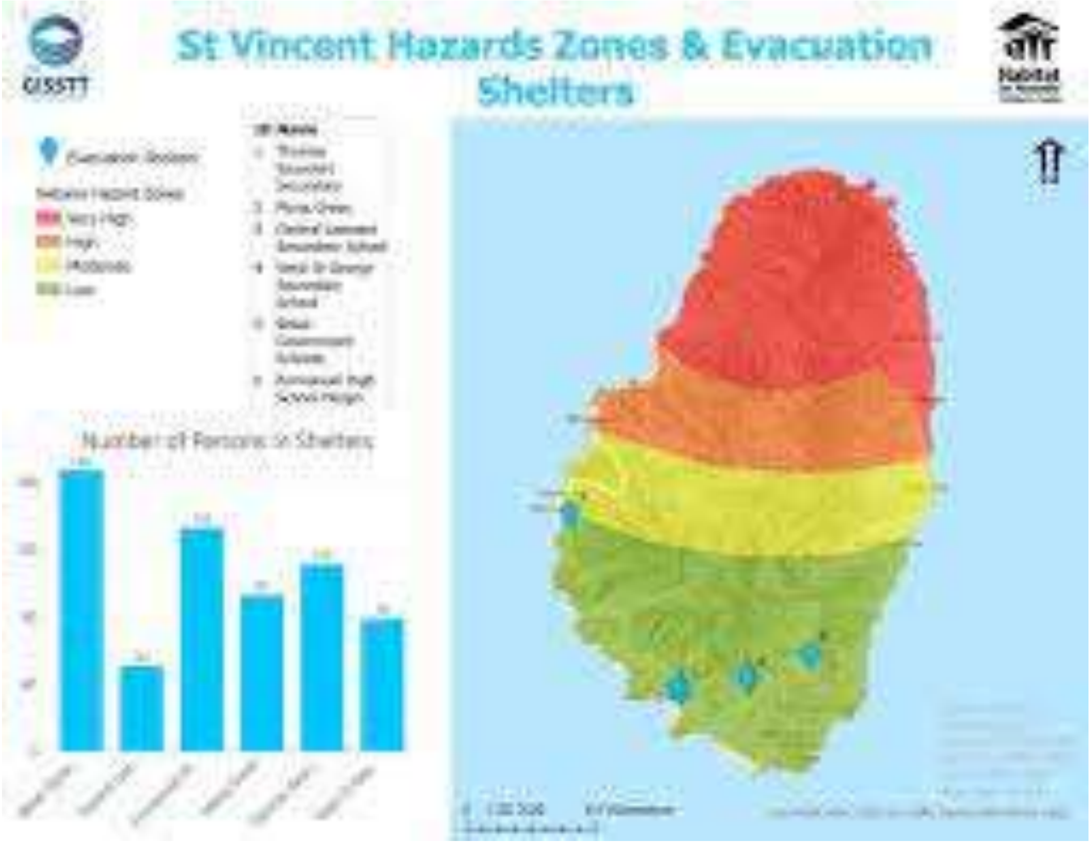
- GIS can provide information that is valuable during real emergencies. Several “what if?” questions can be answered through preparedness training and procedures
- GST is often critical to real-time monitoring for emergency early warning.

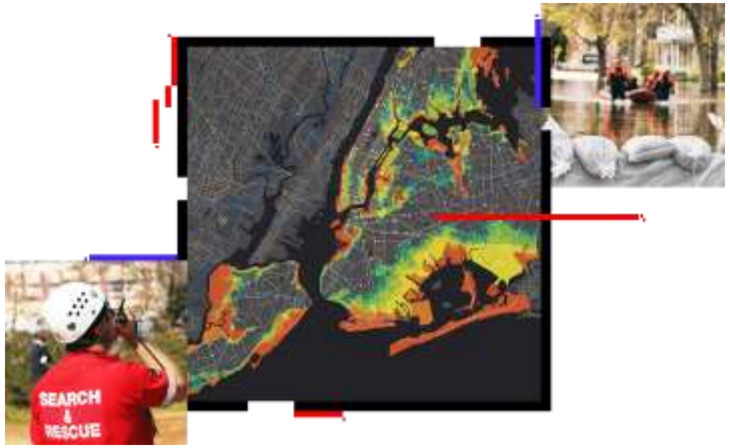
Traffic analysis

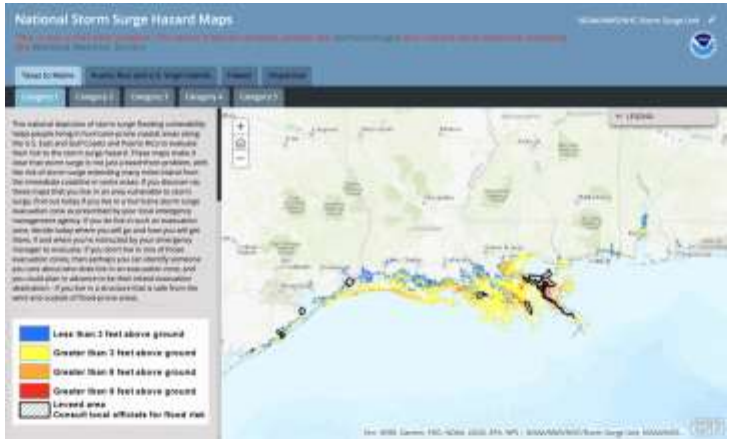


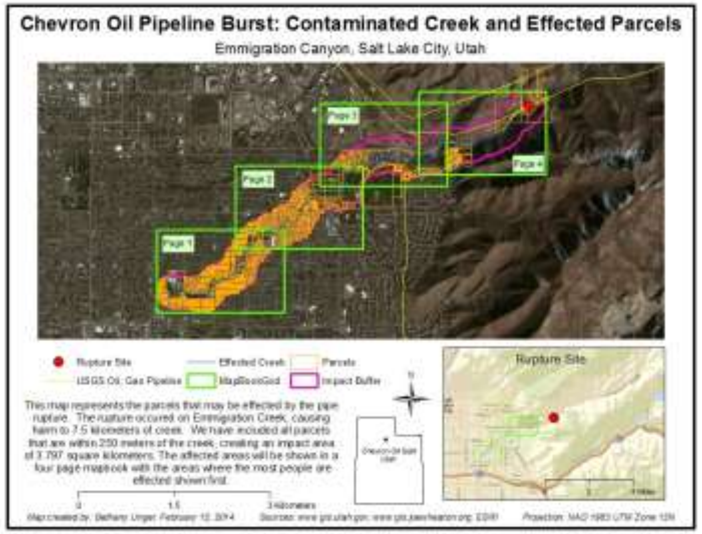


Community Awareness



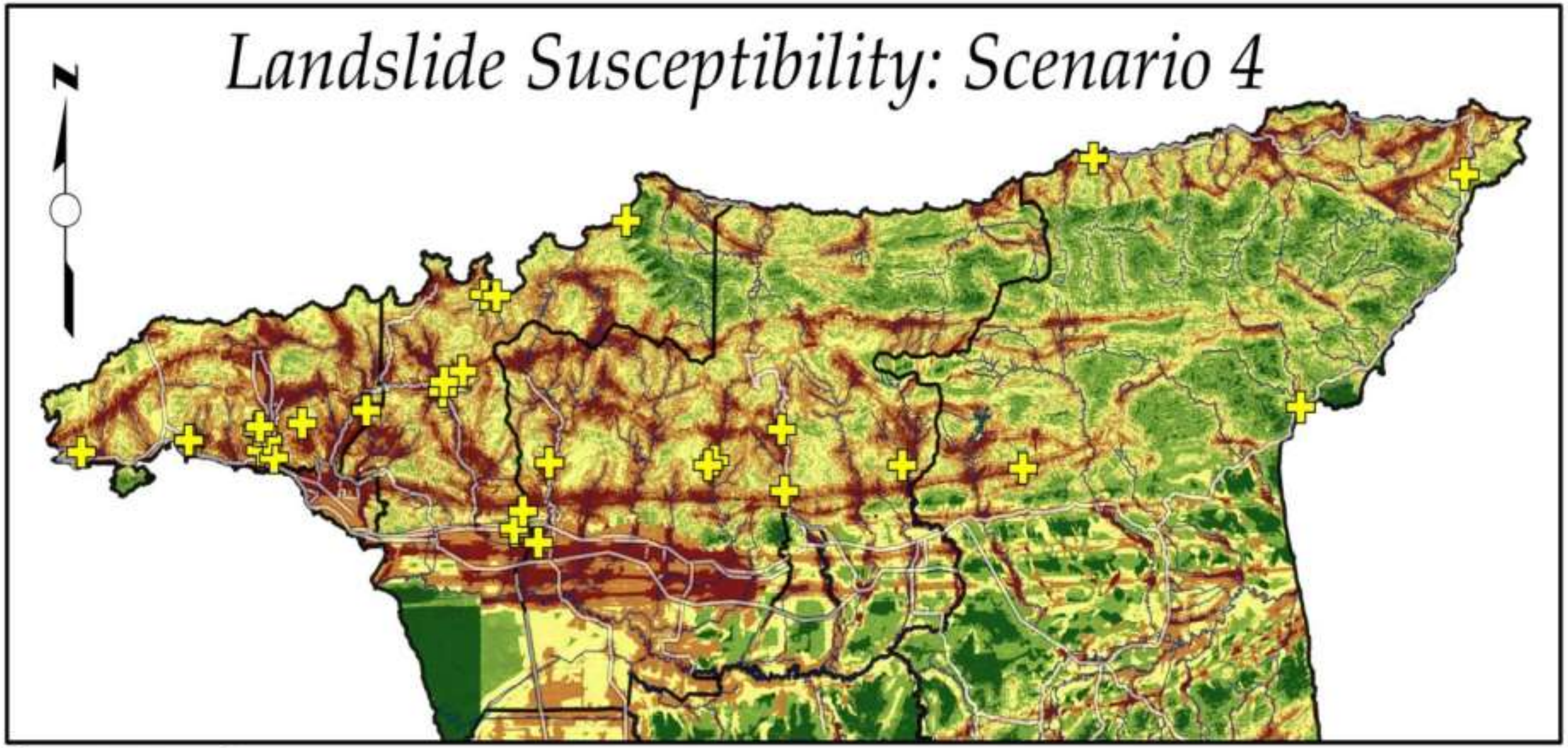






Emergency response

Landslide Susceptibility: Scenario 4



Legend

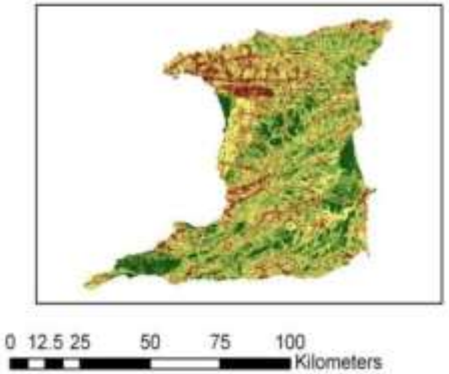
- Landslide Occurence
- Roads
- Streams
- TdadCorporations

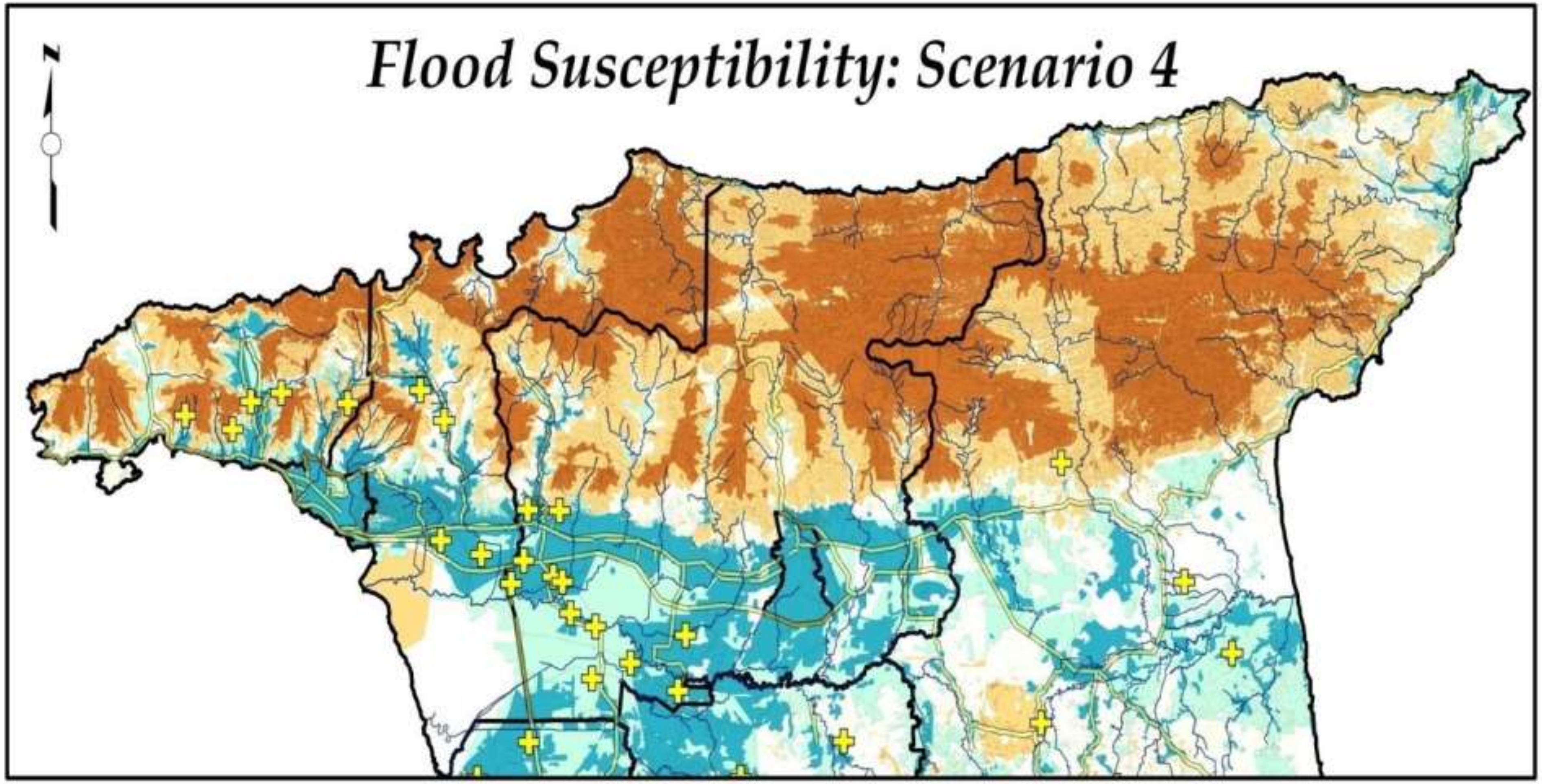
Landslide Susceptibility

VALUE

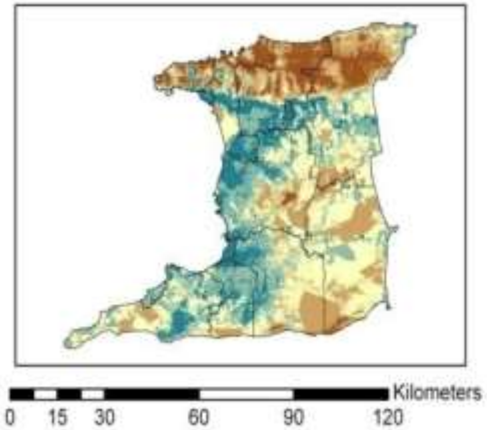
- Very Low
- Low
- Moderate
- High
- Very High

Instability Factor	Weights
Lithology	7
Tectonic Formation	6
Slope	8
Land Use	5
Road	3
Drainage	4
Aspect	1





Flood Factor	Weight
Rainfall	2
DEM	2
Slope	2
Drainage Density	1
Road Density	1
Land Use	2



What made all of these possible?

Access to

- **Technology (currency)**
- **Data (currency, resolution, accuracy)**
- **Policy (relevance, monitoring)**
- **Human resources (skills and benefits)**
- **Funding (driven by applications and results)**
- **Political support (motivation for success)**

Thank you!

- ---------------END-------------------

UNITED NATIONS

ECLAC

CCRIF SPC

The Caribbean Catastrophe Risk Insurance Facility